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Editors

Abukutsa-Onyango, M.O., A.N. Muriithi, V.E. Anjichi, K. Ngamau and S.G. Agong
(HAK, Kenya)

A. Fricke, B. Hau and H. Stützel
(Hannover, Germany)

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Organizing Committee

KENYAN TEAM

Prof. Stephen G.Agong(HAK &JKUAT)	Team Leader
Prof. Mary O.Abukutsa Onyango (HAK &MSU)	Chairperson-HAK
Ms Alice N. Muriithi (HAK)	Secretary-HAK
Dr Kamau Ngamau (HAK&JKUAT)	Treasurer-HAK
Victoria Anjichi (HAK	Assistant Treasurer

GERMAN TEAM (University of Hannover)

Prof Hartmut Stützel	Team Leader
Prof Benhard Hau	Member
Dr Andreas Fricke	Member

Enquiries about this book can be addressed to:
Prof Mary O.Abukutsa Onyango
Chairperson Horticultural Association of Kenya
Department of Horticulture
Maseno University
P.O. Private Bag, 40105Maseno, Kenya.
mabukutsa@yahoo.com

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Organizers

Horticultural Association of Kenya
Department of Horticulture
Maseno University
P.O. Private Bag
Tel: +254-57-351620/2
Fax:+254-57-351221
vc@maseno.co.ke
mabukutsa@yahoo.com

University of Hanonver
Institute of Vegetable and Fruit Sciences
and Institute of PlantDiseases and Plant Protection
Herrenhaeuser Str. 2D-304 19, Hannover
Tel: +49 511 762 2634
Fax: +49 511 762 3606
office@gem.uni-hannover.de

Jomo Kenyatta University of Agriculture and Technology (JKUAT)
P.O. Box 62000, Nairobi, Kenya.
Tel:+254-67- 52181-4, 52711
Fax: +254-67-52197
dvcapd@nbnet.co.ke

November 2005

Website: http://www.gartenbau.uni-hannover.de/gem/svepit.htm

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PREFACE

Millenium development goals include reducing the proportion of people who suffer from hunger and poverty. To achieve this goal the horticultural sector cannot be left out and therefore can play an important part in poverty reduction. In Kenya over 50% of the rural communities live below the poverty line. Horticultural sector remains an important foreign exchange earner to Kenya and contributes significantly in the local diets. Currently it is the second largest foreign exchange earner, after tourism. Development of this sector will stimulate economic growth as well as provide employment opportunities. Due to growing competition for both domestic and export markets, growers, 80% of whom are small scale farmers, require technologies that are environmetal friendly and guarantee good health. Sustainable horticultural production would contribute significantly to the government's effort to alleviate poverty and empower the rural farmers.

The first seminar on sustainable horticulture production in the tropics was held between 3rd and 6th October 2001 where three working groups were formed these were: **Export crops, Biotechnology and African Indigenous Vegetables**. In the second seminar held 6th -9th August 2002, sessions focussed on two key areas **1) Ways to a pesticide-reduced horticultural production in the tropics 2) efficient water and nutrient use in horticultural production in the tropics**. In this this third seminar (workshop) the main focus was on African Indigenous vegetables and the venue was changed from Jomo Kenyatta University of Agriculture and Technology where the first two seminars were held to Maseno University. This University is in a region where a rich diversity of indigenous vegetables exist. Half of the workshop was dedicated to this topic and was in form of plenary sessions. It was realized that we cannot talk about sustainable horticultural production without bringing aboard the indigenous crops that have several value and potentials yet continue to be neglected. In this workshop the three working groups continued with their work that was started in the first seminar. The aim of establishing these groups was to concentrate on important issues in the wide field of sustainable horticultural production. The oral presentations that were complemented by poster presentations were in the first two days of the workshop and in the third and fourth days participants visited farmers growing indigenous vegetables. The workshop addressed several topics under the following themes:

1. Germplasm collection, characterization and seed multiplication of indigenous vegetables
2. Nutritive quality of indigenous vegetables and acceptability by consumers
3. Crop management of indigenous vegetables
4. Economic importance, marketing and technology transfer of indigenous vegetables
5. Export crops
6. Biotechnology
7. Other Horticultural crops

The workshop organizing committee would like to thank all the authors who presented papers contained in these proceedings. We had an overwhelming response to our call for papers and we are grateful for the enthusiasm. We would like to express our appreciation to all the individuals who singly or collectively contributed to the organization and ultimate success of the workshop. We greatly thank the chairpersons of the sessions, rapporteurs, the editorial staff and all other HAK executive committee members for their various contributions.

Special thanks to Prof Frederick N.Onyango, the Vice Chancellor Maseno University for providing us with enabling environment and Officially opening the workshop.Very special thanks go to German Academic Exchange Service (DAAD) for the financial support that made the workshop a great success.

Finally, we wish to sincerely acknowledge the support received from the Vice-Chancellor of JKUAT, Prof N.Wanjohi and Deputy Vice Chancellor (Administration, Planning and Development), Prof S.G. Agong and their presence and useful remarks during the opening session. We in particular, would like to thank Dr Mel Oluoch, training specialist from AVRDC-Regional Center for Africa for delivering a keynote address and Prof William R.Ochieng', the Director, Institute of Research and Post-Graduate Studies (IRPS) , Maseno university for Officially closing the workshop.

OFFICIAL OPENING SPEECH

PROF. FREDERICK N. ONYANGO
The Vice Chancellor, Maseno University

Third Workshop on Sustainable Horticultural Production in the Tropics from 26th -29th November 2003.

Dear Colleagues in Scholarship,
It gives me great joy to be with you today and participate in the opening ceremony of the Third Workshop on Sustainable Horticultural Production in the tropics. First and foremost I take the earliest opportunity to welcome all participants to Maseno University. I sincerely appreciate the fact that the organizers chose Maseno University as a venue for this workshop where the main theme is on African indigenous vegetables. This University is located in a region where you can find unique plants and animals that are currently not found anywhere else and the region is rich in biodiversity. Many of the indigenous plants are threatened with extinction due to neglect by stakeholders and yet these plants possess several advantages

African indigenous vegetables have several values and properties that make them useful plants to the community. These vegetables have been documented to have a high nutritive value with regard to micro-nutrients and in certain cases, their contents supersedes that of the exotic ones. African indigenous vegetables have medicinal properties and can treat ailments that pertain to stomach problems especially the bitter types, they grow very fast and produce a lot of seed within a short period. Most of them can withstand nutritional stress and drought. They have mechanisms within them that enables them to withstand stress. Despite the enumerated value, these vegetables have been neglected by stakeholders in terms of research, extension, education and utilization. It is therefore remarkable that the workshop organizers placed emphasis on these vegetables
It has been reported that 50% of the rural population in Kenya live below the poverty line and this poverty is manifested in malnutrition and poor health. In an endeavour to alleviate poverty, indigenous plants can play an important role in sustainable production and this can be attributed to their many agronomic advantages. These advantages make African indigenous vegetables lend themselves to poverty alleviation intervension programmes through sustainable production.

Deliberations from this workshop are expected to go a long way to enhance development in the horticultural sector and create an impact in the economy and health of people in Africa

It is important to note that, the horticultural sector is a major foreign exchange earner for Kenya coming only second to tourism, but I know that in the near future it will take a lead. It is estimated that the horticulture industry contributes well over KShs 15 billion annually. This is a significant contribution that enhances economic growth. What role can African indigenous plants play in not only alleviating poverty, but in improving the horticulture sector?

I wish to underscore the importance of field trips to horticulture sites during such workshops. The trips play an important part in bridging indoor discussions among the participants. It is vital to understand what the farmers are doing out there. This kind of visits puts meaning to the presentations and interaction between the farmers and experts are quite enriching.
Finally, scholars and researchers, I wish to extend my gratitude to the German Academic Exchange Service (DAAD), Horticultural Association of Kenya, University of Hannover, JKUAT and Maseno University for this collaboration. This joint initiative is impressive and timely.

With these remarks, it is now my pleasure to declare this workshop OFFICIALLY open

THANK YOU

KEY NOTE ADDRESS

Promotion of Indigenous Vegetable Conservation, Production and Utilization In Africa

[1]Mel O. Oluoch and [2]M. L. Chadha
[1]Training Specialist and [2]Director
AVRDC-The World Vegetable Center
Regional Center for Africa (RCA)
P.O. Box 10, Duluti, Arusha, Tanzania
E-mail: info@avrdc-rca.co.tz

INTRODUCTION

African Indigenous Vegetables (AIV's) are an important part of farming and consumption systems throughout Africa and are crucial for food security particularly during famine and natural disasters. They are easy to grow, require minimal external inputs and are very suitable to resource-poor farmers. When consumed frequently and prepared properly to maintain the nutritional value, vegetables can release and make available micronutrients as well as increase the bio-availability and effective absorption of micronutrients in other staple food crops. In many instances, low input AIVs are the only cash resource at the disposal of -the women for the welfare of their families.. Thus their improved consumption and utilization is the most direct, low-cost way for children, lactating mothers and urban and rural poor to improve their nutritional, health and income status. However, their cultivation is increasingly low and in most cases the vegetables are rarely available in the markets during the off seasons. Informal seed production systems of AIVs applied by farmers are limited to subsistence production which is endangered by opening of markets, direct competition between farmers and commercial seed suppliers as well as weak support for community based conservation systems. However, market-oriented farmers fail to meet consumer demands due to limited access to a wide variety of clean and certified seeds. The promotion of these crops will thus be beneficial in meeting emergent needs for food during dry seasons and in smoothening the effects of vegetable seasonality, which contributes to malnutrition.

Since 1998, AVRDC-RCA has been involved in strategies to increase the consumption of under-exploited indigenous vegetables; which plays an important food-based role in eradication of vitamin A, iron and other micronutrient deficiencies so widely prevalent in African countries. Research and Development programs have been/are being implemented to increase the production, consumption and utilization of IV's in order to improve the nutritional, economic and social well-being of low-income groups at rural and urban households, particularly in times of seasonal food shortages when malnutrition is at its peak.

AVRDC-RCA has collected and evaluated over 700 germplasm accessions of IV's but mainly from 15 common indigenous vegetables namely nightshade (*Solanum scabrum/americanum/villosum*), African eggplant (*Solanum aethiopicum/ macrocarpon/anguivi*), Ethiopian Mustard (*Brassica carinata*), spiderplant *(Cleome gynandra*), amaranth (*Amaranthus dubius/ hybridus/lividus/ thumbergiii etc*), jute mallow (*Corchorus olitorius*), okra (*Abelmoschus esculentum/ caillei*), pumpkin (*Curcubita sp*.), moringa (*Moringa olifera*), sun-hemp (*Crotalaria ochroleuca*), and vegetable cowpea (*Vigna unguiculata*). Some of the IV lines have been purified, characterized and their cultivation and utilization practices have been developed, documented and are being disseminated. Twenty promising lines/varieties of Okra, Pumpkin, Moringa, African eggplant, Nightshade, Jute Mallow, Spider-plant, Ethiopian mustard, Amaranth, Vegetable cowpea and Sun hemp are currently available for promotion.

AVRDC-RCA has been implementing several projects and programs geared towards improving the bio-diversity, production, marketing and consumption of indigenous vegetables. The Center has been focussing on the main constraints: collection, selection and purification of superior germplasm, development of cultural practices, adaptation for farmers use, promoting seed distribution and organizing access to seeds.

AVRDC-RCA Research and Development of Programs in Indigenous Vegetables In the past six years, AVRDC-RCA has been involved in implementing several projects in indigenous vegetables. These projects include:

Project 1: Improving Food security in sub-Saharan Africa through increased Utilization of Indigenous Vegetables: Studies on seed production and agronomy of major African vegetables (funded by DFID, 1998-2001).

The goal of this project was to increase household food security of resource poor groups through a greater use of the natural resource base in Cameroon and Tanzania. The project purpose was to enhance the productive potential of a number of selected African vegetables through a landrace enhancement program, seed production and multiplication; and dissemination of advice on cultivation techniques suitable to small-scale farmers. The project objectives included: assembling germplasm of target species of African indigenous vegetables (AIVs); characterizing and purifying collected germplasm; producing base or breeder seed of selected species of AIVs; developing appropriate production techniques of target species of AIVs and disseminating project outputs to NARES, NGOs and farming communities. The target AIV species were: African nightshade, African eggplant, and Jute mallow for activities in Cameroon and Amaranth, African nightshade, African eggplant and Ethiopian kale for activities in Tanzania.

The project was carried out in collaboration with NRI, UK; the University of Dschang, Cameroon; and Horticultural Research Institute (HORTI-Tengeru), Tanzania. Germplasm collection missions were carried out in Cameroon and Tanzania with collaborative NARS. 193 accessions were collected and are being maintained at AVRDC-RCA and at the University of Dschang, Cameroon. Additionally, the collected germplasm were characterized, purified, and the base seed multiplied before being distributed to target farmers. Preliminary descriptor lists for African eggplant, African nightshade, Ethiopian Mustard and spiderflower plant were developed.

Project 2. Germplasm Management of Underutilized African Vegetables for Improving Agro-biodiversity, Food Security and Increasing Income of Rural and Urban Poor in Southern Africa (funded by BMZ/GTZ; 2001).

The project goal was to reduce malnutrition, increase household food security and income generation of resource poor groups of Southern African countries, through a greater use of African indigenous vegetables. The main objectives were: to assemble germplasm of selected African vegetables; to purify and multiply selected germplasm of AIV's and to produce and distribute to farming communities, self-help groups, NGOs and private sector, seed of selected AIV's. 143 accessions of 14 species from amaranthus, nightshade, African eggplant, ethiopian kale, vegetable cowpea and jute mallow were collected, purified and base seed multiplied. Out of those initial collections, the total number of distinct accessions increased to 186 through further purification and selection process. The most promising 10 accessions in yield and horticultural traits were multiplied, and 184 kg seed produced and distributed to 241 farmers for further use.*Project 3. Enhancing production and utilization of African indigenous vegetables through sustainable seed production and distribution for better health, nutrition and small agribusiness in ASARECA member countries (funded by GTZ/BMZ; 2001 - 2003).*

The target countries were Kenya, Uganda and Tanzania. The project was carried out in collaboration with Kawanda Agricultural Research Institute in Uganda, Jomo Kenyatta University of Agriculture and Technology in Kenya, and Horticultural Research Institute in Tanzania. The project aimed to increased production through improved sustainable production practices; enhance availability of good quality seeds through seed enhancement; develop proper storage techniques and improve seed production systems at farm level; enhance recipe preparation, processing, and preservation of selected AIVs; and increase year round consumption and utilization of AIV's. Under this project, package of practices were developed; 1.2 tons of quality seed of Amaranth, African Eggplant, Nightshade, spiderplant and Ethiopian Mustard were produced and distributed in Kenya, Tanzania and Uganda; Mechanisms of seed storage at ambient conditions was elucidated; seed production protocols were developed; twelve short term in country courses on recipe preparation, processing, and preservation of selected AIVs were conducted; and seven hundred seed nutrition kits distributed to households for increased year round consumption and utilization of AIV's.

Project 4. Germplasm Collection, Evaluation and Improvement of African Leafy Vegetables (funded by USAID; 2002 - 2006).

The project is being implemented in collaboration with Ben Gurion University in Israel. The aim of the project is to: collect germplasm; evaluate the collection; carry out survey on indigenous knowledge; and modelling the rate of genetic erosion in Tanzania. So far, 53 accessions of Ethiopian Mustard, 18 accessions of spiderplant and 48 accessions of Nightshade have been collected in Tanzania. 15 accessions of Ethiopian Mustard, 6 accessions of spiderplant and 19 accessions of nightshade have been purified while all the accessions are under evaluation. 50 families have been interviewed on their Indigenous knowledge on IV's. The project is ongoing.

Project 5. Germplasm Management for the Nutritional and Food Security Needs of Vulnerable Groups In Sub-Saharan Africa (2002 - 2004).

This is a partnership project with IPGRI where AVRDC-RCA provides technical support to IPGRI on conservation, capacity building and regional characterization of African leafy vegetables. The project aims to enhance the role of African leafy vegetables in the nutrition of vulnerable groups in sub-Saharan Africa through improved preparation, promotion of consumption, processing, landrace improvement program, and management of their genetic diversity. The AVRDC-RCA technical activities include: holding ex-situ collection of African leafy vegetables; enhancement, characterization, purification, multiplication, evaluation and seed distribution of priority African leafy vegetables; development of on-farm seed production protocols; development of technical guidelines on horticultural practices; capacity building of personnel from partner countries (Zambia, South Africa, Kenya, Cameroon and Senegal) on production, characterization and seed production; and preparation of information leaflets on priority species. So far 235 accessions/lines of African indigenous vegetables have been collected from Senegal, South Africa, Zambia, Kenya, Cameroon and are being held at AVRDC-Genetic Resource Services Unit in Taiwan and AVRDC-RCA in Arusha, Tanzania; Purification, characterization and seed multiplication is ongoing for the target accessions; development of on-farm seed production protocols is being carried out for spiderplant, jute mallow and nightshade; and a Regional course on African leafy vegetable characterization and seed production has been carried out at AVRDC-RCA in Arusha, Tanzania with fifteen personnel from target countries trained.

Project 6. Promotion of neglected indigenous leafy and legume vegetable crops for nutritional health in Eastern and Southern Africa (funded by BMZ/GTZ, 2003-2006)

The project is being carried out in collaboration with IPGRI–SSA, Kenya; Kawanda Agricultural Research Institute, Uganda; Horticultural Research Institute, Tanzania; Bvumbwe Agricultural Research Station, Malawi; Institute of Agriculture Research, Rwanda; and University of Goettingen, Germany. The project aims to improve household food security of resource-poor groups in Eastern and Southern Africa by; 1) Safe-guarding biodiversity of indigenous vegetables, 2) reducing malnutrition and poverty among small farmers and consumers through promotion, production and consumption of indigenous vegetables and 3) diversifying and stabilizing farmers' income and nutritional health through better utilization of indigenous vegetable crops. The activities include: conducting basic and strategic research studies on vegetable legumes; conduct studies on intrinsic nutritional values; collecting base line information on IV's production and consumption pattern and marketing; germplasm collection and evaluation; maintenance of germplasm and seed multiplication; developing production systems; and technology demonstration and transfer. So far, a baseline survey has been completed in Tanzania, Rwanda, Uganda and Malawi and the results are being analyzed. Germplasm collection is ongoing in the target countries with concurrent evaluation being carried out; Seed production institutionalization has also been initiated with three seed companies.

CONCLUSION

The AIV initiatives have resulted in collection of over 700 accessions of IV's but mainly of 15 common indigenous vegetables. The initiatives has resulted in a big systematic work on IVs at AVRDC-RCA which is serving as a base for developing new varieties and to fuel breeding efforts of both AIV's and exotic vegetables.

The project outputs are expected to affect the urban and rural poor. With more vegetables on the table, other family members will also benefit from the nutritious food, which would make a major contribution to their health. Other beneficiaries include NARES, private sector and NGOs. AVRDC will link with Regional Research Organizations and networks to help disseminate information and cultivars, resulting from the projects.

EFFECTS OF WATER STRESS ON DRY MATTER PRODUCTION AND NUTRITIVE QUALITY OF SPIDERPLANT, (*GYNANDROPSIS GYNANDRA* (L.) BRIQ)

P.W. Masinde[1 2], H. Stützel[1], A. Fricke[1] and S.G. Agong[2]
[2]Department of Horticulture, Jomo Kenyatta University of Agriculture & Technology (JKUAT), Kenya

ABSTRACT

Dry matter production, transpiration effeciency and nutritive quality of spiderplant (*Gynandropsis gynandra* (L.) Briq) were investigated in glasshouse studies at Hannover, Germany (2000 and 2002). Two fast growing genotypes (P-landrace and P-commercial), and a slow growing landrace (G-landrace) were grown under droughted and watered conditions. Plants were harvested periodically and dry weight determined. Analyses for nitrogen, nitrate and mineral element were done on blades, petioles, stems and roots of the harvested plants. There was a decline in dry matter production as the fraction of transpirable soil water declined below 0.4. This was accompanied by an increase in the total plant transpiration efficiency (TE) of 16-21% for fast growing genotypes and 8% for the slow growing landrace. In both genotypes groups, plants under severe drought stress maintained significantly higher nitrogen and nitrates as compared to watered plants. The high nitrogen and nitrates concentrations under severe drought stress conditions could be attributed to lack of dilution due to inhibited dry matter production. Mineral content was influenced mainly by genotypes. It is concluded that spiderplant is mainly a drought avoiding species, which reduces expansive growth and increases TE under drought stress. Consumption of blades of spiderplant from plants grown under severe drought stress poses some risk of exposing consumers to the negative effects of nitrates. Also, genotypes showed potential differences in mineral content, providing the possibility to improve the nutritive quality of spiderplant through selection.

Key words: Nitrogen, nitrates, transpiration efficiency, mineral content

INTRODUCTION

Spider plant (*Gynandropsis gynandra* (L.) Briq) is an important traditional leafy vegetable crop in Kenya. It forms a substantial part of the diets of most low and middle level income earners in various parts of the country (Chweya and Mnzava, 1997). Production of spiderplant is mainly rainfed leading to exposure of the crop to varying degrees of drought due to unreliable rainfall. It is generally thought that spiderplant is intolerant to water stress (Chweya and Mnzava, 1997). Rajendrudu et al. (1996) have attributed this to high transpiration rates exhibited by spiderplant due to diaheliotropic leaf movements.

Water deficit affects plant biomass production partly through its negative effects on leaf area. By limiting leaf area development, water deficits reduce radiation interception by the crop and consequently less biomass is produced (Jones, 1992). Furthermore, water deficits can reduce stomatal conductance, leading to reduced carbon assimilation and consequently low biomass production (Medrano et al., 2002).

Plant water use is closely correlated to leaf area development rate. It has been shown that plant species or genotypes with high leaf area development rate also have a high water use rate (Salih et al., 1999). Transpiration efficiency (TE), the ratio of dry matter produced to total water transpired, is an important physiological trait involved in adaptation of plants to drought (Jones, 1992). Under increasing water deficits, partial stomatal closure occurs leading to relatively more reduction in transpiration than photosynthesis (Nobel, 1999). This leads to increased TE. Increased TE under drought would be desirable as it implies that more dry matter is produced for every unit of water used. Even more desirable would be if this increased efficiency is in terms of the economic yield, the leaf in the case of spiderplant, as opposed to the total plant dry weight.

Nitrogen uptake rate is regulated by both soil N availability and crop growth rate (Gastal and Lemaire, 2002). It is however known that the N concentration in plants declines as they grow even when the N supply is ample suggesting that the relationship between N uptake and plant growth is complex (Gastal and Lemaire, 2002). The decline in N concentration with plant growth has been attributed to a dilution effect related to greater plant dry matter increase than N accumulation (Chamorro et al., 2002). Nitrate accumulation in vegetable crops is a well recognized problem that poses health hazards to consumers. Nitrates once ingested by humans are reduced in the liver to nitrites, which in turn combines with haemoglobin rendering it unable to bind oxygen, a condition called methemoglobinemia (Taiz and Zeiger, 1998). Nitrates can also be converted into nitrosamines that are known to be potent carcinogens and are associated with various cancers (Hill, 1991; Taiz and Zeiger, 1998).

When plant metabolism is restricted by unfavourable environmental conditions like low light, low temperature or extremely high temperatures as well as drought, which inhibit photosynthesis, nitrate assimilation is reduced and the nitrates are stored in plant tissues (Roorda van Eysinga and Van der Meijs, 1985; Wright and Davison, 1964). On the other hand, drought may reduce mineral element uptake by plants through reduction in diffusion coefficient and increase in mechanical impedance (Marschner, 1986). Spiderplant is recognized as an important sources of mineral elements to consumers (Schippers, 2000). However, it is also known to accumulate nitrates (Edmonds and Chweya, 1997). With reduced dry matter production and nutrient uptake, and inhibited nitrate assimilation under drought, it is hypothesized that these crops will have lower mineral element and higher nitrates concentrations. The objective of this study therefore was to quantify the effects of the watering regime on dry matter production and contents of nitrogen, nitrates and mineral elements in plant tissues of spiderplant.

MATERIALS AND METHODS

Two pot experiments were conducted in 2000 and 2002 at the Institute for Vegetable and Fruit production at University of Hannover, Germany. Each was a factorial experiment laid out in a completely randomised design with three replications. Two water levels and two broad groups of spiderplant genotypes were used (Table 1).

Table 1. Summary of the experimental factors for the spiderplant glasshouse experiments in 2000 and 2002 at Hannover, Germany

Factor		Description
Genotypes	P-landrace (P-land)	Fast growing and high yielding purple stem and petiole landrace
	P-commercial (P-com)	Fast growing purple stem and petiole commercially available genotype
	G-landrace (G-land)	Slow growing green stem and petiole landrace
Water levels	Droughted	No watering after start of the treatments
	Watered	Rewatered daily to 90% water holding capacity (WHC)

P-landrace and P-commercial genotypes were used in 2000. In 2002, G-landrace was included, while P-commercial was dropped since its responses were similar to those of P-landrace.
The water treatments began at 21 days after sowing in both years, just before onset of flowering. At onset of the treatments, soil moisture in all pots was raised to 100% and 90% water holding capacity (WHC) in 2000 and 2002, respectively. Droughted pots thereafter received no more water, while watered pots were watered daily to maintain the soil moisture at 90% WHC in both years. Five harvests were carried out in both years, at onset of water treatments, at average soil moisture contents of 70, 60 and 40% WHC and lastly when transpiration in droughted plants was below 10% of that in watered plants.

The pots used were made from PVC columns, 1 m in length and 0.20 m in diameter and were filled to a soil bulk density of 1.15 g/cm^3 with loess soil obtained from Ruthe research station. The pot water holding capacity (WHC) was 0.30 and 0.28 w/w in 2000 and 2002, respectively. The experiments were conducted in a glasshouse maintained at 26^{o}C day and 20^{o}C night. Seeds of the selected genotypes were sown directly into the pots on 29th May 2000 and 23rd April 2002. The pots were maintained well watered and emergence was observed after four days in both years. Seedlings were then thinned to one per pot two weeks after planting. Nitrogen was applied at rate of 0.5 and 1.0 g N/plant based on soil analysis results in 2000 and 2002, respectively three weeks after planting by irrigating with fertiliser Floryl 9 (15% N). The soil surface was then covered to a depth of about 3 cm with quartz gravel to minimize soil evaporation. Transpiration was determined by daily pot weight measurements. In this case, the difference in weights between two consecutive days was considered as the water lost through transpiration. The available soil water was expressed as the fraction of transpirable soil water (FTSW) for each pot in the droughted plants. FTSW at day i for each pot was calculated as:

FTSW = Pot weight at day I – Final Pot weight / Initial Pot weight – Final Pot weight

where initial pot weight refers to weight of pot at 100% WHC, while final pot weight refers to weight of the pot when the transpiration of stressed plants was less than 10% of that of the watered plants.

Plant biomass was determined during the destructive harvesting. Plants were cut at the base and separated into petioles, stems and blades. Roots were carefully picked by hand and washed. All plant parts were then dried at 100 °C to constant dry weight (48 hours) and weighed. The dry samples were ground and used for nutrient analysis. Nitrogen content was analysed for blades and petioles in 2000, while in 2002, stems and roots were also analysed in addition. The analysis was done using the Kjeldahl method. Nitrate content was analysed for blades and petioles only in all the experiments, using the colorimetric method. Determination of mineral element content was done by dry ashing followed by use of atomic absorption spectrophotometer for K, Mg, Ca and Fe. P was determined using the colorimetric method with ammonium-vanadate-molybdate. Statistical analysis was done using the GLM procedure of SAS (SAS, 1999).

RESULTS

Drought caused lower leaf dry weights, significant from harvest three in both years (Fig. 1a, b). At end of the experiment (harvest five), dry weight of leaves in droughted plants was 66% of the watered ones in 2000 and 55% in 2002. Total plant dry matter was significantly lower in droughted plants from harvest four in both years **(Fig. 1c, d).** In both years, transpiration efficiency (TE) was higher in the droughted as compared to the watered treatment for all genotypes, being significant only for the P-genotypes (Fig. 2 and Table 2). The P-genotypes responded to drought by increasing their TE by 21% in 2000 and 16% in 2002 as compared to watered plants. On the other hand, G-landrace showed an insignificant increase of only 8%. Overall, both purple stem and petiole, and

The TE of leaf dry weight production (the edible part) was found to be similar under droughted and watered treatment for all the genotypes and in both years (Fig. 3). In petioles, N concentration was significantly lower in watered than droughted plants for the last two harvests in two glasshouse experiments (Fig. 4). When the N concentrations were plotted against dry weights (Fig. 5), blades showed only a slight or no decline in N with increase in dry weight. Their N concentration remained above 5% irrespective of the water level. Petiole, stem and root N concentrations declined with increase in dry weight especially in the glasshouse experiments (Fig. 5). The effect of inhibited dry matter production in maintaining higher N concentrations under droughted conditions was pronounced in the petioles, stems and to a lesser extent the roots. Similar to the case of nitrogen, the NO_3-N concentration of blades and petioles declined over time in all the experiments. The NO_3-N concentration of blades was significantly lower in the watered than droughted plants for the last two harvests of the two glasshouse experiments (Fig. 6).

Table 2. The slope (A), its standard error (SE) and R^2 for the linear relationship between plant dry weight and cumulative transpiration for spiderplant genotypes grown in glasshouse in the years 2000 and 2002 (Fig. 2).

Year	Genotype	Water level	Slope (A)	SE	R^2
2000	P-landrace/commercial	Droughted	6.74a	0.20	0.99
		Watered	5.57b	0.17	0.99
2002	P-landrace	Droughted	6.09a	0.23	0.99
		Watered	5.26b	0.10	0.99
	G-landrace	Droughted	5.82a	0.27	0.99
		Watered	5.38a	0.23	0.99

Slopes followed by the same letter within a genotype are not significantly different green stem and petiole genotypes had similar transpiration efficiencies at similar water levels.

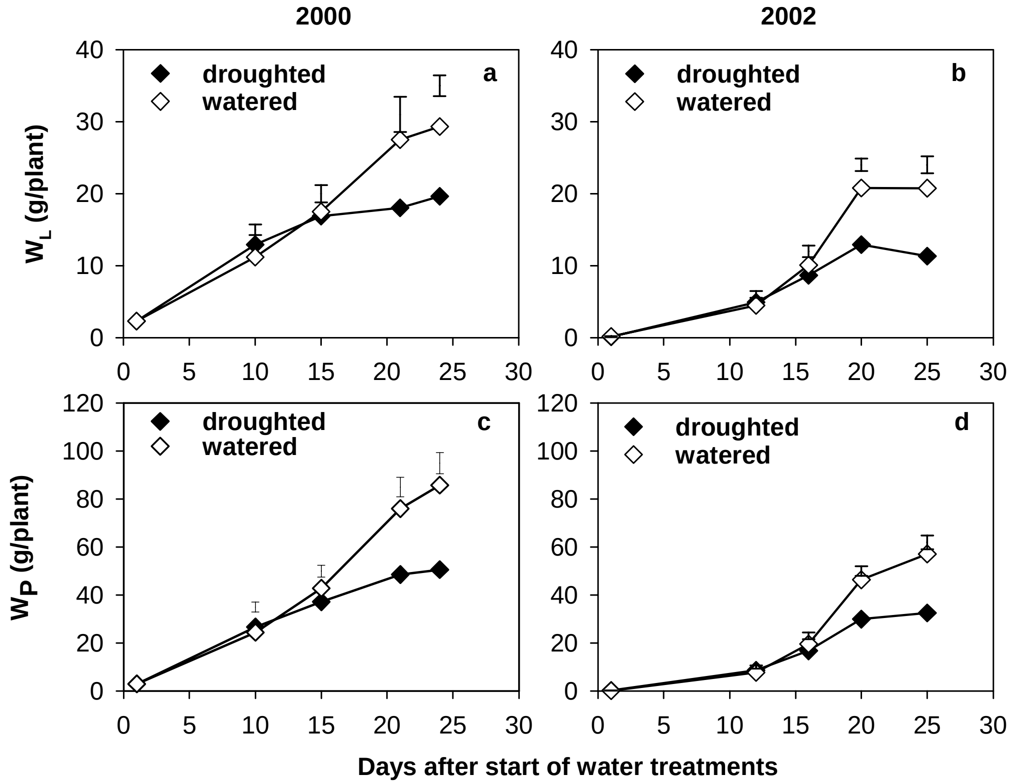

Fig. 1. The Dry weights of leaf (W_L) (a, b) and plant (W_P) (c, d) over time for watered and droughted spiderplant grown in the glasshouse in the years 2000 and 2002 experiments. Points are mean dry weights across genotypes (n=6-9), while vertical bars show $LSD_{0.05}$.

The concentration of mineral element in spiderplant blades showed no consistent significant effects of water treatments and interactions hence only genotype effects are considered. In the 2000 glasshouse experiment, there were no differences between mineral contents of P-landrace and P-commercial. In 2002, P-landrace had higher concentrations of K, while G-landrace had higher Ca concentration (Fig. 7).

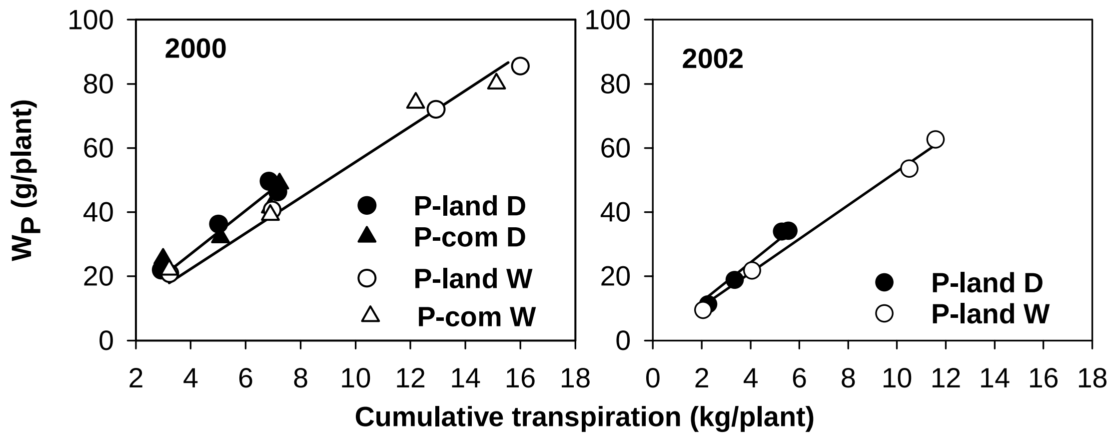

Fig. 2. The relationship between plant dry weight (W_P) and cumulative transpiration (CT) of spiderplant genotypes grown in the glasshouse in 2000 and 2002 under droughted (D) and watered (W) conditions. Points are data means (n=3), while lines are linear functions.

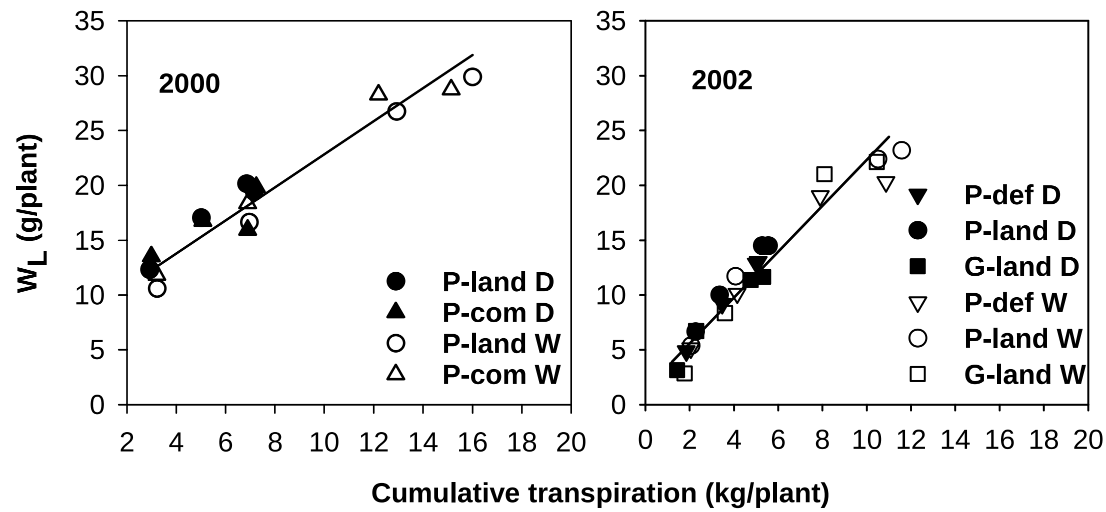

Fig. 3. The relationship between leaf dry weight (W_L) and cumulative transpiration (CT) of spiderplant genotypes grown in the glasshouse in 2000 and 2002. Letters D and W refer to droughted and watered treatments respectively. Points are data means (n=3) while lines are linear functions, $W_L=1.51\pm0.09 \times CT + 7.751\pm0.72$ for 2000 and $W_L=2.09\pm0.24 \times CT + 1.41\pm1.35$ for 2002.

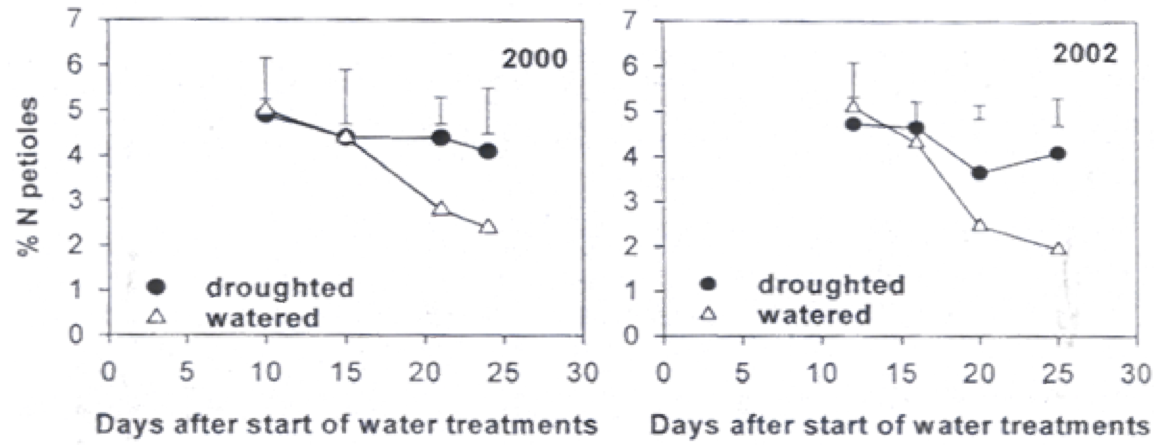

Fig. 4. Changes in % N of petioles for spiderplant (means across genotypes) grown under droughted and watered conditions in the glasshouse in 2000 and 2002. Vertical bars show $LSD_{0.05}$.

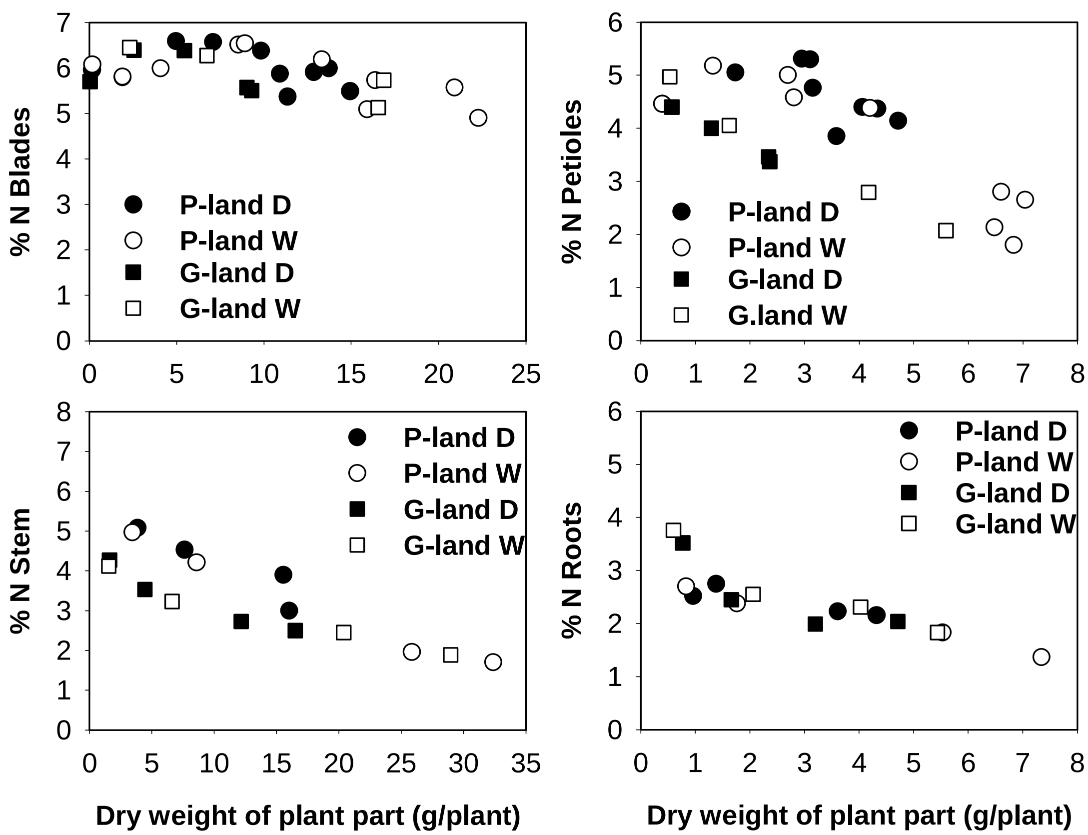

Fig 5. The concentration of N in blades, petioles, stems and roots as a function of dry weight of corresponding organ for spiderplant genotypes P-land (P-landrace) and G-land (G-landrace) grown under droughted (D) and watered (W) conditions in the glasshouse (Data for 2000 and 2002 combined).

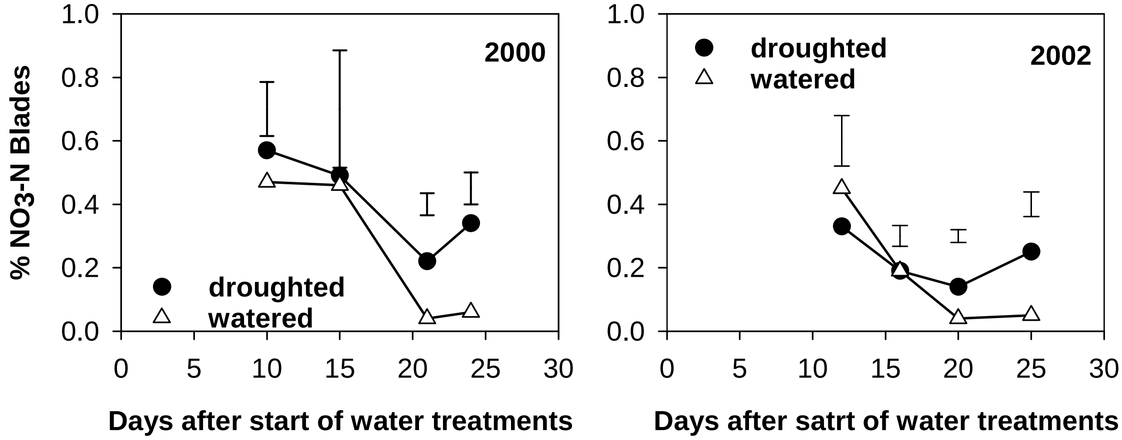

Fig. 6. Changes in % NO_3-N in blades of spiderplant (means across genotypes) grown under droughted and watered conditions in the glasshouse in 2000 and 2002. Vertical bars show $LSD_{0.05}$.

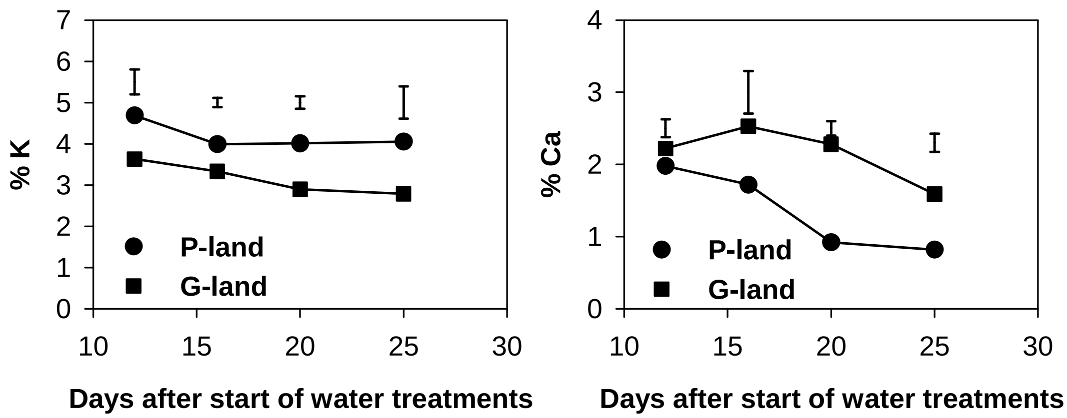

Fig. 7. Changes in % K and Ca in blades of spiderplant (means across water levels) genotypes P-land (P-landrace) and G-land (G-landrace) grown in the field in the glasshouse in 2002. Vertical bars show $LSD_{0.05}$

DISCUSSION

The reduction in spiderplant plant biomass under drought could be attributed to the inhibition of leaf area development and hence low photosynthesis 8Jones, 1992). Water stress is also known to reduce the photosynthetic activity of plants through stomatal closure (Jones, 1992; Medrano et al., 2002). The increase in TE in under drought in this study could be due to partial stomatal closure under moderate stress, which reduces transpiration without affecting photosynthesis (Nobel, 1999). Increasing TE would be desirable since it leads to increased returns to a given amount of water used. The leaf TE of spiderplant did not increase under drought implying that increase in plant TE did not translate into increased leaf yields relative to the amount of water used.

The N concentration of plant tissues declined with increase in plant biomass. This decline was similar under droughted and watered conditions in the early stages of growth, but became more pronounced in the watered treatments with further growth. Thus, watered plants ended up with lower N as compared to droughted towards the end of each experimental period. This was consistently demonstrated for petioles, stems and roots, but for blades the decline was only slight or absent. Alvino et al. (1999) similarly reported that in maize, the leaf N concentration in both well-watered and droughted plants was similar in the early vegetative stages, but that towards the end of vegetative growth, leaf and stem N of well watered plants was significantly lower than that of stressed plants. Decline in N concentration of plant tissues over time is thought to be a general phenomenon reported in vegetative crops (Gastal and Lemaire, 2002). It has been attributed to a dilution effect due to greater dry matter accumulation rate than N accumulation rate (Chamorro et al., 2002). The slower decline in N concentration of plant tissues observed in the droughted treatments coincided with the period at which reduced dry matter production was inhibited as FTSW fell below 0.3-0.4. The reduction in dry matter probably prevented the dilution effect of N concentration. In addition, during this period senescence and leaf shedding were pronounced in the droughted plants. This could have contributed to the maintenance of high N concentration since N is known to be remobilised from senescing organs to growing ones (Justes et al., 1998).

The NO_3-N content of both blades was high in the early stages of plant growth irrespective of the soil moisture content. With time, the NO_3-N concentration declined similar to the case of N described above. The decline was drastic in watered plants, leaving them with just about 20-40 % of the NO_3-N concentrations in blades of droughted plants. The general decline in NO_3-N over time observed in blades resemble that of N that has been attributed to a dilution effect as the plants grow. The higher NO_3-N concentration under water stress conditions was not probably due to increased uptake because firstly no increase in NO_3-N concentration was observed to support such a view. Secondly, it has been shown that the uptake of nitrates reduces under water stress (BassiriRad and Caldwell, 1992). It should be noted that the drastic decline of NO_3-N in watered plants coincided with a higher increase in dry matter production. It is possible that the increase in dry matter production had a dilution effect on the NO_3-N concentration although this presupposes that the rate of dry matter accumulation was higher than that of NO_3-N accumulation (Alam, 1999; Chamorro et al., 2002). At the same time, the slower decline of NO_3-N in droughted plants coincided with decreased dry matter production as FTSW fell below 0.3-0.4.

However, it is more likely that the high growth rate in watered plants caused a higher NO_3-N assimilation resulting in lower concentrations in the tissues. On the other hand, inhibited growth in droughted plants probably led to a low NO_3-N assimilation and hence higher concentrations in the tissues. It is known that when photosynthesis is low, and there is a decrease in plant requirement of protein due to inhibited growth, NO_3-N assimilation is also low but not its uptake, hence NO_3-N accumulates (Lawlor, 2002). Nitrate assimilation is known to occur primarily in the roots when the level of nitrates supplied to the roots decreases (Taiz and Zeiger, 1998). It can therefore be argued that as spiderplant in the watered treatments matured, the nitrogen supplying power of the soil was diminishing and consequently nitrate were mainly assimilated in the roots with less being transolacated to the shoot. At the same time, it is possible that with the declining nitrogen supply to the roots, the watered plants were assimilating most of the nitrates accumulated earlier when nitrogen supply was high.

Considering the 2000 glasshouse experiment, the equivalent NO^-_3 concentration in fresh leaf blades (the edible part) ranged from 1949 mg/kg in the early stages to 1247 mg/kg at the end in the droughted plants, while in watered plants it ranged from 1949 to 226 mg/kg. These concentrations suggest that spiderplant, especially at the early vegetative stages can be classified together with species like endives, leeks, parlsey and rhubarb which are know to accumulate up to 2500 mg/kg of nitrates (Hill, 1991; Santamaria and Elia, 1997). It would appear that spiderplant accumulates less nitrates than high accumulating species (above 2500 mg/kg) like celery, lettuce and spinach (Martignon et al., 1994; Hill, 1991; Andersen and Nielsen, 1992; Roorda van Eysinga and Van der Meijs, 1985). The NO^-_3 concentration of spiderplant blades may seem to pose little health risk to consumers considering the maximum acceptable contents of nitrates in vegetables. For instance, Andersen and Nielsen (1992) quoting relevant sources have outlined the maximum acceptable content of nitrates in lettuce as 3500-4500 mg/kg in Germany and Netherlands. Early literature puts the fatal dose of nitrates in adult humans as 15 to 70 mg NO_3-N per kg body weight (65-304 mg NO^-_3 per kg body weight) (Maynard et al., 1976). While these levels are high and unlikely to be attained at once by consuming spiderplant blades, infants could be at considerable risk considering that their fatal dose is less than 10 % of that for adults (Maynard and Barker, 1972). Moreover, the acceptable daily intake levels are much lower, at 0-3.65 mg per kg body weight for NO^-_3 and 0-0.13 mg per kg boy weight for NO^-_3 (Santamaria and Elia, 1997). Thus there is always the risk of exceeding the acceptable daily intake levels by consuming spiderplant even in adults especially if the crop has been exposed to sever stress. The lower NO^-_3 observed under field conditions was probably due to the fact that analysis was done on older plants as compared to glasshouse experiments. The concentration of K and Ca in blades of spiderplant showed no clear response to soil moisture. However, genotypes had significant differences in the concentrations of these elements. The potential capacity of plants to absorb nutrients in a drying soil is expected to decline due to reduced nutrient demand as growth gets inhibited as well as decline in diffusion rate of nutrients from soil matrix to the root surface (Alam, 1999; Marschner, 1986). Indeed various studies have shown water stress affecting the concentration of mineral elements either by causing increases or decreases (Alam, 1999). In this study, it appears that mineral element uptake in the early stages of growth was sufficient to maintain high concentrations in severely stressed plants when nutrient uptake had reduced. Furthermore, inhibited growth in these plants led to the concentration of mineral elements remaining high and comparable to that in unstressed plants.

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STUDIES ON HORTICULTURAL PRACTICES OF SOME AFRICAN INDIGENOUS VEGETABLES AT MASENO UNIVERSITY

Abukutsa onyango M.O.,Mwai, G.N. and J.C. Onyango
Maseno University

ABSTRACT

African Indigenous Vegetables (AIVs) are those vegetables whose natural home is known to be in Africa or those vegetables whose centre of origin is known to be in Africa. These vegetables have been grown and used traditionally by many African communities for a long time. AIVs have high nutritional value containing high vitamin and minerals essential to the human body. Besides, they have Medicinal, Economic and Agronomic value. Despite these advantages AIVs have been neglected for long periods and some are threatened with extinction. The major constraints of production include poor quality seed and lack of technical packages. The objectives of the study were to identify the most important AIVs in Western Kenya; to collect, multiply and distribute germplasm of the important AIVs and to study some horticultural practices of the identified AIVs. A market survey was conducted in two rural and one municipal market. Seed collection was done for the identified AIVs in Western Kenya and subjected to germination test and then bulked and distributed to farmers. Some of the bulked seeds were used to study responses of AIVs to organic and inorganic sources of fertilizer and salinity studies using RCBD replicated three times. The most important AIVs in western Kenya were found to be cowpeas, leaf amaranths, African nightshades, Jute mallow, spiderplant, slenderleaf, African kale and pumpkin leaves. Seed yields of the above AIVs ranged from 600-950 kg per hectare. Seed distribution and technical advise was given to 75 farmers/groups distributed in Kisumu, Siaya, Vihiga, Butere-Mumias, Kisii, Nyamira Homa bay and Bondo Districts. AIVs studied responded very well to organic sources of manure, some of the organic sources out performed the conventional inorganic sources. Spiderplant was found to tolerate some degree of salinity. Results from this study has contributed to the limited existing body of knowledge on AIVs.

INTRODUCTION

Food insecurity, that is manifested in malnutrition and poor health has been an issue of concern in Kenya (Sessional Paper No 3, 1999). The paper indicates that 50% of the rural population live below the poverty line and yet regions along the Lake Victoria are endowed with agricultural diversity (Maundu *et al*, 1999) which includes Africa Indigenous Vegetables (Schippers,2002). African Indigenous Vegetables are those whose natural home is known to be in Africa or whose primary or secondary centre of origin is known to be in Afrca (Maundu *et al*,1999 and Schippers 2002). Vegetables where Africa is the secondary centre of origin may be refered to as African traditional vegetables (FAO, 1988 and Maundu, 1999). Vegetables are vital component of human diet as they provide essential micronutrients that ensure proper development of the human body (Adams and Richardson, 1977). African indigenous vegetables (AIVs) have been grown and utilized traditionally by many African communities and possess several advantages and potentials that have not been fully exploited (Schippers, 2002). AIVs have been reported to have high nutritional value, where consumption of 100g of the

vegetables provides over 100% of the daily allowance for vitamins and minerals and 40% for the proteins (Onyango, 2002a and 2003). The vegetables also possess medicinal properties and have agronomic advantages over the exotic species and allows the poorest people in the rural communities to earn a living (Schippers,2002). Depite the many advantages, farmers realize very low yields (1-3 tons per hectare) far below the optimal levels that range from 20-40 tons per hectare (Onyango *et al* 1999) . AIVs also have medicinal properties especially the bitter types that have been known to heal stomach related ailments according to Olembo *et al* (1995). There had been no sustainable production of the vegetables due to neglect and lack of quality seed and appropriate production technologies,leading to low production and poor distribution (MOA, 1999). Increased and sustainable production and utilization of African indigenous vegetables can be attained by ensuring supply of quality seed and development of environmental friendly production technologies. Improved production technologies will lead to increased yields and improved nutrition and economic empowerment of the rural communities in Kenya and other parts of africa.

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OBJECTIVES

1.1. To identify some of the most important African indigenous vegetables in western Kenya.
1.2. To collect, multiply and distribute germplasm of the important AIVs
1.3. To study some horticultural practices of the identified AIVs.

MATERIALS AND METHODS

A market survey was carried out in three markets in Western Kenya in June 2001 to determine the important African Indigenous Vegetables in the region. A systematic random sampling scheme was adopted to select traders to be interviewed during the survey. A check list and a structured questionnaire were used to collect data from the traders. The interview considered all farm produce sold on these markets. The survey at Kakamega was conducted for seven days consecutively. An extra survey of the same was conducted in two rural marketing centers Chavakali and Kiboswa on Kakamega-Kisumu road. In a period of seven days 400 traders were interviewed in Kakamega Municipal market and 35 and 30 traders were interviewed in Chavakali and Kiboswa respectively. In 2001 and 2003 seed collection, multiplication and distribution was carried out for the important AIVs identified during the market survey and this included cowpeas, leaf amaranths, African nightshades, jute mallow, spiderplant and slenderleaf. Seed collection and distribution covered areas of Kisumu, Siaya, Vihiga, Butere-Mumias, Kisii and Nyamira, Homa bay and Bondo districts. Collected germplasm were first subjected to germination test by placing 20 seeds in a petri dish lined with a wetted filter paper. Data was collected on number of seeds that had germinated for a period of 14 days. Seed multiplication was carried out at Maseno University Botanic garden using organic sources of fertilizer with no chemical application. In the year 2002 and 2003 studies were conducted on the effect of organic and inorganic sources of fertilizer on growth and yield of cowpeas and spiderplant. The study was designed in a randomized complete block design with six treatments and three replications. The treatments included:

T_1-Control	(0kgN.ha^{-1},	0kgP.ha^{-1})
T_2 -Tithonia leafy biomass Incorporated	(150kgN.ha^{-1},	15kgP.ha^{-1})
T_3 -Tithonia leafy biomass Incorporated + DAP	(150kgN.ha^{-1},	30kgP.ha^{-1})
T_4 -Tithonia leafy biomass only Incorporated	(75kgN.ha^{-1},	7.5kgP.ha^{-1})
T_5 -Diammonium phosphate+Calcium Ammonium Nitrate	(150kgN.ha^{-1},	15kgP.ha^{-1})
T_6 -Farm Yard Manure	(150kgN.ha^{-1},	7.5kgP.ha^{-1}).

In the salinity study spiderplant were grown in pots with the following treatments of osmotic potentials: 0MPa,-0.3MPa,-0.6MPa, -0.9MPa and -1.2MPa in the rooting media as a result of varying the concentrations of the salts

RESULTS AND DISCUSSIONS

Important African Indigenous Vegetables in Western Kenya

A market survey revealed that the most important African indigenous vegetables in the three markets in Western Kenya included Cowpeas (*Vigna unguiculata)*, Leaf amaranths (*Amaranthus blitum)*, African nightshades (*Solanum* species), Jute mallow (*Corchorus olitorius*), spiderplant (*Cleome gynandra*), Slenderleaf (*crotalaria ochroleuca* and *Crotalaria brevidens*), African kale (*Brassica carinata)* and Pumpkin leaves (*Cucurbita moschata/maxima)* as shown in table 1 below. The list agrees with Chweya and Eyzaguire (1999), , Maundu *et al* (1999) Schippers (2002) and Onyango (2002b) where the above vegetables have been reported to be among the most important ones in the East African region and are widely distributed throughout Africa, although the importance of each vegetable varies with regions. Cowpeas seems to be the most popular as shown by high quantities traded especially in the municipal market probably due to its good keeping quality and long shelf life compared to the others (Schippers 2002) and does not have a bitter taste. Slenderleaf has smaller leaves and is tedious in preparation and may not be popular with busy working consumers. African kale and Pumpkin leaves were not sold in the rural markets probably due to their perishability and could have been sold on the farm or used for home consumption.

Collection, Multiplication and Distribution of African Indigenous Vegetables

Results of the six African Indigenous Vegetables collected and bulked are shown in table 2. Germination percentages of seed samples, collected from researchers were higher (60-100%) while those from farmers were lower and ranged from 15% to 92%. The low germination test could be attributed to seed processing and the inherent dormancy problems that have been reported in many of the AIVs.(Schippers, 2002). The minimum acceptable germination percentage for a seed lot is normally 85%. From this study only cowpeas, leaf amaranths and slenderleaf met the stipulated minimum standards

Table 1. Important African Indigenous Vegetables in three markets in Western Kenya.

African Leafy Vegetables	Quantity (%)		
	Kakamega	Chavakali	Kiboswa
Cowpeas	30	18	31
Leaf amaranths	21	18	15
African Nightshades	12	14	15
Jute Mallow	11	18	15
Spiderplant	7	18	16
Slenderleaf	7	14	8
Ethiopian kale	7	-	-
Pumpkin leaves	5	-	-
Total	**100 (8,759 kg)**	**100 (720kg)**	**100 (2,205 kg)**

Seed yields of the six AIVs that were collected indicates that the highest seed yields of 920 kg/ha was obtained from leaf amaranths and the lowest from jute mallow (636 kg/ha) as shown in Table 3. This observation agrees with Onyango *et al* (1999), who obtained seed yields in the same range . Quality seed is paramount to successful vegetable production programmes and promotional strategies (AVRDC, 1990). A total of 75 farmers in 9 districts were provided with seed and technical information on the production and seed processing of the AIVs. The highest coverage of farmers and/or groups was in Vihiga district with 24 farmers reached and lowest of two was in Homabay.

Table 2: Germination percentage the collected germplasm of African Indigenous Vegetables

Name of Vegetable	% Germination	
	Farmers seed	Researchers seed
Cowpeas	50.5	100
Leaf amaranths	65.5	85
African nightshades	5.3	60
Jute mallow	51	75
Spiderplant	15	65
Slenderleaf	92	92

Table 3: Seed yield of six indigenous vegetables

Name of Vegetable	Seed yield kg/hectare
Cowpeas	720
Leaf amaranths	920
African nightshades	724
Jute mallow	636
Spiderplant	700
Slenderleaf	772

Table 4: Seed distribution and technical advice and outreach on AIVs (2001-2003)

District	Number of farmers/groups
Kisumu	14
Siaya	11
Bondo	03
Vihiga	24
Butere-Mumias	05
Kisii	11
Nyamira	05
Homabay	02
Total	**75**

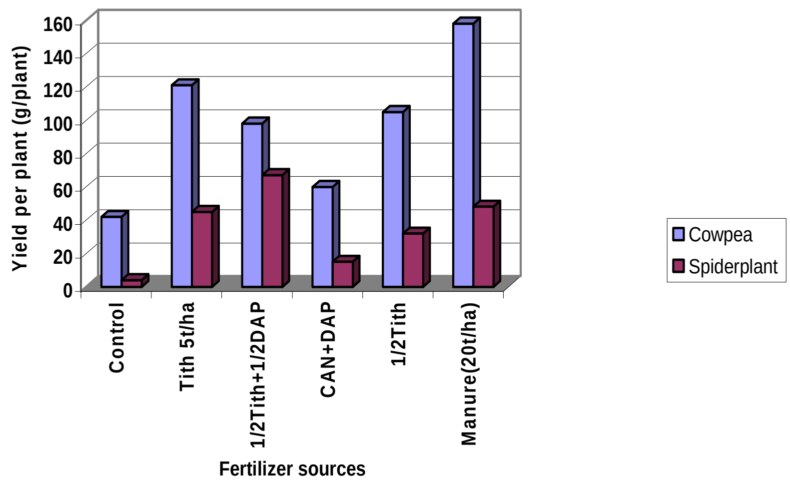

Fig 1: Comparison between response of cowpeas and spiderplant to fertilizers sources at 8 weeks

Organic and inorganic sources of fertilizers had a significant (p≤0.05) effect on growth and yield of cowpea and spiderplant as shown in Figure 1. The leaf yields in cowpeas were consistently higher than spiderplant and this could be attributed to the small leaves in spiderplant. In cowpeas, the best treatments were manure and Tithonia an indication that cowpeas responded better to organic sources compared to inorganic ones. On the other hand spiderplant's best response was the organic-inorganic combination. The above observation indicates the variability of responses depending on the species9Maschner 1995).

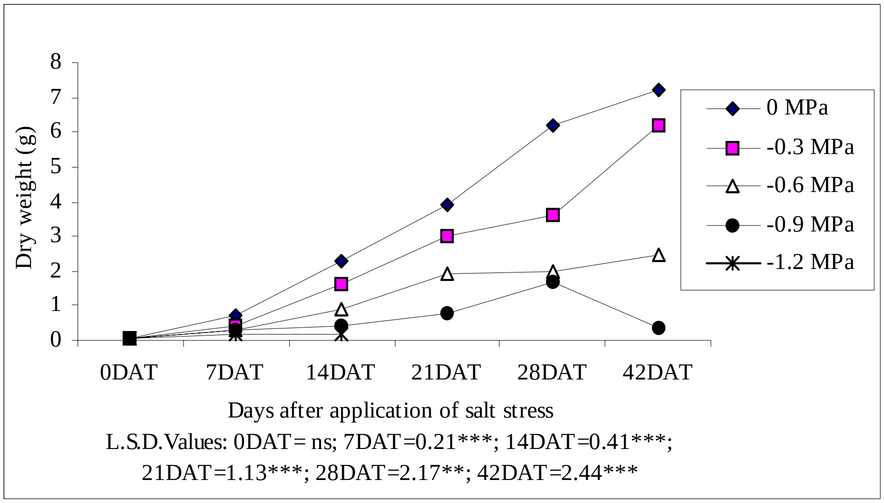

Fig 2: The effect of salinity on total plant dry weight in *Cleome gynandra* L.

Figure 2 shows that salt stress significantly reduced growth of spiderplant. The least saline plants had dry weights that were statistically similar to the control but significantly lower than the other treatments. This response is similar to the report of Yeo,(1991)and Netondo,(1999). Reduced growth could be attributed to the effects of salts in retarding cell division and cell expansion through osmotic dehydration, ion toxicity, nutritional imbalance or a combination of the above factors (Hsiao, 1999)

CONCLUSIONS AND RECOMMENDATIONS

Eight identified African Indigenous Vegetables in three markets in Western Kenya includes cowpea, leaf amaranths, African nightshades,jute mallow, spiderplant, slenderleaf, African kale and pumpkin leaves.

Germplasm of six of the identified AIVs was collected and germination percentage was higher for the seed from research institutions than that from the farmers and seed was multiplied and yields of 630-920 kg/ha were obtained. 75 farmers and groups received technical information and seeds in 8 districts of Western Kenya

Horticultural practices studies on AIVs indicated that these vegetables have short growth period, can tolerate some stress and responds well to both organic and inorganic fertilizers. Promotion of the identified AIVs should be done and more markets surveyed to give a more representative data in the region. Outreach activities to be expanded to other regions of the country. Development of more horticultural utilization and processing technologies should be done to increase yields of AIVs

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MANAGEMENT OF MAJOR VEGETABLE CROP DISEASES IN ETHIOPIA: A REVIEW

Mohammed Yesuf
Ethiopian Agricultural Research Organization (EARO), Melkassa Agricultural Research Centre, P.O. Box 436, Nazareth, Ethiopia
E-mail: mohanarc@yahoo.com or myesuf@freemail.et

ABSTRACT

Vegetables are the most important food and cash generating crops in Ethiopia. Due to the very diverse agroclimatic conditions of the country, there are various types of vegetable crops including indigenous vegetables widely grown at different parts of the country. Currently, due to high population growth in many rural areas of the country, there is acute shortage of cultivated land to feed the family, and earn enough amount of money for all basic necessities of many subsistence farmers. The only and sustainable solution for these types of farmers is to grow high value vegetable crops both for food and cash earnings. There are different types of vegetables grown by farmers and large-scale producers in Ethiopia. Among the widely grown vegetables tomato, onion, cabbage, hot pepper and green beans are the most important ones. Apart from the common vegetables, there are also indigenous vegetables cultivated, and grown as wild plant in the country, which have also great potential as food substitute. There are also different production constraints of vegetables recorded in the country. Among which diseases are considered to be the major limiting factors for vegetable production in many vegetables producing localities. There are different management practices available to be used as components of integrated disease management strategy against major vegetable diseases. This paper presents a review of major vegetable crops and their disease management practices. Moreover, the potential and opportunities of growing indigenous vegetables as food substitute is also discussed.

INTRODUCTION

Ethiopia is dependent on a range of food and cash crops both for the domestic and export markets and to achieve food self-sufficiency. The country is known to have diverse agro-climatical regions for growing various indigenous and exotic horticultural crops in multi-cropping systems both under rainfed and irrigated conditions. The vast majority of the Ethiopian population depends mainly on cereals and food legumes as source of food. The potential of horticultural crops in general and vegetables in particular as a food substitute and export earnings is not yet adequately exploited. These crops have the potential to give high yield per unit area of land compared to cereals, and hence generate high net return due to their market value. The warm season vegetables such as Tomato, Onion and Capsicum are grown in the lowland areas under irrigation, where as the high land areas offers a favourable condition to grow cool season vegetables like cabbage, garlic, shallot, carrot etc. Consequently the area under these crops has showed increase in the last two decades. Currently the area under these crops is estimated to be about 90,000 ha with total production of 6.7 million tons (1).

Table 1. Major diseases associated with major vegetable crops in Ethiopia

Crops	Diseases	Causal agent	Status
Tomato	Late blight	**Phytophtora infestans**	Major
	Powdery mildew	*Leveillula taurica*	Major
	Root-knot nematode	*Meloidogyne spp.*	Major
	Early blight∗	*Alternaria solani*	Major
	Septoria leaf spot∗	*Septoria lycopersici*	Moderate
	Bacterial leaf spot	*Xanthomonas campestris pv. vesicatoria*	Moderate
	Bacterial wilt		Moderate
	Virus complex	ToMV, TMV, TYLCV	Major
Hot pepper	Late blight	**Phytophtora infestans**	Major
	Powdery mildew	*Leveillula taurica*	
	Bacterial wilt∗	**Pseudomonas solanacearum**	Major
	Bacterial leaf spot∗	*Xanthomonas campestris pv. vesicatoria*	minor
	Stem blight	**Phytophtora capsici**	Major
	Virus complex	***PVY, ToMV***	Major
Onion	Purple blotch∗	**Alternaria porri**	Major
	Downy mildew	*Peronospora destructor*	Major
	Bulb rot	*Sclerotium cepivorum*	
Cabbage	Black rot∗	*Xanthomonas campestris*	Major
	Club root	*Plasmodiophora brassicae*	Major
Green beans	Rust	*Uromyces phaseoli*	Major
	Anthracnose∗	**Colletotrichum lindemuthianum**	Minor
	Common bacterial blight∗	**Xanthomonas phaseoli**	Major

∗- Seed transmitted diseases

Vegetables are the most important and widely cultivated food and income generating crops in many parts of Ethiopia. They are widely cultivated both by small-scale farmers and state enterprises. Vegetables are cheap sources of vitamins, minerals, proteins and other essential nutrients (2). They can give high yield per unit area of land compared to cereals and hence they generate high income for the farmers because of high market value and profitability.

There are various production constraints wherever vegetables are grown in the country. Among which diseases and insect pests are in the forefront. Most farmers, especially the small-scale farmers grow vegetable year round and in stager planting using both rain-fed and irrigation water. This type of production system creates a conducive environment for the continuos build-up of major vegetable diseases.

This paper presents a review of major vegetable diseases and their management practices towards the development of Integrated Pest Management (IPM). Moreover, The potential of indigenous vegetables as food substitute will be also discussed.

Disease Surveys

Disease surveys have been made in different vegetable growing areas of the country. Consequently, major diseases of vegetables have been documented.

Disease Management Practices

2.1. Vegetable damping off

Vegetable damping off can be caused by a complex of fungal pathogens such as *Phytophtora sp., Pythium sp., Fusarium sp., and Rhizoctonia sp.* Many of these pathogens are known to be soil borne, and able to survive for longer period in the soil. This disease can cause devastating effect on the young seedlings at the early stage of their establishment. The disease is not only known as important on young seedlings but also the pathogen can be carried along with the seedlings to the main production field. In this case it plays a great role for the carry over of the pathogen and cause severe epidemic to the main production field.

Many of vegetable seedlings like tomato, pepper, onion and cabbage are known to be highly susceptible to the disease. Cultural practices like using raised seedbed and application of irrigation water using watering can was recommended to reduce damping off infection (9, 10).

Attempts were made to develop management practices against vegetable damping off. These include Soil solarization (solar heating), Burning of seedbeds using mulches, and seed treatment using seed dressing chemical. Solarization, and burning the seed beds before seeding gave better control of vegetable damping off (Fig.1). These control options are a non-chemical means, and have been demonstrated as components of integrated disease management under farmers' field by participating vegetable growers. Currently, many of vegetable farmers are practising burning and solarization of vegetable seedbeds for the control of damping off mainly on tomato and hot pepper (6).

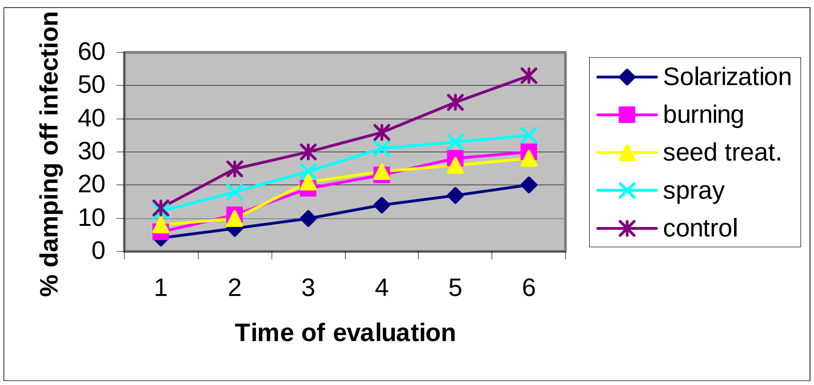

Fig. 1. Management practices of vegetable damping off

Tomato late blight

Late blight, which is caused by *Phytophtophtora infestans,* is considered as a major production threat wherever tomatoes are grown.Different kinds of fungicides have been screened for the control of tomato late blight for the last several years. However, due to their hazardous effect to the environment and consumers most of them have already banned. Recently new fungicides were screened against late blight of tomato (Fig. 2). Fungomil, Ridomil gold and Mancolaxyly significantly reduced late blight severity, and increase marketable yield of tomato (unpublished data). These fungicides will be included in the integrated disease management practices along with other disease control strategies.

There are also different types of tomato both processing and fresh types which show some tolerance level for late blight infection. Among others, Melkashola (processing type), and Marglobe improved (fresh type) are widely cultivated by many tomato growers in the central rift valley of Ethiopia.

Hot paper

Hot pepper (*Capsicum frutescens), (C. annum*) is the most important vegetable, which can be found on the daily dish of every Ethiopians. This crop is severely attacked by a number of diseases, and a significant yield loss has been recorded every year. The most important diseases on hot pepper are damping off, complex of viral diseases, bacterial leaf spot, powdery mildew, stem blight, pod bleaching and root-knot nematode (4, 5, 8, 11).

Seed dressing with Clorox ($Na_3 PO_4$) reduces the incidence of tobamo viruses that are associated with seed surface of pepper. Moreover, Spraying of insecticides such as Karate 2.5 % and Cymbush 25 EC provide effective control of aphid *Myzus persicae*, which is efficient vector for the transmission of potyviruses and cucumo-viruses (4).

Allium (Shallot/ Onion, Garlic)

Shallot (*Allium ascalonicum*) is a traditionally preferred type of onion in Ethiopia next to Allium cepa L., the recent introduced red onion. Among the recorded diseases of Allium, Purple blotch (*Alternaria porri*), downy mildew (*Peronospora destructor*), white rot (*Sclerotimu sp*.) basal rot (Fusarium sp.) are the most important in Ethiopia. Purple blotch of onion can be controlled using seed dressing chemicals (Apron star and Thiram) followed by field application of Ridomil and Mancozeb.

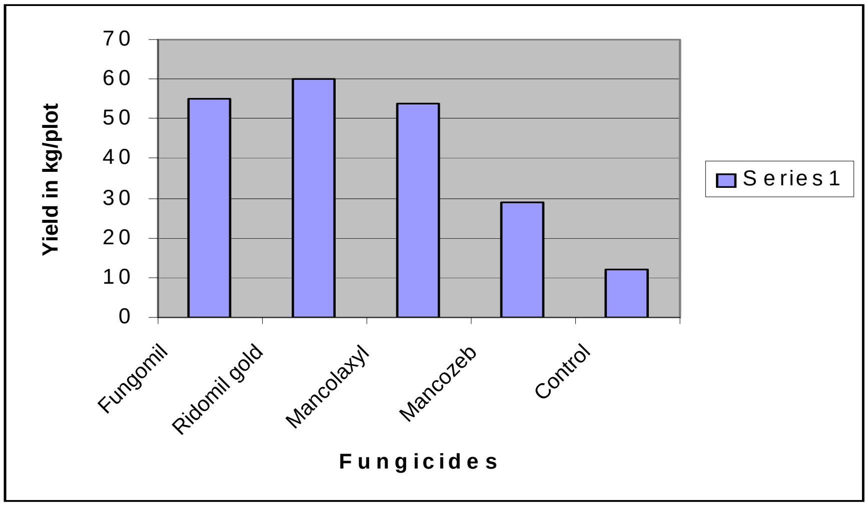

Fig. 2. Effect of fungicide spray on the yield of tomato

Seid, *et al*. 1992 reported that application of Beret special (Fenpiclonil + Imazalil) against basal rot as a bulb treatment gave significant yield advantage as compared to the untreated plots.

Garlic

Next to onion and shallot, garlic (*Allium sativum* L.) is the most widely grown allium species in the high altitude of Ethiopia. Garlic production is also threatened by diseases, among which, rust *(Puccinia allii*), bulb rot (*Corticium rolfsii*) and garlic mosaic virus are predominant.

Fungicides were also tested for their efficacy against garlic rust at Debrezeit. Application of Propicinazole (Tilt), Cyrocanazole (Alto) and Hexaconazole (Anvil) reduced rust severityt. Host-resistance studies at Debrezeit Research Center also indicated that there are some degrees of field resistance in the garlic germplasm collections. Some of the garlic lines showed promising results, which indicate there could be heritable resistance to the disease (7).

Cabbage

There are different types of cabbages grown in the country by small-scale farmers. The widely grown types are head cabbage, Ethiopian mustard and cauliflower. The major disease of cabbage includes black rot (*Xanthomonas campestris*), club root (*Plasmodiophora brasicae*) and white rust (*Albugo candidae*). Many of these pathogens are soil borne, and crop rotation is highly recommended to minimize the infection level. Seed treatment using copper-based fungicides is also reduced black rot severity on cabbage.

Other indigenous vegetables

The diverse agro-ecological region of the country creates favourable condition to growing different indigenous vegetables in many parts of the country. Ethiopia is also considered to be the center of origin for few leafy vegetables, and center of diversity for several other types of vegetables. Among others just to mention few leafy vegetables (Ethiopian mustard, Ethiopian kale, moringa), root and tubers (Anchote, Taro, Yam) are the most important ones.

Despite the potential of indigenous vegetables as food substitute, cropping system and their medicinal value, the scientific research in this sector is nearly untouched.

CONCLUSION AND RECOMMENDATIONS

Due to the ever-increasing population, and scarcity of cultivated land, the majority of small-scale farmers who are entirely dependent on cereal-based agriculture are not able to subsidise their family mainly due to the low productivity and minimum net return from cereal crops. Therefore, subsistence farmers should be assisted to look for high value horticultural crops with major emphasis on vegetables.

Vegetable production is also known to be knowledge intensive, and risk business because of their vulnerability to various disease and insect pest problems. Moreover, both local vegetable consumers and the foreign importers are becoming very cautious on the quality and chemical residues of many vegetable produces. In the other hand, many of the small-scale vegetable farmers are not aware of the kinds of diseases, insect pests, and what kind of remedy to use for a specific problem. Such situations may lead to misuse of agricultural pesticides. Consequently, the farmers, consumers and the environment will remain under risk mainly due to heavy misuse of agricultural pesticides. In this case vegetable growers, development agents and others who are involved with vegetable production need to be trained how to produce and handle vegetables for the local and export market.

Apart from the exotic vegetables, there are also quite a lot of indigenous vegetables, which lacked research attention. The horn of Africa is considered to be the center of diversity for many types of indigenous vegetables like different types of cabbage, moringa and many others. The potential of these vegetables has to be exploited as a food substitute especially in countries where there is no food self-sufficiency.

Researchers must also strengthen their collaborative efforts mainly on germplasm exchange and maintenance, capacity building and to the information access in the area of vegetable production and management with special emphasis on indigenous vegetables. Therefore, the potentials and opportunities of growing various exotic and indigenous vegetables must get due attention towards their food and medicinal value, cropping system, and food self-sufficiency.

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ETIOLOGY OF *SEPTORIA* LEAF SPOT OF COWPEA (*VIGNA UNGUICULATA* (L.) WALP.) IN KENYA

E.K. Kiprop, R.D. Narla[1], R.K. Mibey[2] and L.M-S. Akundabweni[3]
Department of Botany, Faculty of Science, Moi University, P.O. Box 1125, Eldoret, Kenya.
[1]Department of Crop Protection, Faculty of Agriculture, University of Nairobi, P.O. Box 29053, Nairobi, Kenya.
[2]Department of Botany, Faculty of Science, University of Nairobi, P.O. Box 30197, Nairobi, Kenya.
[3]Department of Crop Science, Faculty of Agriculture, University of Nairobi, P.O. Box 29053, Nairobi, Kenya.

ABSTRACT
The study was undertaken to determine the etiology of *Septoria* leaf spot disease on cowpea (*Vigna unguiculata* (L.) Walp.) in Katumani area of Machakos district (Kenya). Cowpea plants with *Septoria* leaf spot symptoms were collected from the field, the pathogen was isolated and identified in the laboratory, and the optimum growth of the pathogen at various temperatures and artificial media determined. *Septoria* leaf spot on cowpea in Katumani is caused by *S. vignicola* V.G. Rao. The disease symptoms in the field and greenhouse were typical of *Septoria* leaf spot. The disease was specific to *V. unguiculata*. The fungus germinated on artificial medium, potato dextrose agar (PDA), by budding and the elongation of the apical cell. Small creamy white colonies that formed were mainly of conidia and short hyphae. The optimum temperature for its growth in culture was 22-24^{o}C, with a maximum and minimum temperatures of over 30^{o}C and below 18^{o}C, respectively. Growth of the fungus on artificial media was restricted, the colony diameter of an eight-day-old culture being 4.9 mm and 4.5 mm on cowpea dextrose agar (CDA) and PDA, respectively. The best media for growth and sporulation of *S. vignicola* are CDA, PDA and yeast malt agar (YMA). *In-vitro* evaluation of fungicides against *Septoria* leaf spot could be done using these media. The same media could be used to obtain adequate conidia for field/greenhouse application during the screening of cowpea genotypes for resistance to this disease.

Key Words: Conidia, cowpea, etiology, *Septoria* leaf spot, *Septoria vignicola.*

INTRODUCTION
Cowpea ranks third as the most important grain legume in Kenya after beans (*Phaseolus vulgaris* L.) and pigeon peas (*Cajanus cajan* (L.) Millsp.) (Anon., 1989). In all parts of Kenya where cowpea is produced, the leaves, green pods and dried grain are utilized for food (Waite *et al*., 1984). Other uses of cowpea include canning of green peas, fodder and protein concentrates for animals, cover crop and green manure (Rachie, 1985; IITA, 1982). In the cowpea farms around Katumani, Machakos district (Kenya) *Septoria* leaf spot cause significant crop losses

(Waite *et al.*, 1984). Worldwide estimates of grain yield losses due to *Septoria* leaf spot of cowpea range between 30 and 50 % (Rawal and Sohi, 1981; Emechebe and Shoyinka, 1985). Appropriate measures to control the disease depend on the correct identification of the causal agent.

Septoria leaf spot was first reported in Kenya in 1926 (Nattrass, 1950; Waite *et al.*, 1984; Gatumbi, 1986). According to Wilkinson (1927), the causal agent was reported to be a species of *Septoria* (? *S. glycines*). Mukunya (1978) observed *Septoria* leaf spot symptoms on cowpeas growing in Katumani but the species was not identified. *Septoria* leaf spot of cowpea is caused by three species of *Septoria*, namely *S. vignae*, *S. vignicola* and *S. kozopolzanskii* (Emechebe and Shoyinka, 1985). The most prevalent and most economically important species of *Septoria* across Africa is *S. vignae*, with reports of *S. vignicola* in East Africa and of *S. kozopolzanskii* in Zimbabwe. Reports by Allen *et al.* (1981) and Waite *et al.* (1984) have indicated that the causal agent of *Septoria* leaf spot of cowpea in Kenya and Nigeria is *S. vignae*. *S. vignicola* has been consistently reported as the causal agent of the disease in India (Rawal and Sohi, 1981). Rawal and Sohi (1981) have reported that cowpea varieties tested for resistance to *S. vignae* were susceptible to *S. vignicola* in India.

Cultural studies are important for any meaningful research on *in-vitro* studies, epidemiology and inoculation trials of any pathogenic fungus. *S. vignicola* has been found to grow well on potato dextrose agar (PDA) (Rawal and Sohi, 1981). *S. tritici* and *S. nodorum*, the causal agents of *Septoria* leaf blotch and *Septoria* head blotch of wheat (*Triticum* spp. L.), respectively, grow on PDA and yeast malt agar (YMA) (Eyal *et*. *al.*, 1987). Wolcan (1989) used PDA, YMA and Czapek

(Dox) agar (CzDA) for the growth and pycnidiospore production of *S. apiicola*, the causal agent of celery (*Apium graveolens* L. var. *dulce* (Miller) Pers.) leaf spot. In view of the importance of cowpea as a food source in Kenya and the presence of *Septoria* leaf spot causing high defoliations at Katumani, this study was undertaken with the following objectives: to isolate and identify the species causing *Septoria* leaf spot at Katumani, and to determine the temperatures and artificial media that give optimum growth and sporulation of the causal agent.

MATERIALS AND METHODS

Identification of the pathogen

Morphology of the fungus in the leaf. Disease symptoms on a susceptible cowpea variety Machakos 66 were observed and recorded in the field and in the laboratory. Vernier calliper was used to measure the diameter of the leaf lesions. *Septoria* leaf spots on the infected cowpea leaves were first observed under the dissecting microscope at different magnifications. Thin sections of the lesions were observed under light microscope. Morphology of the fungus in the leaf tissue was then described. The colour, shape and sizes of mycelia, pycnidia and conidia were recorded.

Morphology and cultural characteristics of the fungus on PDA medium. The fungus was isolated from leaves of cowpea infected with *Septoria* leaf spot that were collected from experimental plots at Katumani (Kenya) using the technique of Eyal *et al*. (1987). Small creamy white colonies that developed on PDA containing 50 mg/l streptomycin incubated at 24^{o}C in darkness for 5-10 days were subcultured onto PDA. The cultures of the single-spore isolates of the fungus on PDA slants and petri plates were kept in cold storage at 4^{o}C after they had been carefully sealed. In the present study, isolation and maintenance of *Septoria* sp. was similar to methods used by Eyal *et al.* (1987). Morphology of the fungal colonies on PDA was studied under a dissecting microscope from the first day of incubation for a period of 21 days. The slide culture technique described by Riddell was used to describe the morphology of the fungus (Riddell, 1950). Conidial germination was studied using the procedure of Commonwealth Agricultural Bureaux (C.A.B) (1983) for single-spore isolation.

Pathogenicity test. Seven to ten days old pure cultures of the isolated fungus in petri plates were flooded with 100 ml sterile distilled water and scraped lightly with sterile bent glass rod, and the suspension filtered through two layers of cheesecloth. The conidial suspension was then adjusted to 10^6 conidia/ml using haemocytometer. Cowpea seedlings of variety Machakos 66 at 3-4 trifoliate leaf stage in pots having sterile soil-sand mixture (3:1 v/v) were inoculated with the above suspension using a one litre hand sprayer. The inoculated seedlings were watered regularly in a greenhouse. Records on symptom development were made, and re-isolation of the fungus on PDA medium was done at 4 weeks after inoculation. The experiment was done two times.

The following ten legumes were used to determine the host range of the pathogen in a field experiment: *Vigna unguiculata* (L.) Walp. (variety Machakos 66), *Phaseolus vulgaris* L. (Common bean), *Glycine max* (L.) Merr. (Soybean), *Pisum sativum* L. (Garden pea), *Cajanus cajan* (L.) Millsp. (Pigeon pea), *Paseolus mungo* L. (Green gram, mung bean), *Cicer arietinum* L. (Chick pea), *Vicia faba* L. (Broad bean), *Lablab niger* L. (Dolicos lablab) and *Arachis hypogaea* L. (groundnut). Four (4)-week old seedlings of these legumes, planted at recommended spacing, were inoculated and records made as described above. The experiment was done two times.

Optimum conditions for growth and sporulation of *S. vignicola*

Growth and sporulation on PDA at different temperatures. This experiment was conducted to find out the optimum, maximum and minimum temperatures for growth and sporulation of *S. vignicola* on artificial medium. PDA medium was used. Conidial suspension was prepared and adjusted to 60 conidia/ml using haemocytometer, and a half a millilitre of this was inoculated into 21 petri plates containing PDA, three plates for each temperature. A sterile glass rod was used to spread the conidia evenly on the plates and these were incubated at 18, 20, 22, 24, 26, 28 and 30^{o}C for eight days.

The growth, in terms of the diameter (mm) of the colonies of the fungus was measured using a vernier calliper. Twenty colonies for each replicate were measured and the average determined. The sporulation was recorded as the number of conidia/ml from a conidial suspension of 2.5 mm diameter colony in 10 ml distilled water. The method adopted was a modification of the technique used by Caulpouzos and Stallknecht (1965). Twenty 2.5 mm colonies were picked from each replicate and each was placed in a universal bottle containing 10 ml of distilled water, then thoroughly shaken for five minutes. The suspension were then filtered through two layers of cheesecloth and their concentrations determined using haemocytometer, and the average determined. The experiment was done two times.

Growth and sporulation on selected media at 24°C. This experiment was conducted to find out the artificial media that give optimum growth and sporulation of *S. vignicola*. Production of inoculum and inoculation were similar to the ones described above. The media used were: PDA, YMA, CzDA, malt extract agar (MEA), tap water agar (TWA), potato carrot agar (PCA) and CDA. Half millilitres of the conidial suspension (60 conidia/ml) were inoculated on petri plates containing the respective media, with three replicates for each medium. The growth and sporulation of the fungus was determined as described in the previous experiment. The experiment was done two times.

Data analysis

Identification of the genus *Septoria* was done by studying the morphological characteristics of mycelium, pycnidium and conidium on PDA and from lesions of cowpea leaves. These were then compared with various descriptions according to Butler and Jones (1949), Alexopoulus and Mims (1979), and Agrios (1988). For species identification of the causal agent, pycnidial and colony conidia measurements were undertaken and compared with those of the C.M.I (1985). Infected leaf samples were further sent to the International Mycological Institute (U.K.) for confirmation of the species identified. Growth and sporulation at various temperatures and on artificial media were analysed by ANOVA procedure using the SAS system software (SAS Institute Inc., Cary, NC, USA). Means were separated by least significance difference (LSD) at P = 0.05.

RESULTS

Identification of the pathogen

Symptoms of *Septoria* leaf spot. *Septoria* leaf spot disease started on the lower foliage and progressed upwards. The symptoms were characterized by bright red to dark red, roughly circular to irregular spots, 2-4 mm wide, which appeared almost identical on both surfaces of the leaf. Some spots had concentric rings, and maybe raised, giving the leaf a freckled appearance. Individual spots could coalesce to form large blighted areas. Severely infected leaves turn yellow and fall.

Morphology of the fungus in the leaf. Microscopic examination of infected leaves revealed immersed, branched, septate, pale brown mycelia of the fungus, which measured 1.0-4.5 µm in width. The growth of hyphae in the leaves was both intercellular and intracellular. The pycnidia were globose with a single ostiole, dark coloured, separate, and ranging from 42 to 140 µm in width. They were either embedded in the epidermis and the mesophyll tissue or on the surface of both sides of the leaf. The middle portion of the 3-celled wall was light dark with the wall surrounding the ostiole being bigger than the rest of the pycnidium. The conidia were hyaline, multiseptate with 1 to 6 septa (but mostly 3), straight to slightly bent and tapering towards the obtuse apex with the base truncate, and measured 18.3-58.4 µm (length) x 1.4-2.5 µm (width). Conidiogenous cells in the pycnidia produced conidia.

Morphology and cultural characteristics of the fungus on PDA medium. Conidia germinated mainly by budding and rarely due to apical cell elongation. Budding cells germinated by increasing the septa number. Cells developed independently into pseudo-hyphae before they separate. The mycelia were septate, branched, hyaline but later turned pale brown, measured 1.1-4.5 µm in width. Pale brown pycnidia started to develop on the colonies of 8 days old culture.

White to cream colonies formed on the surface of PDA plates 5-10 days after incubation. Five-day old cultures exuded white to cream conidia that were expelled through an opening at the tip of colony. A 6-day old culture showed a colony diameter of 2.5 mm. The colonies turned progressively black. Diameter of the colonies after 21 days of incubation was 13 mm. Thereafter the dome-shaped colonies with a relatively smooth look appeared to have a further restricted growth with rough edges. Conidia on PDA were slightly shorter, had a broader, straight to irregular shape with dimensions of 1.5-2.8 µm (width) x 16.5-50.7 µm (length) compared with pycnidial conidia from leaves. Septa ranged from 1 to 6, but mostly 3. Comparative studies of conidia with other reports (Commonwealth Mycological Institute (C.M.I), 1985) implicated *S. vignicola* V.G. Rao as the pathogen causing *Septoria* leaf spot at Katumani.

Pathogenicity test. Pathogenicity test of *S. vignicola* isolate from Katumani on Machakos 66 produced typical symptoms similar to those caused by the original pathogen. Further microscopic examination of the infected leaves and the re-isolation on PDA medium confirmed *S. vignicola* as the cause of the disease. The pathogen caused characteristic symptoms of *Septoria* leaf spot on cowpea but not on other nine legumes.

Optimum conditions for growth and sporulation of *S. vignicola*

Growth and sporulation on PDA at different temperatures. The colonies of *S. vignicola* on PDA were larger when incubated at 24°C and 22°C with 4.7 mm and 4.3 mm in diameter, respectively, but smaller at 30°C and 18°C with 2.5 mm and 2.8 mm, respectively. There was no significant difference (P = 0.05) in colony diameter of the fungus when incubated at the following temperatures: 18, 20, 28 and 30°C; 20 and 26°C; 22 and 26°C; and 22 and 24°C (Table 1). The mean colony diameter was 3.5 mm. The sporulation of the fungus on PDA was high when incubated at 24°C and 22°C with $8.1x10^5$ conidia/ml and $7.5x10^5$ conidia/ml, respectively, but lower at 30°C and 18°C with $3.8x10^5$ conidia/ml and $4.4x10^5$ conidia/ml, respectively. There was no significant difference (P = 0.05) in sporulation of the fungus when incubated at the following temperatures: 18 and 30°C; 18 and 28°C; 20 and 26°C; 22 and 26°C; and 22 and 24°C (Table 1). The mean sporulation was 6.0×10^5 conidia/ml.

Table 1. Growth and sporulation of *Septoria vignicola* on PDA at different temperatures

Temperature (°C)	Colony Diameter (mm)	Sporulation ($x10^5$ conidia/ml)
18	2.8 a	4.4 ab
20	3.2 ab	6.3 c
22	4.3 cd	7.5 de
24	4.7 d	8.1 e
26	3.8 bc	6.9 cd
28	3.1 ab	5.1 b
30	2.5 a	3.8 a
Mean	3.5	6.0
S.E.	0.4	0.5
C.V. (%)	144.7	10.3
LSD (p=0.05)	0.9	1.1

Growth and sporulation on selected media at 24°C. Colonies of eight-day-old cultures of *S. vignicola* incubated at 24°C on PDA, MEA, YMA, TWA, PCA and CzDA were whitish cream while those on CDA were dark. Colonies were hairy on CDA and smooth on other media. Colonies on all the media tested were circular and concave. Older colonies, about 9-10 day-old and above, turned light dark on all media. Conidial exudates on the colonies were whitish to cream on all media.

The colonies of *S. vignicola* incubated at 24°C were larger on CDA, PDA and MA with 4.9 mm, 4.5 mm and 3.7 mm in diameter, respectively, but smaller on TWA and CzDA with 1.0 mm and 1.2 mm, respectively. There was no significant difference (P = 0.05) in colony diameter of the fungus on the following media: CzDA and TWA; MEA and YMA; PDA and YMA; MEA and PCA; and PDA and CDA (Table 2). The mean colony diameter was 3.0 mm. The sporulation of the fungus incubated at 24°C was high on CDA with $56.3x10^4$ conidia/ml, but lower on TWA and CzDA with $3.1x10^4$ conidia/ml and $6.3x10^4$ conidia/ml, respectively. There was no significant difference (P = 0.05) in sporulation of the fungus on CzDA and TWA; but significant difference occurred between the other media. The mean sporulation was 2.7×10^5 conidia/ml.

Table 2. Growth and sporulation of *Septoria vignicola* on selected media at 24°C

Medium	Colony Diameter (mm)	Sporulation ($x10^4$ conidia/ml)
PDA	4.5 de	43.7 e
MEA	3.1 bc	25.0 c
YMA	3.7 ed	37.4 d
CzDA	1.2 a	6.3 a
TWA	1.0 a	3.1 a
PCA	2.7 b	18.8 b
CDA	4.9 e	56.3 f
Mean	3.0	27.0
S.E.	0.4	2.5
C.V. (%)	17.2	11.5
LSD (p=0.05)	0.9	5.4

Means followed by the same letter(s) down the column are not significantly different at P = 0.05.

DISCUSSION

The symptoms of *Septoria* leaf spot on cowpea were similar to that described by Williams (1975), C.M.I (1985), Weite *et al*. (1984) and Agrios (1988). At present, there are no identification keys available for *Septoria* species (C.M.I., 1985). Except for differential length measurements between the conidia of *S. vignae* P. Henn. (20-34 µm x 2.0-2.5 µm) and *S. vignicola* V.G.Rao (20-58 µm x 1.5-2.5 µm), symptoms of both species tend to show similarity. Conidial measurements in our study implicated *S. vignicola* as the causal agent of *Septoria* leaf spot disease at Katumani, which is in agreement with that reported elsewhere (C.M.I., 1985). The causal agent was confirmed at the International Mycological Institute (U.K.) to be *S. vignicola* (IMI number 351193).

Germination of the conidium of *S. vignicola* on artificial medium was by budding and elongation of the apical cell. Germination by budding is in accord with the work of Scott *et al*. (1979). Other workers have not reported elongation of the apical cell, although this process occurs in living tissues (Butler and Jones, 1949; Eyal *et al*., 1987). The colonies of the fungus had restricted growth, mainly consisting of conidia and short hyphae in pure culture. The results are similar to that reported elsewhere on *Septoria* species (Scott *et al*., 1979).

Temperatures between 22°C and 26°C favoured growth and sporulation of *S. vignicola*. However, the optimum temperature for the growth of this pathogen appeared to be at 22-24°C, while the maximum and minimum temperatures are above 30°C and below 18°C, respectively. This is supported by the findings of Eyal *et al*. (1987) and Mudita and Kushalappa (1991) on *Septoria* spp. and *S. apiicola* of wheat and celery, respectively.

The optimum growth and sporulation of *S. vignicola* was obtained on CDA, PDA and YMA media. There were no significant differences (P = 0.05) in growth between CDA and PDA; and PDA and YMA. These media could therefore be used for isolation, growth and sporulation of this fungus. PCA and MEA could be used for the same purpose although with lower growth and sporulation. Other workers have found similar results on PDA, YMA, and medium containing host decoction when *Septoria* species are cultured on them (Rawal and Sohi, 1981; Eyal *et al*., 1987; Wolcan, 1989; Mudita and Kushalappa, 1991). *S. vignicola* produced more conidia on CDA than other media. The reason for this could be that the host (cowpea) could have nutrients that favoured the pathogen growth than that from potato. This result is in agreement with the work of Mudita and Kushalappa (1991).

In addition to *S. vignae* as a causal agent of *Septoria* leaf spot on cowpea in Kenya as previously reported (Allen *et al*., 1981; Waite *et al*., 1984), our study implicates *S. vignicola* as the cause of the disease at Katumani. Temperatures of 22°C to 24°C, and CDA, PDA and YMA media favour the optimum growth and sporulation of *S. vignicola* in culture. A countrywide survey is needed in Kenya in order to determine the incidence, distribution and severity of *Septoria* leaf spot caused by *S. vignicola* and *S. vignae* on cowpea. Use of cultural and morphological characteristics, and genetic markers to determine the variability among field isolates of these pathogens should be one of the priority areas of research. This will assist plant breeding programmes aimed at the development of cowpea varieties/genotypes resistant to *Septoria* leaf spot.

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EFFECT OF SEED OSMOTIC PRIMING ON THE GERMINATION OF SPIDER PLANT (*GYNANDROPSIS GYNANDRA*) SEEDS

Kabue Stephen Thuo
P.O. Box 13553, Nakuru. E-mail: Stevethuo@yahoo.com

ABSTRACT

This research was conducted to investigate the effects of osmotic priming on the germination of *Gynandropsis gynandra* seeds by varying different concentrations of Potassium nitrate (KNO_3). KNO_3 was used for osmotic priming at concentrations of 1%, 1.5% and 2% in distilled water and germination evaluated as germination percentage, rate of germination and root length. It was found that *Gynandropsis gynandra* seeds primed in KNO_3 at 1%, 1.5% and 2% concentrations at 22-25^{0}C for 24 hours had no significant difference with the non-primed seeds. Priming with KNO_3 was thus found to be of no practical benefit on germination percentage, rate of germination and root length. The results also show that priming with 2% KNO_3 concentrations had negative effect on root growth of germinated seedlings. Therefore it can be concluded that this research showed no clear indication that priming of *Gynandropsis gynandra* seeds with various concentrations of KNO_3 (1%, 1.5% and 2%) had any effect on improving germination of the dormant seeds.

Key words: Improve germination of spider plant seeds, Osmotic priming ,Uniform plant stands

INTRODUCTION

General

Spider plant belongs to the family *Cappraceae*. It is a very important indigenous vegetable in Kenya being utilized as a green vegetable. It is commonly found in altitudes of at least 1800metres above sea level (a.s.l.).

Spider plant is highly regarded as a rich source of vitamins (A and C), minerals and some proteins (Chweya and Mnazara, 1997). It is also used in indigenous medicine and as a plant protectant through intercropping.

Spider plant is propagated by use of seeds mostly at the beginning of the short rains (Chweya and Mnazara, 1997). Use of high quality, high vigour seeds is essential for maximizing yield potentials of the plants. While rapid and uniform fields emergence are two prerequisites to increased yield, quality and ultimately profits in production of crops , some seeds of many cultivated crop species can have a slow or delayed germination (field emergence)(Yongqing ,1996). In order to obtain a fast germination and uniform plant stand in the field, various pre-sowing treatments such as priming have been used to reduce the time between seed sowing and seedling emergence (Amy et al., 1994)

Problem statement

Germination of spider plant seeds have been shown to be dormant after sometimes from harvesting. Thus they may delay or fail to germinate especially during rainy season and this leads to poor stand establishment and consequently poor yields (Chweya, 1995). Recent studies indicate the active germination of spider plants seeds starts six months after harvest and increases to 88% in three months. Highest germination occurs after twelve months of storage (Chweya and Mnazara, 1997). Viable seeds germinate within four days. Thus to avoid this dormancy period, farmers collect seeds and keep them for the next seasons planting. This is done by collecting the yellow capsules before they are ripe and dry them in controlled way so that seeds can be retained. However storage of seeds is challenging to commercial seed companies and farmers due to inevitable deterioration of seeds in storage which leads to low vigour and reduced number of viable seeds (Mutegi, 1999). Also dormancy of seeds may prevent an all year round production of spider plant by farmers who cannot afford to buy certified seed, and rely on seed collection. In this case, they have to wait for these seeds to lose their dormancy for them to propagate. Therefore in order to avoid these drawbacks, seed dormancy can be alleviated by treating these dormant seeds with priming solutions such as potassium nitrate KNO_3 in order to induce their viability (Amy et.al., 1994).

Justification of the study

Seed dormancy is defined as the disability of seeds to germinate under favourable environmental conditions. (Yongqing,1996).

Seed osmo-conditions enables seeds to imbibe enough water to become metabolically active and accumulate reserve sugars amino aids, proteins and other substances required for germination (Pessarakli, 1994). Therefore treatment of dormant spider plant seeds may trigger actual germination processes (Bino, 1992) by initiating metabolic processes without radical emergence (Amy et. al., 1994)

The promotion of germination by various compounds such as potassium nitrate KNO_3 have been widely practiced especially in tomato seeds (Devlin, 1989).

However at present, there's no documented work on any osmo-condition treatment that have been carried out on spider plant seeds. It is therefore of great importance to investigate the effects of priming treatments on spider plant seeds.

Research objective

To study the effect of osmotic priming treatments using different priming solution concentrations on the germination of spider plant seeds. The study hoped to get results that will be used in obtaining a quick and uniform plant establishment that will assist in maximizing the yield potentials of spider plant producing farmers, and thus increase food security through promotion of indigenous leafy vegetables.

MATERIALS AND METHODS

Seed source.

The experiment was undertaken using one variety of spider plant (*Gynandropsis gynandra*). Seeds were obtained from Kenya Seed Company Limited (Simlaw Seeds).

Experimental design

The experiment was carried out in Moi University's Crop production and Seed Technology laboratory.
The experiment had three (3) treatments and the control experiment. Each treatment was replicated four times by varying different concentrations of potassium nitrate (KNO_3).

Treatments
The osmotic solutions were prepared by dissolving different weights of the potassium nitrate in distilled water to form different treatments as follows:
T1—Non-primed seeds acted as a control experiment
T2—1% (1 gm per litre) KNO_3
T3—1.5% (1.5 gm per litre) KNO_3
T4—2% (2 gm per litre) KNO_3

Priming procedures
Osmo condition was done in petri dishes lined with 2 whatman No 2. Filter paper discs. For each treatment, 40 seeds were randomly counted and placed in Petri dishes. The appropriate priming solutions were then added in the Petri dishes to partially submerge the seeds (30 ml per Petri dish). The Petri dishes were then covered with two layers of filter paper and placed in the germination cabinet for 24 hours at 22 to 25^{0}C. The seeds from each treatment were washed separately in running tap, drained and blotted on absorbent paper to remove surplus surface water. The seeds were then placed in Petri dishes containing moistened absorbent paper after priming treatments. They were placed in the germination cabinet at 22-25^{o}C and left to germinate and moisture maintained in the petri dishes by addition of water.
Laboratory data collection
The seeds in the Petri dishes were observed at an interval of 24 hours daily. Data collection started on the third day after sowing the seeds. Data collection involved counting the germinated seeds when radicle protrusion was observed. Germination begins with the inhibition of water and ends with radicle protrusion (Yongqing, 1996). Root length was then measured after the ninth day from sowing. This ensured that all the seedlings had achieved maximum root length. Fifteen seedlings were taken at random from the petri dish and their roots measured using a ruler (mm). Data obtained was used to calculate germination percentage as well as the rate of germination.

RESULTS
Germination percentage
Thus comparing F tabulated with the calculated F-ratio (0.1372) it shows that the treatments are not significant.
The results showed that there was no significant difference on the germination percentage of all the primed and non-primed seeds at the 95% level of confidence. This indicated that different concentrations of KNO_3 had no effect on the germination percentage of the *Gynandropsis gynandra* seeds.

Table 1: Total percent germination of *Gynandropsis gynandra* seeds

TREATMENT	REPLICATES				
	R1	R2	R3	R4	Treatment Totals
T1	50	55	62.5	42.5	210
T2	60	50	65	37.5	212.5
T3	42.5	32.5	55	67.5	197.5
T4	70	42.5	45	35	19.5

$F_{(3, 12)}$ =3.49 at 0.05% level of significance.

Germination rate calculations
Rate of germination is determined as when 50% of the seedlings germinated (T_{50}). The value of T_{50} is computed using the equation of Orchard (1977) below;
$T_{50} = \sum (T_i N_i) / \sum N_i$
Where N_i = number of seeds germinated on day T_i; T_i = serial number of the day;
Sum N_i = total number of germinated seeds.

Taking day 5 as our T_i since almost 50% of the germination had occurred; calculation of T_{50} for each replicate in the treatment was obtained as follows;

This results showed that there was no significant difference between seeds primed with 2% KNO_3 concentration and non-primed seeds. Also seeds primed with concentrations of 1% and 1.5% KNO3 had no significant difference. However seeds primed with 2% KNO_3 concentration and non-primed seeds showed significant difference with seeds primed at 1% and 1.5% KNO_3 concentrations.It thus follows that seeds primed with concentrations of 2% KNO_3 and non-primed seeds had higher germination rates than those primed with 1% and 1.5% KNO_3 concentrations.

Table 2: Mean time of germination (T50) of *Gynandropsis gynandra* seeds

TREATMENTS	Mean Germination Time
T1	4.10
T2	4.41
T3	4.38
T4	4.02
Significance	$p \leq 0.05$
LSD at 5%	0.08

Root length measurements

Table 3: Root lengths (mm) of *Gynandropsis gynandra* seeds

TREATMENTS	Root lengths (mm)
T1	191.25
T2	176
T3	175
T4	153.75
Significance	$p \leq 0.05$
LSD at 5%	37.5

These results show that all the primed seeds showed no significant difference in root length growth (seedling vigor). However non-primed seeds had significant difference with seeds primed with 2% KNO_3 concentrations but showed no significant difference with those primed at 1% and 1.5% KNO_3 concentrations.

DISCUSSION

Effect of priming on germination percentage

There was no significant difference of primed *Gynandropsis gynandra* seeds compared with the non-primed seeds. However the germination percentage at 1% KNO_3 concentration was higher, although too small to be of practical significance. The germination percentage decreased with a decrease in osmotic potential (higher concentrations of KNO_3) showing that KNO_3 had very limited effect on the germination percentage of *Gynandropsis gynandra* seeds. It was also observed that concentrations of 1.5% and 2% KNO_3 had lower total germination percentage as compared to non-primed seeds. This can be explained as in different plant species respond differently to different osmo-priming treatments as in the case where *Rudbeckia fulgida* had lower total percentage and longer days to 50% germination when primed with polyethylene glycol(PEG) (Amy,1994).

Effect of priming on germination rate

Germination rate is necessary in increasing uniformity of seedling emergence in the field and thus obtaining a uniform plant establishment. The germination rate which was computed as the number of days the seedlings took to reach 50% germination was higher in seeds primed at 2% KNO_3 concentration and the non-primed seeds. However seeds primed with 1% and 1.5% KNO_3 concentrations took more days to germinate showing significant difference as compared to those at 2% KNO_3 concentration and the non-primed seeds.

This indicates that increased levels of KNO_3 may lead to increased germination rate of *Gynandropsis gynandra* seeds. However this concentration of KNO_3 (2%) does not justify to have any significant effect on the germination rate as it's not significant with the germination rate of the non-primed seeds. It was thus observed that concentrations of 1% and 1.5% KNO_3 had a negative effect on the germination rate since it was lower and significant when compared to that of non-primed seeds.

Effect of priming on growth of seedling roots

Root length measurements were significantly lower at high concentrations of KNO_3 (2%) as compared to the 1%, 1.5% KNO_3 concentrations and the non-primed seeds. It was observed that the treatments at 1% and 1.5% KNO_3 concentrations had no significant difference in terms of root length as compared to the non-primed seeds. This indicates that KNO_3 had no effect on seedling vigour at 1% and 1.5% KNO_3 concentrations.

It can also be concluded that seedling vigour is negatively affected by high concentrations of KNO_3 (at and above 2%)

CONCLUSION

This research showed no clear indication that priming of Gynandropsis gynandra seeds with various concentrations of KNO_3 (1%,1.5% and 2%) had any effect on improving germination of the dormant seeds. In terms of germination percentage, treatments of the seeds with 1% KNO_3 concentrations showed a higher germination percentage but insignificant compared with the non-primed seeds. While the treatments at 1.5% and 2% had lowered germination percentages even below that of non-primed seeds. The germination rate of seeds primed at 2% was higher but also insignificant compared with the non-primed seeds. Also germination rates of treatments at 1% and 1.5% was significantly lower compared to the non-primed seeds showing that these concentrations had negative effect on germination rate of the dormant seeds. Consequently root growth was significantly lowered at high concentrations (2% KNO_3) as compared with 1%, 1.5% KNO_3 concentrations and the non-primed seeds. There was no significant difference in root growth between non-primed seeds and primed seeds at 1% and 1.5% KNO_3 concentrations. It can therefore be concluded that KNO_3 was not a satisfactory priming osmoticum for this species.

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ON FARM SEED PRODUCTION IN KISII DISTRICT: AN OVERVIEW OF THE PRESENT SITUATION.

Ngoze S[1] and Okoko N[2]

[1]Ministry of Agriculture and Rural Development, P. O. Box 52 Kisii, Kenya

Tel. 254-381-20308, 30273; E-mail sngoze@yahoo.co.uk

[2]Kenya Agricultural Research Centre (KARI) RRC Kisii.

ABSTRACT

The Kisii highlands in south west Kenya have high agricultural potential with reliable rainfall, which enable production of a wide range of food and cash crops. The region is one of the densely populated areas in Kenya hence provides ready market for most agricultural produce. The Ministry of Agriculture and Rural development and the Regional Research Centre (RRC), Kisii, one of the Kenya Agricultural Research Institute (KARI) have played a major role in ensuring that farmers are advised on appropriate crop husbandry methods to boost crop production. Use of farmers'

own seeds is a common practice on many smallholder farms in Kisii District. Farmers prepare and plant their own local vegetable and bean seeds. This is because the certified seeds that are available on the market are either too expensive for the farmers to purchase or farmers do not prefer their taste. The presence of fake seeds on the market has further discouraged farmers from purchasing certified seeds. This paper outlines some of the experiences of on-farm local vegetable and bean seed production and storage in Kisii District.

Key words: Onfarm, seed production.

INTRODUCTION

The central policy of the Kenyan national food security policy as stated in the sessional paper no.4 of 1981 is to ensure that adequate supply of nationally balanced food is available in all times (Anon, 1981). The policy advocates the use of indigenous food sources to achieve this objective (MOA, 1981). According to Kenya government 's recent sessional paper, poverty alleviation is one of main areas the government is addressing.

Traditional green leafy vegetables (Table 1) are important among the Southwest Kenya people since they form an important part of their staple diet. The most commonly grown and consumed traditional vegetables in Kisii include; Cowpea, (*vigna ungulata)* Pumpkin leaves (*curcubita spp)*, Black nightshade (S*olanum nigram) Spider flower(Gyndropsis gynandra)* and Amaranthus (*amaranthus spp*).

Indigenous vegetables play an important role in income generation for majority of rural small-scale farmers especially women. Recent surveys carried out in western Kenya markets indicate that indigenous vegetables offer a significant opportunity for the rural poor people to earn a living because they do not require large capital investments (schippers, 1996). Most resource poor rural households especially women earn income from sale of these vegetables. Indigenous vegetables also provide important source of employment for those outside the formal sector in peri-urban areas in many African cities because of their generally short labor intensive production systems, low levels of purchase input use and high yields (schippers 2000). Communal growers can make a lot of money from the fast growing leafy vegetables commonly found in most markets in within Kisii District.

Indigenous vegetables are very nutritious and provide essential food elements such as proteins, minerals and vitamins (Table 2) however, their production is hampered by lack of good quality seed (Onyango, 2000). Lack of certified seed for indigenous vegetables is one of the main factors that determine the success of a crop. Many farmers use their own seed because commercial seed is either unavailable or not the right type for their area. The demand for these vegetable seed is always high throughout the year. To increase yield and acreage, high quality seed must be available. However, some of the major constraints in seed production are disease and pests.

Production of local vegetables

Majority of Western Kenya people have traditionally made use of edible leaves of species growing wild as weeds (Table 1). These plants are well known to the rural people and are often planted in home gardens. These vegetables are well adapted to hash climatic conditions and disease infestations are easier to grow.

Most local vegetable farmers in Kisii have an average of 0.4acres under local vegetables. Apart from being very nutritious and providing essential food elements such as proteins, minerals and vitamins (Table 1), these local vegetables are considered to have some medicinal value (Opole *et al* 1991). For example, concoction made from spider flower and black nightshade reliefs stomach pain and also boosts the health of expectant mother. The Kisii people belief that Gynandropsis gynandra adds blood to the body (Mosot 1997). Therefore, it is recommended for use by newly circumcised boys and girls to restore lost blood and pregnant and lactating mothers to increase milk production.

Seed production Technology at farmers own field seed is the basic input and a primary requisite for vegetable growing. Success of a crop is determined by the use of good quality seed. Good seed in terms of high viability and vigour contributes nearly 30 per cent to the total production.

Vegetable seed production at the farm level by the farmers is still the most common source of seeds for vegetable farmers in Kisii District. Very often the seeds produced are of poor quality. Frequently, the fruits harvested for seeds are those that were missed during harvesting for fresh vegetables and those left over at the end of the production season. No proper selection is carried out to choose the best plants and fruits for seed production. The plants are weak at the end of the production season, thus producing seeds that are not physically and physiologically fully mature. The correct varietal isolation distance is not usually followed to prevent cross-pollination. The plant population then becomes genetically mixed in subsequent planting. Because the planting is continuos, disease infection particularly by viruses may become a problem. The weakened infected plants produce poor seeds, and if the virus is seed-borne, it will be carried into the next generation. Kisii is one of the wettest districts in Kenya receiving a mean annual rainfall of 1800mm. The produced seed may come from a wet season crop, which is exposed to fungal and bacterial disease infection. Again this allows seed-borne pathogens to infect the next crops. Moreover, the seeds are not properly extracted, processed and stored. All these contribute to use of inferior seeds by many farmers.

Soil Management Project (SMP) concept

The objective of this project (SMP II) was to demonstrate to farmers' techniques of indigenous vegetable seed production and to train farmers on pest and disease control, and soil fertility management. The research components of the Soil Management Project phase one produced technology packages that aimed at addressing some of the constraints of smallholder crop farming in Kisii: low soil fertility, lack of seed. Participatory on-farm local vegetable seed production activities are on going in Rikenye village, Kisii District and Nyatieko

A workshop was held to train members of farmer research committees on various aspects of crop management and post-harvest handling. These included field preparation, sowing of the seed, pest and disease control, selection of healthy plants for seed production, seed harvesting and processing, package and storage. The project is using locally available organic and inorganic fertilizers i.e. the SMP recommendations (30 kg P_2O_5 and 30 kg of N ha^{-1} plus 10 ton ha^{-1} FYM). The harvesting regimes tested are as follows: Weekly, one and half weeks, and two weekly harvesting interval done for three months for spider flower and four months for black nightshade. This is to find out if there is an interaction between harvesting regime and amount of seed produced for each vegetable. At the end of the project (Dec, 2002), the project will have achieved the following: ten Research Farmer Committee members trained in local vegetable seed production and processing and local vegetable seed available in local markets and at stockists shops.

Integrated Pest management (IPM) concept for seed production

The objective of this program is to train farmers on pest and disease control, and soil fertility management and started on 12th November 2001. This is a collaboration of researchers (KARI)/ Extension officers (MoARD) and farmers and is being undertaken in Bototo A village, Mosocho Division. A group of 20 farmers meet with researchers and Extension officers every Mondays to share experiences on different technologies. During these meetings farmers identify pests and diseases on the test crops, which include Solanum nigram (Managu), Spider plant (Chinsaga) and beans. For the pest and diseases that cannot be identified on the farm, samples are taken for laboratory analyses.

The group has adopted and using the SMPI recommendations (30 kg P_2O_5 and 30 kg of N ha^{-1} plus 10 ton ha^{-1} FYM) for crop production (Okoko N. Makworo 2000). The group has been trained on various aspects of crop management and post-harvest handling. These included field preparation, sowing of the seed, pest and disease control, selection of healthy plants for seed production, seed harvesting and processing, package and storage. The group uses low priced seed dress chemicals: diazinon and Murtano. Seeds are stored in tightly closed plastic cans. Seeds that the group has produced and sold out include climber beans, Managu and chinsaga. The group has also improvised various farm implements to cut down the cost of seed production. The implements incude: Bototo jembe, used for making furrows and planting and Bototo pump for spraying chemicals. The group is also preparing and using pesticides from different plant species found in their farms.

Table 1. Some local vegetables in Kisii District

Common Name	Botanical Name	Local Name
	LEGUMINOSAE	
Cowpea leaves	Vigna unguiculata	Egesare♣/Likhubi♠/A lot bo♥
Rattle pod	Clotolaria brevidens	Mitoo/Emiro
	Clotolaria ochroleuca	
	SOLANACEAE	
African nightshade	Solanum nigrum	Managu♣/Lisutsa♠/Osuga♥
	Solanum villosum	
	Solanum americanum	
	AMARANTHACEAE	
Pigweed	Amaranthus blitum	Emboga♣/Tsimboka♠/Ododo♥
	Amaranthus lividus	
	Amaranthus hydridus	
	CAPPARACEAE	
Spiderplant	Cleome gynandra	Chnsaga♣/Tsaka♠/Dek♥
	Glynadropsis gynandra	
	Cleome pentaphylla	
	TILIACEAE	
Mrenda	Corchorus olitorius	Mutere♣/Murere♠/Apoth♥
	CUCURBITACEAE	
Pumpkin leaves	Cucurbita maxima	Risosa♣//Lisebebe♠/Budho♥

♣= Kisii,♠= Luhiya ♥= Luo
Source: Imbuga, 1973; Chweya, 1985; Olembo *et al*., 1995; Schippers, 2000; Onyango, 2001

National Agriculture and Livestock Extension Programme (NALEP)

SUGGESTED PRODUCTION GUIDE

Production from fresh vegetables plots. The best plants in terms of growth and yield and the best fruits should be selected for seed production. Any plant or fruit with suspected symptoms of diseases and pest attach should be excluded one or two fruits should then be allowed to mature fully, either on the plant or during post-harvest incubation before seed extraction. The mother plants would therefore, continue to be productive.

Maintaining the variety To prevent species/varietal mixture, it is important to know and use the correct varietal isolation, distance and to harvest and process different varieties separately, lot by lot. The varieties of cross-pollinated species are grown at sufficient distance if the genetic purity of a variety is to be maintained. The recommended isolation distance for some vegetables is presented in the table 3.

Currently the district has over 350 farmers in the six NALEP focal areas who have been trained on various aspects of local vegetable seed production.

Table 2: Percentage contribution of RDA (recommended daily allowances) by some indigenous leafy vegetables.

Vegetable species	% RDA (Raw leaves)			
	Vitamin A	Vitamin.C	Ca	Fe
Gyndropsis gynandra	196	437	56	80
Solanum nigrum	122	210	27	34
Amarantus spp	170	320	100	34
Crotolaria brevodens	131	420	32	28
Corchorus olitorius	113	521	32	56
Cucurbita spp	110	467	5	17
Vigna spp	150	260	110	35

(Imungi 1989)

Table 3: Mode of pollination, viability period, minimum isolation requirements and seed count of different crops

Crop	Mode of Pollination	Viability (Years)	Approximate Requirements	ISOLATION (metres)	Seed count
Tomato	SP	4	50	100	225/gm
Beans	SP	1	20	10	4000/kg
Cowpea	SP	3	20	10	8000/kg
Amaranthus	CP	3	400	200	

CP = Cross Pollination, SP = Self Pollination

CONCLUSION

Some farmers in Kisii adopted both SMP and IPM concepts with the aim of commercializing local vegetables/seed production. As a result of the KARI/Ministry of Agriculutre projects, more than five hundred farmers in participating and neighbouring villages are actively involved in bean and local vegetable seed production. These farmers see local vegetables and bean seed production as an alternative way to generate income since coffee is now less successful in the region. The income generated assists small-scale farmers to meet their household requirements and to pay for their children's education. Therefore more farmers should grow indigenous vegetable and beans for nutritious food and income generation.

WAY FORWARD

Future work will concentrate on sensitizing more farmers in the region on importance of using clean seed for higher vegetable and bean crop yields. Participating farmers at the present sites will be encouraged to increase production of good quality seed. In addition, economic analysis and sensitivity analysis will be undertaken to ensure the technologies being recommended are sustainable.

INTEGRATED CROP PROTECTION RESEARCH FOR SUSTAINABLE PRODUCTION OF INDIGENOUS VEGETABLE CROPS IN EASTERN AFRICA

S. Sithanantham[1], C.M. Matoka[1], M. Maundu[2], M. Jakari[3] and S.G Agong[4]
[1]International Center of Insect Physiology and Ecology (ICIPE), P.O Box 30772, Nairobi, Kenya (E-mail: ssithanantham@icipe.org).
[2]International Plant Genetics Resources (IPGRI), P.O Box 30677, Nairobi, Kenya.
[3]Gene Bank of Kenya, P.O Box 30148 Muguga, Kenya
[4]Jomo Kenyatta University of Agriculture and Technology, Juja, P.O Box 62000, Nairobi, Kenya.

ABSTRACT

Pests and diseases constitute an important constraint to sustainable production and enhanced utilization of indigenous vegetable crops. Current knowledge on the pest/disease problems is mostly limited to listing of names and describing the symptoms of pests/diseases that occur commonly on a few indigenous vegetable crops such as – *Cleome gynandra, Crotolaria* spp., *Solanum* spp. and *Amaranthus* spp. in Eastern Africa. While the economic loss due to pests has been estimated on-station in Kenya, there is need to conduct on-farm assessments so as to characterize the range in the severity of pests/diseases in the 'real world' which will be based on the 'farmers' field scenario of yield losses. An understanding of the seasonal and regional pattern of the production losses caused by pests / diseases and the identification of the key pests/diseases that would require control interventions are important pre-requisites to plan a focused and Integrated Pest Management (IPM) research. The potential options may include the use of pest tolerant cultivars/landraces, cultural practices like companion cropping and rotations, besides botanical products (e.g. neem), which are effective on the pest and safe to both man and the environment. Recommended crop protection practices should use locally available materials, simple to adopt, economical and compatible with the crop ecosystem and so help enhance marketable quality of the produce. Inter-disciplinary research approach linking regional, national and international research across countries as well as advanced research institutions, through a coordinated Regional IPM Network Linkage could be visualized for catering to these urgent needs.

IMPORTANCE OF AFRICAN INDIGENOUS VEGETABLE CROPS

African indigenous vegetables refer to crops, which originated from the region and which either grow spontaneously in the wild or have been semi-domesticated in home gardens in many parts of Africa (Schippers, 1999). Poor people obtain most of their nutrients from indigenous vegetables, which are cheaper and more accessible than the exotic ones (Rubaihayo, 1994; Schippers, 1997a; Schippers, 1999). The leaves of these plants are good sources of protein, phosphorus and iron as well as vitamins (Mnzava, 1997). In many cases, they are of higher overall nutritive food value and more tasty than exotic vegetable species (FAO, 1997; Mnzava, 1997; Schippers, 1999). They contain vitamin A, B and C, proteins and minerals such as iron, calcium, phosphorus, iodine and fluorine, in amounts adequate for normal growth and health of human beings (FAO, 1988).

Although these crops are well known among traditional societies in Africa, they have been neglected in recent times due to the priority shifting to introduced vegetables among researchers, policy-makers and donors, so they remain unimproved and underutilized (Chweya, 1985; Chigumira, 1995). Renewal of interest in these crops is justified on the basis of their contribution to agricultural diversification, better use of marginal land, food security and more balanced diet, better safeguard of agro biodiversity and associated cultural heritage, self-reliance of agricultural systems, additional source of income to farmers, and employment opportunities (Padulosi, 1998). The interest in conservation and improved utilization of indigenous vegetables is re-emerging in Africa (Schippers,1997a). *Amaranthus* spp. (Amaranthaceae) and *Corchorus* spp. (Tiliaceae) have been identified as priority crops for research and development in sub-Saharan Africa (Schippers and Budd, 1997). Country-wide assessment in Kenya has shown that *Amaranthus lividus* L., *Corchorus olitorius* L., *Cleome gynandra* L. (=*Gynandropsis gynandra* (L.) Briq.) and *Crotalaria brevidens* Benth. are among the commonly grown species (Maundu *et al*., 1999) and these crops are also among the popular indigenous vegetables grown elsewhere in Eastern Africa (Rubaihayo, 1994; Schippers, 1997b). *Amaranthus* spp. and *C. brevidens* are also popular leafy vegetables in Tanzania (Uiso and Johns, 1996). *C. gynandra,* (Chweya and Mnzava, 1997) has been a semi-domesticated volunteer crop in home gardens or on fertile land near homesteads in many parts of sub-Saharan Africa. It is probably more commonly grown as a leafy vegetable in Kenya, than in other parts of Africa (Schippers, 1997b; Goode, 1989). *C. olitorius* is also a popular leafy vegetable elsewhere in Africa besides in Asia and some parts of the Middle East (Oomen and Grubben, 1978). The five common groups of indigenous vegetable crops are listed below:

- Amaranthaceae: *Amaranthus* spp.; *A. blitum* - Amaranth/ 'Mchicha' / 'Mbuga' / 'Dodoo'
- Capparaceae: *Cleome gynandra;* - Spider plant / 'Mgagani' / 'Dek' / 'Saga'
- Leguminosae: *Crotalaria* spp.; *C. Brevidens* and *C.ochroleuca* - 'Nyasamo' / 'Mitoo'
- Solanaceae: *S. nigrum* complex; - African nightshade / 'Managu'
- Tiliaceae: *Corchorus* spp.; *C. olitorius* – Jute, Jew's mallow / 'Mrenda'

IMPORTANCE OF INSECT PESTS AS CONSTRAINTS TO INDIGENOUS VEGETABLE PRODUCTION

The damage by insect pests has often been mentioned as one of the major constraints to the production of indigenous vegetables (Gockowski and Ndumbe, 1997; Schippers, 2000). The common pest problems on African indigenous vegetables (AIVs) as revealed by Schippers (2000) and Sithanantham *et al.,* (2003) include the following groups:

- Defoliators - Beetles, Caterpillars
- Sucking pests - Aphids, mites, thrips, bugs
- Stem borers found in *Amaranthus*, *Cleome*
- Fruit / pod borer - African bollworm
- Leaf Miners and Webbers found in *Amaranthus*, *Cleome*

Information is lacking on the species range of insect pests infesting these crops in Eastern Africa and there are no published estimates of the extent of yield loss caused due to insect pest damage. The need for collaborative research to establish base line information for evolving appropriate pest management options for the more common crops has been pointed out (Sithanantham *et al*., 1997). The following sections illustrate the past research efforts made besides the knowledge gaps, and to identify priority themes for future research for evolving appropriate pest management technology options for four commonly grown African indigenous vegetable crops *C. gynandra*, *C. brevidens*, *C. olitorius* and *A. lividus* in Eastern Africa.

BUILDING UP A KNOWLEDGE BASE ON YIELD LOSS AND SPECIES RANGE IN INSECT PESTS

Quantitative estimates of yield loss due to pests

Recent studies in Kenya have provided on station estimates of avoidable yield loss due to insect pests on *C. gynandra, A. lividus*, *C. olitorius* and *C. brevidens*. The overall (average of 2-3 seasons) yield loss in these four crops has been estimated as 17.0, 20.3, 13.1 and 21.3 percent, respectively (Sithanantham *et al*., 2003) (**Fig.1**). These apparently are the first known estimates on the extent of yield loss due to pest attack on these crops in the region. Obviously, they would provide a basis for future research on pest management

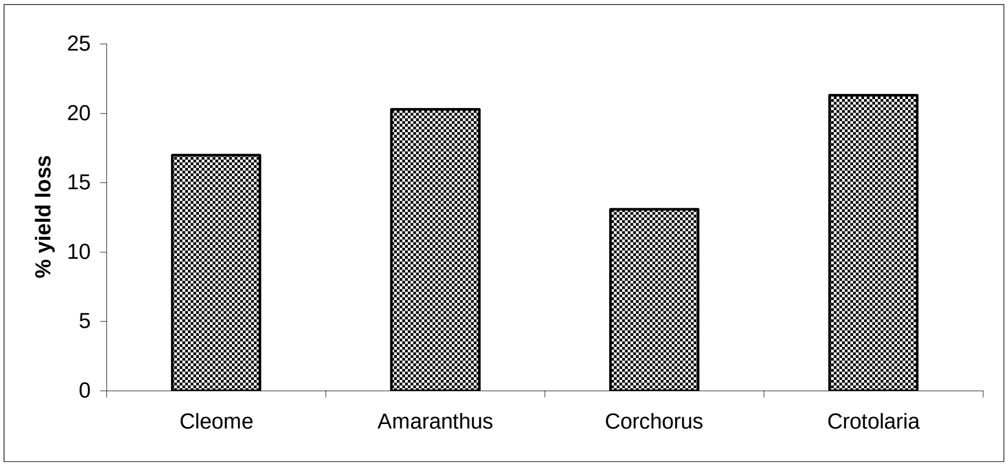

Fig. 1. Estimates of overall avoidable losses due to insect pests on four indigenous vegetables in Kenya, 1996-98 (Mean of 2-3 seasons)

As follow-up, studies should be undertaken to quantify the yield losses caused by individual major pest groups, in order to prioritize the pest groups for further research and to evolve cost-effective options to manage them. This sort of crop protection complementation would be useful in further popularizing these relatively neglected categories of precious vegetable crops (Schippers, 1999; Sithanantham *et al*., 1997).

Pest spectrum on indigenous vegetables

The number of insect species so far recorded in Kenya (Sithanantham *et al*. 2003) is furnished (**Table 1)**. An illustration of means of linking the pest numbers and/or damage observed in the crop, to the observed differences between 'protected' and 'non-protected' plots is provided in **Table 2**. An indication of the impact of 'protection' in reducing the damage by stem borers in *C. gynandra*, along with enhancement of plant height (**Table 3**), illustrates the potential gain in crop growth / productivity due to protection from the key pests in these crops.

Table 1: Number of pest group species in four indigenous vegetables

	Defoliators	**Sucking bugs**	**Borers**	**Others**
Cleome	3	3	2	1
Amaranthus	5	6	2	3
Corchorus	2	4	2	1
Crotalaria	3	2	1	1

Table 2. Incidence of insect pests in *Cleome gynandra* and *Amaranthus lividus,* Mbita Point, Kenya, 1997

Crop spp	Treatment	Damage rating¥				Insect counts/plant¥		
		Beetles	Leaf miners	Caterpillars	Aphids	Beetles	Leaf miners	Caterpillars
C. gynandra	Protected	1.0 a	1.2 a	1.6 b	1.1 a	1.0 b	1.3 a	0.2 a
	Unprotected	1.4 b	1.4 a	2.0 a	1.1 a	1.7 a	1.4 a	0.1 a
	‡$F_{1,17}$	1.0^{ns}	10.6**	11.4**	0.2^{ns}	13.1**	3.8^{ns}	2.3^{ns}
A. lividus	Protected	1.0 a	2.6 b	1.6 b	1.1 a	1.0 b	1.3 a	0.2 a
	Unprotected	1.0a	2.8 a	2.0 a	1.1 a	1.7 a	1.4 a	0.1 a
	‡$F_{1,17}$	1.0^{ns}	10.6**	11.4**	0.2^{ns}	13.1**	3.8^{ns}	2.3^{ns}

¥ Means are for three sampling dates (24 November, 8 December 1997 and 4 January 1998; ‡F value and significance for differences between treatments: * significant at 5%, ** significant at 1% and *** significant at 0.1% level, ns non significant.

Table 3. Effect of pesticidal protection on plant height and stem borer damage in *Cleome gynandra*, Mbita Point, Kenya, 1996

Protection	Plant height (cm)	Borer damage length (cm)
Protected	136.2±2.9 a	24.0±1.3 a
Unprotected	113.3±5.4 b	40.5±2.0 b
$F_{1, 6}$	12.3*	46.4**

* significant at 5%, ** significant at 0.1% level, ns non significant.

POTENTIAL CONTROL OPTIONS

Considering that the fresh produce from the African Indigenous Vegetables may also be consumed as raw salad, it is important to develop pest control options that are safe, besides being cheap and simple to adopt. Some of the promising options are as follows:

Botanicals

The seeds and leaves of neem (*Azadirachta indica*) and its relative Persian lilac (*Melia azedarach*) are known to have potential pest control properties. In Kenyan market, standard neem products (e.g. Achook) are also available. These and any other promising botanicals could be evaluated.

Microbial biopesticides

For caterpillar pests, there is scope to use products derived from the *bacterium, Bacillus thuringiensis* (*B.t.*). In Kenya, there are three *B.t.* products available from agro–input retailers, namely Dipel, Thuricide and Xentari. The potential for a new *B.t.* product (Greenguard) from China has also been documented (Sithanatham *et al.,* 2003).

Other biorational/organic products

There are organic products like 'spinosad' (metabolite from actinomyectous fungus) as well as insect growth regulators (IGRs), which are also considered to be safer than synthetic pesticides and could be evaluated, especially for caterpillar pests.

Beneficial cultural practices

Planting companion crops which may divert the pests (e.g. trap crops) could also be considered. For example, cruciferous crops are known to benefit by planting of more attractive crops (e.g. Indian mustard) or repulsive crops (e.g. coriander, tomato) in the vicinity, to reduce the infestation by the key caterpillar pest – diamond back moth (Raini, 2001; Makatiani, 2002). A similar approach could be developed for Ethiopian mustard.

It is also possible to adopt rotation crops, which suppress soil pest infestation. For instance, African marigold (*Tagetes erecta*) and *Crotalaria* spp. can help reduce nematode buildup. *Tithonia* choppings (mulching) is known to provide relief from termite infestation.

Use of pest resistant varieties

This approach is a relatively inexpensive method of reducing the pest-caused losses. The potential for this method is indicated in another paper in these proceedings.

INTEGRATED CROP PROTECTION

The approach

Integrated pest management (IPM) approach seeks to combine compatible pest control methods, so as to maximize their impact through complementation, and minimize any negative effects on the crop ecosystem. It is based on combination of knowledge with wisdom, so as to promote sustainability of the crop protection practices. The potential for adopting IPM in vegetable crops in sub-Saharan Africa has been well documented (Sithanantham and Matoka, 2001).

The implementation

Awareness building models have been developed for IPM in vegetable crops in the region (Sithanantham *et al.,* 2003). The adoption of Farmers' Field School (FFS) strategies would be useful in popularizing IPM options for sustainable crop protection among African indigenous vegetable crops.

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A REVIEW ON THE SEED PRODUCTION AND HANDLING OF INDIGENOUS VEGETABLES (SPIDERPLANT, JUTE MALLOW AND AFRICAN NIGHTSHADE COMPLEX)

K'Opondo, F.B. O.*, R.M., Muasya and O.K. Kiplagat
Department of Crop Science and Seed Technology, Moi University
P.O. Box 1125, Eldoret, Kenya.
E-mail: seedtech@africaonline.co.ke

ABSTRACT

Although researchers, agriculturalists and policy makers, have largely neglected them African leafy vegetables have over the years featured prominently in diets of many communities especially in resource poor areas. They are mainly used in the preparation of relishes that supplement and add flavour to diets, which are usually based on starchy staples. These vegetables fall in many species and are widely distributed. Among the important ones are Spiderplant (*Cleome gynandra* L.), Jute mallow (*Corchorus* spp.) and African nightshade (*Solanum nigrum* L. Complex). Since these vegetables gained the attention of researchers only recently, there are still wide knowledge gaps in the various aspects of production. One important area where knowledge is required is that of seed production, handling and storage. Information on the current methods of seed production, harvesting, drying, processing and storage is important in identifying bottlenecks that hamper productivity and subsequent commercialization of these vegetables. For commercialization, more uniform crops are desirable and methods of breaking seed dormancy, which is common in these crops, should be studied. A review of seed production and handling of three indigenous vegetables spiderplant, jute mallow and African nightshade complex is presented.

Key words: Indigenous vegetables, seed production, seed handling, seed quality,

GENERAL INTRODUCTION

Kenyans have traditionally made use of edible leaves of some indigenous plant species for health, nutrition, income generation and food security (Chweya and Eyzaguirre, 1999). Researchers, agriculturalists, policy makers and granting agencies, have neglected these indigenous vegetables, of which some are nutritionally equal or superior to exotic ones (see Table 1). Limited research has identified some of the indigenous leafy vegetables that could be developed as commercial horticultural crops and these include spiderplant, jute mallow, African nightshades, amaranth, , *Crotalaria* ("mitoo"), cowpea and Ethiopian kale.

Lack of seeds in terms of availability, seed quality and choice of varieties, among other constraints, hinder the production of these vegetables
A study carried out in the three districts of Kilifi, Kisii and Tharaka in Kenya revealed that seed systems are still not well in place (Chweya and Eyzaguirre, 1999). Farmers lack the proper skills that would enable them to produce quality seed. Seed production is also low since most of the harvest is for consumption and not for seed production.

In Kenya, the formal seed sector focuses on the few crops of commercial value most of which are the exotic crops. Little attention is paid to the other crops of importance to subsistence farmers who produce over 80% of the food crops in the country, and contribute greatly to food security. This is particularly true in the case of indigenous vegetables where most of these smallholder farmers grow their crops from seed of non-authentic sources obtained from informal seed systems (own-farm, local market, neigbours and relatives and from the wild) (Chweya and Eyzaguirre, 1999).

Table 1: Mean composition per 100 Gram Edible Portion of Selected Traditional Leafy Vegetables Compared with Cabbage

Nutrient	**Spiderplant**	**African nightshade**	**Cabbage**
Water (g)	86.6	87.2	91.4
Iron (mg)	6.0	1.0	0.7
Protein (g)	4.8	4.3	1.7
Calories	34	38	26
Carbohydrates (g)	5.2	5.7	6.0
Fibre (g)	1.4	1.3	1.2
Ascorbic acid (Vit. C) (mg)	13	20	54
Calcium (mg)	288	442	47
Phosphorus (mg)	111	75	40
Beta-carotene (Vit. A precursor) (μg)	10452	3660	100
Thiamine (Vit. B1) (mg)	-	-	0.04
Riboflavin (Vit. B2) (mg)	-	0.59	0.1

Adapted from the chart provided by Kenya Resource Centre for Indigenous Knowledge (KENRIK) of the National Museum of Kenya. Seed quality is largely influenced by seed production conditions, timing of harvesting, harvesting methods, subsequent treatments and storage. The increasing awareness on the importance of some of these vegetables calls for re-evaluation of research priorities to enable allocation of more research resources in the development of these crops. Knowledge on proper seed production and handling methods will go a long way in removing bottlenecks hampering production of these crops. With improved production, utilization and conservation of local vegetables, there will be corresponding improvement in the health, nutrition and economic status of the communities in Kenya.

Seed Production and Handling of Spiderplant (*Cleome gynandra* L.)

INTRODUCTION

Spiderplant is found in many countries in Asia, Africa and the Americas, where it grows and is regarded as a weed, although semi-cultivated as an indigenous leafy vegetable in some areas (Chweya and Mnzava, 1997). In most African countries it is no longer considered as a weed, but is most welcome as a source of food and even income (Schippers, 2000). It is used both as medicine and as food crop (Waithaka and Chweya, 1991; Chweya and Mnzava, 1997; Maundu *et al*., 1999; Schippers, 2000). The plant's nutritional value may vary with soil fertility, environment, plant type, plant age and the production techniques used.

Seed Production Agronomy

Studies in Kenya indicate that there are phenotypic variations among spiderplant populations (Chweya, 1990; Kemei *et al*., 1995), although the genetic diversity has hardly been studied.

It has been observed that the plants in the species can be both self and cross-pollinating. According to Omondi (1990), observations on populations indicate uniformity for most characters. Such uniformity can only arise from predominantly self-pollinating species. Although it is possible that *C. gynandra* is predominantly self-pollinating, this needs to be qualified. There is likely to be a high rate of outcrossing, owing to diverse phenotypic variability, and the phenomenon of anthers dehiscing when flowers have been open for a long time and their stigmas exposed (Omondi, 1990). Pollinators may include insects such as honeybees, spiders and wind.

Plants require a thoroughly prepared seedbed to a depth of 15 cm, with all weeds removed (Waithaka and Chweya, 1991; Chweya and Mnzava, 1997). After digging, the soil is harrowed to a fine tilth. Organic manure is applied and worked into the soil. Spiderplant responds well to organic manure application as it results in delayed flowering and therefore a longer harvest period, and significantly higher yield of leaves and shoots. The seedbed is then levelled before sowing. Plants can be grown on flat beds or on traditional raised beds, which are normally 1 m wide. Seedbed length is variable, but may not exceed 3 m. Narrow paths are usually left between the beds to facilitate access for weeding and harvesting. These paths also act as drainage channels during wet season, as plants do not withstand water logging. When raised beds are used, application of organic manure is delayed until the beds have been made, so as not to waste it where pathways are likely to be constructed.

Direct sowing is done at the onset of the rains. Seeds are either broadcast or drilled in rows, which are spaced about 30 cm apart. Shallow seeding in drills of depths of less than or equal to 1 cm is recommended to avoid uneven seedling emergence and poor stand establishment. Seeds are dropped in the drills and covered over
with a layer of fine soil, with a light pressing down on the filled-in drills to ensure that seeds are covered with firm soil. This allows the roots to obtain a good hold in the soil when germination begins. Seed requirement is about 4g of seed per m^2 (about 40 kg/ha) (Waithaka and Chweya, 1991). The seeds germinate after 4-5 days in a well-drained moist medium (Waithaka and Chweya, 1991), with seedling emergence after 6-8 days. Germination can be rather uneven when some of the seeds are dormant. This dormancy will ensure that there will always be some seeds ready to germinate in a climate with unreliable rainfall patterns.

For good yields liberal and repeated applications of nitrogen (N)-fertilizers (organic or inorganic) are necessary. Use of Farm Yard Manure (FYM) has been observed to give better results than use of inorganic N-fertilizers (apart from adding nutrients to the soil, it also improves soil structure, cation exchange and water-holding capacity). Up to 20 tonnes/ha of FYM or compost manure is recommended (Waithaka and Chweya, 1991). When manure is not available, 200 kg/ha of Diammonium phosphate (DAP) should be used at sowing (Waithaka and Chweya, 1991). The N in DAP gives the plant a good start and promotes good continuous vegetative growth, resulting in good leaf yields.

Thinning is done 3 weeks after emergence, to leave 10-15 cm between plants and the thinnings may be consumed as vegetables. At thinning, top-dressing with 100 kg/ha of Calcium Ammonium Nitrate (CAN) is recommended (Chweya and Mnzava, 1997). Generous application of nitrogen delays flowering of plants hence extends the harvesting period, although seed yield has been observed not to be responsive to application (Chweya and Mnzava, 1997). At higher N rates, stems become too succulent and regeneration is reduced, a disadvantage where plants are periodically harvested (Chweya and Mnzava, 1997).

Spiderplants do not have dense foliage and such cannot compete with weeds. It is therefore essential that seedbeds are kept weed-free at all times from early stages, until when plants would have developed the canopy to cover and smother the weeds. Shallow cultivation or hand pulling of weeds should be practiced. Damage on roots adversely affects growth of plants, leading to reduced leaf yield and quality.
Water stress reduces leaf yield and quality. The plants therefore require adequate moisture supply in the soil throughout their growth. When rainfall is inadequate, frequent watering is necessary during vegetative growth period, with frequency depending on water-holding capacity of the soil. Over-watering should be avoided, as plants do not withstand flooding. Plants tend to flower very early, within 4-6 weeks of growth. The vegetative growth declines rapidly with onset of flowering with leaves senescing very quickly starting with the old ones, which is the main reason why farmers who aim at leaf production remove the flowers to prolong vegetative growth and increase leaf yield per plant. Fruit development and maturation take the longest time (3-4 months), and flowering which is gradual, starting with the

terminal shoot and followed by the axillary shoots may last for at least 2 months, due to continuous development of axillary shoots.

Seed Harvesting and Handling
The fruits (capsules) take a long time to mature and dry properly, and at the end seeds are shattered through dehiscence. The easiest way is to collect yellow capsules before they are fully ripe and dry them in a controlled way so that seeds can be retained (Schippers, 2000). From the respondents from the study carried out in three districts of Kenya it was indicated that the seed storage methods include plastic tins and polythene bags because they are readily available (Chweya and Eyzaguirre, 1999). A seed yield of up to 500 kg/ha of seeds has been mentioned (Chweya and Mnzava, 1997). Seed counts in a trial in Uganda averaged 140 seeds/pod, and the number of seeds/gram was 1244 (Schippers, 2000). When seeds have been put in their various containers, they are mixed with ash to prevent them being eaten by pests. In Zambia, the Zambian Seed Company promotes the crop through advisory leaflets and by making the seeds available. Kenya Seed Company is also producing and marketing seeds.

Seed Production and Handling of Jute/Jew's Mallow/Tossa Jute (*Corchorus olitorius* L., C*. tridens* L. and *C. trilocularis* L.)

INTRODUCTION
The genus *Corchorus* is mainly known for its fibre product jute and for its leafy vegetables, with jute mainly extracted from *C. olitorius* and *C. capsularis*, a species from India (Schippers, 2000). Several species of *Corchorus* are used as a vegetable, of which *C. olitorius* is most frequently used. *Corchorus* is naturally occurring in the tropical and subtropical regions of the world.

C. olitorius is widespread as a low-growing weed in the tropics of the Old World, and is ancient and popular vegetable in Africa, the Middle East and India. Jute mallow is popular as a vegetable in both dry and semi-arid regions and in the humid areas of Africa (Schippers, 2000).
African edible species of *Corchorus* are annual or short-lived perennial crops, up to 2 m high, and belonging to the family of *Tilliaceae*. Their stems are well developed with abundant fibres in the phloem tissue, which is why they are used as fibre crops. The leaves of the three cultivated species have serrated leaf margins, they are alternate and show the characteristic 'swallow tails' or setae at the base of their lamina (Schippers, 2000). The fruit is straight or slightly curved capsule that terminates in a beak. The shape of the capsule is an important characteristic for species identification (Schippers, 2000).

Corchorus olitorius L.- is the most frequently cultivated and most common species in Africa. It is highly variable in size, branching and shape of its fruit and leaves. The leaves are generally dark-green and glossy. The capsule is 5-7-valved with a straight beak of up to 12 mm long. There are also forms with thick capsules and virtually no beaks or with short spreading horns. Plants often reach more than 1 m at maturity.

C. tridens L.- is woodier and mainly seen in warmer and drier areas. It has oblong to lanceolate non-shiny leaves and thin 3-valved capsule with 3 small, spreading horns at the apex. The leaves are often light to yellowish-green. It tastes bitterer than *C. olitorius*. Plants generally do not exceed 1 m in height.

C. trilocularis L.- it looks rather similar to *C. tridens*, but its leaves are often broader. It has a long capsule split into 3-4 valves when dry. The capsules have a straight beak without horns. This species is more common in East than West Africa.

From studies carried out it was concluded that dry weight increased with rising temperature with the largest leaf areas observed with 30 ^{0}C during the day and 25 ^{0}C during the night (Schippers, 2000). But lower and higher temperatures had a negative effect on leaf development. Plants stopped growing when temperatures fell below 15 ^{0}C. With studies on photoperiodic effects it was concluded that the greatest fresh and dry weight of shoots, longer stems and more roots and increased leaf areas were obtained with 12.5 hours of day length, but conversely under short-day length conditions of 10 hours the fruit production was the highest (Schippers, 2000).

Seed Production Agronomy

The best period for seed production is at a time with reducing daylength and preferably with limited rainfall (Schippers, 2000). The small-seeded jute mallow requires a thorough soil preparation, also to make weed control easier especially in the first weeks after sowing. In most traditional cropping systems, farmers plant on flat land, on ridges, or on raised beds. Only a few farmers sow or transplant in lines and most broadcast their seeds. The broadcasting method is often wasteful, especially when the seed is not mixed with sand and many seedlings of poor quality are produced. For the traditional mixed-cropping system, farmers sow directly. Most farmers consider the combination of *Corchorus* with staple food crops as a profitable means of early revenue generation while waiting for other crops to mature, although it has a low competitive ability when combined with vegetables. Where sowing lines are used they are preferred to facilitate interculture. Seed are sown 3-5 cm deep, with a spacing of 20-30 x 6-10 cm. With broadcasting the seedrates are 6-9 kg/ha; while with drilling the seedrate is reduced to 4-6 kg/ha. Plants about 15 cm tall are used for transplanting and spaced at 30-50 x 10 cm, depending on the variety used. Alternate plants can be pulled out during the first harvest, thus leaving a spacing within the row of 20 cm. Research in Ghana showed that transplanting is not always successful but when plants survive they produce more and stronger side shoots (Schippers, 2000).

Application of manure or fertilizers significantly influences the vegetative yield. Well-decomposed poultry manure applied at the rate of 20 t/ha is ideal (Schippers, 2000). Alternatively, a fertilizer application at the rate of 75 kg N, 20 kg P and 40 kg K/ha will provide optimum yields (Schippers, 2000). For the more readily available 15-15-15 compound fertilizer, an application of 250 kg/ha is recommended. Seed dormancy is a major difficulty. A general solution to seed dormancy is to parboil the seed, placing them in simmering water for 5-10 seconds. This gives the best seed germination and uniform seedlings (Schippers, 2000). Treated seeds need to be sown immediately since they cannot be stored. When seedlings reach 20 cm thinning out is done to 20-30 x 10 cm, to maintain appropriate populations. Plants can be topped to give stronger side shoots, although such action may reduce fruit and seed yields. Irrigate the crop as and when necessary. The first hand weeding should be done when the crop is 3-4 weeks old. Subsequent 1-2 hand weeding(s) can be done as required.

Seed Harvesting and Handling

Most farmers produce their own seed, mainly by beating the dry stems and branches with sticks, followed by winnowing. When fruits are left on the plant for too long, some fully ripe capsules will shatter their seeds. The overripe, black capsules collected from dry plants at the end of the season were found to contain more seeds with dormancy symptoms than yellow or brown capsules (Schippers, 2000). Ideally, yellow or brown capsules should be picked by hand and left to dry on a canvas or similar sheet and be shelled in a controlled way, such that any shattered seeds will drop onto the sheet, allowing for effective recovery. Seeds need to be dried to a 9% moisture content to retain their viability until the next season. Yields of about 100 g seed/plant are possible (Schippers, 2000). Plants need to be spaced at 50 x 50 cm and well fertilized. Seed yield is higher from plants that have not been topped to induce side shoot production. Rainy season crops, which are closely spaced usually, give no more than 2 g seeds/plant.

Extracted seeds can be stored for up to 1 year, after which the germination capacity will rapidly deteriorate. Seed germination is partly affected by seed size. Bigger seeds germinate faster and produce larger seedlings than small ones. There are indications that the position of fruit on the plant affects the germination capacity since seeds extracted from capsules at the top and middle of the stem are better than those from the base (Schippers, 2000). As long as the seeds are kept dry they can be stored for a long period. Experiments in Zimbabwe with *C. tridens* showed that 25-year old seeds had germination of 70%, whereas fresh seeds did not germinate well because of dormancy problems (Student Project by Ms V. Machakaire). The number of seeds/capsule depends on the number of locules and their lengths. For *C. olitorius* there are usually 5-8 locules, each with 15-30 seeds. The average is about 100 seeds and large ones may contain up to 230 seeds. There can be up to 500 seeds/g. Seed yield of 600 kg/ha have been recorded from Kenya (Onyango, 1992).

Seed Production and Handling of African Nightshade Complex (*Solanum nigrum* L. Complex)

INTRODUCTION

African nightshade species that are most frequently cultivated are *Solanum scabrum*, which is dark-purple-berried, and mainly found in West Africa and *S. villosum*, orange-berried and cultivated in East Africa (Schippers, 2000). There are several species with black berries that are cultivated to a limited extent, of which the most important is *S. americanum*. All these species belong to the *S. nigrum* complex, which are referred to as the African nightshade group of species (Schippers, 2000).

Seed Production Agronomy

Seeds can either be produced on the farm or purchased at the market. Some of the seed producers also specialize in the production of seedlings for sale to others. A piece of land is prepared by digging the soil, harrowing and, working in some well-decomposed manure, leaving a well-drained structure with fine tilth. For nursery planting, a layer of grass or similar material is usually placed on top of the prepared nursery bed and burnt to sterilize the soil and avoid both soil-borne pathogens and weeds. This will also provide a layer of ash that is full of nutrients, especially potash. The seedbeds can be made flat or raised, with narrow paths left between them, to facilitate weeding, harvesting and even for irrigation purposes.

Small bees and black syrphid flies can affect pollination (Schippers, 2000). A crop grown for seed production should have care taken to avoid cross-pollination. The seed crop is recommended to be planted in blocks (and not in lines); the outer rows will be discarded and berries only collected from the inside block (Schippers, 2000). The block should be exclusively made up of plants grown from seeds extracted from one selected plant (Schippers, 2000).

African nightshades produced for subsistence are mainly sown at the beginning of the rainy season. When sowing directly, a few (3-10) seeds are used per location, for example, next to the companion crop in a mixed cropping system. The strongest plants will be kept and the others removed as a first harvest or for planting in a different place. To avoid seedlings from becoming too spindly, sowing should not be done too dense. Direct sowing during the rainy season results in taller plants and, when there is adequate room, in more and larger leaves and branches and better dry matter content compared to transplanting. Direct sowing results in earlier flowering (Schippers, 2000).

Nurseries are used to grow a commercial crop mainly in the dry season, and for monocropping. The nursery bed is sown with lines about 20 cm apart or, alternatively, seeds are broadcast. Seeds are either mixed with dried poultry manure and/or sand. Some farmers mix seeds with ash to spread the seeds more evenly. After sowing, the bed should be covered with a thin layer of soil, which also helps to prevent ants from carrying the seeds away. The seeds normally germinate in 5-10 days. Seeds sown for a commercial crop will be in the nursery for about 1 month from sowing to transplanting. At the time of transplanting, seedlings are selected for their strength and freedom from diseases. Seedlings should be at least 8 cm tall, with 5-6 true leaves. Transplanting is done late in the afternoon. Adequate water is needed just before and immediately after transplanting since the roots are sensitive to drought. While transplanting it is essential to ensure that there is a good root-to-soil contact by covering the roots with soil and by applying a slight pressure to it. The planting distance for a seed crop should be about 50 x 50 cm to 100 x 100 cm, depending on species and variety (Schippers, 2000). Nightshades require large amounts of nitrogen and other nutrients and therefore do well on soils that are rich in organic matter (Schippers, 2000). They also grow well on land covered with ash from recently burned vegetation. Fertilizers have been found to be effective and farmers mainly use NPK: 20-10-10, urea or sulphate of ammonia when there is no poultry or farmyard manure available. A trial done in Kenya had shown a significant increase in plant growth with a nitrogen application at the optimum rate of 5 g N/plant (19 g of CAN/plant) (Murage, 1990).

Daily irrigation is needed for the first week after transplanting, especially during the dry season. The irrigation interval can later be reduced to three times per week, depending on temperatures, cloud cover or possible rains. Watering can be through the paths (gravity irrigation) in between the raised beds or by using a hose or watering can. Overhead irrigation should be avoided because of the potential to spread diseases (Schippers, 2000). Weeding is needed during the early stages of development. Once the lower branches have spread out, weeds are generally suppressed. Side dressing is practiced after every second harvesting with the source of nitrogen being organic fertilizers, e.g. dry poultry manure, or inorganic fertilizers, e.g. urea, sulphate of ammonia. Extra nitrogen increases yield, but high nitrogen levels make the crop more vulnerable to diseases unless there is a proper balance with potassium. It will also have an impact on the level of nitrites in the leaves, which could become a human health hazard. Strong plants with desirable characteristics are normally selected after the third or fourth harvest when no further shoots will be plucked and the plant is allowed to produce flowers and berries (Schippers, 2000).

Seed Harvesting and Handling

S. scabrum berries are easy to collect since they remain on the plant, whereas the berries from most black-fruited types drop on the ground. The orange berries of *S. villosum* only drop when the fruit is over-ripe and could be collected from the plant. Collecting berries from black-fruited African nightshades, mainly carried out by children, for example in Kenya, takes a lot of time. For this reason seeds from black-berried nightshades are far difficult to obtain than seeds from *S. scabrum*, this being a major constraint to their production. The Kenya Seed Company has started to sell *S. villosum* seed. The fermentation process of extracting the seeds involves squashing fruit inside a container with water and leaving it for several hours up to 1 day to separate the fleshy parts from the heavy seeds, which will settle at the bottom of the container (Schippers, 2000). The seeds can be collected by pouring the water with the floating material out of the container; once this has been repeated up to three times, most seeds are left which may then be dried in the shade on a piece of cloth. Some farmers simply squeeze out the over-ripe berries, wash the seeds and dry them.

From 1 kg of *S. scabrum* berries, farmers will obtain 40 g of seeds (Schippers, 2000). The number of seeds per berry varies from about 20-60 depending on the variety. There are about 1000 seeds in 1 g of the larger varieties of *S. scabrum* whereas there are up to an estimated 3500 seeds per gram for the smaller-fruited African nightshades (Schippers, 2000). *S. scabrum* seeds can remain viable for several years when kept dry, but will rapidly lose their germination capacity, when kept in humid condition (Schippers, 2000). This viability can be extended for up to 10 years when seeds are kept under cold conditions. Seeds can be kept dry by keeping them in air-tight container, ideally with a dessicant such as oven-heated rice placed at the bottom, separated from seeds by a piece of cloth.

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THE ECOBIODIVERSITY OF DOMESTICATED AND WILD TRADITIONAL LEAFY VEGETABLES OF NYANG'OMA, WESTERN KENYA

Orech, F. O. *[1], .J. Ochora[2], T. Akenga[3], J. Aagaard-Hansen[4], H. Friis[5]
[1]Botany Department, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000, Nairobi, Kenya.
[2]Botany Department, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000,Nairobi, Kenya.
[3]Chemistry Department, Jomo Kenyatta University of Agriculture and Technology, P.O Box 62000, Nairobi, Kenya.
[4]Danish Bilharziasis Laboratory, Jaegersborg Allé 1D, DK-2920 Charlottenlund, Denmark.
[5]Research Department of Human Nutrition, Rolighedsveg.30, 1958 Frederiksberg, Denmark
forech@yahoo.com

ABSTRACT.

Aspects of ecobiodiversity of traditional leafy vegetables used was recorded based on a one-year field research. Purposive sampling was the main method used in the study. Interviews and vegetable collection from varied habitats were conducted in seeking the traditional vegetable uses and names. 29 aged and 17 middle-aged women, and 3 aged men were the key informants. Voucher specimens were deposited at the Jomo Kenyatta University of Agriculture and Technology and the East Africa herbaria. The study revealed a rich usage of both wild and domesticated traditional leafy vegetables. Entries of 60 vegetable species in 47 genera of 29 families were made. 62 per cent of the traditional vegetables are procured from the wild while 33 per cent are domesticated in kitchen gardens and farmlands and 5 per cent are either domesticated or collected from the wild. 35 per cent are also used as medicinal remedies. The five families with most members consumed are Papilionaceae, Amaranthaceae, Acanthaceae, Asteraceae and Solanaceae respectively. The threatened (rare, endangered and vulnerable) vegetable species are also recorded.

Key Words: Ecobiodiversity, domesticated, wild, traditional leafy vegetables, Nyang'oma, western Kenya.

INTRODUCTION

Traditional leafy vegetables are those plants whose leaves or aerial parts have been integrated in a community's culture for use as food over a large span of time. They may be procured from the wild (in nature) or may be domesticated in kitchen gardens and farmlands (Ogoye-Ndegwa and Aagaard-Hansen, 2003; Midmore *et al.,* 1991). Consumption of vegetables from the wild or from home gardens is important for nutrition of rural as well as urban populations (FAO, 1998; FAO, 1996; FAO, 1988). Wild species and secondary crops are important for local nutrition for many reasons. First, they make up a large percentage of food intakes even if bought food substitutes are available. Secondly, they give diversity, and add flavour and zest to daily food intake (Shackleton *et al.,* 1998; Asfaw, 1997). Third, they have a high nutrition value compared to the introduced varieties such as cabbage and lettuce (Ezekwe *et al.,* 1999; Mathenge, 1997; Nordeide *et al.*, 1996; Humphry *et al.,* 1993). Fourth, they may be preserved by drying during the rainy season hence important for food security during times of drought and poor harvests (Jacks, 1994).

Whereas researchers and extension workers increasingly approve traditional vegetables for many nutritional, economic and agricultural advantages, it seems that local people to an increasing extent favour introduced vegetable varieties. The latter are regarded as modern and prestigious in contrast to traditional vegetables that are associated with a poor, rural way of life (Chweya and Eyzaguirre, 1999; Chweya, 1997; Maundu, 1997).
According to the local perceptions in Nyang'oma, traditional leafy vegetables compare very unfavourably with other food items such as meat and fish. While some vegetables are still consumed, many of them are used rarely, except for the lean days. They constitute an under-utilized food and nutrition resource for the poor. The abundance of many of the traditional vegetables is also very restricted unlike in the past when they were widespread (Ogoye-Ndegwa and Aagaard-Hansen, 2003).

Besides being used as food, some of the vegetables are known to be of medicinal value (Olsen and Nielsen, 1999; UNESCO, 1997). They are used to treat different kinds of ailments, ranging from simple wounds affecting various parts of the body, to treating the more complex ailments such as "chira", spirit possession, and the evil eye. They can also be used for love potions and as protective charms (Ogoye-Ndegwa and Aagaard-Hansen, 2003; Geissler *et al.,* 2002). Traditional leafy vegetables are also important in their ecological value, agronomic value, cultural value and creation of employment (Abbiw 1997; Okafor, 1997). Ecologically, traditional leafy vegetables have a unique advantage within the local farming systems in that they thrive during the hot and wet season and many of them are environment friendly hence require no pesticides and fertilizers in their management (Chweya and Eyzaguirre, 1999; UNESCO, 1999). Agronomically, they are often grown as intercrops with staples hence improve soil quality and it is easier to get large quantities of seeds in contrast to introduced varieties (Mnzava, 1997). The use of some vegetable species is part of the cultural heritage, playing an important role in customs and traditions (Chweya and Eyzaguirre, 1999). These vegetables can also have considerable potential as cash income earner for the poor especially women with little capital, limited access to land and working under labour constraints (Lewis, 1997).

In addition, traditional leafy vegetables such as legumes have the potential of improving soil fertility. Some like amaranth are used as soil fertility indicators. Others like *Crotalaria* spp. suppress weeds. A few species are also used as pest repellants and suppressors. Farmers report little evidence of insect pest attack on these vegetables compared to the introduced varieties. Farmers practicing organic farming in western Kenya, have been observed incorporating leaves and stems of bitter plants in vegetable gardens with the aim of keeping off nematodes (Nekesa and Meso, 1997). Wild and domesticated traditional leafy vegetables are gathered from diverse habitats. These may include forest areas, fallow land, abandoned homesteads, marshy areas and bog, lakeshore, papyrus swamps, seasonal swamps, ponds, grasslands, village common lands, abandoned fields, thickets, hedges, forest edges, scrubs, termite mounds and agricultural fields. Some vegetable species are habitat specific (Brookfield *et al.,* 2002; Sarah, 2002; Maundu *et al*., 1999).

The ecobiodiversity of the traditional vegetables is the variability within and between the species and the ecosystems or habitats of which they are part (Sarah, 2002). In Kenya, the diversity of physical and climatic conditions is reflected in the high diversity of plants and animals. Kenya has a total of 7,100 plant species and several subspecies and varieties (Maundu *et al*., 1999). Traditional vegetables are, however, threatened (IPGRI, 2000). Since the onset of the market economy and modernization of agriculture, prominence has been given to exotic vegetable varieties that offer a potential for export. Conventional agronomy has also to a large extent concentrated on conserving the genetic pool of the exotic crops and vegetables. As a result, traditional vegetables are threatened with extinction as they have to compete for attention with the more popular introduced ones (Cooper *et al.,* 1992). Deforestation and destruction of watersheds, in addition, has dramatically affected water relations and meteorological cycles. These in turn have contributed to crop failures and drought (Hladik *et al*., 1993). In Kenya 3.75 per cent of the flora is threatened with 6,506 species. Some families (also reported in this study) with members threatened include Acanthaceae, Amaranthaceae, Araceae, Asteraceae, Basellaceae, Boraginaceae, Capparaceae, Caricaceae, Chenopodiaceae, Convolvulaceae, Cruciferae, Cucurbitaceae, Hydrocharitaceae, Malvaceae and Nyctaginaceae. Also threatened are Onagraceae, Oxalidaceae, Papilionaceae, Pedaliaceae, Polygonaceae, Solanaceae and Tiliaceae (IUCN, 1998).

There was, therefore, need to identify the traditional leafy vegetables diversity in relation to ecosystems or habitats in the study area so that the ecological, biodiversity and conservation status are validated. This would help in identifying the threatened species and habitats and in turn place them on conservation policies for implementation hence improve in the community's nutrition-intervention and food security programmes. The sampling of the traditional vegetables was carried out in an area within Nyang'oma sub-location of Bondo District, western Kenya (Figure 1). The district lies along the shores of Lake Victoria and covers a total area of 1,069km². Bondo District in which Nyang'oma falls, was projected to have a total population of about 96,107 people; according to the Siaya District Development plan for 1997-2001.

JUSTIFICATION OF THE STUDY

Despite their high nutritional value, the factors that have contributed to traditional leafy vegetables limited consumption in Kenya are macro-economic, political changes, religious changes, introduced vegetable varieties, neglect by government in policy development and the perception by Kenyans that these vegetables are primitive and a sign of poor rural life. Albeit all the above resistance to utilize traditional vegetables the following factors made it justifiable to continue to revive interest in research into traditional vegetables:

1. Traditional vegetables are a rich source of vitamins, minerals, trace elements, oil, protein, energy, dietary fibre and in some cases Bioactives with curing abilities.
2. For adequate conservation measures to be implemented, proper validation of the entire traditional vegetables with regard to their habitats or ecosystems and species status (abundance, rarity and vulnerability) need to be documented.

3. There is also a danger that much of the knowledge and practice concerning traditional vegetables species and their use is vanishing without being passed to the younger generations. In Africa in general and Kenya in particular, there are very few ethnobotanical studies that have been undertaken to tap this information from the elderly custodians.

OBJECTIVES OF THE STUDY

General objective

To establish the ecobiodiversity of the domesticated and wild traditional leafy vegetables of Nyang'oma, western Kenya.

Specific objectives

Identify and document the ecobiodiversity of the domesticated and wild traditional leafy vegetables utilized in Nyang'oma, western Kenya.

METHODS

Sampling of the traditional leafy vegetables

throughout the investigation data was collected using purposive sampling and emic categories; those drawn from the way people perceive things through their own eyes and classify objects in their own language (Cummingham, 2001; Martin, 1995). The main method of data collection was by interviewing knowledgeable persons on the traditional vegetable species uses and vernacular names. Participant observations and species collection approaches were also applied. The informants were interviewed using a questionnaire based on questions about the ecology, distribution, management, season, status and storage. Detailed observations were made and informed discussions held on the research topic with the resource persons. A part from the focussed discussions, meant to describe the distinct perspectives and experiences of various groups, attempts were made to interview informants independently. Its major advantages are the personalized interaction and handiness in cases of literacy problems (Peil, 1995). A series of short-term visits were also made in the subsequent months to enable variation in species collection. The interviews were conducted in two main places: homes of the informants and in the field during species collection. The interview period was kept as short as possible to avoid monotony. Before the interview the informants were told an overview of the project, to ensure informed consent, followed by light conversation leading into the questioning phase, usually this lasted between 60-90 minutes, though occasionally this would lengthen. The guided field walks were preferred, though in other cases the informant requested to collect the plants in advance because of personal reasons. For the guide field walks, the plant was first photographed in its natural stand in the habitat. The herbarium specimen was collected in triplicates and was photographed on a large white paper for a clear background. This was subsequently labeled with the vernacular name(s), a collection number together with the name of the informant. The specimen was then spread in standard size newspapers (about 30x40cm) when folded and placed in a plant press. This was then placed in a plant dryer at the field station for approximately 5 days, to ensure sufficient lost of moisture (Martin, 1995).

Identification of the traditional vegetables ethnoflora

The very important foundation of this ethnobotanical work lay in the ability to identify the traditional vegetable plants of Nyang'oma. During the first two months of the study, a pilot study was carried out with the aim of:

Identifying the common vegetable species.

This exercise was very important for field interviews with resource persons. The final identification of the traditional vegetable species was done according to Agnews' (1994) and the Flora of Tropical East Africa (FTEAs).Herbarium specimens at the Nairobi University Herbarium, Chiromo Campus and the East African Herbarium were also studied as aid to identification of material collected from the field. The identification and classification of the herbarium specimen was determined in consultation with the plant taxonomists at the University of Nairobi herbarium and The National Museums of Kenya Herbarium.

Preparation of ethnobotanical reference collections

After identification, the specimens were mounted using standard herbarium procedures, poisoned and stored as reference material: -

The dried herbarium specimens were mounted on mounting papers (30cmx45cm) using a special white glue, which dried to translucent. Taxonomic information concerning each species was attached to each mounted specimen and filed in a genus cover inside a family folder. These were poisoned according to Martin (1995). One mounted specimen was deposited as field reference in Nyang'oma field station. The second and the third duplicates were deposited at the Kenya National Museums Herbarium and at the Jomo Kenyatta University of Agriculture and Technology, Botany Department. These would serve as permanent reference specimen records of traditional leafy vegetables from Nyang'oma, western Kenya.

RESULTS

The ecobiodiversity of traditional leafy vegetables

Table 1: A list of vegetable species and the collection spots in Nyang'oma sublocation (worked out from figure 1). The family, genus and vernacular *(Luo)* names are given. The locations where the vegetables occurred are given by the grid reference system. The ecology shows vegetation type(s) associated with the vegetables. The types of soil are also recorded. The perennial vegetables are asterisked.

Table 1: List of vegetable species and the collection spots in nyangoma sub-location

Family	Genera	Grid reference for species' habitats	Ecology
1. ACANTHACEAE	**Asystasia gangetica (NYOHONYOHO)*	348778 and 331804	In scrubs
	A. mysorensis (ATIPA)	322818, 338826, 328815, 334778, 324847, 297813 and 345839	Along paths, in farmlands, secondary regrowths, and abandoned fields. Soil units UIC and Ulr1
	Dyschoriste radicans (ATEK MIN ANGASA)	322827, 330848 and 328783	In grassland, abandoned fields and farmlands. Soil units UIC and Ulr1
	Justicia calyculata (PIU PIU)	314824, 316847, 334796 and 347787	In grassland, disturbed scrubs and on roadsides. Soil units UIC and Ulr1
2. AMARANTHACEAE	*Achyranthes aspera (AYUCHA* or*TUNGU)*	296817, 322835, 304798, 317846, 337833 and 310784	In scrubs, grassland, seasonal watercourses and along lakeshore. Soil units UIC, VAC and Ulr1
	Amaranthus graecizans ssp. *silvestris (OMBOK ALIKA)*	322818, 336836, 325841, 295813, 303792, 327813 and 343833	Along paths, in thicket edges and farmlands. Soil units UIC and Ulr1
	A. hybridus (ODODO MAYOM)	316834, 326842, 306815, 305843, 326812, 325800, 328784 and 345772	On roadsides, built-up areas, thicket edges, in farmlands and along riverine. Soil units UIC and Ulr1
	A. lividus ssp. *polygonoides (OSOI* or*SOI)*	322775, 315792, 323828 and 304847	In farmlands, waste grounds and along lakeshore. Soil units UIC, VAC and Ulr1
	A. spinosus (ODODO MAR KUDHO)	324827, 333837, 322842, 302818, 327818, 347776 and 325801	In swamps, grassland, waste ground, farmlands and along riverine. Soil units UIC and Ulr1
3. ARACEAE	**Colocasia esculenta (IT NDUMA)*	303848, 320793 and 324783	In swamps, marshy places and along riverine and lakeshore. Soil unit VAC
4. ASCLEPIADACEAE	*Penterrhinum inspidum (OKUURO)*	329804, 318837 and 342818	In dry grassland and thicket edges
5. ASTERACEAE	*Aspilia kotschyi*	315835, 306795, 321794 and	In abandoned homesteads,

	(NYAMAND DHIANG)	326783	scrubs and along lakeshore. Soil units UIC, VAC and Ulr1
	Bidens pilosa (ONYIEGO)	326822, 334834, 319848, 313818, 329812, 334777, 303790, 348845 and 325800	Along paths, in farmlands, grasslands, disturbed bushland and scrubs. Soil units UIC and Ulr1
	Lagascea molis (BRANGET)	328802, 325832, 335827, 324841, 292828, 333807, 327776, 310794 and 340841	In farmlands, abandoned fields and along lakeshore. Soil units UIC, VAC and Ulr1
	Launaea cornuta (ACHAK)	329821, 335834, 321847, 297804, 327806, 326774 and 297784	In farmlands, disturbed grasslands and on roadsides. Soil units UIC and Ulr1
6. BASELLACEAE	**Basella alba (NDERMA)*	303848, 338785 and 332790	Along riverine, the lakeshore and in swamps. Soil unit VAC
7. BORAGINACEAE	*Trichodesma zeylanicum (NYALAK DEDE)*	313837, 340833, 332846, 308818, 325807 and 344787	In abandoned fields and farmlands. Soil units UIC and Ulr1
8. CAESALPINIACEAE	*Senna occidentalis (NYAYADO)*	293815, 340843, 332797, 343782, 310845 and 321793	On roadsides, open plains, in grasslands, scrubs, marshlands, swamps and along the lakeshore and riverine. Soil units UIC, VAC and Ulr1
9. CAPPARACEAE	*Cleome hirta (NYADEG DANI)*	343822, 337796 and 348772	Along paths, in farmlands and cattle enclosures. Soil unit UIC
	Gynandropsis gynandra (AKEYO or *DEK)*	333840, 321833, 327805 and 332807	In abandoned homesteads, kitchen gardens, farmlands and cattle enclosures. Soil units UIC and Ulr1
10. CARICACEAE	**Carica papaya (IT KIPOYO)*	321823, 339832, 320847, 296844, 326814, 332783, 293790, 342839 and 327805	In home-gardens. Soil units UIC and Ulr1
11. CHENOPODIACEAE	**Chenopodium opulifolium (NYATIGATIGA)*	337823 and 345772	In waste places, kitchen- and home-gardens. Soil unit UIC
12. COMMELINACEAE	*Commelina benghalensis (ANGAYO* or *NYANDHODHO)*	324817, 335826, 295836, 307797, 335847, 318818 and 335793	In farmlands, secondary regrowths and disturbed areas. Soil units UIC and Ulr1
	C. africana (KALAPUK)	314807, 325816, 292826, 317787, 325817, 316818 and 323820	In secondary regrowths and farmlands. Soil units UIC and Ulr1
13. CONVOLVULACEAE	*Ipomoea batatas (IT RABUON)*	329832, 342828, 297806, 328812, 337802, 299788 and 328785	In home- gardens and along lakeshore. Soil units UIC, VAC and Ulr1
	I. sinensis (NYAWEND AGWATA)	319834, 332817, 296816, 328812, 317800, 298798 and 328784	In thickets, on scrubs edges and riverine. Soil units UIC and Ulr1
14. CRUCIFERAE	*Brassica juncea (KANDHIRA)*	326823, 325845, 318802 and 345776	In kitchen gardens and farmlands. Soil units UIC and Ulr1

	Erucastrum arabicum (KABICH SAMBA)	338808, 327817, 345824, 348843, 329845 and 293832	In secondary regrowths and farmlands. Soil units UIC and Ulr1
15. CUCURBITACEAE	*Coccinia grandis (NYAMIT KURU)*	330818 and 308822	In scrubs, grassland and on roadsides. Soil unit UIC
	Cucurbita maxima (SUSA)	337776, 328822, 340816, 299805, 328802, 327802, 297787 and 318787	In home-gardens and farmlands. Soil units UIC and Ulr1
16. EUPHORBIACEAE	**Erythrococca bongensis (HARIADHO)*	322822 and 344777	In thickets, and on rocky sites of scrubs and riverine. Soil unit UIC
	**Manihot esculenta (IT OMUOGO)*	326818, 327814, 330836, 323846, 295812, 329813, 327774 and 314792	In farmlands. Soil units UIC and Ulr1
17. HYDROCHARITACEAE	**Ottelia ulvifolia (OYOMBE)*	320793 and 333790	On riverine and inside the lake. Soil unit VAC
18. MALVACEAE	**Hibiscus calyphyllus (BINDA)*	294844, 322823, 303805 and 338811	In farmlands, thickets, on roadsides and scrubs edges. Soil units UIC and Ulr1
	**Sida acuta (ADONGO NYAR YUORA)*	328824, 340836, 328847, 299822, 327812, 337776, 304790, 345837 and 324798	In farmlands and abandoned fields. Soil units UIC and Ulr1
	**Sida rhombifolia (OWICH)*	332827, 336834, 328843, 298833, 315812, 346775, 304796, 345846 and 314802	In thickets, farmlands, disturbed areas, along paths and on roadsides. Soil units UIC and Ulr1
19. NYCTAGINACEAE	**Boerhavia diffusa (OBUDO)*	323835, 327846 and 332781	In scrubs, abandoned homesteads and undisturbed areas. Soil unit UIC
20. ONAGRACEAE	**Ludwigia stoloniferae (NYASGUMBA)*	333803, 335788 and 349781	Along the lakeshore, on marshy places and riverine. Soil unit VAC
21. OXALIDACEAE	**Oxalis latifolia (AWAYO MADONGO)*	327827, 341838, 325840, 298819, 323803 and 346776	In farmlands and secondary regrowths by roadsides. Soil units UIC and Ulr1
22. PAPILIONACEAE	*Crotalaria brevidens* var. *intermedia (MITOO MADONGO)*	324831, 344837, 328843, 292806, 328815, 328777, 343837 and 324801	In farmlands and kitchen gardens. Soil units UIC and Ulr1
	C. lanceolata ssp. *lanceolata (ONDHIDHO)*	307847, 341782, 308822, 325783 and 315790	On thicket edges, riverine, in scrubs and along lakeshore. Soil units UIC, VAC and Ulr1
	C. pycnostachya (NER MITOO)	313849, 347780, 330794 and 320776	In grassland, scrubs, on riverine and along lakeshore
	Phaseolus vulgaris (IT OGANDA)	327823, 345835, 295840, 326807, 323777, 303787, 347848 and 324806	In farmlands and along the lakeshore. Soil units UIC, VAC and Ulr1

	Vigna schimperi (BOO DHOK)	323813, 335845, 294830, 316817, 324774, 302785, 336838 and 327803	In farmlands, grassland, scrubs and along the lakeshore. Soil units UIC, VAC and Ulr1
	V. luteola var. *luteola (DINDI or LESORIADORE)*	292831, 314816, 324776, 302784 and 328803	In farmlands and a long lakeshore. Soil units UIC, VAC and Ulr1
	V. unguiculata (BOO)	334794, 328784, 330827, 326824, 327833, 296832, 314812, 336774, 305796, 345847 and 314812	In farmlands, kitchens-gardens and along the lakeshore. Soil units UIC, VAC and Ulr1
23. PEDALIACEAE	*Sesamum calycimum* var. *angustifolium (ONYULO)*	327834, 320847, 334813, 316805, 343847, 346773, 314794 and 296812	In Scrubs, grassland and on roadsides. Soil units UIC and Ulr1
	S. indicum (NYIM)	327802	In farmlands. Soil unit UIC
24. POLYGONACEAE	*Oxygonun sinuatum (NYATIE GWENO)*	313812, 345844, 296835, 316817, 314974, 300784, 337848 and 31824	In secondary regrowths and farmlands. Soil units UIC and Ulr1
	Polygonum seneghalense (AURAO)	310848, 325785, 320792 and 344782	In swamps, on riverine and along lakeshore. Soil unit VAC
25. PORTULACACEAE	*Portulaca quadrifida (OBWANDA)*	328815 and 330780	In degraded land, stony grounds, scrubs and grassland. Soil unit UIC
	**Talinum portulacifolium (AMONDI)*	305835 and 324819	Is strictly found on termite mounds in scrubs. Soil units UIC and Ulr1
26. SOLANACEAE	**Capsicum frutescens (IT PILU)*	328823, 342839, 324843, 297818, 324802 and 345777	In kitchen gardens and along paths. Soil units UIC and Ulr1
	Lycopersicon esculentum (IT NYANYA)	324817, 325815, 332831, 326844, 299814, 329813, 328773 and 316798	In kitchen gardens and farmlands. Soil units UIC and Ulr1
	Physalis minima (NYATONGLO)	326848 and 335786	In old and fallow fields and on thicket edges. Soil units UIC and Ulr1
	Solanum nigrum (OSUGA)	322822, 338833, 322846, 297845, 326817, 331784, 293798, 344836 and 326807	In farmlands, under trees, along hedges and built-up areas. Soil units UIC and Ulr1
27. TILIACEAE	*Corchorus olitorius (APOTH)*	332812, 328834, 302842, 299844, 323827, 331784, 303797, 345834 and 325817	On roadsides, grassland, riverine, in kitchen gardens, farmlands, swamps and along lakeshore. Soil units UIC, VAC and Ulr1
	C. trilocularis	322814, 334813, 302822,	On roadsides, open plains,

	(APOTH MATINDO)	297846, 327822, 336782, 314798, 342839 and 337809	riverine, in farmlands and along the lakeshore. Soil units UIC, VAC and Ulr1
28. VITACEAE	**Cyphostemma cyphopetalum (BWOMBWE MATINDO)*	330812 and 323803	Along hedges. Soil units UIC and Ulr1
29. ZYGOPHYLACEAE	*Tribulus terrestris (OKURO)*	334826, 342839, 305847, 295816 and 325800	In waste places and trodden earth. Soil units UIC and Ulr1

DISCUSSION

The vegetables collected in Nyang'oma showed diverse habitats as indicated in Table 1. Most of the 60 vegetable species in 47 genera of 29 families were found mainly in the wild. Since Nyang'oma area is found in the Lake Victoria Regional Mosaic as described by White (1983), the vegetation type is supposed to comprise of *Acacia-Commiphora* deciduous bushland and thicket. In this region, there are about 3,000 species of plants of which very few, for example, *L. molis,* are endemic (Agnew and Agnew, 1994) but there are probably no endemic genera (White, 1983).

The vegetation of Nyang'oma area, however, is disturbed and patchy. There are large areas of cultivation and secondary thickets. Most areas have also been extensively cleared for settlement, agriculture, grazing and gold mining (Ogoye-Ndegwa and Aagaard-Hansen, 2003). These ecological areas form grounds for cultivation of the domesticated vegetable species. The vegetables are mostly intercropped with the local staples like maize and sorghum in farmlands and occasionally, they are grown in pure stands in kitchen gardens. The remaining vegetation is represented by small areas of degraded relics, which survive chiefly on shallow stony-sandy soils, and by small patches of secondary regrowths. The vegetation types associated with the wild vegetables comprise mainly the scrubs, thickets, grasslands and papyrus swamps. There are smaller areas of scrub forests, thickets, edaphic grassland, secondary grassland and wooded grassland, which probably represent the climax vegetation. Papyrus swamps also occur extensively on the shores of the Lake Victoria. Some wild vegetable species are also procured from roadsides, along paths, around built up areas and in waste grounds. Vegetable species like *T. portulacifolium* is habitat specific and strictly occurs on termite mounds.

According to the Soil Survey of Kenya (Table 2), there are mainly three soil units or types in Nyang'oma area coded as UIC, VAC and Ulr1 (Gicheru and Gachene, 2002). The UIC soil units were developed on delorites and andesites. Most traditional leafy vegetables of Nyang'oma grow on this soil type (as indicated in Figure 1). The VAC soil type was developed on recent alluvial deposits. A few vegetables flourish in this soil which mainly occurs around the lakeshore. The Ulr1 soil type was also developed on delorites and andesites and several vegetable species grow on this soil.

Table 2: The soil types of Nyang'oma sublocation as described by the Soil Survey of Kenya.

Soil type	Characteristics
1. UIC	Complex well drained, shallow deep, dark reddish brown to strong brown, friable to firm, gravelly clay to clay, over pisoferric material or petroplinthite (murram) and/or rock; in places fairly stony
2. VAC	Complexes of moderately well drained to imperfectly drained, deep, stratified soils of varying colour, consistence, calcareousness and texture
3. Ulr1	Well drained, deep to very deep, dark red to dark reddish brown, friable to firm, clay

Nyang'oma area experiences two extreme seasons namely hot/wet and hot/dry. The extent of seasonal variation with respect to consumption of the vegetables arise in March, April and May, and in September and October. These are the long and short rainy seasons respectively and are the periods when most of the vegetables, both domesticated and wild, are abundant. The consumption plummets in the subsequent months due to recurrent droughts. During these periods, only the drought-resistant species like *C. frutescens, C. papaya, C. hirta, C. grandis, Crotalaria* spp., *C. maxima, E. bongensis, M. esculenta, P. inspidum, P. quadrifida, S. occidentalis, Sesamum* spp., *S. acuta* and *T. portulacifolium* are available, therefore, consumed.

The dominant traditional leafy vegetable families, with most of their members consumed, are Papilionaceae, Amaranthaceae, Acanthaceae, Asteraceae (Compositae), Solanacea, and Malvaceae respectively. The ten mostly consumed traditional vegetables are *A. mysorensis, Amaranthus* spp., *B. juncea, G. gynandra, C. maxima, Corchorus* spp. *Crotalaria* spp., *Sesamum* spp., *S. nigrum,* and *V. unguiculata.* Their consumption is determined by the fact that they are considered more nutritious, readily available, drought resistant, inexpensive and tastier than the introduced varieties such as cabbage and kale.
The domesticated vegetable species number twenty (33 per cent) and include *A. graecizans* ssp. *silvestris, A. hybridus, A. lividus* ssp. *polygonoides, A. spinosus, B. juncea, C. frutescens, C. papaya, C. opulifolium, C. esculenta, C. olitorius, C. trilocularis, C. maxima, C. brevidens* var. *intermedia, I. batatas, L. esculentum, M. esculenta, Phaseolus vulgaris, S. indicum, S. nigrum* and *Vigna unguiculata.* The rest are mainly procured from the wild.

About 35 per cent of the vegetable species of Nyang'oma area are also used for their medicinal values. They include *A. kotschyi, A. mysorensis, B. diffusa, C. papaya, C. opulifolium, C. grandis, C. esculenta, C. olitorius, C. trilocularis, C.cyhopetalum, E. bongensis, G. gynandra, L. cornuta, L. esculentum, O. sinuatum, P.senegalense, P. quadrifida, S. occidentalis, S. rhombifolia, T. terrestris* and *T. zeylanicum.* The vegetable species which are currently rare and probably threatened in Nyang'oma area number twelve (20 per cent) and include *A. gangetica, B. alba, C. opulifolium, C. grandis, C. hirta, C. pycnostachya, C. lanceolata, J. calyculata, P. minima, S. indicum, T. portulacifolium* and *T. terrestris.* This rarity may have been as a result of overexploitation and/or habitat destruction.

CONCLUSIONS

The study has demonstrated that the flora of Nyang'oma offers a largely untapped source of potentially useful traditional vegetables. It has also been revealed, in this study, that there is high diversity of plants used as vegetables as well as diversity in the vegetable ecosystems or habitats.
Despite the immense importance of the traditional vegetable resources, their value is rarely taken into account in terms of land use, planning, management and conservation. It is always assumed that these vegetable resources are harvested sustainably by the resource users-a fact that is not true. Many ecosystems and harvested species population are resilient and have a long history of use but can be pushed beyond recovery through habitat destruction and/or overexploitation.

RECOMMENDATIONS

It is important that traditional vegetables and farming practices are not done away with but rather be improved on. There is, therefore, need for implementation of traditional vegetable conservation and management programmes with, rather than for, the resource users. This is because; all research and management activity by outsiders, come and go, but food security-land and resource surety-is a long-term, life and death issue for the local people of Nyang'oma and the civil society in general. Problem identification, innovative, decentralized and local approach has a way of catching on and spreading. It can combine people's control of the species harvesting with its effective management.

For research on traditional vegetables to continue, conservation measures would have to be taken seriously. These would include protection measures such as the proper harvesting of traditional vegetables so as to avoid serious damage. Protection of the habitats of indigenous vegetables such as the lakeshore, thickets, scrubs, marshy places, ponds, hedges, rivers, allowing certain plants to rejuvenate, and rotational grazing. The checking of bush encroachment by undesirable plant species is also vital. Domestication of some of the nutritionally desirable wild species in kitchen gardens and farmlands will be a big step forward in conservation and increasing the diversity of the gene pool of these vegetables. These gardens would provide a ready source of fresh material for ethnobotanical, nutritional and phytochemical studies. This will also change the attitude and encourage more people to cultivate and consume the desired vegetables. There is also a need to investigate the sustainability of the current practice of gathering plants in the wild. Legislation against the removal and exportation of traditional vegetables species by implementing strict control on export of traditional vegetable plants for commercial exploitation and the protection of the intellectual property rights (IPR) of the local people is very important for the government in policy making and implementation.

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COMMUNITY SEED PRODUCTION OF AFRICAN INDIGENOUS VEGETABLES

Okong'o Paul TatroFarmers Group, Yala, Kenya

INTRODUCTION

Vegetables are vital and absolutely essential for health diets, productive farmers and strong economies. Women farmers mostly grow indigenous vegetables and possess indigenous knowledge on how to cook them. For sustainable production it is important to have a reliable source of quality seed

SEED PRODUCTION

Seed production, processing, storage and distribution and supply in the community remains a big gap. The research gap presents itself to the end users and the farmers. TATRO farmers group in western Kenya became committed to the communities in the region to solve the seed probem and fill up the seed gap. Some factors that contribute to the gaps include: lack of indigenous knowledge on seed production; soil degradation;lack of seed processing and storage skills in the community;lack of inerest in traditional vegetables and lack of market supply of the germplasm.

INTERVENTIONS

TATRO has been collaborating with other partners in major vegetable research networks:western Kenya consortium, International Plant Genetic Resources Institute,National Museums ofKenya(KENRIK) and Maseno University. Specific areas in the community seed industry include: production,processing, storage and distribution.

Production and processing

This includes operations like: land preparation; planting; weeding 3 times; strict control of pests and diseases; pollen control; time of harvesting;selection before harvesting, choose healthy mother plant, with resistance qualities to stress and bearing quality. Preparation of seed before storage includes: drying;cleaning;sorting;treatment;cooling;labelling and packaging of seed

Storage

It is important to remember that seeds are alive and shall germinate into young plants, therefore a lot of care should be taken during storage. Areas that need serious consideration include:Storage facilities available-type and nature of containers,controlling post-harvest pests and diseases, the conditions of the storage and the temperature of the seed at the time of storage and duration of storage. Other factors to consider include: type of seeds to be stored, dusting chemicals used, handling of seeds during storage. High standard of record keeping: label every facility used and indicate the seed inside, store, storage date and expiry date, weight and directions for the users,Store inspection schedules and mechanisms should be put in place. Record of handlers before, during storage period. There should be a good relationship between the owners and users. The store must be monitored and evaluated periodically. The seed producers must form linkages with researchers for collaboration. Seed of African indigenous vegetables must be stored for future generations.

CONCLUSION

In conclusion, sharing and generating knowledge on germplasm, is important using information technologies and human resource exchange and this could be enhance through networking and collaboration. Secondly reliable seed supplies are one of the farmers greatest needs. Last but not least, TATRO is committed to the industry and sustainable production of indigenous vegetables through seed production as a business.

SEED PRODUCTION AND SUPPLY SYSTEM OF THREE AFRICAN LEAFY VEGETABLES IN KAKAMEGA DISTRICT

Ndinya Christine Moi University

ABSTRACT

African leafy vegetables are important for food and as source of income to farmers in Kakamega District, Kenya. Despite this there is a paucity of scientific research, especially with regard to seed production of these crops in the district. This study was undertaken to establish the general seed production and supply systems of African leafy vegetable (ALV) in the district. The study was confined to three vegetable species considered as among the most popular ones, namely: African nightshades (*Solanum* spp.), slenderleaf (Crotalaria spp.) and spiderplant (*Cleome gynandra*). The study comprised of a survey using structured questionnaires to interview 210 farmers. The survey data were analysed using descriptive statistics. The results show that seed production and supply in Kakamega District are mainly informal. Farmers grow their own seed in small plots not following any regulations, unlike formal seed production systems. Most Farmers obtain initial seed from local landrace plants. Mainly it is the middle-aged women who carry out farming and seed production of African leafy vegetables. They grow the vegetables during the long and the short rains for home consumption and for sale. Drilling is the method of sowing most preferred by the farmers and farmyard manure is the most popular source of plant nutrients for the vegetables. Most farmers retain seed produced from their own gardens for future use, although they disseminate some as gifts. The majority of farmers dry the seeds in direct sunlight whether the seed is still in the pods or after the seed has been threshed. Wood ash is the most common material used to dress seeds for protection against insect pests during storage. *Keywords*: African leafy vegetables, informal, on-farm, seed production, seed supply.

INTRODUCTION

African nightshade (*Solanum* spp), spiderplant (*Cleome gynandra*) and slenderleaf (*Crotalaria* spp.)are some of the popular and commonly grown African leafy vegetables (ALV) in Kakamega District in Kenya. They are valued for their taste, nutritional qualities, medicinal and culinary properties. They are important in cultural and are used during ceremonial occasions for food. ALV have adapted easily to the environment and so are easy to maintain. A market survey done by Schippers (1996) in collaboration with Kenya Agricultural Research Institute (KARI) showed that there is more volume traded in African indigenous vegetables than exotic ones in this District. Women are the main traders in ALV making these vegetables an important source of income for them.

Initially these vegetables were left to grow in the wild but with population pressure they have now become domesticated. For several years they have been grown traditionally and farmers have been the custodians of knowledge of these vegetables until recently when scientific research is now being done on them. African leafy vegetables are propagated by seed but there is little information on seed production and supply. Observations made are that their seeds are more expensive than expected and are found in very little quantities in the market while some are not found at all. The study reported in this paper was undertaken to determine the seed production and supply system of these vegetables and the farmers priorities and constraints during production.

MATERIALS AND METHODS

Sampling procedure and seed collection

A formal survey was undertaken in Lurambi, Municipality, Ikolomani, Shinyalu, Navakholo, Ileho and Malava divisions of Kakamega District A multistage sampling procedure with simple random sample selection for locations and villages was used to select farmers in the survey. Thirty farmers were sampled from each location . In total 210 farmers were interviewed. Information was obtained from sampled farmers by direct interviews using structured questionnaires. Information gathered was on general farming system, on, ALV production practices, which determine vegetable leaf and seed production and supply systems. Farmers' values in production, consumption, economy and culture in ALV were captured. Constraints to leafy vegetable and seed production were also asked.

RESULTS

Farmer Characteristics

The average farm size is 1.9 ha. The staple crop is maize, which is often inter-cropped with beans, and occupies an average of 0.8 ha on each farm. Sugarcane is the main cash crop occupying an average of 1 ha. Sugarcane is mainly grown in Malava and Navakholo divisions. The farming system is such that farmers who grow sugarcane do not commercially grow maize and vice versa. African leafy vegetables rank third in importance after cash crops and maize/beans.

Women are the main growers of African leafy vegetable (Fig. 1). They formed 80% while 20 % were men, some of whom work together with their wives on these vegetables. Statistical analysis showed a high significant difference ($p \leq 0.01$) between the sexes who grow local vegetables. Decisions on where to source seed, when to harvest and distribution of seed are often left to women. Women made such decisions in over 85% of the cases. In 10% of the cases, couples made such decisions and only in 5% of the cases did men make decisions. Of the cases studied of those who decide on where to grow local vegetables, only 15% were men, 15 % were couples and 70 % were women.

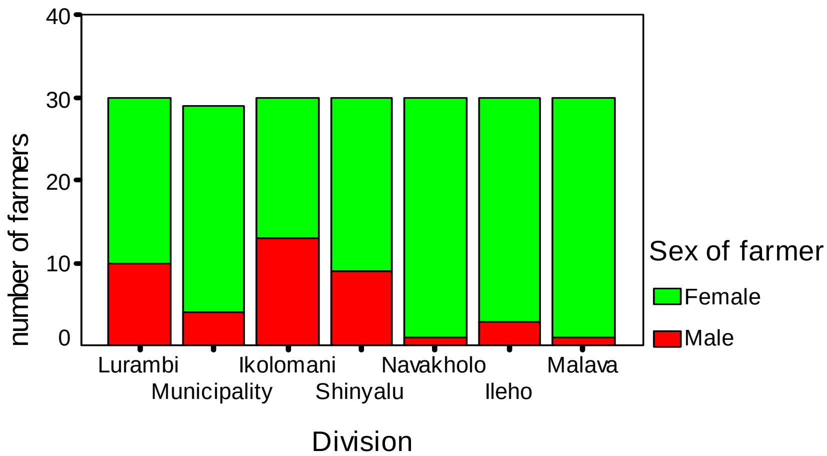

Fig. 1: Number of male to female of African leafy vegetable farmers in Kakamega divisions.

Characteristics of local vegetable farmers interviewed are shown in Table 1. Fourty- six percent of farmers interviewed had primary education while 32 % had secondary education. Vegetable farmers with no education and those of tertiary level were 20 % and 3 %, respectively. The average age of the farmers in each division ranged between 40 and 50 years and most of the farmers were married (94 %).

Slenderleaf

Of the three vegetables under study, slenderleaf occupied the largest land area, averaging 0.06 ha under cultivation. Most farmers (68%) grow slenderleaf for food and sale. Thirty percent grow it for food only and 2% for sale. Farmers grow slenderleaf during most part of the year with 78% of farmers growing it during both the long and the short rains. The most preferred method of sowing is drilling (53%), followed by broadcasting (32%). Only 6% of farmers grow slenderleaf using spacing. Farmyard manure is commonly used by farmers (62%) as the source of fertilizer in slenderleaf production. Only 2% of farmers use inorganic fertilizers while 27 % apply no fertilizers to their local vegetables. The average seed yield is 78kg/ha.

Spiderplant

Spiderplant occupied an average of 0.05 ha. The average seed yield produced was 35 Kg/ha. Spiderplant is popularly grown both for food and for sale. Only 2 % and 30% grow it solely for sale or food, respectively. Over 60% of farmers grow it during both the long and short rain season while 36% of farmers prefer to grow spiderplant during the long rains only. The sowing methods of broadcasting and drilling are equally popular with the farmers (43% for each) and are the most commonly used methods. About 5% of the farmers' use spacing of 30 cm x 30 cm and 7% combine several methods of sowing. Sixty eight percent of farmers use farmyard manure as fertilizer while 42% use no fertilizers in growing spiderplant

African Leafy vegetable production practices

African nightshades

The average size of plot under cultivation of African nightshade was 0.04 ha (Table 2). Most farmers (57%) grow African nightshade vegetables for both food and for sale although a substantial number (43%) grow them solely for food. While 43% of the farmers growing African nightshades plant the crop during the long rains only, 39% of the farmers grow it both during the long and short rains. Twenty three percent of farmers sow African nightshade seeds by drilling and an almost equal percentage (20%) sow by broadcasting. Those who plant the vegetable using any spacing are 17% while those who let the seeds fall and leave them to grow voluntarily are 13%. About half of the farmers (53%) use farm yard manure as the source of nutrients for vegetables, 42% do not add any fertilizer and only 2% use inorganic fertilizers. The average seed yield of African nightshade in the District was 7 Kg/ha.

TABLE 1: CHARACTERISTICS OF FARMERS INTERVIEWED

CHARACTERISTICS		DIVISIONS			DISTRICT MEAN		
	1	2	3	4	5	6	7	
Farm size (ha)	2.5	1.2	1.3	2.0	1.5	1.7	2.6	1.9
Age of farmer	47.7	47.2	46.5	51.2	40.2	41.5	44.5	45.
Education (%)								
Primary	60	48.3	40.0	34.5	43.3	41.4	50.00	45.7
secondary	20	24.1	36.7	41.4	33.3	37.9	30.0	31.7
None	10	24.1	23.3	17.2	23.3	20.7	20.00	19.7
Tertiary	10	3.5	0	6.9	0	0	0	2.9
Marital status (%)								
Married	96.7	79.3	100	93.3	100	100	90.0	94.3
Widowed	0	17.2	0	3.4	0	0	6.7	3.8
Single	3.3	0	0	3.3	0	0	3.3	1.4
Divorced	0	3.5	0	0	0	0	0	0.5
Sex of farmer (%)								
Male	66.8	86.2	58.6	70.0	96.7	90.0	93.3	80.5
Female	33.3	13.7	41.4	30.0	3.3	10.0	6.7	19.5
Source of information (%)								
Relatives	36.7	44.8	44.8	46.7	63.3	50.0	66.7	50.7
Other	13.3	17.2	27.6	26.7	23.3	16.7	26.7	21.5
MOA	13.3	17.2	7.0	10.0	0.0	26.7	3.3	11.0
Multiple sources	13.3	17.3	10.3	0.0	6.7	0.0	0.0	9.6
Neighbours	3.3	3.5	7.0	13.3	6.7	3.3	3.3	5.7
Friends	0.0	0.0	3.4	3.3	0.0	0.0	0.0	1.0
NGO	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.5

1- Lurambi 3- Ikolomani 5- Navakholo 7-Malava
2- Municipality 4- Shinyalu 6- Ileho
MOA- Ministry of Agriculture and Rural Development
NGO- Non -governmental Organization

Seed processing and supply system

It was not easy to get seed samples from the farmers although they produce seed directly. Seed samples could only be collected from 61 farmers out of the 200 farmers interviewed (Table 3). The highest number of slenderleaf was collected from Ileho and Shinyalu while spiderplant samples were highest from Navakholo and African nightshade from Lurambi and Ikolomani. The most available seed was slenderleaf and the least African nightshade. Farmers' responses on seed processing and supply systems (Table 4) show that most farmers (64%) prefer to produce their own seeds than to source it from other places. About 10% of the farmers buy seeds from local markets and 20% get it from multiple sources. Distribution of seeds is mainly done by giving away seeds as gifts or by selling to neighbours or from the local market. Twenty six percent do not distribute the seeds at all and 4% exchange seed with other seeds. Over 80% of farmers dry their seeds under direct sunlight but only 6% dry indoors or under shade. Twelve percent of farmers who grow African nightshade do not deliberately dry seeds. About half of the farmers dress their seeds before storage and the other half do not treat their seeds.

Table 2: African leafy vegetable leaf production practices

PRACTICE	S	SP	AN	Mean
Average area (ha)	0.06	0.05	0.04	0.05
Purpose of growing ALV (%)				
Both	67.8	68.6	56.8	64.4
Food	30.2	29.2	41.5	33.6
Sale	2.0	2.2	1.7	2.0
Season of growing LV (%)				
Both	78.2	60.9	38.7	59.3
Long rains	12.4	35.8	42.9	30.4
Short rains	9.4	3.4	0.9	4.6
Others			17.9*	
Sowing method (%)				
Drilling				
Broadcasting	53.4	43	22.6	39.7
Spacing	2.2	43	20.3	31.8
Other	5.8	4.7	17.3	9.3
volunteers	8.2	7.3	4.5	6.7
	0.5	0.5	13.5	4.3
Fertilizer use (%)				
Farm yard manure				
None	62.4	68.4	53.3	61.4
Other	27.3	24.1	42.4	31.3
Inorganic fertilizers	7.7	5.9	2.2	5.3
	2.1	1.1	2.2	1.8

S-Slender leaf, **SP**-Spiderplant, **AN**-African nightshade, **ALV**-African leafy vegetables
* Percentage of farmers who do not grow African nightshades but harvest those that grow in the wild.

Table 3: Number of seed samples of African leafy vegetables collected during the survey

Division	Slenderleaf	Spiderplant	African nightshade
Lurambi	7	3	2
Municipality	4	3	0
Shinyalu	10	3	1
Ikolomani	4	0	2
Navakholo	8	8	1
Ileho	14	1	1
Malava	8	4	1

Most farmers use ash to treat seeds for storage and only 2% use inorganic pesticides. Only 10% of farmers select seeds specially for planting. The rest (90%) use any available seed.

Table 4: Farmers' responses (%) on processing and supply system of African leafy vegetable seed

Practice	S	SP	AN	Mean
Sources of seed (%)				
Own	61.8	60.6	68.8	63.7
Multiple sources	21.7	23.4	15.1	20.1
Local market	12.6	12.2	7.5	10.8
Neighbour	1.9	1.6	6.5	3.3
Relative	1.4	1.1	1.1	1.2
Friend	0.5	1.1	1.1	0.9
Distribution of seed (%)	34.4	29.8	16.3	26.8
Gift	10.2	13.1	56.5	26.6
No distribution done	26.9	25.0	13.0	21.6
Sell	23.9	26.8	10.9	20.5
Various methods	4.6	4.8	3.3	4.2
Exchange				
Seed drying methods (%)	89.2	87.6	84.0	85.8
Direct Sunlight	6.4	7.9	2.2	5.4
Under shade	0	0.6	12.0	4.2
Indoors	2.2	1.7	2.0	2.0
Other	2.5	2.2	0	1.6
No drying				
Seed treatments (%)	52.7	51.2	41.8	48.5
Ash	38.3	41.0	49.1	42.8
Inorganic pesticides	3.5	3.4	5.5	4.1
Assortment of treatments	3.0	2.2	3.6	2.9
Other	2.5	2.2	0.0	1.6
None				

S-Slenderleaf **SP**-spiderplant **AN**-African nightshade

Table 5: Constraints in African leafy vegetable seed production

Farmers' responses (%)	S	SP	AN	Mean
Pests and diseases	8.5	6.9	7.4	7.6
Lack of capital	9.5	12.2	4.3	8.7
Bad weather (hailstones)	10.9	8.9	7.4	9.1
Lack of market for leaves	9.5	6.7	4.3	6.8
Lack of knowledge	2.5	1.1	13.8	5.8
Poor seed quality	5.5	12.8	6.4	8.2
Over harvesting of leaves	11.4	10.6	7.4	9.8
Several constraints given	21.9	20.6	29.8	24.1
None	20.4	20.6	19.1	20.0

S-Slenderleaf, **SP**- Spiderplant, **AN**-African nightshade

Farmers priorities and constraints in seed production

Farmers consider their priorities in seed production to be quality and yield. The problems that farmers face in seed production are shown in Table 5. About 20% of the farmers stated that they have no problems in producing seed. Twenty four percent of the farmers gave several constraints which they felt were of equal importance. The three most important constraints in seed production were high demand for leaves, which leads to frequent leaf harvesting resulting in low seed production, hailstones which often destroy leaves and prevent pod and berry formation and shortage of land. Important seed production constraints for each individual vegetable differed. In slenderleaf, hailstones were considered as the most important constraint to seed production. In spider plant, poor quality of seeds was the farmers' greatest problem and in African nightshades, lack of knowledge on how to produce seeds was the most important constraint.

DISCUSSION

African leafy vegetables are grown by the middle age farmers, most of whom are women. The farmers' education levels were mainly that of primary and secondary. The literacy level of Kenya is 59% (Johnston, 1993) which is high and therefore though considered as traditional crops African leafy vegetables are cultivated by people who are fairly well educated. Though farmers would like to grow African leafy vegetables throughout the year, they grow them only during the rainy seasons to avoid dry spells. It is only those who live along riverbeds who plant vegetables any time they wish. When planting slenderleaf and spiderplant, methods of drilling and broadcasting are both popular with farmers. Farmers like seed drilling because it facilitates operations like weeding, thinning and harvesting; but they also like broadcasting because it saves on planting time and gives a higher plant population. Recommendations given by Schippers (2000) for planting slenderleaf state that; seed should be planted at a spacing of 30 by 5 cm before thinning and 30 by 15-20 cm after thinning. Chweya and Mnzava (1997) recommend that for spiderplant, seedbeds at least 3 m long should be thoroughly prepared and seed drilled in rows 30 cm apart. Thinning can be done to leave a space of 10-15 cm between plants.

Although farmers sow African nightshade by broadcasting, drilling seeds, Spacing is the most preferred method. Those who use spacing method usually raise seedlings from the nurseries and a few make cuttings from African nightshade plants in the forests. Schippers (2000) suggests various ways of planting African nightshade vegetables. These methods are the similar to those already being done by farmers in Kakamega. He states that African nightshades can be planted by direct sowing, stem cutting and transplanting. In stem cutting plants should be spaced at 40 by 40 cm or 40 by 60 cm for *S. scrabrum.* In transplanting, spacing of 15 by 15 cm for normal planting and 25 by 25 cm for staggered planting are his recommendations. If the crop is to be kept for a long period then spacing of 25 by 40 cm is adequate. Though a higher percentage of farmers fertilize African leafy vegetables using manure and to a lesser extent inorganic fertilizer, a substantial percentage does not add any fertilizers. Many farmers stated that slenderleaf could do well without fertilizer. The farmers, in deciding this may not have been aware that slenderleaf fixes nitrogen (Reddy *et al.*, 1984). But as much as slenderleaf fixes nitrogen, Schippers (2000) recommends that 20 t/ha of farmyard manure should be added. From their experiences, farmers were of the opinion that spiderplant requires plenty of farmyard manure. Chweya and Mnzava (1997) recommend 20 t/ha of FYM for spiderplant.

Other recommendations they give for spiderplant of inorganic fertilizers are 2 t/ha of di-ammonium phosphate and 1 t/ha when using calcium ammonium nitrate. They give the optimum fertilizer rate as 120 kg N/ha during rainy seasons. Fertilizers are effective in African nightshade too and both farmyard manure and inorganic fertilizers can be used. Some of the inorganic fertilizers that farmers use in African nightshade are NPK (Schippers, 2000). Farmers believe that selling seeds to close relatives, friends and neighbours would bring a curse upon their seeds and cause the seed quality to deteriorate. Therefore most of the seeds distributed to friends, relatives and neighbours were given as gifts. If a farmer wants to sell African leafy vegetable seeds, it is best done at the market. Farmers prefer distributing their seeds within their villages and from close by marketing centres because transporting to major towns is considered uneconomical.

CONCLUSIONS AND RECOMMENDATIONS

The African leafy vegetable seed production system in Kakamega district is informal. Farmers produce and store their own seeds and distribute seeds themselves. There is no formal breeding programme, and variety selection is minimal so variety development is slow. Variety selection is mainly done for the taste of the leaves whether bitter or mild. Farmers' systems of drying and storage are not efficient because important factors like temperature and moisture content of the environment are not observed strictly. They do not have the facilities or scientific know-how to monitor precise temperature and moisture content during seed storage. Women remain the key role players in African leafy vegetable seed production and supply but the few men involved are more in commercial than domestic production.

Farmers' priorities are high seed yield and good seed quality. When seed yield is high they will only need to harvest seed from a relatively smaller area and save the rest of the vegetable plots for leaf production. Good quality seed will also make it possible for them to use a small amount of seed and still be able to get good emergence of the crop unlike now when they have to sow a lot of seeds to be sure of good emergence of the vegetable crop. Farmers growing African leafy vegetables stated that lack of know-how in processing seeds could be affecting the quantity and quality of the seed they produce.

Farmers have a lot of knowledge on Indigenous vegetables but there are areas which need to be supplemented with scientific studies and documentation. Agronomic studies that would help improve on seed yields need to be done.

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EFFECTS OF PACKAGING AND STORAGE CONDITIONS ON SEED QUALITY OF *CLEOME GYNANDRA* L.

Kamotho[1*] N. Grace, Dr. Muasya[1] Reuben M., Dr. Mathenge[1] Patrick W. and Dr.Dulloo[2] Mohammand E.

[1]*DEPARTMENT OF CROP SCIENCE AND SEED TECHNOLOGY,*
MOI UNIVERSITY
P.O. Box 1125,Eldoret, Kenya
E-mail: seedtech@africaonline.co.ke
[2]*International Plant Genetic Resources Institute,*
Via dei Tre Denari 472/a, 00057 Maccarese, Rome, Italy. E-mail: e.dulloo@cgiar.org

ABSTRACT

Quality of *Cleome gynandra* L. is affected by one or more factors that cause negative response during seed handling and storage. The purpose of this research was to increase insight into how the seed quality of *Cleome gynandra L.* is affected by different packaging and storage conditions, with a view to finding out the optimal method of packaging and storage of these seeds. The experiment for this study was set using seeds dried above silica gel to four target moisture levels: 20,10, 5 and 2% moisture content. Dried seeds were sealed in aluminum foil and polythene packets and stored at three storage temperatures: ambient, 5°C and minus 20°C for three and six months. After each storage period, seed samples were drawn and viability and vigour tests carried out. Seed stored for six months at 5% moisture content and minus 20°C recorded the highest seed quality. There were no significant differences (P=0.05) between seeds packaged in foil and polythene.

Key words: *Cleome gynanadra L., moisture content, seed quality, storage conditions, viability, vigour*

INTRODUCTION

The primary objective of storing seeds for plant genetic resource conservation is to maintain the genetic integrity of preserved accessions for as long a period as possible. Commercial seed companies and farmers are also faced with the task of prolonging life span of certain seed lots, for future seed production and planting seasons respectively. This is a challenging task due to inevitable deterioration of seeds in storage, which leads to low vigour, reduced number of viable seeds and genetic drift (Mutegi *et al*., 1999). Seeds may be stored by farmers in such a way that their levels of germination and vigour are least affected at the time of sowing in the forthcoming or subsequent season(s). For this reason, agricultural seeds need to be stored for one or two cropping seasons or years. Secondly, some quantity of seed may be stored for two to three years (or more) for utilization in commercial seed production, as "carry over stock". The third and the much more difficult task in seed storage is for the conservation of plant genetic resources in genebanks for utilization in crop improvement programmes by present and future generations. In this, seeds of a wide range of species and cultivars are stored for prolonged periods of time, normally extending to hundreds of years. While factors that influence the lifespan of a seed lot (population) during storage are the same for the above three categories of seed storage, the stringency of measures taken to minimise seed deterioration vary. The basic objective, however, is to maintain genetic integrity by minimising the loss of seed viability and vigour for a desired period of time. All seeds lose viability during storage with a loss of vigour preceding the loss in germination (Agrawal, 1986). There is considerable evidence that damage to chromosomes, some of it resulting in heritable changes; takes place as seeds loose their viability. Deterioration of seeds under storage is, therefore, an important issue to consider.

MATERIALS AND METHODS

Storage experiments were set using seeds dried above silica gel to four target moisture levels: 20, 10, 5 and 2% moisture content. Dried seeds were sealed in aluminum foil and polythene packets and stored at three storage temperatures: ambient, 5°C and minus 20°C for three and six months. There were 72 different treatments each using 600 seeds. For each treatment, 400 seeds were used for germination, 100 for moisture content determination and the remaining 100 seeds were used for electrical conductivity test. After each storage period, seeds were removed from the storage conditions and germination and vigour tests carried out according to ISTA (1995).

RESULTS

Three Months Storage

After three months of storage, temperatures had a significant effect (*P*=0.05) on percent germination, mean germination time and electrical conductivity. Room temperatures gave the least percent germination and vigour while minus 20°C recorded the highest germination and vigour (Table 1).

Table 1: Effect of storage temperatures on percent germination, mean germination time and electrical conductivity of Cleome seeds packaged in foil packets and stored for three months at 5% moisture content.

Storage temperature	Germination (%)	Mean germination time (days)	Electrical conductivity ($\mu Scm^{-1}g^{-1}$)
Room temperatures	67.50 (0.58)	2.27 (0.005)	31.67 (0.006)
5°C	72.00 (0.58)	2.12 (0.00)	28.81 (0.005)
- 20°C	78.00 (0.58)	2.10 (0.006)	26.36 (0.005)
F (0.05)	*228.00	*2322.60	*21943.90

In brackets are standard deviation values, *Values significant at *P* = 0.05

Reduction in storage moisture content had significant (*P*=0.05) effects on percentage germination and vigou. In general, viability and vigour improved with decrease in moisture content up to 5%, but further reduction to 2% moisture content resulted to decrease in seed quality (Table 2).

Table 2: Effect of seed storage moisture content on percent germination, mean germination time and electrical conductivity of *Cleome* seeds stored at minus 20°C for 3 months.

Moisture content	Germination (%)	Mean germination time (days)	Electrical conductivity (μScm⁻¹g⁻¹)
20	71.5 (0.58)	2.18 (0.007)	28.27 (0.006)
10	73.5 (0.58)	2.17 (0.006)	27.99 (0.006)
5	77.5 (0.58)	2.10 (0.006)	26.37 (0.006)
2	46.5 (0.58)	2.29 (0.006)	31.83 (0.006)
F (0.05)	*2032.286	*1153.286	*623098.00

In brackets are standard deviation values, *Values significant at *P* = 0.05

The two containers (polythene and aluminium foil) used in this study for storage of Cleome seeds did not differ significantly (*P*=0.05) in their effect on seed percentage germination, mean germination time and electrical conductivity. However, the trend in Table 3 shows that aluminium foil recorded higher seed quality and could therefore be better than polythene.

Table 3: Effect of storage containers on percent germination, mean germination time and electrical conductivity of Cleome seeds at 5% moisture content stored at minus 20°C for three months.

Storage container	Germination (%)	Mean germination time (days)	Electrical conductivity (μScm⁻¹g⁻¹)
Foil	78 (0.58)	2.10 (0.006)	26.36 (0.006)
Polythene	76 (0.58)	2.11 (0.007)	26.44 (0.008)
F (0.05)	6.00 ns	3.00 ns	3.00 ns

In brackets are standard deviation values, ns = not significant at *P*=0.05

The three temperature regimes used in this study were significantly different (*P*=0.05) in their effects on percent germination, mean germination time and electrical conductivity of Cleome seeds stored for six months. Seeds stored at minus 20°C recorded the highest viability and vigour, while seeds stored at room temperature had the least seed quality (Table 4). Seeds stored at 5°C were intermediate in quality.

Table 4: Effect of storage temperature on percent germination, mean germination time and electrical conductivity of Cleome seeds stored for 6 months at 5% moisture content.

Storage temperature	Germination (%)	Mean germination time (days)	Electrical conductivity (μScm⁻¹g⁻¹)
Room	85.0 (0.58)	2.33 (0.005)	36.24 (0.006)
5	89.0 (0.50)	2.27 (0.005)	31.65 (0.005)
-20	95.0 (0.58)	2.21 (0.006)	29.27 (0.006)
F (0.05)	*329.727	*1084.200	*164248.10

In brackets are standard deviation values, *Values significant at P = 0.05

Reduction in moisture content had a significant (*P*=0.05) effect on percent germination, mean germination time and electrical conductivity. Results of Table 5 show a general trend of seed quality improvement with moisture content reduction up to 5%. However, further drying to 2% moisture content resulted into a decline in seed quality (Table 5). Lowest germination of 55.5% was recorded at 2% moisture content and at 5% moisture content germination was highest at 94.5% (Table 5). Vigour as indicated by mean germination time and electrical conductivity was also lowest at 2% moisture content and highest at 5% moisture content (Table 5).

Table 5: Effect of moisture content on percent germination, mean germination time and electrical conductivity of Cleome seeds stored for six months at minus 20°C.

Moisture content	Germination (%)	Mean germination time (days)	Electrical conductivity (µScm^{-1}g^{-1})
20	76.5 (0.58)	2.26 (0.006)	33.41 (0.006)
10	78.8 (0.50)	2.23 (0.005)	31.99 (0.005)
5	94.5 (0.58)	2.21 (0.006)	29.27 (0.010)
2	55.5 (0.58)	2.38 (0.005)	35.67 (0.005)
F (0.05)	*605.488	*666.692	*634768.700

In brackets are standard deviation values, *Values significant at P = 0.05

In this study, foil and polythene did not differ significantly (*P*=0.05) in their effects on percent germination, mean germination time and electrical conductivity of Cleome seeds stored for six month. Results of Table 6 indicate that foil gave higher seed quality than polythene.

Table 6: Effect of container on percent germination, mean germination time and electrical conductivity of Cleome seeds stored for six months at minus 20°C and 5% moisture content.

Storage container	Germination (%)	Mean germination time (days)	Electrical conductivity (µScm^{-1}g^{-1})
Foil	94.5 (0.58)	2.21 (0.005)	29.27 (0.006)
Polythene	93.5 (0.58)	2.22 (0.005)	29.28 (0.006)
F (0.05)	6.00 ns	3.00 ns	3.00 ns

In brackets are standard deviation values, ns = not significant at P = 0.05

Storage period caused positive significant effects (*P*=0.05) on viability of Cleome seeds. Initially, germination was as low as 14.5%, but increased to 78% and 95% after three and six months respectively (Table 7). This could be attributed to relative dormancy exhibited by freshly harvested Cleome seeds, which is then released in storage. There were negative significant effects (*P*=0.05) caused by storage period on vigour of Cleome seeds. Vigour as indicated by mean germination time and electrical conductivity decreased in storage (Table 7).

Table 7: Effect of storage period on percent germination, mean germination time and electrical conductivity of Cleome seeds dried to 5% moisture content.

Storage period	Germination (%)	Mean germination time (days)	Electrical conductivity (µScm^{-1}g^{-1})
0 months	14.5 (0.58)	2.04 (0.008)	25.94 (0.005)
3 months	77.5 (0.58)	2.10 (0.006)	27.36 (0.006)
6 months	94.5 (0.58)	2.21 (0.005)	35.25 (0.006)
F (0.05)	*15987.00	*604.059	*1330009

In brackets are standard deviation values, *Values are significant at P = 0.05

Interaction effects of moisture and temperature after six months storage were significant (*P*=0.05) for percent germination, mean germination time and electrical conductivity. Seed stored at 5% moisture content and minus 20°C gave better seed quality than seed stored at 2% moisture content while seeds stored at room temperature had the least quality. Highest germination and vigour were realized at minus 20°C and 5% moisture content, while the lowest germination and vigour were recorded at room temperatures and 2% moisture content (Figure 1,2,3).

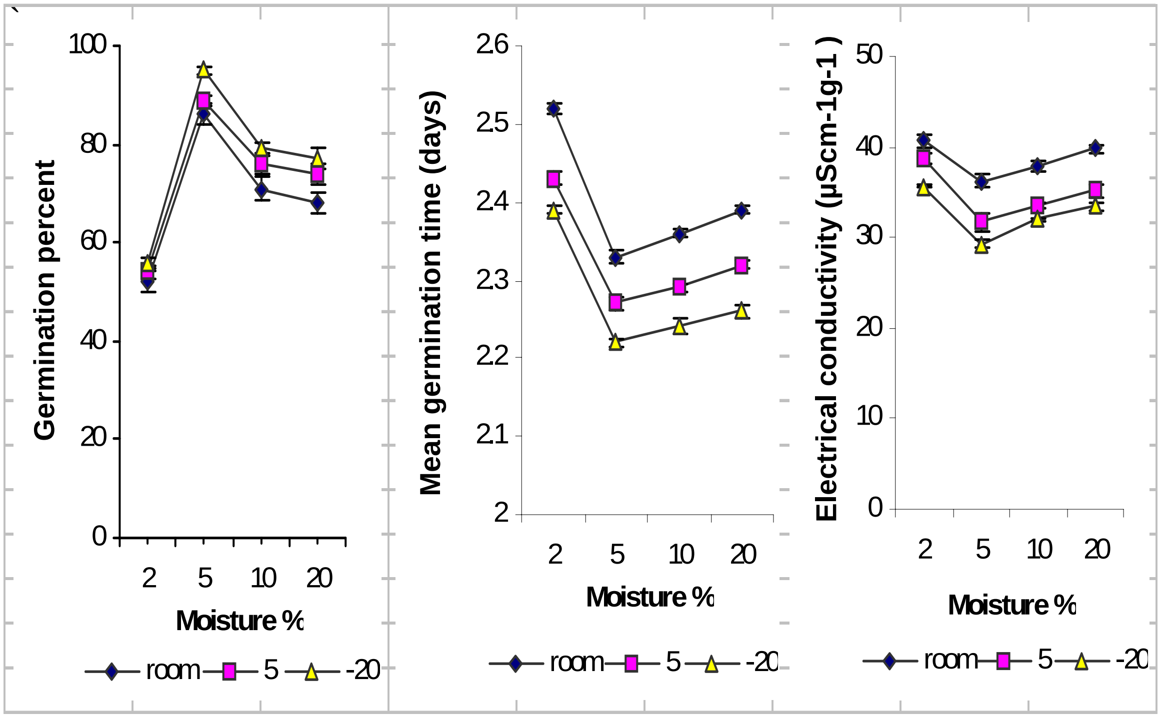

Fig.1, 2, 3: Interaction effect of moisture and temperature on germination percent, mean germination time and electrical conductivity of Cleome seeds stored for six months. Each point is an average of 4 determinations ± standard error of the difference (SED). Standard error bars are used to compare points within a temperature regime.

DISCUSSION AND CONCLUSIONS

Viability increased in storage possibly due to loss of dormancy. After-ripening dormancy loss in stored seed has been observed in *Amaranthus retroflexus* (Omami *et al*., 1992) and *Festuca idahoensis* (Goodwin *et al*., 1995). Storage temperatures of minus 20°C gave seeds of highest quality, implying that Cleome seeds are cold tolerant and probably chilling has a dormancy breaking effect.

Orthodox seeds can be dried to low moisture content (5 % or less) without damage and, over a wide range of environments, their longevity increases with decrease in storage moisture content and temperature in a quantifiable and predictable way (Roberts, 1973a). The findings of this study concurred with the above observation as Cleome seeds dried to 5% moisture content and stored at minus 20°C had the highest quality. Removing every last bit of water from seeds is detrimental (Ellis *et al*., 1985). Thus reports of low germination in seeds stored under extremely dry conditions (Nishiyama, 1977) were not unexpected. Reports using numerous species (Chai *et al*., 1998) have demonstrated that detrimental effects were not initially evident, but became more apparent with time. In other words, the seeds aged more rapidly under extremely dry conditions. Hence it can be concluded that drying to extremely low water contents may shorten seed longevity and for many seeds there is an optimum moisture level for storage at which longevity is maximized and below which seeds are damaged. This is the critical water content (Ellis *et al*., 1985). In the present study, there was an increasing trend in germination percent with moisture reduction up to 5% but the trend declined at 2% moisture content (Table 3,5). In the two storage periods, seed dried to 2% moisture content recorded the least germination percent and the least vigour (Table 3,5). Therefore the findings of this study are in agreement with the aforementioned observation by Ellis *et al*., (1985) that drying seeds to extremely low water contents could be detrimental.

Although viability increased in storage, there was gradual seed deterioration as indicated by mean germination time and electrical conductivity (Table 7). Seeds stored at room temperatures and 20% moisture content recorded the lowest vigour while seed stored at minus 20°C and 5% moisture content recorded the highest vigour. This confirms the physiological influence of temperature and moisture content during storage that deterioration of orthodox seeds increases with increase in seed moisture and temperature (Perry, 1981). It has generally long been known that, the greater the moisture content and storage temperature of orthodox seeds, either singly or in combination, the shorter is the period of seed survival (Roberts, 1973a). Therefore the high percent germination and high vigour (low mean germination time and low electrical conductivity) exhibited by Cleome seeds stored at 5% moisture content and minus 20°C is in agreement with the above observation. Roberts (1984), has pointed out that, a viability test is limited in detecting quality differences among high germinating seed lots. Tekrony and Egli, (1997) further observed that the results of seed storage are unlikely to adequately reflect the degree of seed deterioration that has taken place. This has been reflected in this study by the high germination of 95%, yet the seeds have deteriorated as indicated by the electrical conductivity measurements (Table 7).

Electrical conductivity measurement of soak water in which bulk samples seeds have been soaked identifies such deteriorated seed lots. Such seed lots have high electrolyte leakage and are classified as low vigour, while those with low leakage are considered high vigour (ISTA, 1995). In the present study, results of the electrical conductivity measurements revealed significant changes in amount of electrolyte leaked from seeds stored at different storage periods (Table 7). This could be attributed to deterioration of Cleome seeds in storage due to ageing. This study has confirmed the beneficial effect of drying seeds to low moisture contents and storing at low temperatures. Based on the results of this study, it may be concluded that, to achieve high seed quality, Cleome seed should be dried to 5% moisture content and stored at sub zero temperatures (preferably at minus 20°C). However these conditions can only be available in such places as the gene banks and other institutes that conserve seed for long-term storage. In this study, a germination of 85% was recorded for seed stored at room temperatures and 5% moisture content (Table 4). Since Cleome seed has high lipids content (Mnzava 1990), low moisture content can be achieved by sun drying. Moreover, less than 10% moisture content at the end of maturation drying has been reported in orthodox seeds developing in dry dehiscent fruits such as rapid cycling *Brassica* (Sinniah *et al*., 1998a). The study showed that foil and polythene are equally good as packaging materials for cleome seed (at least for short-term storage). Therefore farmers can dry their seed at about 5% moisture content, package them in polythene (since readily available) and store at room temperatures for six or more months.

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TOWARDS UTILISING PEST RESISTANCE AMONG LANDRACES IN INDIGENOUS VEGETABLES IN KENYA: APPROACHES AND OPPORTUNITIES

[1]Sithanantham, S., [2]Seme, C. N., [3]Maundu, P., [2] Muthamia, Z. and [3]Rao, N.K.
[1]International Center of Insect Physiology and Ecology (ICIPE)
[2]National Gene Bank of Kenya (NGBK)
[3]International Plant Genetics Resources Institute-Regional Office for Sub-Saharan Africa (IPGRI-SSA)

ABSTRACT
The improved cultivation and utilization of indigenous leafy vegetables would require among others interventions, the empowerment of the farmers with simple and affordable means of reducing the losses caused by insect pests. It is important to evaluate the available germplasm for detecting and utilizing any available source of pest resistance or tolerance among them. An outline to the approach and methodologies for field screening and evaluation for pest resistance / tolerance is provided in this paper. Illustration has been provided of data collection from an exploratory field screening of a few Kenyan accessions of the spider plant (*Cleome gynandra*) for stemborer infestation / damage.

INTRODUCTION
Farmers of African Indigenous vegetables (AIVs) require simple methods of managing the key pests on these crops as means of minimizing the losses caused to the yield and quality of produce. Schippers (2001) pointed out the lack of knowledge on safer and affordable pest control means as one of the major constraints to sustainable cultivation of these crops by African farmers. If farmers are provided with cultivars which have capacity to compensate for (tolerate) such pest damage, it would enable them to reduce the production losses due to pests at minimal or no cost. Host plant tolerance is a mechanism by which a genotype of the crop is able to compensate for the pest damage/infestation and produce satisfactory yields, although it may not be able to deter the infestation (non preference) or affect the development/survival of the target pest (antibiosis). After assembling local landraces of African indigenous vegetables from different ecologies/ agroecozones, it should be possible to test for this compensating trait to pest infestations, by evaluating them in 'hot spot' locations and/or 'severe' infestation seasons. This paper is focused on the approaches and methodologies that are appropriate to developing such a program for identification and popularization of pest tolerant land races of indigenous vegetables, along with a case study of exploratory testing undertaken in Kenya on *Cleome gynandra*.

HOST PLANT TOLERANCE MECHANISM

Host plant resistance to pests is a valuable means of inexpensive reduction in pest–caused losses. While 'antixenosis' (non – preference) discourages the on set of infestation (Oviposition/ feeding) and 'antibiosis' interferes with the sustained pest infestation (breeding/development / survival), ' tolerance' is manifested simply as the ability of the plant 'to compensate for' the pest damage. The advantage in tolerance mechanism is that it is less cumbersome to identify as well as to utilize at the farm level, with very little research resource investment. It is also possible to undertake the identification of this mechanism among the local races, as part of the overall agronomic and quality/marketing evaluation involving researchers and farmers' groups in community – led initiatives.

Pest range and 'model' pests in AIVs

The range of pests (species spectrum) in five indigenous vegetables grown in Kenya and the extent of pest-arbitrated losses in four of them has been documented (Sithanantham *et al.,* 2003). For the purposes of methodology development for screening against pests in these crops, some candidate pests may be identified. Based on their importance as well as ease of handling/ evaluating them in the field, the following may be chosen as model pests for the common groups:

- Soil pests: Termites
- Sucking pests: Aphids/ bugs
- Chewing pests: Beetles /caterpillars
- Boring pests: Stem or fruit borers

STEPS IN IDENTIFYING PEST RESISTANT/TOLERANT LANDRACES

The major steps in identifying local land races for pest tolerance are visualized as follows:

(i) Assembling from ecologies/ecozones
(ii) Exploratory testing to ' reject' susceptible types
(iii) Verifying 'resistance' and 'tolerance' by testing under 'infested' and 'pest – free' situations.
(iv) Assessing 'stability of performance' of landraces across benchmark sites and seasons.

Observations to identify the pest resistance mechanisms

The number of insects, if counted early on at the time of start up of infestation, by counting the eggs laid per plant, could provide a criterion for assessing non-preference (antixenosis) mechanism. The extent of feeding, survival and/or developmental duration of the pest (to be supplemented by laboratory rearing), could indicate the occurrence of any 'antibiosis' mechanism. For detecting 'tolerance' (compensation ability), the relative yields (quality) of leaves from 'pest-infested' and 'pest-free' (protected by a pesticide spray regime) could be compared and those accessions which are able to yield satisfactorily, even with normal levels of pest infestation, could be considered tolerant.

System proposed for documenting pest resistance / tolerance among land races

Evaluation stages and steps

As part of overall evaluation of the germplasm collections, the reaction to important (key) pests could be assessed in the following stages and criteria.

Steps in identifying pest resistant / tolerant accessions

The common steps in identifying pest resistant / tolerant accessions are as below:

- Assemble available genetic diversity
- 'Ascertain' suitability for local market / consumption
- 'Reject' pest susceptible accessions in 'screening' nursery
- 'Test' performance of promising selections 'with' and 'without' pest infestation
- Verify 'stability' of performance in 'hot spot' and 'bench mark' sites

Guidelines for screening nursery

It is important to consider the following guidelines for planning and screening nursery observations on pest resistance / tolerance:

- Identify 'hot spots' or 'suitable' seasons
- Plant the trials more than once to avoid 'escape'
- Develop criteria to document pest numbers, crop damage and yield (quality)
- Include 'check' accessions to enable comparison

Guidelines for assessing pest tolerance

The specific guidelines for assessing pest tolerance are listed below:

- Compare marketable 'yields' of accessions between 'protected' and 'infected' regimes.
- Include comparison with yields of 'check' cultivars / accessions.
- Verify the benefits of 'tolerant' accessions under varying levels of pest infestation.

Testing the stability of resistance / tolerance

Testing for stability of performance of the promising landraces chosen for pest resistance/tolerance should take into account the following points:

- Different ecologies may affect the pest severity/strain and plant vigour levels that affect compensating ability
- Benchmark sites to represent major ecologies (climate/seasons) should be utilized.
- Include cultivation guidelines, based on results of stability of performance tests

RESISTANCE SCREENING AMONG LANDRACES OF SPIDER PLANT FOR STEM BORER: CASE STUDY

Accessions studied:

Six landrace accessions of spider plant (*Cleome gynandra* L.) from the Gene Bank of Kenya were evaluated in open field screening at Mbita Point Field Station of ICIPE during 1996-97. The details of these landraces are furnished in Table 1.

Observations on borer incidence and damage

A sample of 10 plants per accession was cut at the base of the stem and the stem was split open vertically. The number of stem borer larvae per plant as well as the length of stem bored were recorded.

Observations on other pests:

Counts or visual scores (1-5 scale), as described by Sithanantham *et al*. (2003), were adopted for other pests like green stink bug, etc. that were found to occur during the 8-12 weeks' age of the plants.

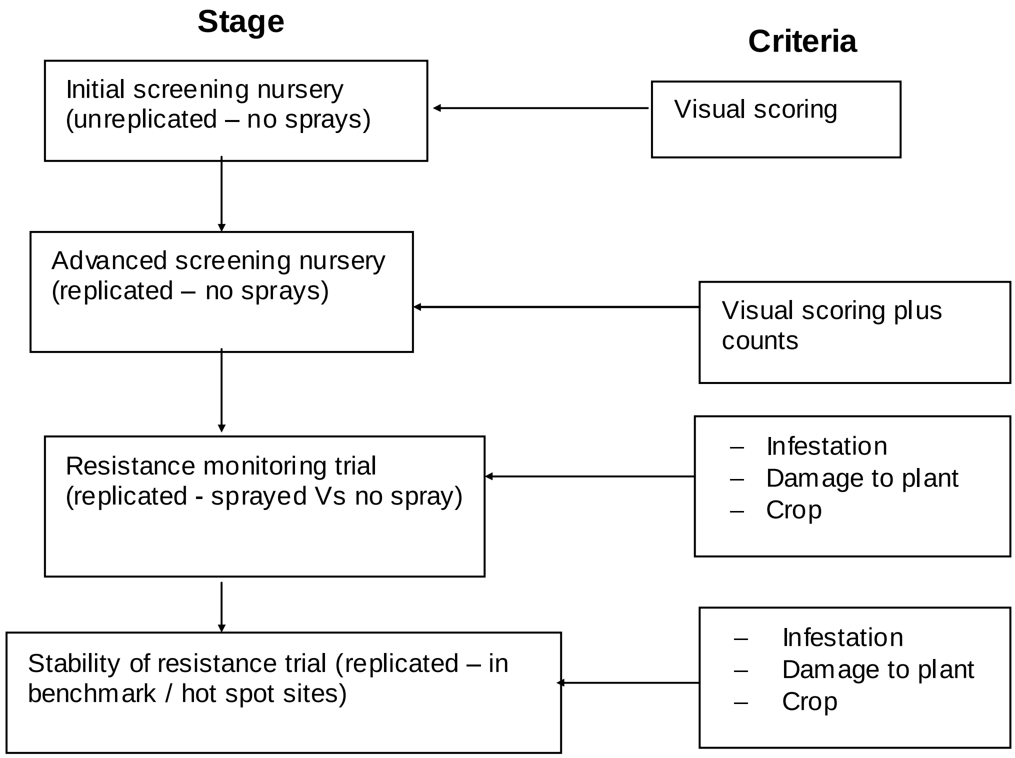
Overall assessment of resistance

The extent of infestation by stem borer (number of borer larvae per plant) and the extent of injury to the plant (length of stem bored per plant) were together compared across the landraces (Fig. 1). . It is expected that stem damage levels will more directly affect the yield loss than insect numbers per plant. Based on both the parameters, ICCG 6 was found more promising for resistance to stem borers, since it sustained substantially lower extent of stem injury, although the mean larval numbers (infestation) was not the lease in this accession. By contrast, ICCG 4, although recorded the least infestation, had suffered greater stem damage than ICCG 6Counts were also made of other pests which are of y importance and there were significant differences in severity of infestation by two of them, the green stinkbug leaf hoppers, besides the stem borers (Table 2). These pests were The relative incidence by these two pests (Fig. 2) was also found to be less in the accession ICCG 6.This enabled identifying ICCG 6 as potentially resistant to the key pest (stem borer) as well as second-level pests (green stink bug and leaf hoppers).

RELATED CONSIDERATIONS IN ASSESSING PEST RESISTANCE / TOLERANCE AMONG LANDRACES:

Linking with other desirable traits:

Pest resistance/tolerance screening and related evaluations could be easily linked to routine observations planned for identifying landrace accessions that are potentially acceptable to the farmers and consumers. The goal should be to enable the end-users to utilize accessions that may combine pest resistance / tolerance as a bonus, while focusing on agronomically acceptable (productive) and consumer-preferred (tasty/cooking qualities) traits.



Catering to variations within landraces:
Since landrace collections may often include more than one genotype, it is important to document the reaction / response to pest infestation / damage by sub-grouping them into two or more distinct classes and assigning the individual as well as overall scores (direct and weighted averages, representing the proportion of the subgroups). This will ensure that landrace composition (heterogeneity) is catered for at the different steps of documentation.

Integrating the pest resistance parameters as descriptors in passport information

The pest resistance / tolerance related information may be simplified into the following parameters and scoring / grouping.

i. Insect infestation levels:
Based on insect numbers per unit plants or plant parts;
ii. Plant injury / damage levels:
Based on extent of injury / damage to the plant or plant parts;
iii. Crop yield (marketable / acceptable quality)
Based on the extent of leaf or other parts' yield that is of acceptable quality for consumption and/or marketing. Incase of tolerance, the closeness between yields/quality in 'pest–infested' and 'pest–free' (protocol) plots should be considered as per the parameters

1 = Distinctly less than check entry (above 25%)
2 = Slightly less than check entry (up to 25%)
3 = Neutral same as check entry
4 = Slightly more than check entry (up to 25%)
5 = Distinctly more than check entry (above 25%)

THE WAY FORWARD FOR UTILIZING PEST RESISTANT / TOLERANT LANDRACES.

By proper integration of the criteria and steps in identifying the promising accessions and mechanisms of resistance, it is possible to provide suitable guidelines to the crop production / promotion personnel on the relative resistance/tolerance of the candidate landraces. By simplifying and standardizing the criteria for pest infestation (numbers) crop injury (damage) and yield levels (of marketable quality), it is possible to include them as descriptors in the passport information and related documentation.

7. ACKNOWLEDGEMENTS

Grateful appreciations are extended to ICIPE colleagues (Drs. Ampong Nyarko, Seshu Reddy and Messers. Nyagol, Gideon Jira and Joseph Ondijo) for their advice / assistance and to Drs. Hans Herren and Johann Baumgaertner, for their keen support.

Table 1. Details of landrace accession

Gene bank code	Source (Location)	ICIPE code
027131	Gene bank of Kenya	ICGG-2
028554	"	ICGG-3
028476	"	ICGG-4
027195	"	ICGG-5
028542	"	ICGG-6
028598	"	ICGG-8

Table 2. Extent of significance in incidence of other pests among the six landraces of *Cleome gynandra*, Mbita, 1997

Green stink bug	*
Brown coreid bug	NS
Leafhoppers	*
Whiteflies	NS
Beetles	NS
Leaf miners	NS

* = Significance at 5% level NS = Not significant

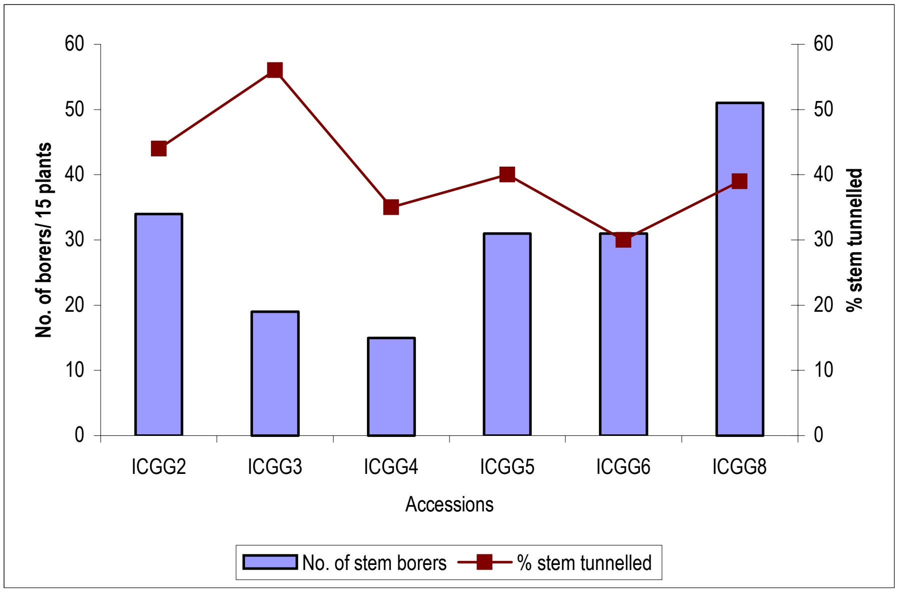


Fig. 1. Number of borers and stems tunneled in mature plant of different accessions of *Cleome gynandra*, Mbita 1996

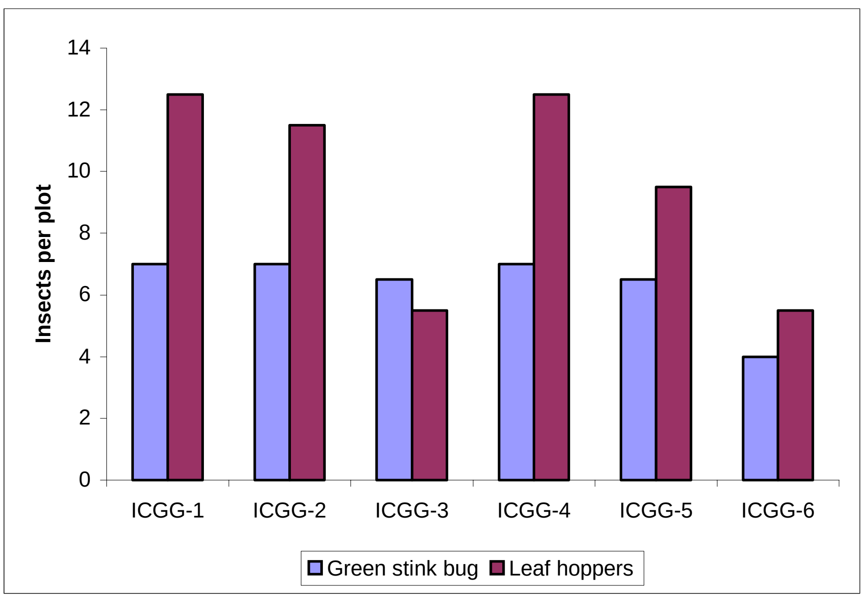


Fig. 2. Relative incidence of green stinkbugs and leafhoppers in six landraces of *Cleome gynandra*, Mbita, 1997

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TAXONOMIC CHARACTERIZATION AND IDENTIFICATION OF AFRICAN NIGHTSHADES (*SOLANUM* L. SECTION *SOLANUM*)

G.N. Mwai[1], B. Tiomo[2], L. Manoko[1], C. Mariani[2], G.M. van der Weerden[2], R.R. Schippers[3]
[1]Botany Department, Maseno University, P.O. Private Bag Maseno, Kenya. E-mail: mwaign@yahoo.com
[2]Botanic and Experimental Garden, University of Nijmegen, Toernooiveld 11 6525 ED Nijmegen, The Netherlands. Respective e-mails: btiomo@yahoo.fr, lmanoko@hotmail.com, mariani@sci.kun.nl,gerardw@sci.kun.nl
[3]Horticultural Development Services LLP, 19 Travertine Road, Walderslade, Chatham, Kent ME5 9LQ, England. E-mail: rrschippers@aol.com

ABSTRACT

African Nightshades play an important role in meeting the nutritional needs of rural households, being particularly rich in protein, vitamin A, Iron and Calcium; and are among three top priority African Indigenous Vegetables identified for further research and improvement. A major constraint facing this objective is the lack of taxonomic resolution of African Nightshades resulting in extensive synonymy and confusion; with the consequence it has been, at best, difficult to identify the toxic taxa, as well as those with good agronomic traits for genetic enhancement.This study was conducted to characterize, identify and delimit African nightshades. 50 accessions of *Solanum* L. section *Solanum* taxa from eastern, southern and western Africa were raised in a greenhouse at the Botanic Garden, University of Nijmegen. A descriptor list was developed and used to score for 48 morphological characters on flowering and fruiting plants. Chromosome counts obtained from root squash preparations using root tips from 1-week-old seedlings. The data was organized into a matrix of character states and cluster analysis done using a cladistic computer package. Results showed that nine species were represented, including three diploid, four tetraploid and two hexaploid species. Seven formally recognized and described species were positively identified. A tetraploid species provisionally named *Solanum eldoretianum*, was identified and described; and *Solanum tarderemotum* was tentatively identified. The study underscored the need to extend this study to include a more comprehensive and representative collection to elaborate the taxonomic status of several taxa.

Key words: African nightshades, taxonomic characterization, identification.

INTRODUCTION

Africa is richly endowed with plant genetic resources, with many well-adapted indigenous food crops that have long been grown on the continent. These crops play an important role in the food security of many resource poor farming families, and have potential value as a genetic resource for the global community. Hence it's sad that African researchers, policy-makers and farmers have neglected the potential of these crops in reducing food insecurity and poverty. Leafy vegetables, including several African Indigenous vegebales (AIVs), are highly valued in the typical African diet as accompaniment to carbohydrate-based staples.

Concerns regarding agrobiodiversity use and conservation, coupled with poverty alleviation have, therefore, greatly contributed to reawakened interest in AIVs. It is also increasingly recognized that communitites are, almost exclusively, the custodians of knowledge on AIVs i.e. how they are grown, used, their cultural value and genetic diversity. The best way to reduce the threat of loss of AIVs biodiversity is to improve their conservation through increased production and utilization, and improve their productivity, to make them more competitive with exotics.

Although Nightshades have for long been considered as inedible poisonous plants and troublesome agronomic weeds in other areas (Schilling and Andersen, 1989; Onyango, 1993; Edmonds and Chweya, 1997; Schippers, 2000), their story is completely different in Western, Eastern and Southern Africa as well India, Indonesia and China, where they have for long been used as leafy herbs and vegetables, as a source of fruits and dye, and for various medicinal uses (Onyango, 1993; Edmonds and Chweya, 1997; Schippers, 2000). In Kenya, black nightshades occur in many areas where they are known by a variety of local names such as managu (Kikuyu), ndulu (Kamba), osuga (Luo), lisutsa (Luhya), rinagu (Kisii), mnavu (Giriama), ksoyo (Pokot), kisochot (Elgeyo), where they are often cultivated in small kitchen gardens, and occasionally collected from the wild for domestic use and sale in markets. These vegetables play an important role in meeting the nutritional needs of rural households, being particularly rich in protein (especially the amino acid methionine, rarely found in plants) , vitamin A, Iron and Calcium. Medicinally, they are used for stomach upsets, duodenal ulcers, swollen glands and teething problems (Edmonds and Chweya, 1997; Onyango, 1993).

Vegetable African Nightshades are among the three top priority AIVs identified for further research and improvement due to their potential role in improving the nutritional and economic status of marginalized and poor rural populations, and poverty reduction (Onyango, 1993; Guarino, 1997; Schippers, 2000). Recent studies in Western Kenya have revealed increased use of AIVs and decreased use of exotics (cabbage, kale, spinach), mainly because AIVs are low-input (cheaper to produce) compared to exotics and consequently more affordable for rural many households in the low-income bracket. AIVs are easily available and cheap in village markets, but expensive in undersupplied urban markets, indicating that they have potential to become commercially important and increase their market share (Schippers, 2000).

The nightshades comprise a group of approximately 30 species making up section *Solanum* of the genus *Solanum*; constituting a large number of closely related morphogenetically distinct taxa, and typified by the true black nightshade, *Solanum nigrum* L. (Edmonds, 1977). This species group is one of the largest and most variable groups in the genus *Solanum* L., with species that are distributed from temperate to tropical regions, and from sea level to altitudes above 3500 meters (Edmonds and Chweya, 1997). Nightshades grow well under high moisture conditions, rainfall about 1500mm, and temperature between 20-30^{o}C. They do well in fertile soils that are rich in nitrogen, phosphorus, and a high organic matter content (Onyango, 1993).

Nightshades taxonomy has long been beleaguered by complexity, resulting in extensive synonymy and confusion (Gray, 1968; Schilling and Andersen, 1989). The causes for such complexity include historical reasons, phenotypic plasticity, genetic variation, polyploidy, natural hybridization and discordant variation (Edmonds, 1977). Much of this complexity has been resolved for Europe, India, the Americas and Australia, leaving Africa and Malesia as the two major geographic regions where a comprehensive taxonomic treatment of the section is lacking (Edmonds, 1977, 1978; Heiser *et al*, 1979; Schilling and Andersen, 1989; Edmonds and Chweya, 1997). Taxonomic resolution is necessary not only for effective biodiversity conservation, but also to understand the economic potential and opportunities that might accrue from these genetic resources. Consequently, Edmonds and Chweya (1997) recognize the need for such a treatment using living experimental material of the African, to supplement the previous work of several authors (e.g. Jaeger, 1985; Bukenya and Carasco, 1985; Bukenya and Hall, 1988), who had largely depended on herbarium material.

All nightshades are known to contain solanines, solanidines and other related glyco-alkaloids, as well as high levels of nitrate-nitrogen. Consequently, consumption of some nightshades reportedly causes stomach problems, indicating potential toxicity (Schippers, 2000). Due to the previously mentioned lack of adequate taxonomic resolution of the African taxa, it has been, at best, difficult to identify the taxa containing high levels of toxins, as well as those with good agronomic traits for genetic enhancement. Consequently, popularization and genetic enhancement of these otherwise nutritionally rich and cheaply available vegetables has been hindered.

OBJECTIVES

This study was conducted to address the above-mentioned taxonomic complexity using living material from eastern, southern and western Africa. The objectives of the study were therefore to characterize, identify and delimit African accessions of *Solanum* L. section *Solanum* taxa.

MATERIALS AND METHODS

The study material consisted of 50 accessions of African nightshades collected from eastern, western and southern Africa. Morphological characters were scored on the more or less mature plants (flowering and fruiting) grown in a greenhouse at the Botanical Garden, University of Nijmegen in The Netherlands. The strategy adopted was to use taxonomic morphological characters and chromosome counts of the experimental living material to distinguish taxa belonging to different ploidy levels:

Descriptor list:

A descriptor list was developed based on a descriptor provided by Mr. R.R. Schippers (unpubl.), and one used by Edmonds and Chweya (1997). This descriptor list was revised several times to cover the variation actually present in the current experimental plants growing in the greenhouse to produce a final version which had 48 characters.

Scoring for morphological characters:
Scoring for 47 morphological characters was done according to the final version of the descriptor list using flowering and fruiting plants. ***NB:*** Hair-type characters were scored for with the aid of a dissecting microscope and the presence or absence of stone cells in mature berries was checked in all the 50 African accessions.

Chromosome counts:
Fresh seeds of all the 50 African accessions were sowed in vermiculite. One week after seedling emergence, root tips were obtained from these seedlings, and used to make root squash preparations for the chromosome counts as described below:

- Freshly cut root tips were fixed in 50% ethanol acetic acid for ten minutes.
- Root tips were then digested in 10% HCI (hydrochloric acid) for five minutes.
- Digested root tips were then placed on a microscope slide and one or two drops of Fuschin stain applied on the root tips and allowed to stand for three to five minutes, then washed using 45% acetic acid, at the same time blotting away the excess stain.
- Stained root tips were mounted in a drop of 45% acetic acid, a cover slip put on, then squashed by tapping on the cover slip gently to spread the root tip, taking care not to scatter the cells too wide.
- The root squash preparations (slides) were preserved using nail varnish, and storing them at 4°C for a few days before being observed under a compound microscope.
- Counting of the chromosomes was done by selecting plates (cells) at the late anaphase/early metaphase or late metaphase/early telophase stage of mitosis, in which chromosomes were properly condensed and well spread out such that individual chromosomes were easy to distinguish and count. Microscopic images were digitally enhanced to expedite the counting.

Organization and analyses of the data:
All the data collected were entered into a computer in the form of a matrix of character states, based on a precise description of all the character states scored. Character states were determined for each character so as to represent the whole range of variation observed for that character as expressed in the greenhouse-grown plants. The data in the matrix of character states were then run through a computer package for cluster analyses, and results obtained in the form of a dendrogram and a cladogram.

RESULTS AND DISCUSSION

The consequences of the above results were discussed below, based on visual observation of the available living plant material, chromosome counts, cluster analyses, and taxonomic descriptions of *Solanum* L. section *Solanum* species in available literature.

Generally, all the accessions belonging to the same species as stipulated above clustered together both in the dendrogram and in the cladogram. Out of the 50 accesssions studied, 40 were positively identified from the results, representing seven of the already recognized and formally described species in *Solanum* L.section *Solanum* (Edmonds and Chweya, 1997). Three out of the four ploidy levels reported in literature (Edmonds, 1977; Schilling and Andersen, 1989); including three diploid species, two tetraploid species and two hexaploid species to which provisional scientific names were assigned accordingly (Table 1).

Table1: Summary of provisional names for 40 positvely identified African *Solanum* L. section *Solanum* accessions.

Provisional name	PLOIDY LEVEL	Number of accessions
Solanum americanum	Diploid	1
Solanum chenopodioides	Diploid	1
Solanum sarrachoides	Diploid	1
Solanum retroflexum	Tetraploid	2
Solanum villosum	Tetraploid	14
Solanum nigrum	Hexaploid	7
Solanum scabrum	Hexaploid	14

The species identified as the tetraploid *Solanum retroflexum* was represented by two pubescent accessions with eglandular haired stems and glandular haired leaves. However, there was another apparently closely related glabrous taxon, also tetraploid, represented by one accession. Other than for the pubescence, the latter taxon is superficially identical to the *S. retroflexum* described above. Although the two taxa were considerably separated by the cluster analysis, it is unlikely that they represent two distinct species. In line with the recognition of the great variation in the pubescence of *S. retroflexum* by Edmonds and Chweya (1997), it is hereby argued that these two represent two subspecies of *S. retroflexum*, just as there are subspecies of *S. villosum* that are differentiated mainly by their pubescence. Incidentally, the two sub-species of *S. villosum* were similarly separated by cluster analysis. Of the remaining ten accessions, nine were identified as belonging to the tetraploid taxon which is referred to herein as *Solanum eldoretianum*. The names *Solanum "eldoretii"* and *Solanum "eldorettii"* were first used by the late Professor Kilian Mtotomwema from Tanzania in 1987 without a proper description and without a publication, for the sake of convenience because he was of the opinion that this species with green berries that is frequently grown around Eldoret in Kenya cannot possibly represent *S. nigrum* since its name implied that it should have black fruit. It is now very clear, however, that this taxon does indeed belong in *Solanum* L section *Solanum*. So far, none of the descriptions given in literature (Edmonds and Chweya, 1997) for recognized tetraploid species fit this taxon. The accessions contained in this taxon clustered together, although there was considerable variation in the morphological characters. There were variants with green ripe berries and some with purple berries; some also had simple cymose inflorescences and others branched/forked cymes; some had protrate habit while others were erect; and all had stone cells. This taxon, by all means, is most likely a distinct tetraploid species in its own standing, probably with two or more disctint subspecies.

Since 1987, students in Kenya followed Mtotomwema's example, which led to some confusion because the name was not validly published. The more appropriate name, *Solanum eldoretianum*, is used in more recent publications. This species is only known from a limited area in several highland regions in East Africa including Central province, Rift Valley and Southwestern highlands in Kenya and the Northern Tanzania region bordering these areas. Plant populations found in southwest Tanzania may belong to this species and it is expected that once the species is better understood, it may also be found in other East African countries (Schippers, 2002).
The one remaining tetraploid accession clustered close to the tall hexaploid *S. scabrum*. The description for this taxon closely fits the one for *S. tarderemotum* as given in Edmonds and Cweya (1997).
Below are descriptions each of the nine species represented per the current work:

***Solanum americanum* Miller.**
Plants medium to tall upto 1.1m with erect branches, up to tertiary branches. Stem and nodes purplish green in color, glabrous and without wings. Leaves: ovate-lanceolate with entire margins and acute apex, greenish purple with purplish veins, glabrous, petiolate with petioles winged all the way, blade length 2x blade width and 2x petiole length. Fruiting peduncle facing upward, 2x as long as fruiting pedicel, glabrous. Fruiting pedicels erect. Inflorescence cymose-umbellate, with medium sized (11-15 mm diameter) few (≤ 7) flowers. Flowers with white corolla fused at the base, petal length 2x petal width; anthers yellow; styles not exserted; mature sepals lanceolate, reflexed away from berries. Mature berries globose to slightly flattened, black, very shiny, falling from calyces when ripe, purple flesh at physiological ripeness. Stone cells present. Cytology 2n = 24, diploid.

Solanum chenopodioides **Lam.**

Plants medium to tall upto 1.1m with erect branches, branched to tertiary level. Stem greenish purple with small finely dented wings, densely pubescent with long eglandular intermediate hairs. Leaves ovate-lanceolate with entire margins and acute apex, greyish green with light green veins, densely pubescent with short eglandular intermediate hairs, petioles winged half-way, blade length 2x blade width and 3x petiole length. Fruiting peduncle deflexed, densely pubescent, 3x longer than fruiting pedicel. Fruiting pedicel reflexed. Inflorescence a mixture of simple cymes and forked cymes on same plant, with few (cyme) to many (forked cyme) flowers. Flowers large (≥ 16mm diameter), corolla white, fused below half-way, petal length 4x petal width; anthers yellow; styles exserted just beyond the anthers and straight; mature sepals broadly triangular, adherent to berries, sepal length and width ≈ equal. Mature berries slightly flattened, black, dull, remaining on plant when fully ripe, green flesh at physiological ripeness. Stone cells absent. Cytology 2n = 24; diploid.

Solanum nigrum **L.**

Plants medium sized upto 1.1m, widely spreading with erect branches, branched to tertiary level and above. Stems purple with purple nodes, small to medium sized wings either prominently or finely dented, glabrous to sparsely pubescent with short eglandular appressed hairs when present. Leaves ovate or lanceolate with entire sinuate or sinuate-dentate finely lobed margins and acuminate to acute apices; greyish green to purple with greenish purple to purple veins; glabrous or sparsely pubescent with short, glandular appressed hairs when present. Fruiting peduncle horizontal or facing upward, sparsely to densely pubescent, ranging from equal to 3x pedicel length. Fruiting pedicel reflexed. Inflorescence either cymes, or a mixture of cymes and extended forked cymes on same plant, few (below 7) to many (above 20) flowered. Flowers medium sized (11mm) to large (above 16mm); white corolla fused either at the base or below halfway; petal length 2-3 times petal width; yellow anthers; styles exserted either just beyond or clearly beyond anthers, either curved or straight; mature sepals triangular ovate or broadly triangular, usually reflexed away from (occassionasly adherent to) berries, sepal length equal to or 2x longer than wide. Mature berries slightly flattened to rounded, pinkish purple to dark purplish black, to black, shiny or dull, falling with pedicels still attached or remaining on plant when fully ripe, fruit flesh green to purple at physiological ripeness. Stone cells absent. Cytology 2n = 72; hexaploid.

Solanum retroflexum **Dunal**

Plants short to medium herb upto 0.7m with widely spreading erect branches, branched upto 4^{TH} level. Stem purplish green in color with green to purplish nodes, small wings along the stem with or without dents, densely pubescent, with long eglandular erect hairs. Leaves ovate with clearly lobed dentate margins and acute to obtuse apices, greyish green in color with light green or purplish veins, densely pubescent with short or long glandular erect hairs, petioles winged all the way, blade length equal to blade width, and 2x petiole length. Fruiting peduncle facing upward, densely pubescent, 2x longer than fruiting pedicel. Fruiting pedicel reflexed. Inflorescence cymose, few to many flowered (7-19). Flowers medium sized to large (≥ 11mm), white corolla fused half-way or below half-way, petal length 2x petal width; anthers yellow; styles either not exserted or exserted clearly beyond the anthers and straight; mature sepals either lanceolate or triangular-ovate, reflexed away from berries. Mature berries slightly flattened, black or dark purplish black in color with dull surface, remaining on plant when fully ripe, purple flesh when physiologically ripe. Stone cells either present or absent. Cytology 2n = 48; tetraploid.

Solanum sarrachoides **Sendtn.**

Plant medium sized herb upto 1m, widely spreading with extensively branched (upto 5^{TH} level) erect branches. Stem green with green nodes, not winged, densely pubescent with long glandular erect hairs. Leaves ovate-lanceolate with clearly lobed dentate margins and acute apices, greyich green in color with light green veins, densely pubescent with long glandular erect hairs. Fruiting peduncle facing upward, densely pubescent and twice as long as fruiting pedicel. Fruiting pedicel reflexed. Inflorescence cymose, few flowered (≤ 7). Flowers large (>16mm), white corolla fused below half-way, petal length 2x petal width; anthers yellow; styles exserted clearly beyond the anthers, straight; mature sepals lanceolate, 3x as long as wide, adherent to berries. Mature berries slightly flattened, light green with dull surface, remaining on plant when fully ripe, green flesh at physiological ripeness. Stone cells present. Cytology 2n = 24; diploid.

***Solanum scabrum* Miller**

Plants medium to tall upto 1.8m; erect to slightly spreading branches, mostly with primary and secondary branches (occassionally tertiary). Stem and node colour ranging from green to purplish green to purple with medium to prominent wings that are prominently dented; glabrous to sparsely pubescent with short eglandular, appressed or intermediate hairs where present. Leaves ovate with entire to sinuate margins and acute (occassionally obtuse) apices, color ranging from light green to green, dark green and greenish purple, and vein color ranging from light green to purple; glabrous to sparsely pubescent with short, eglandular appressed to intermediate hairs where present; blade length equal to blade width and 2x, 3x or more times longer than petiole length, petiole winged half-way. Fruiting peduncle facing upward, sparsely to densely pubescent and 3x or more longer than fruiting pedicel. Fruiting pedicel erect or reflexed. Inflorescence cymose-umbellate, many flowered (8-20). Flowers large (16mm or more), corolla white or light purple and fused below half-way, petal length 2x petal width; anthers yellow or brown; styles not exserted or exserted either clearly or just beyond the anthers, either curved or straight; mature sepals rounded in shape, reflexed away from berries, sepal length equal to width. Mature berries large, slightly flattened, dark purplish black, shiny and remaining on plant when fully ripe; with purple flesh at physiological ripeness. Stone cells absent. Cytology 2n = 72; hexaploid.

***Solanum villosum* Miller**

a: subsp. *miniatum* (Bernh. Ex Willd.)Edmonds

Medium to tall plants upto 1.5m with slightly spreading erect branches, branched to 4^{TH} level. Stem green with node color ranging from green to purplish green to purple; small to medium sized wings (1-2mm) either finely dented or not dented; glabrous to sparsely pubescent with short, eglandular appressed to intermediate hairs where present. Leaves lanceolate to ovate with entire, sinuate, sinuate-dentate or dentate margins that may have clearly defined lobes or none, leaf apex acuminate to acute, light green to green lamina with light green or green veins; blade length either half as long or equal to blade width, and ranges from half as long to 3x longer than petiole length; petiole winged all the way or half-way. Fruiting peduncle facing upward, sparsely to densely pubescent, 3x or more longer than fruiting pedicel. Fruiting pedicel reflexed. Inflorescence cymose, occassionally cymes mixed with forked cymes on same plant, few (7) to many flowered (above 20). Flowers small (< 10mm) to large (>16mm), corolla white fused either half-way or below half-way, petal length to width ratio ranging between 1 and 3; anthers yellow; style not exserted or exserted just beyond the anthers, straight where exserted; mature sepals lanceolate (occassionally triangular-ovate), reflexed away from berries, sepal length 2 to 4 times sepal width. Mature berries ranging from slightly flattened to globose to higher rounded; orange; dull; remaining on plant when fully ripe, orange flesh at physiological ripeness. Stone cells absent. Cytology 2n = 48; tetraploid.

b. subsp. *villosum*

Plants medium upto 1.1m with widely spreading erect branches, branched to tertiary level only. Stems greenish purple with greenish purple nodes; small wings without dents, densely pubescent with long, glandular erect hairs. Leaves ovate with finely lobed dentate margins and acute apex, greenish purple with light green veins; densely pubescent with long glandular erect hairs; blade length equal to blade width and 2x petiole length, petioles winged all the way. Fruiting peduncle densely pubescent, horizontal, 2x as long as fruiting pedicel. Fruiting pedicel reflexed. Inflorescence cymose, few flowered (< 7). Flowers small (< 10mm) to large (>16mm); corolla white, fused half-way, petal length equal to width; anthers yellow; styles clearly exserted beyond anthers, straight; mature sepals triangular-ovate, reflexed away from berries, sepal length equal to width. Mature berries rounded; orange; dull; remaining on plant when fully ripe; fruit flesh orange when physiologically ripe. Stone cells absent. Cytology 2n = 48; tetraploid.

Solanum eldoretianum

Plants short (upto 0.7m) with widely speading erect or prostrate branches, branched to 5^{th} level. Stem green to greenish purple with purplish nodes and small finely dented wings; glabrous to sparsely pubescent with short appressed eglandular hairs. Leaves small to medium sized, lanceolate to ovate with entire margins and acuminate to acute apices; light green to green with light green or purplish veins; sparsely pubescent with short, eglandular appressed to erect hairs; blade length 2x blade width and 3x to 4x petiole length;, petioles winged all the way or half-way. Fruiting peduncle deflexed, horizontal or facing upward, sparsely to densely pubescent; twice as long as fruiting pedicel or more. Fruiting pedicel reflexed. Inflorescence cymose or extended forked cymes; many flowered (8-20 or more). Flowers medium to large (above 11mm); corolla white fused below half-way or at the base; petal length 2 to 3 times petal width; anthers yellow; style either exserted well beyond the anthers, curved or straight, or not exserted; mature sepals lanceolate to ovate to broadly triangular, either reflexed or adherent to berries, sepal length equal or 2x sepal length. Mature berries slightly flattened, occassionally rounded; light green or pinkish purple; dull; falling with pedicels still attached; green or purple flesh at physiological ripeness. Stone cells present. Cytology 2n = 48 tetraploid.

***Solanum tarderemotum* Bitter ??**

Plants tall, upto 1.8m with erect branches, branched to tertiary level only. Stem green with greenish purple nodes and prominent wings that are prominently dented; sparsely pubescent with long eglandular intermediate hairs. Leaves ovate-lanceolate with clearly lobed sinuate-dentate margins and acuminate apices; green with light green veins; sparsely pubescent with long eglandular intermediate hairs; blade length 2x blade width and 3x petiole length; petiole winged all the way. Fruiting peduncle facing upward, sparsely pubescent, 3x as long as fruiting pedicel. Fruiting pedicel reflexed. Inflorescence cymose mixed with forked cymes on same plant, many flowered (8-19). Flowers large (>16mm), some tetramerous rather than pentamerous (?), corolla white, fused below half-way; petal length 2x petal width; anthers yellow; styles exserted clearly beyond anthers and curved; mature sepals broadly triangular, adherent to berries, sepal length equal to sepal width. Mature berries slightly flattened, light green; dull; falling with pedicels still attached; flesh green at physiological ripeness. Stone cells present. Cytology 2n = 48; tetraploid.

CONCLUSION

The current work achieved its objective of describing several African taxa of *Solanum* L. section *Solanum*. However, it would best be viewed as a foundation upon which the resolution of taxonomic complexity associated with this section in Africa may be based. Although the initial descriptions of the several species were achieved and subsequently used for the identification of these species, there still remains a lot of work to be done before any claim of a comprehensive treatment of the section in Africa can be made. Currently, more research on the section is underway by a doctoral student at University of Nijmegen, mainly concentrating on the molecular/genetic relationships between the accessions used in this study, to be supplemented by further collections, mainly from East Africa.

RECOMMENDATIONS FOR FUTURE RESEARCH

Some among the areas that remain to be covered include:

- The refining of the current work using molecular and/or e.g. biochemical techniques to ascertain that the conclusions made from the current work are reflected at the genetic level. Currently, a Ph.D. student at the University of Nijmegen is conducting molecular taxonomic studies on the same plant material used for this study, which is expected to further resolve the taxonomy of African nightshades.
- The use of more collections from other areas of Africa in order to ensure that the descriptions thus obtained are as representative of the variation existing within the whole section as possible.
- Some of the species were represented by only one accession; more accessions would obviously be needed to compare and make the conclusions more watertight; and to cater for the wide diversity always inherent in species belonging to this section.
- There seems to be enormous variation in *S. villosum* subsp. *miniatum*, *S. scabrum*, and *Solanum eldoretianum*. There is need to further investigate these taxa more thoroughly to establish whether each taxon constitutes a single or several closely related taxa. Molecular taxonomic techniques would especially be helpful in this regard.
- Decisions also need to be made, after more investigation, on the seemingly yet to be described tetraploid species *S. eldoretianum*. The claim that the species is not yet described is supportable in view of the fact that it is a tetraploid whose description does not fit in with any of the recognized tetraploid species. Furthermore, it would seem to agree with the observation of Edmonds and Chweya (1997) that in Africa, ‘there are a number of other taxa which may represent good species, but about which little is known.’ This argument also applies to the taxon tentatively identified as *S. tarderemotum*. Such work should however be based on more accessions as well as adequate reviewing of the existing literature.
- More literature search as well as experimental work also needs to be done in order to resolve whether the two variants identified herein as *S. retroflexum* represent two subspecies of one species, or different species.

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AFRICAN EGGPLANTS PROMISING VEGETABLES FOR HOME CONSUMPTION AND SALE IN TANZANIA

E.S. Macha, Plant Protection Division, Tropical Pesticides Research Institute, P.O. Box 3024,Arusha, TANZANIA

ABSTRACT

Eggplants belong to the genus *Solanum* L. in the family Solanaceae. They include the edible purple-fruited *Solanum melongena* L. that originated from Asia but now cultivated worldwide including Tanzania. Also included are the African eggplants, popularly known as “Ngogwe” (Swahili), which will be the focus of this paper. They are *Solanum aethiopicum* L. complex, *S. macrocarpon* L. and the *Solanum spp*. (*S. anguivi* Lam., *S. delagoense* Dun., *S. repandifrons* Bitt. and *S. schumannianum* Dam.) all indigenous to Africa. They produce egg-shaped fruits, which are cooked and edible as vegetables or food seasoning to add flavour in other foods. A review of the status of these species through literature, herbarium, seed bank studies, field observations and market visits, suggests that they are highly diverse in Tanzania and complex relationships exist between them which are not clearly described taxonomically. They are cultivated in gardens and farms. Others occur in the wild. Fruits vary in shape, size, colour and taste. Unripe fruits coloured cream-white or variegated green-white are harvested for cooking while the ripe orange-red or scarlet to yellow-brown or golden are for production of seeds. Horticulture, Tengeru in collaboration with Alpha Seed

Company, multiplies and distributes seeds to farmers. The common varieties seen in markets are round and elongate-round and less so the egg-shaped (garden eggs), all with smooth or grooved surfaces, which all belong to *S. aethiopicum* complex. "Ngogwe" are potential food and cash crop for urban and rural dwellers. Data collected year 2002 show the following consumption and sales per week: Tengeru market (Arumeru-rural) is over 420bags, each manila bag 50Kg ("Kiroba" in Swahili) priced at Tshs 2,000-8,000=(U.S$ 2-8 (- 10); Central & Kilombero markets (Arusha-urban) over 70 bags; elsewhere over 350. African eggplants are promising crop for promotion and development to meet consumption demands and increased markets supply sales for higher cash income generation. Due to their importance, sustainable utilization for food security, income generation to improve livelihood of urban and rural poor, requires collaborative efforts for study, collection, screening characteristics of available germplasm and development of new varieties, multiply and distribute to farmers and enhance their *on-farm, in-situ* and *ex-situ* conservation.

Key words: African eggplants, diverse, food and cash crop, distribution, urban and rural dwellers, sustainable utilization

INTRODUCTION

Plants are sources of foods containing essential nutrients- carbohydrates, proteins, oils& fats, minerals, vitamins, and water for mankind. These compliment to form a balanced diet. The world population including Tanzania depends on different plants including eggplants for food security. African eggplants contribute more than one of the mentioned essential nutrients contained in their edibles fruits.

The exotic shrubby herb, *S. melongena* L. which originated from Asia (Eastern India) with its edible egg-like purple fruits it bears, known as "Brinjal" (Indian language) is now cultivated worldwide including all over Tanzania (Purseglove, 1968). It contains all essential nutrients required by man (Tindal, repr.1992). It is popularly called "Biringanya" or "Biringani " (Swahili).

African eggplants originated from or are native to Africa, bearing edible fruits of different sizes, shapes, colour and taste (Hora & Greenway, 1940; Brenan & Greenway, 1949, Williams, 1949; Blundell, 1987; Schippers, 2000 and Macha, 2002). In Tanzania, they are popularly known as "Ngogwe"(Swahili) and rarely, "Nyanyachungu"(Swahili). These indigenous plants with –egg shapes and surfaces are in sizes from chicken egg- size especially the cultivated ones to smaller pea-size fruits especially those picked from the wild plants. It is for this shapes and sizes and perhaps the skin surfaces of the fruits that they are given the name of the eggplants or garden eggs (Schippers, 2000).

Their fruits are economically important food cooked as vegetables as well as food seasoning to add flavour. The consumption demand, which is increasing, could possibly be higher than supply. The aim of this paper is to share information on how these African eggplants in Tanzania have been realized to be promising fruits used as vegetables and food seasoning in urban and rural dwellers and sold in local markets as source of income generation.

MATERIALS AND METHODS

Data to review the status of the African eggplants in Tanzania was collected from literature, herbarium and gene bank studies, field observations and market visits where interviews were conducted during the year 2001 and 2002.

RESULTS

The following presentation include taxonomy; cultivated species; areas of cultivation and natural distribution; reproduction, multiplication and distribution of seeds; agronomy; preparation as cash crop for marketing and pests and diseases.

Taxonomy

Eggplants belong to the genus *Solanum* L. in the family Solanaceae, which is among the most economically important plant group. The indigenous ones, which are referred here, are African eggplants.
They are herbaceous shrubs with hermaphroditic flowers, which are self or cross-pollinated by bees (Schippers, 2000). They reproduce by seeds. They contain alkaloid compounds - a number of spirosolane alkaloids, including solanine

and solanidine, which are bitter tasting, found in all *Solanum* species (Schippers, 2000). It is a characteristic of all Solanaceae family (Hawkes, Lester and Skalding, 1979; Lester and Niakan, 1986).

There are overlapping morphological characters in flowers, fruits and leaves among the six documented species of eggplants that are edible in the country (Hora and Greenway, 1940; Brenan and Greenway 1949; Williams, 1949; Shao, et al , 1990; Schippers, 2000; Macha,2002).

The six species consists of many subspecies, varieties and forms according to older botanists (Hora and Greenway, 1940; Brenan and Greenway, 1949 and Blundel, 1987).
Schippers (2000) showed that *Solanum gilo* group is not actually different species from *S.aethiopicum*, as they can interbreed and produce fertile offsprings (hybrids). The six edible eggplants species in the country are as presented in **table 1** below.

Table 1: Showing edible specie in Tanzania, their common names and occurrence status

No.	Eggplant species	COMMON NAMES	Occurrence Status and short notes
1	*Solanum melongena* L. Cultivated in 3 varieties: - Common, globose-shape fruit var. *esculentum* with 2-5 fruits per cluster -Dwarf, round var.*depressum* ,Slender curved fruited- var. *serpentum*	Eggplant (English), Brinjal (Indian), Aubergine (Indian), , melongene (French), Biringanya (Swahili), Biringani (Swahili).	Exotic purple fruited eggplant from Asia, cultivated in garden and farms. Plants closely related to East African *S.incanum, with* leaves hairy, flowers purple, unripe fruits purple, ripe ones yellow.
2	*S. aethiopicum* L. complex Many varieties and forms including S. gilo Raddi group. e.g.- var. *ellipsoideum* -var. *monteiroi, with cytological chromosome counts 2n=24.*	African eggplant (English) Garden egg (English) Scarlet eggplants (English) Ngogwe (Swahili) Nyanyachungu (Swahili)	Indigenous or African eggplant Cultivated in gardens and farms. Generally, 3 main fruits shapes occur in various sizes: -Round (Spherical or globose) -Elongate-round -Oval or ellipsoid Plants with leaves hairy or glabrous, flowers always white with free petals and diameter less than 25mm, Few fruits per cluster, unripe fruits vary from cream-white to variegate green-white turning orange to scarlet red. Fruit surfaces vary from smooth to grooved or ribbed..
3	S.anguivi Lam.	Wild eggplant (English) Ngogwe (Swahili) Ntula (Haya language in West L.Victoria)	Occur in fully wild, weedy or semi-cultivated state in-home gardens. An ancestor of *S. aethiopicum* complex. Syn.: *S. indicum,* and *S.anomalum.* Plants with mostly prickly stems and leaves, few unarmed especially semi-cultivated ones, highly polymorphic variable in plant structure, fruit and leaf characters, regarded as species complex consisting of different taxa. Flowers white, Inflorescences more than 9 per cluster of fruits of pea-sizes 8-15mm, varying from white, dark-green with intermediates colours. Ripe frts from yellow, light orange to red. Said to be of interest in breeding program's to improve cultivated

			garden eggs such as increasing the number of frts per cluster.
4	*S.delagoense* Dunal Consist of 5 varieties	Wild eggplant (English) Ngogwe (Swahili)	Fully wild or perhaps weedy. Plants with 4 flowered inflorescences, corolla light purple. Fruit berries 2cm diameter, yellow when ripe and eaten in Lindi region in time of famine.
5	*S.macrocarpon* L. There is only one variety- Var. *primovestitum*	Local garde egg (English) African eggplant (English) Gboma (Ewe language of West Africa) Ngogwe (Swahili)	Domesticated. Known only in cultivation, in garden and farms. It has glabrous leaves flowers large with fused petals light purple (or rarely white which has not yet been seen in this country) with diameter 25-45 mm. Fruits with large often clasping calyx, sub spherical, cream-white, variegated green-white to green when unripe. Ripe one, yellow, brown or golden. *S. dasyphyllum* Sch.& Thonn. Is an ancestoral species, a common weedy species in the country.
6	*S. repandifrons* Bitter	Wild eggplant (English) Ngogwe (Swahili)	Full wild and weedy especially in lowland e.g 400m asl more or less . Plants with prickles-0.2-0.3mm long on branches; Leaves large, 12-20x 5-7.5cm, 6 flowers per cluster .
7	*S. schumannianum* Dam.	Wild eggplant (English) Ngogwe (Swahili)	Fully wild or weedy. Plants with bristles up to 0.7mm long. Leaves hairy when young but almost glabrous when mature. Inflorescence with white corolla or mauve about 1-1.2cm in diameter. Fruits pea-size berries 0.7-0.8cm diameter and red when ripe. The ripe small red berries eaten by Shambaa community.

The species of the genus *Solanum* and the family Solanaceae in Tanzania and the other East African countries are taxonomically understudied. Taxonomic work on the flora of East Africa produced family wise as flora parts of the *Flora of Tropical East Africa (FTEA)* is not yet completed for publication.
A review of the status of these species of *Solanum* including the edible African eggplants, suggests that they are highly diverse in Tanzania and complex relationships exist between them, which are not clearly described taxonomically (Hora and Greenway, 1940; Brenan and Greenway, 1949; Blundell, 1987; Macha, 1988, 2002 and Shao, *et al* 1991).

The edible eggplants alone within the genus *Solanum* in Tanzania consists of complex of related subspecies and varieties occurring naturally in the wild, weedy plants or cultivated.
However Schippers (2000) in his work showed that conducting cytological studies (Chromosome counts) and breeding programme such as self and cross pollination within same or across different pure line plant respectively, a nu8mber of species can be identified or confirmed to belong to either same single species or separate. For example *S. anguivi* Lam. that is, as ancestor of *S. aethiopicum* when crossed, could not produce offsprings, which are able to survive naturally.
Although have related characters but they are separate species. But *S. macrocarpon* if crossed with *S. dasyphyllum* produces offspring hybrids, which are fertile, showing they belong to one species.
Such studies and others will lead to better understanding of the complex groups and be able to classify them better.

The cultivated species Apart from the *S. melo*ngena L., which is exotic eggplant in Tanzania, there are two horticulturally important indigenous edible eggplants, or African eggplants. The most common and preferred, is the *S. aethiopicum* complex. They bear round, elongate-round and oval fruits with smooth or grooved surfaces and varying taste from almost sweet (or bitter less) to most bitter ones especially the oval-shaped.

The round and elongate-round fruits with smooth or grooved surfaces and least bitter, of *gilo* group, are the most popular known as Tengeru-white varieties. They are multiplied are distributed by Alpha Seed Company in collaboration with Horticulture-Tengeru.

The second one which is less common, is *S. macrocarpon* with globose or round fruit and sweeter and also most preferred.
The other of minor importance is the semi-cultivated *S.anguivi* Lam., which are found in some home gardens and used as a seasoning to add bitter flavour. The pea-size berries of this species are very bitter compared to the other two.
The eggplants cultivated in gardens are for home consumption while those produced from farms are intended mainly for sale in various local markets in the country. Seeds are produced from mature and ripe fruits, dried and packed in small-labeled packets, which are sold to farmers.

Areas of cultivation and natural distribution All the species mentioned earlier except the exotic *S. melongena* are indigenous to Tropical Africa and in particular to Tanzania. Tindall (1992) mentioned that center of origin of *S. macrocarpon* is West Africa but Schippers (2000) reported that this eggplant if crossed with the weedy
S. dasyphyllum, which is common in Tanzania (East Africa), less so in West Africa, produce fertile hybrids indicating that they belong to a single biological species. Furthermore, *S. macrocarpon* is also common and flourish best in warmer humid areas of the coastal regions of the country, including areas around the great Lakes. For this reason, further studies of these plants are required to confirm or identify the native country (s) of origin besides Tanzania.

The following are the areas of cultivation and natural distribution of the edible eggplants in Tanzania:

S. aethiopicum L. complex Many varieties and forms including *S. gilo* Raddi group which include var. *ellipsoideum* - var. *monteiroi*

It is first important eggplant species in horticulture. It is cultivated in gardens and farms in all regions from low to highland zone especially midland zones where they flourish well –eg. The Northern regions (Arusha, Kilimanjaro, Tanga), where production is more from farms than gardens.

S. anguivi Lam.

Occurring naturally in all regions except Western, which needs to be surveyed. More frequent in Usambaras and around Lake Victoria regions. The unarmed varieties are cultivated in home gardens, some occur as weeds in arable land.

S. delagoense Dunal – This consist of 5 varieties

Grow naturally as wild plants in all regions especially the coastal belt from Northern to Southern regions of Lindi and around Lake Victoria, Shinyanga, Central Regions, Arusha and Kilimanjaro.

S. macrocarpon L. There is only one variety - Var. *primovestitum*

Only found in cultivations in all regions but mostly in warmer humid Coastal regions and some areas around the great lakes.

S. repandifrons Bitter

Growing wild in Coastal regions, Morogoro and the Western regions of Ufipa, Rukwa and Tabora. Field survey for this species is required.

S. schumannianum Dam.

Occurring naturally all over the country especially Tanga region, except central regions -Singida, Dodoma and some parts of Tabora.

Reproduction Propagation (Multiply) and Distribution of Seeds

Farmers cultivate them for two objectives, one is for harvesting unripe fruits, which are eaten in homes and sold in local markets. The second objective is for production of seeds, which are removed from ripe fruits, washed, dried, put in packets and sold. Some farmers use seeds from their own gardens for reproduction of new crop plants.
Whichever the objective in mind for growing African eggplant, a farmer prepares a good fertile farmland or garden where water will be available for irrigation during dry season.

If the farmer's objective is to produce seeds for distribution, then the farm area should be isolated 100m apart from other eggplant farms.

Farmer's preference (selection of what he wants for consumption), sale and continues cultivation, threatens the conservation of unselected varieties *on-farm*. The Alpha Seed Company in collaboration with Horti-Tengeru multiply about 7 or more of eggplants seeds varieties and distribute to farmers which are sold in small packets.

Agronomy
The cultivation of eggplants includes S*. aethiopicum* complex and *S. macrocarpon* which are the most preferred eggplants. The round variety of *gilo* group is most popular.
S. aethipopicum varieties are cultivated in gardens and farms in farmland areas around Tengeru-rural in Arumeru district and elsewhere in Arusha, Kilimanjaro and other places of the country. Farmers are advised to prepare gardens and farms well in appropriate time. Consumers prefer and select best tasty fruits, which are least bitter. These have better market and chances of continued cultivation for reproduction. The bitter ones are less cultivated and least marketable.

Seeds propagate young plants or seedlings raised from seeds mixed with fertile sandy or loamy loose soils. The seeds may be broadcasted on the nursery plot of 1 meter wide, where is irrigated or sown in furrows made in lined rows with optimal spacing. Then they are irrigated once every day until one month or one and half months old ready for transplanting to a well-prepared big home garden or in big farm.
Strong disease free seedlings of about one month or one and a quarter months old are planted in about 10cm deep pits of 1metre apart between rows and individual plants.
Water and then handful of organic or compost manure or synthetic fertilizer are added to the 10cm pits, and seedlings are planted in them. Farmers should check that the eggplant gardens or farm soils, stays moist, irrigated if there is no rain and to see that they are pest and disease free.

Weeding
Eggplants are weeded several times, removing weed plants, which may carry pests and diseases.
Some more organic or compost manure or fertilizer should be added to the farm or garden two or three weeks after transplanting.

Other pests and diseases control
Regular inspection is required to see if there is indication of the presence of any pest or disease so as to take control measures.

Harvesting
When fruits are mature, the unripe one are harvested for cooking as vegetable and as food seasoning. Some are harvested for selling in local markets. Tengeru-white (S.aethiopicum) is the most common and preferred "Ngogwe". Besides consumption in home they are packed in 50Kg manila bag called " Kiroba" (Swahili) and transported to local market. The ripe fruits- orange or scarlet red of *S.aethiopicum* and the golden *S. macrocarpon*, are harvested for production of seeds. Harvesting may continue to about six months.The fruits are cut in the middle and seeds removed by hand, stick or knife. Alternatively, the cut fruits can be kept for 2 – 3 days and then seeds are removed easelier. Then seeds are washed with clean water and dried under shades until all water drains out. Then are sun dried for 2 - 3 days and winnowed to remove all the dirt.

Seed storage and packaging
The clean seeds are stored in plastic containers and kept in cool dry places for a month before can be used or sold. Thereafter, they are put in nylon packets labeled with small descriptions including the quality and type of seeds.

Uses and nutrition
The cooked "Ngogwe" vegetable is eaten with starchy meals such as "Ugali" (stiff porridge), rice, "chapati" (pancakes), bananas and cassava. The most bitter are from wild species with pea-size fruits. They are used as food seasoning in either fresh or cooked condition as table appetizer to add bitter flavour in meat and other soups and curries, cassava,

sweet potatoes and bananas. The communities in Kagera region on west of L. Victoria prefer the bitter eggplant fruits to flavour foods such as bananas, cassavas, sweet potatoes and meat soups. Sometimes in preparing this seasoning, the red berries are boiled and left to cool and then mixed with sour milk which has been boiled, then the resulting mixture become a seasoning to flavour cooked bananas, cassava and sweet potatoes. Nutritionally, garden eggs or Ngogwe and in particular *S. macrocarpon* was shown by Tindall (1992) to provide in the diet of man the essential nutrients such as 89% water, 4%, protein 1.0% fat, 1.5% fibre and 13.0% calcium. Eggplants are therefore sources of essential food nutrients for mankind and so contribute to the food security of the country.

However, Schippers (2000) emphasized the presence of a number of *spirosolane* alkaloids including *solanine* and *soladine* which are bitter tasting and potentially poisonous. They are found in all *Solanum* species. When taken in excess, toxicity symptoms such as vomiting and diarrhea may be noted. Therefore, plant breeders need to develop cultivars, which have less than 20mg per 100g fresh weight of edible part, which is the upper acceptable limit.

Preparation as cash crop for marketing

African eggplants are sources of income generation to families and individuals. Fresh unripe fruits are picked from plants and carried in baskets from farms to market places for retail selling. A retail price for a collection of 10 – 20 fruits of eggplants are sold at Tshs. 100 – 200=.

The fruits intended for whole sales are packed in manila bags of 50 Kg (Kiroba). Rarely packed in wooden boxes too expensive, but these are used for packing tomatoes, since they are more fragile and consumption is more local than “Ngogwe” which are transported and distributed to many near and far places in the country.

Interviews conducted shows that manila bags of 50kg are transported farms to local markets of Tengeru as a “collection and distribution place” from rural farms in Arumeru district (Arusha region). At the market, wholesale price for I “kiroba” full of the fruits is Tshs. 2,000 – 8,000= (-10,000=) (~ U.S $ 8 –10) in Tengeru rural, sub-urban and urban markets. Lorries transport them from Tengeru to elsewhere in the country including, Tanga, Dar –Es –Salaam, Coast region, Morogoro and Zanzibar. Consumptions per week in the markets: Tengeru, over 420 bags, Central and Kilombero, is over 70; elsewhere outside Arusha 350. Consumption in Tengeru is higher than the other markets because it close to the main Dar-Moshi-Arusha-Nairobi road, and so much of it is transported to other markets outside Arusha region. Seeds of eggplants are packed and sold in markets, shops and Horti-Tengeru.

Pest and diseases

“Ngogwe” plants are damaged and yields reduced by the following pest and diseases:

“Red spider mite”

This is a small insect pest which form a film or a thin cushion cover undersides of leaves especially during dry season. The leaves rolls downwards appearing mixed yellow and green colour at the beginning and finally turning copper colour on drying. How to control: Farmers are advised NOT to grow eggplants close to other vegetable crops (okra, tomato, melongene,beans, etc.) which are infested with the pest. Insecticides such as Folimat, Diazion, others including acttellic 50 EC may be used. Frequent irrigation with plenty of water is needed during dry season.

“Fusarium wilt”

This is a disease caused by a fungus, which is found in warm soil. The disease may lower the yields up to 40% (Unpublished document source of the Ministry of Agriculture and Food Security). It also attacks tomato and Irish potatoes. It attacks the inner stem parts such as xylem and phloem, thus blocking transportation of water and food nutrients to circulate within the plant. The toxin from fungus damages the stem-appearing brown, young seedling to rotting and falling down after early growth. Young leaves turn yellow followed by wilting and death of the plant. Control: There is no available treatment or eradication, but farmers are advised to conduct crop rotation period of at least 3 years; avoid bruising young stems and roots during weeding and carry out burning of post-harvest remains of plants from garden or farm.

“Verticillium wilt”

A disease also caused by soil fungus, which can survive there for long time. No available fungicide to eradicate the wilting disease. The fungus causes root knots in roots of eggplants especially during the dry and cold season. The damage may lead to loss up to 60%. The stem appears ash colour due to damage in the inner part, leaves turn yellow, then witling of whole plant and death. Control: No available fungicide for control, but farmers are advised to use good quality seeds, crop rotation and remove all post-harvest remains from farms and gardens. In general, good quality seeds must be evaluated in seed laboratory and recommended for use before they are sold.

CONCLUSIONS

From above presentation the following conclusions can be made:

- The two horticultural important African eggplants, *S. aethiopicum* complex and *S. macrocarpon* are edible as vegetables and also used as food seasoning and so contributing to the food security of the nation.
- Farmers, in local markets all over the country, retail and whole sell business people sell them for cash income generation.
- African eggplants are potential food and cash crop that can improve the livelihoods of families and individuals.
- There is high diversity of edible wild and domesticated species which presenting areas of further taxonomic studies and further breeding program to improve and develop new hybrids or cultivars which are more nutritious and least bitter (or sweet tasting), bigger in size, more number of fruits per cluster, etc.
- Increased reproduction, multiplication and distribution of good quality seeds by Seed Company in collaboration with Horticultural institutions, also enhance popularity or commonness and marketability of African eggplants in the country.
- Sustainable utilization of the wild and domesticated African eggplants species require *in-situ, ex-situ* and *on-farm* conservation.

RECOMMENDATIONS

1. Horticulture institutions and Seed Business organizations working in collaboration are in good position to do the following:
   - To promote certain varieties of African eggplants of high priority in consumption preferences and improvement.
   - To reproduce, multiply and distribute good quality seeds to farmers
   - To meet consumption preference and supply and cash sale market demands
2. These two organizations need to conduct regular survey to their end-users so as to be able to identify from time to time achievements, problems and consumption and market demands.

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PROMOTING COMMUNITY ACTION FOR SUSTAINABLE CONSERVATION AND UTILIZATION OF INDIGENOUS VEGETABLES AMONG SMALLHOLDER FARMERS

Walter Okello **Ogutu**[1], Callistus K.P.O. Ogol[2] and George Isaiah Oduor[1]
1. CAB International, Africa Regional Centre (CABI-ARC), P. O. Box 633-00621, Nairobi, Kenya
2. Department of Zoology, Kenyatta University, P. O. Box 43844, Nairobi, Kenya

ABSTRACT

Indigenous, leafy or traditional vegetables are perishable, low yielding and their value as commercial crops has not been fully exploited. The vegetables play an important role in traditional diets of many Kenyan communities, as they are staple foods, a vital source of vitamins and act as food security diets in most of the farming families. Apart from vitamins they contain proteins and minerals in varying amounts but adequate for normal growth and health. Therefore, these vegetables meet the major protein-calorie nutritional needs especially in children, the elderly and the sick, expectant and lactating mothers. Although some of these vegetables have been domesticated, others occur seasonally or sporadically. In Kenya, just like in other developing countries of the world, most of the indigenous vegetables are produced mainly in kitchen and home gardens. The commonly grown indigenous vegetables include *Solanum nigrum* (Solanaceae), *Gynandropsis gynandra* (Capparaceae) *Commelina* (Commelinaceae) *Corchorus trilocularis* (Tiliaceae), *Crotolaria brevidens* (Pappelionaceae) and *Amaranthus hybridus* (Amaranthaceae) among others. Unfortunately, the consumers have not been sensitized to appreciate the role of the indigenous vegetables in fulfilling their protein-calorie nutritional needs. Again a lot of effort is being invested in promoting the exotic vegetables to produce enough food for the growing population at the expense of indigenous vegetables. Local indigenous ethnic groups have relatively better knowledge of biodiversity of the area, as they are the ones who are more closely related to the various components of biodiversity for livelihoods. However, since their knowledge is not taken into account in the decision-making processes, such knowledge system is being degenerated. Awareness on values of plants appears to encourage local people to search for existing knowledge and revive it for their use. In this paper a participatory action and learning process method is suggested as the way forward for promoting sustainable conservation and utilization of indigenous vegetable. In this method local knowledge is taken as the beginning point and additional external knowledge may then be strategically integrated as further questions to learn arise. Policy options are also suggested which could prompt policy makers and development managers to reassess and give more weight to the neglected production and consumption of indigenous vegetables so as to enhance nutrition, income generation and food security for the small-scale households in the tropics.

INTRODUCTION

Indigenous or leafy or traditional vegetables (IVs) play an important role in traditional diets of many Kenyan communities, as they are staple foods, a vital source of vitamins and also act as food security diets in most of the farm families (Maundu, *et al*., 1999). Apart from vitamins they contain proteins and minerals in varying amounts but adequate for normal growth and health. These vegetables therefore meet the major protein-calorie nutritional needs especially in children, the elderly and the sick, expectant and lactating mothers. Unfortunately, the consumers have not been sensitized to appreciate the role of the indigenous vegetables in fulfilling their protein-calorie nutritional needs. This is because a lot of effort is being invested in promoting the exotic vegetables to produce enough food for the growing population at the expense of indigenous vegetables. These vegetables are perishable, low yielding and their value as commercial crops has not been fully exploited. Local indigenous ethnic groups have relatively better knowledge of indigenous vegetables of the area, as they are the ones who are more closely related to the various components of these vegetables for their livelihoods (Ogol *et al.,* 2002). Although some of these vegetables have been domesticated others occur seasonally or sporadically (Ogol *et al.,* 2002). In Kenya, just like in other developing countries of the world, most of the indigenous vegetables are produced mainly in kitchen and home gardens. Some of the commonly grown indigenous vegetables by the Luo and Suba of Nyanza are shown in table 1.

Conventional models for transferring new methodologies to smallholder farmers in tropical crop production have focused on extension of products, messages or technology packages. This technology transfer model is mostly undertaken by Government extension services or agrochemical companies. In this model, the farmer has usually been considered the passive recipient of external technologies, which he or she is expected to implement. This model usually does not consider local processes or variation; messages are intended to be relevant over large areas. They are therefore simple, for instance "use pesticide A after every 14 days or when pest B reaches a certain level". Although this remains the principal means of extending new methodologies to farmers, this extension model has not worked well in conventional, input-based agricultural systems and, for reasons given above, is not at all appropriate for indigenous vegetable production systems.
Again, farmers often ignore conventional extension messages because these are inappropriate to their local situation. This form of extension often does not increase the farmer's understanding of the crop system or capacity to make decisions beyond following simple instructions. Thus, if what is to be measured cannot be measured, or if the product to be used is not available, then no action can be taken. In such systems, there is also a high risk that external interventions may be so inappropriate to the local situation that they cause even greater problems

Table 1. Some of the IVs known to the Luo and Suba of Nyanza

Scientific name	Family	Luo name	Suba name
Gynandropsis (*Cleome*) *gynadra*	Capparaceae	Dek	Omkenda
Amaranthus hybridus	Amaranthaceae	Omboga	
Solanum spp.	Solanaceae	Osuga	Esiga
Corchorus trilocularis	Tiliaceae	Apoth	
Commelina Africana	Commelinaceae	Odielo	
Crotalaria brevidens	Papilionaceae	Mitoo	
Asystasia schimperi	Acanthaceae	Atipa	Kimarausima
Cucurbita pepo	Cucurbitaceae	Budho	
Capsicum frutescens	Solanaceae	It pilo	

In summary, some of the factors that hinder the transfer of new technologies to the benefit of small scale and resource poor farmers include; a) poor terms of services, lack of facilities or equipments for the extension agents, b) minimum private sector participation or involvement in the model, c) failure to involve the target groups, communities and other potential beneficiaries and even those facing real or imaginary losses, d) donor control or directly or indirectly setting research agenda, e) ineffectively packaging and disseminating of important and relevant information and technologies and f) lack of testing and adapting of already proven systems from other areas

Inadequate policy guidelines

In vegetables and other crops, problems like this have stimulated new approaches to the extension of new methodologies based on what is known simply as the "farmer participatory and learning approach" (Fals-Borda and Rahaman 1991, Malla *et al*., 2000). The main features that differentiate participatory methodologies and the conventional extension system of training and visit are as shown in table 2 below.

Table 2. Main features that differentiate participatory methodologies and the conventional extension system of training and visit.

Aspect or feature	Training and Visit	Participatory
Objectives	Predetermined	Variable, evolving
Training aim	Farmer motivation	Farmer empowerment
Knowledge hierarchy	Scientists-Extension-Farmer	None
What farmers do	Adopt or use	Adapt or modify
Role of research	ICM prescription	ICM options
Role of extension	Deliver messages to farmers	Facilitate farmers
Extension method	Dissemination	Participation
Learning method	Instruction	Discovery

In the absence of much experience with extension in indigenous vegetables production, farmer-participatory systems provides an insight into how awareness creation and production methodologies might be disseminated in a way which satisfies their need to be locally relevant, knowledge-intensive and ecologically-based.
Participatory action and learning process model is based on the learning process where the partners identify issues/problems, make an action plan and initiate action to address the problems, monitor the actions, and then reflect/share results and improve the future actions. The model is presented in figure 1 below.

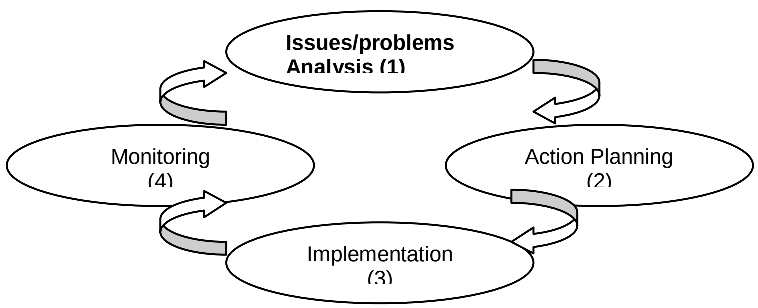

Figure 1: Participatory Action and Learning Process

Participatory methods are carried out through a series of meetings and using a range of participatory methodologies. Farmers, farmer groups, NGOs, religious groups, credit providers, community based groups, small industries, extensionists and scientists. In this model each partner provides specific inputs and at the same time also gains as shown in table 3 below.

The participatory action and learning model used in a given area or project has to be made useful to the user group or local situation, and by documenting the process, attention can be paid to how this can be made applicable to wider contexts. An example of how such a farmer-participatory approach can be developed and the effect it has on smallholder systems has been demonstrated by an Integrated Pest Management (IPM) programme in coffee/vegetable systems in Central Highlands of Kenya (Loevinsohn *et al.* 1998). This programme was well analyzed and has elements of organic production, tree crops and disease management, all relevant to indigenous vegetable production systems in the tropics.
The background for this programme was that the smallholders in the central highlands of Kenya grow cash crops such as coffee in mixed cropping systems with vegetables and increasingly apply pesticides on a calendar basis. The cost of agrochemicals absorbs a large proportion of farmers' income and sometimes pesticides destined for coffee were diverted onto vegetables and other food crops, for which they are not recommended and may pose risks to human health.

Many small-scale farmers in these areas had virtually abandoned their coffee bushes due to low coffee prices and the rise in pesticide costs. Although alternative pest and disease control options exist, there was very little readily available information on IPM and Integrated Crop Management (ICM) which reaches this group of farmers, while many of the non-governmental organizations (NGOs) promoting organic farming focus on kitchen gardens and subsistence crops only.

The approach used in this programme to disseminate methods of pest and soil management was the Farmer Field School (FFS). Each FFS consisted of about 25 farmers from a village who agreed to a programme of season-long training, meeting monthly to weekly for facilitated exercises. Facilitators were farmer training experts from CABI, scientists from Coffee Research Foundation (CRF), and organic farming specialists from Kenya Institute of Organic Farming (KIOF). They organized a season-long training of trainers programme for extensionists who then were the support teams for the farmer field schools. Regular field schools involved three principal activities:

a) Agroecosystem analysis involved farmers in discovering the phenology of their crop and the pests and diseases, which affect it, and helped them to develop skills at observing crops and interpreting their growth and health. On a regular basis, they recorded and shared these observations in groups.

b) Group dynamic exercises, often games or role playing, helped farmers to 'own' technical ideas, such as predator and prey relationships, and created group cohesion.

c) Finally, farmers developed experiments to evaluate in their own fields different new methodologies from outside, as well as existing and indigenous methods for crop production and protection.

Decisions about experimentation were made by farmers' groups, based on their needs, and also on the methods which were important to them. During and following the season-long FFS training, an analysis of the impact of training was made with the help of local socioeconomists and specialists from the International Service for National Agricultural Research (ISNAR). From this analysis, we pulled out a few points of particular relevance to the issue of indigenous vegetable production. Farmers, through their own efforts, gained a strong degree of agroecological literacy. These included an understanding of biological and ecological processes such as life histories and transmission of disease (which helped them to improve their phytosanitary practices), crop compensation for damage, phenology of the crop and its pests, to better time interventions.

FFS farmers realized considerable direct benefits from training, for example they harvested 1.05 kg/tree coffee (average 500 trees/farm of 2-4 ha) as compared to the non-FFS farmers who harvested 0.43 kg/tree. FFS farmers also realized reduced production costs, relying less on purchased inputs and preventative application and more on monitoring crops and making efficient use of local sources of compost, manure and botanical pesticides. At least some farmers also reduced their reliance on hired labour, for instance by doing their own pruning of coffee. Based on conservative estimates cash savings from these changed practices amounted to KSh (Kenyan shillings) 8600 per year ($145/yr) per household. Although some of the IPM and organic methods, such as compost making, were more labour-intensive than agrochemicals, most FFS farmers were convinced of the net benefits. FFS farmers saved an average of KSh 1,052 per household in agrochemical inputs on kales and cabbages and KSh 4,803 in coffee. At the time of the evaluation by ISNAR, 18 months after the finish of the programme, it was revealed that there was a substantial farmer-to-farmer dissemination of new methodologies.

Table 3. The inputs and gains of the various partners in a participatory process

Partner	Input	Gain
Farmer	-Contribute some of their store of traditional knowledge – that of the current generations as well as that of their forebears	-Opportunity to extend their knowledge of new technologies and to pass this on to other farmers -Improved management plans and practices
Government	-Financial support for specialist extension service	-Knowledge generated simultaneously absorbed by state officials -Opportunity to collect information for policy formulation
Civil society (NGOs, religious groups etc.)	-Means of making and maintaining the essential contacts with farmers	-Enhanced status within the communities they serve. -Technical capacity is extended -Receive financial stability
Scientist	-Provide linkage to scientific knowledge -Collect appropriate data and to transform developed technologies into products adapted to farmers needs.	-Opportunity to interact with and learn farmers knowledge, attitudes and practices towards a given production system
Agrochemical companies	-Provide expertise, financial support, distribution of inputs (for example safety kits for spraying, education material) and access to new technology	-Company products are exposed for evaluation to the agricultural community. -Their staff have the opportunity to learn about non-chemical approaches to pest management -Company can also demonstrate in realistic terms its policy of promoting sustainable agricultural practices through the enhancement of for example IPM knowledge

There was considerable spontaneous diffusion of IPM concepts and practices to other farmers, either relatives, friends or neighbours. On average, FFS farmers interviewed had shared their learning with four other farmers, who in turn implemented one or two of the ideas and methods passed on from FFS farmers.

Finally, farmers became active innovators and experimenters. In the year following training, FFS farmers developed new ideas and methods than non-FFS farmers. Facilitators from the CRF, who were initially unwilling to work with farmers because they were not following national guidelines on coffee production, e.g. by intercropping, soon gained respect and ultimately enthusiasm for the participatory approach, because trained farmers were willing and interested to test disease-resistant germplasm which the institute had previously failed to encourage farmers to take up.

Following the FFS period, farmers and researchers continued to experiment together. A group of organic tomato farmers developed a joint research activity to look at seedbed improvement, testing pesticides, burning of crop residues, and local botanical preparations and milk for disease and insect suppression. Some local preparations proved as effective and less expensive than pesticides, and their adoption reduced production costs for farmers.

Another example of a successful participatory model in Kenya, is the FFS for Kenyan Dairy Farmers in the Central and Rift Valley Provinces, whose main objective was to develop farmers learning skills, rather than to increase knowledge on a particular technical issue. Record keeping and accurate observation were important components of this model. Agro-ecosystem analysis was designed to improve observation skills and to develop decision-making skills, and this technique was utilized to record and observe the results of tick-borne diseases (TBD) experiments. This observation process formed the basis for understanding the interactions between livestock and other elements of the ecosystem, as they relate to the problem or technology being studied. For example, where the subject was expected to have a direct outcome on the animal, such as a feeding or health management practice, the AESA was focused on the animal (Minjauw, *et al.,* 2003)

Other participatory approaches and their relevance to organic indigenous vegetable production

These results are typical of FFS programmes in a range of crops such as exotic vegetables, rice and cotton, but application of this method to indigenous vegetables has been limited. Currently, over 1000 Farmer Field Schools (FFS) on integrated pest management (IPM) and/or integrated soil management are being successfully implemented in Kenya. Apart from FFS approaches other participatory methods available include Local Agricultural Research Committees (CIALs) and the *Campesino a Campesino* programme based. These methods resemble FFS approach on the common principles of discovery learning, group experimentation and community action. For example, CIAL farmer members in Latin America are conducting location-specific research on agronomic and natural resource management problems in maize, beans and potato, with an emphasis on appropriate varieties and management practices. In the area of soil fertility and conservation, discovery learning and group study tools are used in Zimbabwe and Australia to help farmers understand soil biophysics and the causes and effects of erosion.

Beyond its general applicability, the specific detail of farmer-participatory IPM models is relevant to organic production, in that it has developed discovery-learning curricula for understanding soil and pest ecology and alternatives to fertilizer and pesticide use, including disease control, clean germplasm, the use of resistant varieties, intercropping and composting.

One feature of indigenous vegetables and other tropical crops is the diversity of production systems, which range from smallholders to large plantations. Are farmer-participatory methodologies for dissemination relevant only to smallholder systems? To answer this, consider that there are three players of importance in an organic production system, as in an IPM system: the farmer, the local expert and a technology provider. The local expert is critical, because of the need to develop production and protection systems based on local processes and local knowledge, and to adapt technology from the technology provider to the local conditions. For the smallholder system, in the absence of effective local extension services, the farmer-participatory approach has focused on making the farmer the local expert, as there is no one else.

CONCLUSION

In summary indigenous vegetables are important sources of household food and make a substantial, though really appreciated contribution to the food security and medicine of the rural communities in Kenya. Therefore extensive awareness building and capacity development about their importance as a nutritionally balanced food, source of medicine and as a direct and indirect source of income, particularly for the resource poor families, must be included in the national development plan and agricultural policy. Participatory approach methodologies provide a realistic tool through which such information dissemination and technology development can be achieved.

Policy makers and development managers should consider the following issues for the reassessment and enhancement of the conservation and utilization of neglected production and consumption of indigenous vegetables. Some of the issues, which could be considered among others, include:

- A need to concertedly continue inventorying local indigenous vegetables their use and conservation status.
- Planning and execution of community based participatory approach towards wise and sustainable use and conservation of indigenous vegetables.
- Establish seed bulking units with a continuous planting regime in designated areas (alternating) at both household or community level, with access to such resource base controlled for sustainable utilization and conservation

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A SURVEY ON PRODUCTION AND CONSUMPTION OF TRADITIONAL LEAFY VEGETABLES IN ARUSHA REGION, TANZANIA

By;

Elvania Bujulu[1] and Matee J.J. [2]

Tropical Pesticides Research Institute

P.O. Box 3024, Arusha, Tanzania

E-mail: tpri@habari.co.tz

[1]E-mail: **elbujulu@yahoo.co.uk**; [2]E-mail: jjmatee@yahoo.com

ABSTRACT:

Traditional leafy vegetables have an important role in household nutrition in Arusha Region, Tanzania. They are rich source of essential minerals and vitamins, and secondary source of proteins. Furthermore, they are produced and marketed both in rural and urban areas for consumption and income generation. Traditional leafy vegetables are becoming more important within rural and urban home gardens as a pleasant way of exercising and economizing on food cost. As a result, a study was conducted with the main objective of determining the production and utilization of Traditional Leafy Vegetables species in Arusha Region, Tanzania. Using participatory interviews, twenty different people were interviewed in Central and Kilombero markets (Arusha town), production areas in Usa-River (Tengeru) and two Research Institutes: Horticultural Research Training Institute - (HORTI) Tengeru and Asian Vegetable Research and Development Centre - Southern Africa Development Coorporation - (AVRDC - SADC). Up to eight (8) traditional leafy vegetables were identified which included Black nightshade - *Solanum nigram*. Sweet potatoes, *Ipomoea batatus,* Cowpea - V*igna unguiculata,* Amaranth - *Amaranth* spp. Pumpkin leaves - *Cucurbita moschata*, Spider plant - *Cleome gynandra*, Ethiopian spinach *Brassica carrinata* and Watercress - *Nasturtium officinale.* Five (5) species: *Solanum nigram, Vigna unguiculata, Amaranthus*, *Ipomea batatus and Nasturtium officinale* were highly preferred because they are easy to cultivate, drought resistant, mature early, easy to cook, palatable and have high demand. Problems associated with the production of these traditional leafy vegetables include: low production knowledge, poor marketing, and unavailability of reliable seed, pests and diseases.

INTRODUCTION

Tanzania is a large country with an estimated area of 884,000m², divided into twenty six (26) regions. Arusha region with cool weather is bounded by Kenya to the north. Arusha region is one of the beneficiaries of horticultural crop production knowledge and modern techniques from Research Institutes situated in Arumeru district, Arusha. These are the Asian Vegetable Research Institute – Southern Africa Development Co-operation (AVRDC - SADC), Horticultural Research and Training Institute (HORTI - Tengeru) and Tropical Pesticides Research Institute (TPRI). The research activities conducted by above institutes are gradually transmitted to small-scale horticultural crop growers through their technical service staff. The knowledge is enhancing more production and income generation to the small scale farmers. According to FAO (1988), Traditional Vegetables are all in the category of plants whose leaves, fruits or roots are acceptable for use as vegetables. They are widely consumed all over the world. It is estimated that there are at least 10,000 plant species used as vegetable world wide although only about 50 are of great commercial value. Researchers in Sub-saharan Africa have listed and given an account of many Traditional Vegetables species (Getaham, 1974; Tallantive and Goode, 1997 and 1980; Flenvet, 1979; Chweya, 1985; Ogle and Grivetti, 1985; FAO 1988; Juma, 1989; Ogle *et. al.* 1990; Mnzava, 1997; Guarino, 1997; Schippers and Bud, 1997.

IMPORTANCE OF TLV's IN ARUSHA REGION, TANZANIA

Traditional leafy vegetables have an important role in household nutrition in Arusha Region, Tanzania. They are a rich source of essential minerals and vitamins and a secondary source of proteins. Furthermore, they are produced and marketed both in rural and urban areas for consumption and income generation. Traditional leafy vegetables are becoming more important within rural and urban home gardens as a pleasant way of exercising, economizing on food cost and a source of income to subsidize the family budget. As a result of this, a study was conducted with the main objective of determining the production and utilization of Traditional Leafy Vegetable species in Arusha Region, Tanzania.

OBJECTIVE

The objective of the study was to determine the production and utilization of Traditional Leafy Vegetable species in Arusha Region Tanzania.

MATERIALS AND METHODS

Using participatory interviews, twenty (20) different people were interviewed in Central and Kilombero markets in Arusha town, production areas in Usa-River, (Tengeru) - Arusha, and two Research Institutes: Asian Vegetables Research and Development Centre (AVRDC-SADC) Tengeru and Horticultural Research Training Institute (HORTI - Tengeru) (Table 1.)

Table 1. Production areas, markets and institutions selected for the Survey of Traditional leafy vegetables in Arusha Region.

PRODUCTION AREAS	MARKETS	RESEARCH INSTITUTES
Tengeru - Arusha	Central market	HORTI - Tengeru, Arusha
Usa River - Arusha	Kilombero market	Tengeru AVRDC – SADC
Arusha town		

RESULTS

Up to eight (8) traditional leafy vegetables were identified which included Black nightshade - *Solanum nigram*. Sweet potatoe leaves, Ipomoea *batatus,* Cowpea leaves - V*igna unguiculata,* Amaranth - *Amaranth* spp. Pumpkin leaves - *Cucurbita moschata*, Spider plant - *Cleome gynandra* and Watercress – *Nasturtium officinale* and Ethiopian cabbage – *Brassica carinata*. About five (5) of them were highly produced, consumed and demanded in the markets by Arusha families. These include; *Solanum nigram*, *Amaranthus* spp, *Vigna unguiculata*, *Ipomea batatus* and *Nasturtium officinale* (Table 2). The main factors contributing to increased production/cultivation of the above-mentioned species in order of importance include: (Table 3).

- Good taste e.g. *Solanum nigram* and *Vigna unguiculata*
- Very easy to preserve e.g. *Vigna unguiculata* and *Ipomea batatus.*

- Early maturing e.g. *Amaranthus* spp and *Nasturtium officinale*.
- Increased market demand e.g. *Solanum nigram, Vigna unguiculata* and *Amaranthus* spp.
- Drought resistant and hence grown for food security.
- High yield e.g. *Amaranthus* spp.
- Easily available (most traditional vegetables).

Table 2: Rank of species after surveys against the criteria

No.	Species	Criteria and Rank					
		1	2	3	4	5	
		Taste	**Traditional Dish.**	**High Market Value**	**Availability**	**Cooked in many dishes**	**Total Score**
1	*Solanum nigram*	1	1	1	1	1	5
2	*Amaranthus* spp.	1	1	2	2	2	8
3	*Nasturtium officinale*	2	3	1	2	1	9
4	Ipomea batatas	2	1	2	2	2	9
5	*Vigna unguiculata*	1	1	2	2	3	9
6	*Cucurbita moschata*	2	1	2	3	3	11
7	*Cleome gynandra L.*	2	2	3	3	3	13
8	*Brassica carrinata*	2	3	3	3	3	14

Table 3: Preparations, uses, preference and nutritional values of Traditional Leafy Vegetable species (TLV's) in Arusha.

Species	Preparation and Use	Taste and Preference	Nutritional Value
Solanum nigram	Boiled or fried in sunflower cooking oil with tomatoes	Highly preferred and very marketable	Vit. A & C, Calcium, Iron
Amaranthus spp.	Leaves are chopped, boiled or fried and used as side vegetables	Highly preferred and marketable	Vit. A & C, Protein, Starch, Calcium, Fibre
Nasturtium officinale	Cooked in soap with meat Boiled of fried	Preferred but low in production	Vit. A & C, Calcium, Iron
Ipomea batatas	Fried in cooking oil after sundrying for about 12 hrs.	Preferred and marketable	Vit. A. & C, Calcium, Iron
Vigna unguiculata	Young fresh or dried leaves boiled or fried in cooking oil.	Preferred and marketable	Vit. A & C, Calcium (ca), Iron (Fe)
Cucurbita moschata	Boiled and mixed with groundnuts or coconuts milk, Cooked in soup with meat.	Preferred but low in production.	Vit. A & C, Calcium, Iron
Cleome gynandra L.	Cooked in soup with meat Boiled or fried	Preferred but not sold in the markets.	Vit. A & C, Calcium (ca), Protein
Brassica carrinata	Boiled or fried in cooking oil.	Preferred but low production.	Protein

During this study, interviewees in production areas and in markets also mentioned several constraints as the factors of decreasing production and consumption of the three species namely; *Brassica carrinata*, *Cleome gynandra* L. and *Cucurbita moschata*. Constraints mentioned include:

- Low market value
- Poor taste e.g. *Cleome gynandra* L. (bitter).
- Low yield.
- Long preparation process e.g. *Cleome gynandra* L.
- Lack of seeds.

PRODUCTION

In Arusha Region, Tanzania main Traditional Leafy Vegetables are grown in homesteads and commercial gardens, which are fields of, specialized production areas, outskirt of urban areas, rural areas and home gardens. Most of the species are only available locally during the long rains or short rains, the rest grow wildly.

Watercress is locally known as Saladi, a traditional leafy vegetable though it seems as exotic. During dry spells farmers greatly produce watercress along rivers, streams and permanent ponds. It is highly produced in Arusha Region because of its many rivers flowing from the slopes of Mt. Meru hence cool climate. In Arusha, people prefer the above leafy vegetable because they are easy to cultivate, drought resistant and of early maturity.

Production venture on TLV's vary in farm size, amount of investment put in production methods employed, and economic role. The commonest systems are either market or for home consumption. Its main purpose is to provide a supplementary source of essential nutrients for the family diet.

Raising vegetables in a *home garden is a pleasant way of exercising and economizing on food cost.* Traditional leafy vegetables are easily grown without too much care with practically no cash expenses. Kitchen refuse and droppings of small livestock are utilized as fertilizers/compost manure. Seeds and cuttings are used in propagation of most of the leafy vegetables.

PREPARATION BEFORE COOKING

The young leaves of TLV are usually sandy so they have to be washed before cooking. Preparation mainly involves boiling although there are variations in actual recipes. The boiling could be for 15 - 20 min. depending on the species. In some cases, as for bitter vegetables they need to be washed once after boiling to remove the bitter taste and then cooked. During cooking the vegetable require constant stirring. In urban areas the leaves can be fried using oil, mixed with tomatoes, coconut milk and groundnuts to make them more palatable.

CONSUMPTION

TLVs are rich source of essential minerals and vitamins (Table 3). They are also a secondary source of proteins and can be eaten with staples as main course or as supplement food in cooked or raw form. They also form a variety of the diet and make meals more appetizing. They also give more flavour, better appearance and zest to dishes. Young leaves are mostly preferred for consumption.

HARVESTING

Harvesting is mostly done by women and children. Young tender leaves are picked from the plant by hand throughout the growing period. In some cases, however, whole plants are uprooted or desired branches are cut. Vegetables growing in the wild are harvested by uprooting the whole plant and later on the leaves are pulled off at home, their seeds are thrown around the compound, later grow and form future source of seeds.

MARKETING

Traditional Leafy Vegetables are exported from areas where they are grown easily and cheaply to neighbouring areas where they are preferred but cannot be grown in adequate amounts. They are more efficient converters of farm resources than other crops in terms of yield since they grow very fast. Growers especially women tend to earn cash for minor home requirements as most of the TLVs are grown on a very small scale where small quantities are taken to the market.

PRESERVATION

Most of TLVs can be dried and stored for future use, but this practise greatly reduces the crop's nutritional value. Processing for future storage is common in Tanzania but done in different ways. TLVs can be dried uncooked. Tender leaves are picked and a bit clashed by hand or cut in to small pieces by knife and sun dried. Processing for preservation for a long period involves steam boiling by wrapping in a clean white material and immersed in salted boiling water for about 5 minutes. After boiling the vegetables are sieved, opening the material and sun dried on a clean flat container for about two (2) days. Vegetables are usually stored in containers in a well-ventilated place. Such produce can be stored for over a year.

DISCUSSIONS

The first five mostly produced, preferred and marketable TLV's were: (Table 2.)

1.	*Solanum nigram*	-	5
2.	*Amaranthus* spp	-	8
3.	*Vigna unguiculata*	-	9
4.	*Ipomea batatus*	-	9
5.	*Nasturtium officinale*	-	*9*

They ranked first because of good taste, preference, availability and high market value.

RESEARCH ON TRADITIONAL LEAFY VEGETABLES

TLVs serve as supplements to the normal food resources and are well adapted to the marginal soils and erratic rainfall often experienced in Tanzania especially in Arusha Region. Most of the TLVs have been identified as having potential for commercial exploitation and production for human consumption.(Taylor and Moss 1982). Recently, there has been a deliberate effort to identify the role of the indigenous under utilized plants in national food dynamics and how they can be mainstreamed into the country's agriculture. Initially the work on uncultivated plants has concentrated on developing the utilization and processing of these plants. Research on TLVs is still at an early stage and need more advocacies on their utilization.

RECOMMENDATIONS

- There should be an awareness campaign about the value of the indigenous vegetables in the form of advertisements and education as is done with exotic vegetables.
- Nutritional studies of all indigenous vegetables should be done, investigations have to be carried out to determine the effect of over cooking for preservation and preparation for eating and on nutritional quality.
- Gatherers and harvesters should be taught on the best ways of preservation to avoid overcooking.
- Farmers should be taught the best ways of using organic farming against diseases and insects.
- Marketing strategies through research institutions linked by extension officers to farmers should be developed.
- Data on sales could be accompanied by proper record keeping.
- Seeds should be collected and deposited with the gene bank for preservation and breeding.
- Farmers should be educated on how to propagate and domesticate the vegetables also to be assisted in modern technologies.

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AFRICAN INDIGENOUS VEGETABLES RECIPE DOCUMENTATION AND THEIR ROLE IN FOOD SECURITY.

Musotsi, A.A, A.J. Sigot and M. O. Abukutsa Onyango
Maseno University

ABSTRACT

Food security has been an issue of concern in many parts of the developing world. Food consumption among traditional African societies has undergone many changes since pre-colonial days, these being brought about mainly by interaction with other cultures. Leafy and fruit vegetables form a part of the traditional diets of agricultural communities. About 200 indigenous plant species are used as leafy vegetables in Kenya. The variety of species used as a vegetable, the diversity within the species and the knowledge about their utilization is currently on the decline among many communities. The survey on collection and standardization of recipes of priority leafy vegetables in western Kenya was carried out in Butere, Lurambi and Khwisero divisions of Butere-Mumias district. The broad objective was to collect recipes of African leafy vegetables (ALVs) in western Kenya, while specific objectives were to: determine the types of ALVs used within the community, establish methods of procuring ALVs and establish the existing methods of preparing and cooking ALVs. A study population of 40 respondents was selected purposively. Data was gathered using panel group discussions, an interview schedule and an observation checklist. Results showed that there were varieties of ALVs within the community. These were mainly produced locally in home gardens. A number of recipes were collected and standardized. These findings will be useful to rural communities; the government and non-governmental organizations that are proponents of food security and also the data will contribute to the general body of knowledge.

INTRODUCTION

Background

Food is a basic need of life. While developed countries exhibit high technological advancement in food production, gardening remains the most important method of food production for majority of the people in developing countries. The World Food Summit (WFS) and the Food and Agriculture Organization (FAO) of the United Nations (UN) reaffirmed in 1996 the right of everyone to have access to safe and nutritious food, consistent with the right to have adequate food and the fundamental right of everyone to be free from hunger (Eide, 1999). This right had been proclaimed in 1948 by the General Assembly, through the adoption of the Universal Declaration of Human Rights. Nevertheless, hunger continues to be widespread and the right of everyone to adequate food is extensively violated. This shows a wide gap between rights and reality. Kenya has been experiencing a decline in food production since the late 80's, while the population growth rate has been increasing. Further, many African countries have suffered steep devaluation of their currencies in the recent years, making imported foods or foods grown with external inputs more costly (Chweya & Eyzaguirre, 1999). The result has been a dramatic decline in the nutritional well being of populations. According to Oniang'o (2001), over 89% Kenyans are food poor, which means they are not adequately nourished. Chweya & Eyzaguirre, (1999) noted that African Indigenous vegetables are crucial to food security particularly during famines and natural disasters. The plants grow as weeds in the wild and/or cultivated areas, are semi-cultivated or cultivated. Maundu et. al. (1999) have argued the need to domesticate these vegetables. If domesticated, they are the crops that require few inputs. Most of these vegetables are compatible in use with starchy staples and represent cheap but quality nutrition for the populations in both urban and rural areas. The vegetables are a valuable source of vitamins (A, B-complex and C), minerals (iron and phosphorus), carbohydrates, protein and fiber (Mnzava 1997).

Statement of the problem

Though over 200 species of African Indigenous Vegetables have been identified in Kenya, very few are in use today. It has been argued that these vegetables have been neglected owing to cultural changes and urbanization (Chweya & Eyzaguirre, 1999). Many traditional vegetables are associated with poor rural lifestyles and low status. The decline in production, consumption and diversity of African vegetables may have negative impacts on the nutritional status of households and probably their income as well. This survey, therefore, was done to collect, for the purpose of documenting the existing species and recipes of African vegetables, so as to avoid further loss of biodiversity and indigenous knowledge.

Broad objective of the study

- To collect recipes of African leafy vegetables (ALVs) in western Kenya.

Specific objectives

- Determine the types of ALVs used within the community,
- Establish methods of procuring ALVs and
- Establish the existing methods of preparing and cooking ALVs.

RESEARCH METHODS

Research Design

The descriptive survey design was used in the study in order to measure the observable characteristics of the population. Experimentation was used to obtain the standardized recipes of the African vegetables.

Area and time of study

The study was carried out in Butere-Mumias district of western Kenya between January and March 2002. The divisions involved were Butere, Lurambi and Khwisero divisions. This district is dissected by a number of streams and rivers, giving it ample surface water resources. This, combined with good climate and underlying rock often gives a high potential for agriculture (Butere-Mumias District Development Plan, 2001-2006).

Population sampling and data collection
The target population were the women groups affiliated to Rural Outreach Program, a non-governmental organization that promotes agriculture and nutrition among the rural communities. Purposive sampling was used to select four groups. Panel group discussions, directed by the researcher were conducted with each group independently. From each group, a sample of ten members was randomly drawn, to whom an interview schedule and observation checklist were administered. Also, wherever found, secondary data sources were used to supplement primary data.

Data analysis
The following methods were used:

- Qualitative analysis where general statements were made about the findings.
- Quantitative analysis where descriptive statistics were used.
- Experimentation done to standardize the recipes.

RESULTS
Types of ALVs

Results revealed that there were various types of African indigenous vegetables in use today. The following types of African vegetables were identified to have been in use with the community.

TYPE OF VEGETABLES

English name	Local name
Amaranth	Tsimboka, litoto, libokoi)
Bitter leaf	Miro
Spider plant	Tsisaka
Black nightshade	Isutsa
Pumpkin leaves	Lisebebe (liro)
Cow pea leaves	Likhubi
Local kale	Kanzira
Jute leaves	Murere
African vine spinach	Nderema

Methods of vegetable procurement
Four methods of African vegetables procurement were identified:

- Local production from home gardens. This was the most popular method, with 100% respondents having African vegetables in their home gardens. This could be attributed to the promotion extension of these vegetables being done by the Rural Outreach Program.
- Buying: A negligible size of the research population indicated that they buy vegetables either from the market or from their neighbors who have surpluses. This method was not popular among the respondents.
- Exchanging: This method proved to be valuable to a significant number of respondents who argued that one cannot have all types of vegetables in the gardens at the same time. This argument holds true, owing to the small land sizes available to the households in the district (Butere-Mumias District Development Plan, 2001-2006).
- Gathering: The method was in use among all interviewees, except that it is not reliable. This could be explained by the fact that there is very little fallow and forest lands available in the district.

Existing methods of preparing and cooking African vegetables
The rationale behind the cooking of African vegetables is to improve the bioavailability of nutrients and destroy aflatoxins, which may cause poisoning. The main methods of cooking African vegetables involve boiling in unspecified amounts of water, or some form of wet heating. This may contribute to nutrient loss. Most of the micronutrients, especially vitamins, are heat-sensitive and/or can be oxidized easily. Their levels, therefore, become reduced in preparation. Further, additives such as bicarbonate of soda destroys vitamins. Consequently, methods of preparing ALVs had to be standardized in order to ameliorate the above limitations.

Findings from the indigenous knowledge survey on recipes recommend the use of pots rather than pans for cooking, as pots retain heat and give better simmering effects. Also, the covering of the cooking pot was preceded by sealing it completely with banana leaves. This would help to retain steam, which escapes with some volatile nutrients and the aroma. Results also showed that the recipes were based on a mixture of

vegetables whose different nutrient components would complement one another. After the vegetables are simmered, there would be some additives such as milk, cream, ghee, groundnut sauce or simsim sauce. These were not only to make the vegetables palatable, but also to improve the nutrient quality. Today's methods of preparing African vegetables deviate from the above recommendations, thus the fear of nutrient loss.

The following are recipes collected and standardized.

RECIPE COLLECTION AND STANDARDIZATION

VEGETABLE	RATIO	METHOD OF PREPARATION	VARIATION
Omusundulu **Amaranth** CROTOLARIA SPIDER PLANT Black nightshade Pumpkin leaves Water Salt Milk	 250g (1 large bunch) 1000g (4 large bunches) 500g (2 large bunches) 500g (2 large bunches) 1000g (4 large bunches) 1000 c.c.(4 cups) to taste 450 c.c. (2 cups)	Prepare the leaves Wash the leaves Cut the pumpkin leaves Heat water and add vegetables. Cover vegetables Simmer vegetables for about 45 minutes Add salt and milk Cook for another 10 minutes Vegetables are ready to serve.	Omit pumpkin leaves
Atwaka **Amaranth** Cowpea leaves Local kale Water Salt Milk	 250g (1 bunch) 1000g (4 bunches) 1000g (4 bunches) 1000c.c. (4 cups) to taste 225 c.c. (1 cup)	Pluck the vegetables Wash vegetables separately. Remove stalks from kale Cut the kale Mix all the vegetables Boil water in a pot/pan Add vegetables and cover Simmer for about 30 minutes Add salt and milk Cook for another 10 minutes Vegetables are ready to serve.	
Amaranth mixed with Crotolaria AMARANTH CROTOLARIA Decanted salt Water Salt Fresh milk/ ghee	 250g (1 bunch) 500g (2 bunches) 56 c.c. (¼ cup) 450 c.c. (2 cups) to taste (225 c.c.) 1(cup)/ 1 tablespoon	Prepare the leaves Wash the leaves Warm the water Add decanted salt Let the water boil, then add vegetables Cover the vegetables Simmer for 5-7 minutes Turn the leaves and continue boiling for another 8 minutes Add salt and fresh milk or ghee. Stir the vegetables, boil for another 5 minutes. The vegetables are ready to serve.	Substitute for Crotolaria: Cow-pea leaves Pumpkin leaves
Amaranth mixed with spider plant Amaranth Spider plant Water Salt (optional) Sour milk/ ghee	 250g (1 large bunch) 250g (1 large bunch) 675 c.c. (3 cups) 225c.c. (1cup) / 1 tablespoon	Pluck the leaves Wash and drain the vegetables Heat water in a pot/pan Add vegetables to the water Cover the vegetables with banana leaves, then a lid. Simmer slowly for about 40 minutes. Remove vegetables from the fire and turn them. Mash the vegetables.	Substitute for spider plant: Black nightshade

		Add sour milk/ ghee and cook for another 5 minutes Vegetables ready to serve.	
Local kale mixed with amaranth Local kale Amaranth Water Cooking fat Spring onion Tomato Salt	 200g 100g 335 c.c. (11/2 cups) 1 teaspoon 2 leaves 1 medium to taste	Prepare the amaranth leaves Remove stalks of the local kale Wash the vegetables separately and drain Cut the kale Heat water Put in the vegetable mixture Simmer for about 15 minutes Remove from fire Cut the onion and tomato Heat fat in a separate pan Add onion and fry until golden brown Add tomato and cook until tender Add vegetables and cook for 5 minutes. Vegetables ready to serve.	Add fresh milk
Lipoka *Cowpea leaves* *Amaranth* *Salt* *Water*	 200g (1 bunch) 200g (1 bunch) to taste 675 c.c. (3 cups)	Prepare the leaves Wash the leaves Heat water in a pot/ pan Mix vegetables with salt on a tray Add vegetables to the boiling water Cover with banana leaves then lid Simmer for 25-30 minutes Vegetables are ready to serve.	
Murere **COWPEA LEAVES** Jute leaves Decanted salt Water Milk/ghee	 200g 100g 28 c.c. (1/8 cup) 450c.c. (2 cups) 225 c.c. (1 cup) /1tablespoon	Pluck the vegetables Wash and drain Heat water Add decanted salt Add vegetables and simmer for 15-20 minutes Keep turning the vegetables with a cooking stick as you boil Add milk/ ghee Cook for another 5 minutes Vegetables are ready to serve.	Substitute for Cowpea leaves: Crotalaria Fry with cooking fat and spring onion.
Eshikangulu **COWPEA LEAVES** Decanted salt Water Salt Milk/ ghee	 200g (1 bunch) 56 c.c. (¼ cup) 225 c.c. (1 cup) to taste 115 c.c. (½ cup) / 1 teaspoon	Pluck the vegetables while removing the fibrous parts Wash and drain Heat water and decanted salt Add the vegetables and cover with a lid Simmer for about 20 minutes. Add fresh milk/ ghee. Cook for another 5 minutes Vegetables are ready to serve	Crotalaria plain can also be prepared in the same way. Fry with cooking fat, onion and tomato.

Nderema **COWPEA LEAVES** **NDEREMA LEAVES** **WATER** **DECANTED SALT** **MILK/ GHEE** ***Salt***	 200g (1 bunch) 200g (1 bunch) 225 c.c. (1 cup) 56 c.c. (¼ cup) 225 c.c. (1 cup) / 1 tablespoon to taste	Prepare the leaves Wash and cut. Heat water, add decanted salt Add vegetables Simmer for 15 minutes Add milk/ ghee Cook for 5 more minutes Vegetables are ready to serve.	Substitute for Cowpea leaves: Amaranth Fry with cooking fat and spring onion
NDEREMA MIXED WITH AMARANTH AND BLACK NIGHTSHADE Nderema leaves Amaranth Black nightshade **WATER** **MILK/ GHEE**	 100g 100g 200g 562 c.c. (21/2 cups) 225 c.c. (1 cup)/ 1 tablespoon	Prepare the leaves Wash separately Cut the Nderema leaves Mix the vegetables Heat water Add the vegetables and cover Simmer for 20 minutes and turn with a cooking stick Boil for 15 minutes Add milk or ghee Cook for another 10 minutes Vegetables are ready to serve.	

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

This study was done to survey and establish the existing African vegetables and the methods of preparation and cooking. Results showed that in Butere-Mumias district, there were a number of African vegetable species existing and being consumed. The methods of procuring these vegetables included production from home gardens, buying, exchanging and gathering. Existing recipes were also collected and standardized.

CONCLUSION

From the findings of this survey, it is evident that the number of species of African vegetables existing in Butere-Mumias has declined. Those identified are far below the total number of species existing countrywide. However, due to campaigns by some stakeholders for African vegetables within the districts, production and diversity trends are expected to improve. The methods of procurement of these vegetables are diverse, hence giving households an opportunity to access them relatively easily. The recipe collection survey revealed that there is a wide range of knowledge on the cooking of African vegetables, which needs to be collected and safeguarded for future generations. The methods of preparation of African vegetables today are more or less hurried up and do not maximize the opportunities to make them more nutritious and safe to the human body.

Recommendations

In the light of various findings that have emerged from the study, the following are recommended:

- That the campaign for production and consumption of African vegetables should be enhanced. This can be done through agricultural research and extension.
- The government, through the Ministry Of Social Services should encourage formation and membership of people to social groups through which such campaigns for food security can be done. This has proved an effective way.
- Households should be encouraged to domesticate existing species of African vegetables in order to avoid genetic loss.
- Some households and groups who have already undertaken the production of African vegetables and are having surpluses should be assisted to find market for them.

Suggestions for further research

There is need to carry out studies on the following:

- Ways of reducing on cooking time so as to make the methods less cumbersome and also keep nutrient loss to the minimum.

- The composition and effect of decanted/traditional salt on nutritive value of vegetables. This would help to compare with the effect of bicarbonate of soda.
- Nutritive value of the vegetables, especially after cooking should be studied.

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POTENTIAL FOR INCREASED USE OF INDIGENOUS KENYAN VEGETABLES AS FUNCTIONAL FOODS

Makokha A.O. and Ombwara F.
Jomo Kenyatta University of Agriculture and Technology,
P.O. Box 62000, Nairobi.
E-mail: anmakokha@yahoo.com

ABSTRACT

Indigenous Kenyan vegetables are widely consumed among Kenyan communities. They make an important nutritional contribution to the diet of these communities. In this context, they mainly supply vitamins and minerals. However, their nutritional value as a source of vitamins is limited by the fact that they have to be boiled for a relatively long time during preparation. This boiling reduces the content of heat sensitive vitamins, particularly Vitamin C. The mineral availability from these vegetables may also be constrained by the occurrence of mineral binding anti-nutritional factors such as phytates in these vegetables. These factors bind important dietary minerals, including iron and zinc. The indigenous vegetables are also extensively used as functional foods in Kenya, with alleged health benefits that cannot directly be attributed to their nutrient content. Studies elsewhere have identified a number of functional factors in vegetables.. There is probability that some of the functions may be due to antioxidants, as these have been found to be the source of functional properties in other vegetables. The relatively high fibre content in these vegetables may be another source of functional factors, such as active sterols and phytoestrogens. Some of the vegetables may even possess anti-microbial components, while others could contain immune boosting factors. Some of the vegetables have high catechin content. Catechins were previously regarded as anti-nutrients, but are now considered important functional factors. Elsewhere, technology has been developed to incorporate the functional factors into other popular processed foods. There is therefore the potential that even in Kenya, functional factors in the vegetables could be extracted and incorporated in other processed foods. There is therefore need to identify the functional factors through which these vegetables confer their alleged functional benefits, and develop a strategy of expanding the use of these vegetables as functional foods. As is the case in some other countries, these vegetables could turn out to be more important as functional foods, rather than as nutrient sources.

INTRODUCTION

Indigenous vegetables are widely used as food in Kenya. They constitute part of the staple diet of many Kenyan communities. Over 250 traditional leafy vegetables are used in the country (Maundu *et al*., 1993). Some of the species are cultivated while many are still growing wild. Analysis of the fresh leaves has revealed that these vegetables are a good source of micronutrients – vitamins and minerals. They specifically contain relatively high amounts of beta-carotene, the precursor of vitamin A and vitamin C (Chweya, 1994). They also contain modest levels of minerals, such as iron and calcium. On the other hand, they generally contain low levels of macro-nutrients – proteins and lipids. One reason for this is their high content of water, 80 – 90% (FAO, 1995). Chweya (1994) reported a protein level ranging from 0.8 to 5.5 g/100 g fresh leaves of nine species of traditional leafy vegetables commonly eaten in Kenya. The fat content is generally below 0.5% (FAO, 1995). The vegetables are also low in energy (calories), since they contain very low levels of starch and sugars. Most of their carbohydrates are in the form of dietary fibre, which is not easily metabolized into energy in man (Belitz and Grosch, 1999).

Limitations as a nutrient source

In terms of provision of nutrients, the indigenous vegetables are therefore important mainly as a source of some vitamins and minerals. It is noted, however, that most of the data available about the content of these nutrients is in the fresh leaves. The actual amount of nutrients available to the human body may be much lower after preparation and cooking of these vegetables. Most of these vegetables have to be cooked for a relatively long period of time before they are consumed. Makokha and Kebenei (2001) reported a loss of between 57% and 78% of vitamin C after 30 minutes of cooking. There can be a maximum cooking loss of up to 100% in the case of vitamin C and folic acid (Ihekoronye and Ngoddy, 1995). These vegetables are rarely used in salad form, which would conserve such vitamins. For the case of vitamin A, there is a low conversion factor of beta-carotene to retinol equivalent, the form in which vitamin A is utilized in man. This conversion ratio from beta-carotene to retinal equivalent is more than six to one (ILSI, 1990). Additionally fat is required in the diet to enhance absorption and bio-availability of the beta-carotene. In the case of minerals, plant foods including vegetables generally contain relatively high amounts of compounds which bind them, such as phytates and tannins (Makokha et al., 2002; Gibson and Ferguson, 1999). The bio-availability of mineral nutrients such as iron and zinc from indigenous vegetables may therefore generally be low, even when absolute mineral content is high. The bio-availabile nutrient is the proportion of that nutrient in a food or diet that is available for intestinal absorption in a form that is physiologically useful to the body (Miller, 1998). In the case of iron, the available iron from plant foods may be less than 10% of the iron content in the food (Wardlaw and Kessel, 2002).

Functional foods

The significance of indigenous vegetables as a source of nutrients (vitamins and minerals) is limited by some of the factors mentioned above. For successful commercial exploitation of these vegetables, alternative uses of these vegetables have therefore to be explored. Traditionally, many communities used the vegetables for benefits other than as nutrient source. They were widely applied to enhance health. For instance among the coastal people of Kilifi, *Launaea, cornuta* is reported to prevent and cure malaria while *Cucurbita maxima* is said to keep diseases away (Maundu et al., 1999). The same workers reported that among the Kisii *Basella alba* is said to cure skin diseases while *Solanum nigrum* is used for regaining appetite among the Tharaka people.

In the above context, there is a tradition of the application of indigenous vegetables as functional foods among the various Kenyan communities. There is no universally accepted definition of the term “functional foods”. Several definitions have been suggested by different organizations. The definition given by the International Food Information Council and the International Life Sciences Institute (ILSI) is that they are “foods that provide health benefits beyond basic nutrients” (Cladesdale, 1999) They are also defined as “foods that exert health properties beyond the traditional nutrients that they contain” by the Food and Drug Administration (FDA) (NAS, 1998).

The different definitions all lay emphasis on the reduction of disease risk through availability of health promoting properties of the food beyond the traditional nutrients in functional foods. This is in contrast with the traditional emphasis on role of nutrients in treating disease symptoms. The definitions also distinguish functional foods from medicines, which have to demonstrate a dose response relationship in combating disease causing agents such as microbial pathogens or chemical and physical agents (FDA, 1997) .

In plant foods, functional foods can be placed into two broad categories (Messina and Messina, 1996):

Phytochemicals or Nutraceuticals – these are foods that contain biologically active, non-nutrient compounds that provide health benefits. Designer foods – These are food products specifically formulated to have higher amounts of phytochemicals or nutrients than would naturally occur. Phytochemicals only occur in plant foods. Many vegetables and fruits are natural sources of phytochemicals. Though not necessary for the maintenance of life in the same way as nutrients, these phytochemicals help promote optimal health by lowering risk for the occurrence of chronic diseases such as cancer and coronary heart diseases (CHD). They are believed to have many other health benefits.

Phytochemicals - examples

Though they are many phytochemicals, mechanisms of action of only a few of them are understood. These include the following:

Allyl sulphides: These decrease cancer risk by stimulating activity of enzymes that help eliminate toxic compounds (You and Blot, 1989). They are found in onions, leeks.

Isothiocyanates: These decrease cancer risk by increasing activity of enzymes that help to detoxify carcinogens (Lampe, 1999). They naturally occur among vegetables of the Cruciferous family such as cabbageand broccoli.

Indoles: These are phytoestrogens – phytochemicals that interfere with oestrogen metabolism (Lampe, 1999). They help reduce oestrogen related cancers such as breast cancer. They also occur in the Cruciferous family.

Lignans – these also act as phytooestrogens, therefore reducing cancer risk (Lampe, 1999).

Flavonoids: These include hundreds of different plant pigments, such as flavonones and anthocyanins. Most are excellent antioxidants, and reduce negative oxidative reactions, lowering cancer risk (Cody and Middleton, 1988).

Polyphenols/catechins: These act as anti-oxidants and reduce risk of coronary heart disease. They are naturally found in tea (Messina and Messina, 1996).

Carotenoids: This group also includes a wide group of pigments. Among the important members of the group is β-carotene, the precursor of vitamin A. β-carotene is also a phytochemical linked to reduced risk of lung cancer (Poppel and Goldbohm, 1995). It occurs in carrots and many green leafy vegetables. Lycopene, the pigment which naturally occurs in tomatoes, is another important phytochemical within this group. It is linked to reduced risk for prostate cancer. Lutein is another carotenoid which is a phytochemical (Poppel and Goldhem, 1995). It is linked to reduced risk for cancer. It naturally occurs in green leafy vegetables.

Global Perspective of Functional Foods

In Asia, particularly in countries such as China and Japan, functional foods have been part of their people's culture for centuries (Pariza, 1999). Foods with medicinal effect were documented in China as far back as 1000 BC. To date the Chinese regard food not only as a source of nutrients, but it is also understood to have both preventive and therapeutic effects.

In the West, generally there was no tradition of using functional foods. However, in recent years the use and sale of these foods has increased so rapidly that it may be regarded a revolution. The functional food sector represents a very fast growing segment of the food industry in the USA and in many countries of western Europe (Schmidt et al, 1997). Many companies – food, drug and chemical companies are racing to bring functional foods to the market. For instance, in the USA, the functional food trade and market was almost non-existent in 1990. It is now estimated to be a $10 billion per year industry, with a growth rate of 8 – 10%.

Potential for increased use of indigenous vegetables as Functional Foods

In recent years, there have been a rapid expansion of knowledge of phytochemicals world wide. Since vegetables and fruits are very good sources of phytochemicals, indigenous vegetables are equally likely to be rich in these substances. As observed above, there is a tradition of using these vegetables for disease prevention or therapeutic purposes among various Kenyan communities. However, there has been very little research done to identify and quantify the phytochemicals in the various indigenous vegetables. Equally lacking is the information on the identification of the mechanisms of physiological action of the phytochemicals in these vegetables.

There are various potential modes of utilization of indigenous vegetables as functional foods. They can be used in the form of traditional recipes developed by the various Kenyan communities. Alternatively, these recipes can be modified to enhance the effect of functional properties in light of new information about the type of phytochemicals present.

Phytochemicals can also be extracted from the vegetables. Such phytochemicals can then be used alone or in combination with other ingredients.

Safety is an important issue of concern in the use of phytochemicals. However, unlike food additives or drugs, the ingredients in functional foods don't have to undergo tests to see if they cause disease. This is generally due to the fact that many of the vegetables or foods in which these phytochemicals occur have been used as food for a long time. However, for commercial production and marketing of these foods or their extracts as functional foods, it is important to design studies which may be used to determine their toxicity, if any. Such toxicity could arise from the presence of other naturally occurring components in the functional food, other than the phytochemicals (Birk and Peri, 1980). For instance, the vegetables in the cruciferous family are rich in phytochemicals, but also contain goitrogens. The latter inhibit the metabolic activity of iodine in the synthesis of thyroid hormones (ILSI, 1990). Apart from the possibility of long term risks such as cancer or liver toxicity, there is also the concern that some of the functional foods may cause allergy to some people.

In the USA, the Food and Drug Administration (FDA) has to approve a "health claim" label for commercial functional foods. Products that carry such a claim have been convincingly demonstrated to be beneficial for their intended purposes (FDA, 1997).

Related with the issue of safety is that of safe levels of intake. This may not be an important issue to address in the case where the phytochemicals are ingested in the form of food, such as the indigenous vegetables. However, it is specifically an important issue in the case of extracted or concentrated phytochemicals. Levels which offer optimal beneficial activity have to be established for the different phytochemicals.

In the application of functional foods, it should be remembered that much as they may be useful, they are only one aspect of diet, and diet is only one aspect of a comprehensive life style that ensures good health. Other important aspects such as regular exercise, tobacco avoidance, maintenance of a healthy body weight and stress reduction have also to be practised in pursuit of good health.

CONCLUSION

In conclusion, functional foods (phytochemicals) have recently gained prominence as they address health aspects of chronic diseases which are not easily curable. The indigenous Kenyan vegetables have traditionally been used as functional foods by various communities. They probably contain a wide variety of phytochemicals. However, research work is required to identify and quantify the phytochemicals in these vegetables. There is great potential to increase the commercial utilization of the indigenous vegetables as functional foods, as has been done in Asia, USA and Europe.

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EVALUATION OF THE GROWTH AND NUTRITIONAL QUALITY OF AFRICAN NIGHTSHADE ACCESSIONS (*SOLANUM SPP)* AT DIFFERENT DEVELOPMENTAL STAGES.

S.V. Muchiri [1], S.G. Agong[1], E.M. Kahangi[1], P.W. Masinde [1], M.L. Chadha[2] and M.O. Oluoch[2].
[1] Jomo Kenyatta University of Agriculture and Technology, P.O.Box 62000, Nairobi, Kenya.
[2] World Vegetable Research Centre, P.O. BOX 10, Duluti, Arusha, Tanzania.

ABSTRACT

A study was conducted to evaluate the nutritional quality, growth as well as the appropriate time for harvest time for *Solanum nigrum* and *Solanum villosum* accessions. Accessions namely S49, S52, SV, S.04.2 (all from WVRC, Tanzania) and Local (from Kakamega, Kenya) were grown in a completely randomized block design at Jomo Kenyatta University of Agriculture and Technology (JKUAT) farm. Purification through rouging out (those that did not conform to the general population's mean) was done before the start of flowering stage so as to ensure that true to type plants were achieved. Evaluation of nutritional levels of crude fibre, crude fat, calcium, zinc, beta-carotene, carbohydrates, proteins, nitrogen, iron, ascorbic acid and moisture content was done before and at onset of fruiting to determine their levels at these developmental stages. While the leaf yields, leaf area and leaf numbers were recorded at each harvest. There was a difference in nutritional levels between the accessions and across the developmental stages. Nutritional levels with respect to crude fibre, calcium and zinc increased significantly ($P < 0.05$) while ascorbic acid, iron and beta-carotene decreased significantly with change in developmental stage. Moisture content, crude fat and nitrogen remained consistent over the plant developmental period. However levels of carbohydrates and protein increased or decreased depending on the accessions. The best harvest stage for all accessions was prior to fruiting as it had better nutritive quality and comparatively, S.04.2 had a relatively higher nutritional level than the other accessions.Leaf yields and leaf area were at the peak on the twelfth and fourteenth weeks for most accessions while leaf numbers were highest on the fourteenth and sixteenth week of harvest depending on the accession. S52 had the highest leaf yields and largest leaf area at every harvest, recording a total leaf yield of 126g per plant and total leaf area of 3176.02 cm^2

per plant. SV produced the highest leaf number at every harvest, recording a total leaf number production of 79 leaves per plant.

INTRODUCTION

According to F.A.O. (1988), traditional vegetables are all categories of plants whose leaves, fruits or roots are acceptable and used as vegetables by rural and urban communities through custom, habit and tradition. African nightshades are widely consumed as they are crucial to food security particularly during famines or natural disasters (Chweya and Eyzaguirre 1999). They play an important role in enhancing health and nutrition of vulnerable groups in Africa by supplying most daily dietary requirements of the rural people, as they are important sources of micronutrients, vitamins and minerals (Attere, 1995) , they serve as a source of farm income to rural communities as they grow quickly under adverse environmental conditions and their diversity permits production across all seasons and they also have an ecological, agronomic and cultural value (Mnzava, 1989; 1993).

African nightshade is often seen as a weed with global distribution however it is considered very popular especially in the fresh vegetable markets (Schippers, 2000). According to Maundu, et al., (1999), African nightshade is rated as a high priority vegetable in Kenya as it serves as an important leafy vegetable to various communities such as the kikuyu, kamba, maasai, luhya among others who know it by its local name. The frequently cultivated African nightshades are the *Solanum scabrum,* (West Africa), *Solanum villosum* (East Africa), *Solanum americanum* and *Solanum nigrum.*

This research was based on an increase in levels of neglect by scientific research (especially after the introduction of exotic crops) that has led to a limitation on available information on production methods, opportunities and utilization. This lack of attention has meant that their potential value is under-exploited which places them in danger of continued genetic erosion and ultimately disappearance, further restricting development options for the poor (Thies, 2000; Padulosi, 2000; Padulosi et al., 2002 and Schippers, 2000). African nightshade also provides a complex taxonomic puzzle due to its high levels of genetic diversity and plasticity and hence serves as a source of confusion to the correct identity of its variants and as a result further research is needed to select and purify them (Schippers, 2000). Their low cultivation makes them un-available in the markets year round and hence creating a shortage in seed material (WVRC, 2002).

There is a nutritional dilemma that has been caused by decreasing food choice and inadequate prioritization of a balanced nutrition. The agricultural revolution radically altered human economic systems and nutritional patterns due to the permitted development of urban societies, this has created a basic human nutritional paradox because the increased reliance on domesticated food has led to a decreased dietary diversity meaning a reduction in food choice (Grivetti et al., 1987). In that context, about 40% of women in child bearing age have anaemia while an almost equal number of children under five years do not consume enough nutrients to maintain full physical health. Micronutrient deficiency has been identified as a major cause of morbidity and mortality and can impair learning ability, growth and development (Thies, 2000; Padulosi, 2000; Padulosi et al., 2002 and WVRC, 2002). The objectives of the study are to evaluate the nutritive value of African Nightshade leaves among selected accessions and to determine the best developmental stage to harvest with respect to nutritional quality.

Materials and Methods

The accessions S49, S.04.2, S52 and SV from WVRC (Tanzania) and local from Kakamega (Kenya) were sown in a nursery and pricked out after two weeks. Transplanting was done onto the field, two weeks later, in a complete randomized block design. The treatments consisted of the five accessions with four replications. Each plot contained fifty plants of each accession, thus giving a grand total of one thousand plants for the study. A starter fertilizer of DAP (46% P_2O_5) at the rate of 150kg per hectare and two top dressings of CAN (26 % N) at the rate of 100kg/hectare on the sixth and ninth week after planting were applied. Irrigation was done three times a week after establishment in the field. Rouging out of off types to purify the accessions was done before the start of flowering to ensure that only true to type plants remained in the field.

The first harvest was done eight weeks after planting, and latter harvests done fortnightly. The total production per plant (fresh weights), leaf number per plant and the average area of each leaf during harvest were calculated. Only the first and the third harvests were analyzed for nutritive value. Three replications were made for each nutritional element analyzed per individual accession. The elements analyzed according to AOAC (1984) and Osbourne and Voogt (1978) were -Crude ash (dry ashing method); Crude fibre (Hennenberg-stohman method); Moisture content; Crude protein (kjedahls method); Crude fat (soxhet method); Nitrogen (kjedahls method); Ascorbic acid (titration method); Beta-carotene (Spectrophotometric method); Calcium, Iron and Zinc (Atomic Absorption method) and Carbohydrates.

Data analysis was done using Genstat 5th edition (2002) statistical analysis method and mean separations were done using LSD (5%).

Results
S52 had the highest leaf yield (fresh weights) for every week of harvest, while SV the lowest (Figure 1). The leaf yields were highest on the twelfth and fourteenth week for accessions S52, S.04.2 and S49 while yield in SV and local was consistently similar over the harvest period. S52 had significantly ($P< 0.05$) higher leaf yields than other accessions during the twelfth, fourteenth and sixteenth week.

The leaf area (per plant) was optimal on the twelfth and fourteenth week and smallest on the tenth week in all accessions except in SV where observations were consistently low over the harvest period (Figure 2). Individual leaf sizes differed with S52 exhibiting larger leaves (Plate 2). S52 had a significantly ($P< 0.05$) larger leaf area per plant than all other accessions while SV had the smallest leaf area through-out the harvest period.

SV recorded the highest weekly leaf numbers over the harvest period while S.04.2 had the least (Figure 3). SV leaf production (number) was significantly ($P< 0.05$) higher than other accessions on the tenth week. The leaf count was highest on the fourteenth and sixteenth week for all accessions.

There was a general increase in crude fibre over time for all accessions. Only S.04.2 had significantly higher crude fibre than SV in both developmental stages (Table 1). There was a significant difference in nitrogen only between local and S52 accessions in the vegetative stage (Table 1) while there was no significant difference between the accessions in the reproductive stage (Table 1). The local accession had significantly higher crude protein than the other accessions in the earlier part of development (Table 1) however; there was no significant difference in the reproductive stage. There was a slight increase in crude fat levels for most accessions with time. SV had significantly higher fat than other accessions in the vegetative stage; however, there were no significant differences between the accessions in the reproductive stage (Table 1).

Crude ash was higher before fruiting and decreased after fruiting started (Table 2). In the vegetative stage, local, S49, and S.04.2 had significantly higher crude ash than S52 and SV; while in the reproductive stage there were no significant differences among the accessions. The moisture levels at both stages were considerably similar meaning no considerable loss or gain was achieved between the stages however most accessions recorded a slight increase in moisture levels with time (Table 2). There was an increase in Zinc levels over time (Table 2). SV and S52 had significantly higher Zinc levels than all other accessions in the vegetative stage, while S.04.2 had significantly higher zinc in the reproductive stage. S.04.2 and SV had significantly accumulated higher carbohydrate levels than other accessions in the vegetative stage, while in the reproductive stage SV maintained a significantly higher carbohydrate level than all the other accessions (Table 2).

The levels of Ascorbic acid decreased with time. Before start of fruiting, S.04.2 had significantly higher ascorbic acid than other accessions (Table 3). SV had the lowest ascorbic acid. After start of fruiting, S49 and S.04.2 had significantly higher ascorbic acid than SV and local (which was the lowest) (Table 3). There was a general decline in levels of beta-carotene with time (Table 3). The local accession had significantly high beta-carotene at the stage before fruiting compared to all other accessions, while after fruiting, S49 and local had significantly higher beta-carotene compared to other accessions. There was an increase in Calcium levels for all accessions with time (Table 3). SV had significantly higher calcium than the other accessions before and after fruiting started. There was also a general decrease in iron levels with time except for local accession (Table 24). S.04.2, S52 and SV had significantly higher iron before fruiting, while after start of fruiting, S.04.2, S52 and local had significantly higher iron than other accessions. Accession S49 had significantly lower iron than the rest in both developmental stages.

Vitamin A content (Table 4) has a similar trend to beta carotene content (Table 3).

African nightshade leaves for all accessions were found to meet an active mans' recommended dietary allowances (RDA) for ascorbic acid in both the vegetative and reproductive stages while vitamin A requirements could be met with a little supplementation in either of the stages (Table 5). Iron and calcium contents in all accessions could not meet the % RDA on either of the growth stages.

Results

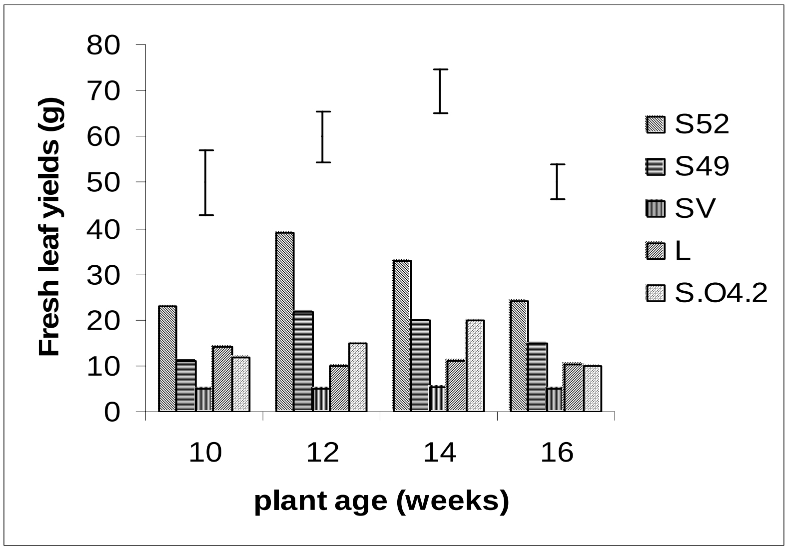

Figure 1: Variations in plant fresh leaf yields (g) per plant. Vertical bars represent mean separation by LSD (5 %).

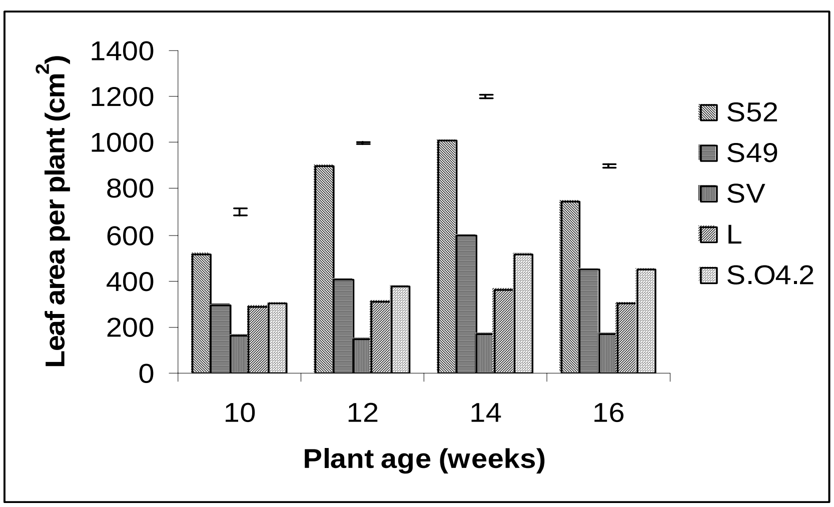

Figure 2: Variations in leaf area (cm^2) per plant over the harvest period. Vertical bars represent mean separation by LSD (5 %).

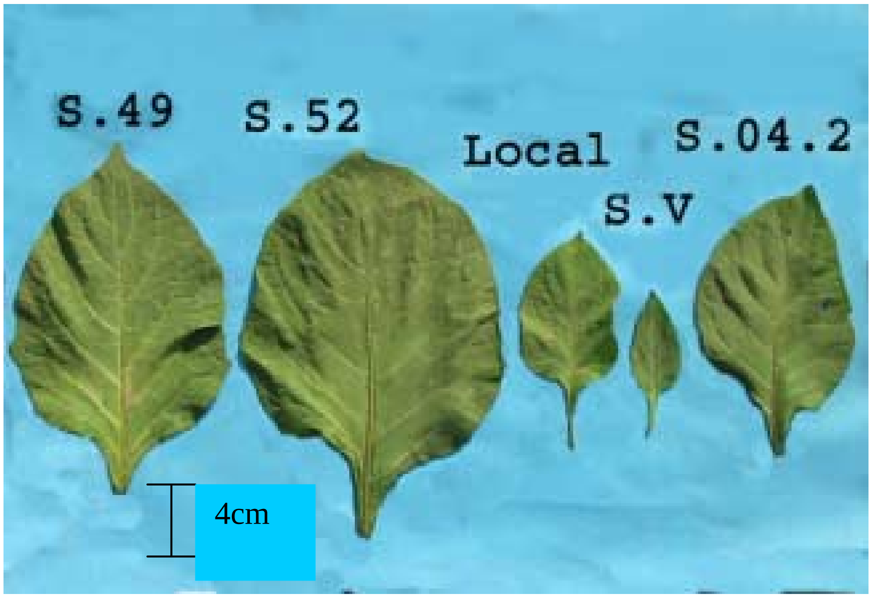

Plate 1: Variations in the leaf morphology of the accessions. The vertical bar represents the scale.

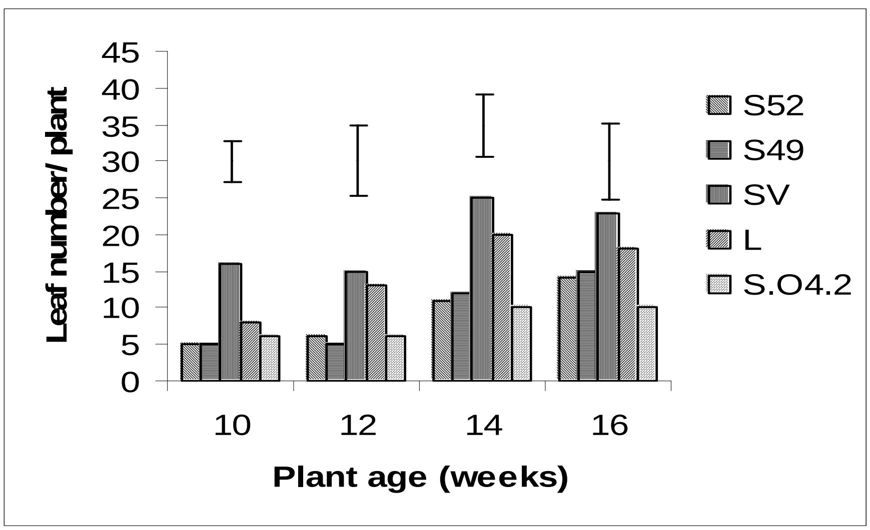

Figure 3: Variation in Leaf number per plant in the African nightshade accessions over the harvest period. Vertical bars represent mean separation by LSD (5 %).

Nutritional and Proximate Analysis

Table 1. Variations in the crude fibre, nitrogen, crude protein and crude fat contents in the leaves of the African nightshade accessions during the vegetative and reproductive stages, on fresh weight basis.

Accession	Crude fibre (g per 100g)		%Nitrogen		% Crude protein		Crude fat (g per 100g)	
	Vege .	Rep	Vege .	Rep	Vege .	Rep.	Vege .	Rep
S.04.2	1.243 a†	1.65 a	0.541 ab	0.541 a	3.382 b	3.40 a	0.550 b	0.600 a
S49	1.170ab	1.23 b	0.533 ab	0.491 a	3.367 b	3.08 a	0.524 b	0.635 a
S52	1.090ab	1.51 ab	0.449 b	0.493 a	2.833 b	3.12 a	0.475 b	0.600 a
SV	1.010 b	1.38 b	0.526 ab	0.572 a	3.463 b	3.60 a	0.930 a	0.700 a
local	1.051ab	1.37 b	0.661 a	0.507 a	4.150 a	3.16 a	0.529 b	0.600 a
SE	± 0.071		± 0.0527		± 0.2284		± 0.0618	
CV	9.7%		17.2%		11.8%		17%	
LSD5%	0.2092		0.1553		0.6736		0.1823	

Vege- Vegetative stage
Rep- Reproductive stage
† - Values followed by the same letter along the columns are not significantly different according to LSD test at 5% probability level.

Table 2. Variations in the crude ash, moisture, zinc and carbohydrate contents in the leaves of the African nightshade accessions during the vegetative and reproductive stages, on fresh weight basis.

Accession	% Crude ash		% Moisture content		Zinc (mg per 100 g)		Carbohydrates (g per 100 g)	
	Vege .	Rep	Vege .	Rep.	Vege .	Rep.	Vege .	Rep
S.04.2	3.439a †	2.44 a	87.67a	85.30ab	0.728 b	2.000 a	8.388 a	7.380 ab
S49	3.538a	2.40a	86.50 a	85.83 a	0.725 b	1.240 b	6.716bc	6.446 b
S52	2.728b	2.70 a	84.30 b	83.50bc	1.010 a	1.470 b	5.930c	6.823 b
SV	2.780b	2.18 a	85.50ab	85.50b	1.050 a	1.462 b	8.336 a	7.820 a
local	3.476a	2.37 a	84.30 b	82.83c	0.695 b	1.483 b	6.945 b	7.000 ab
SE	± 0.211		± 0.414		± 0.0930		± 0.3158	
CV	13%		0.8%		13.6%		7.6%	
LSD5%	0.6624		1.221		0.2742		0.9315	

Vege- Vegetative stage
Rep- Reproductive stage
† - Values followed by the same letter along the columns are not significantly different according to LSD test at 5% probability level.

Table 3. Variations in the ascorbic acid, beta-carotene, calcium and iron contents in the leaves of the African nightshade accessions during the vegetative and reproductive stages, on fresh weight basis.

Accession	Ascorbic-acid (mg per 100 g)		Beta-carotene (μg per 100g)		Calcium (mg per 100 g)		Iron (mg per 100 g)	
	Vege .	Rep	Vege .	Rep	Vege .	Rep	Vege .	Rep
S.04.2	124.3a †	78.1a	3450c	3230b	113.1b	141.2b	3.036a	2.443a
S49	103.0b	77.7a	3235d	3330a	117.5ab	150.4ab	1.512c	1.040c
S52	104.8ab	63.7ab	3605b	3200b	121.1ab	158.8a	3.087a	2.968a
SV	65.7c	49.3bc	3255d	3220b	127.5a	169.1a	2.887a	2.015b
local	85.7b	55.8b	4240a	3270a	104.5bc	121.6c	2.133b	2.640a
SE	± 19.56		± 31.56		± 3.93		± 0.1798	
CV	15%		1.6 %		8.2%		13.1 %	
LSD5%	19.56		93.09		11.58		0.5304	

Table 4. Vitamin A contents (µg per 100g) on fresh weight basis.

Accession	Vegetative stage	Reproductive stage
S.O4.2	575.00^{c}	538.33^{b}
S49	539.00^{d}	555.00^{a}
S52	600.00^{b}	533.33^{b}
SV	542.50^{d}	536.67^{b}
local	706.60^{a}	545.00^{a}
SE	± 5.20	
CV	0.27%	
LSD 5%	15.515	

† - Values followed by the same letter along the columns are not significantly different according to LSD test at 5% probability level.

Table 5. Percentage (%) recommended dietary allowances (RDA) of an active man satisfied by consumption of 100g of African nightshade accessions leaves during the vegetative and reproductive stages.

Accession	Ascorbic-acid (mg per 100 g)		Vitamin A (µg per 100g)		Calcium (mg per 100 g)		Iron (mg per 100 g)	
	Vege .	Rep	Vege .	Rep	Vege .	Rep	Vege .	Rep
S.04.2	414.33	260.33	76.67	71.78	28.3	35.30	60.72	48.86
S49	343.33	259.00	71.87	74.00	29.4	37.60	30.24	20.80
S52	349.33	212.33	80.00	71.10	30.3	39.70	61.74	59.36
SV	219.00	164.30	72.33	71.56	32.0	42.28	57.74	40.30
local	285.67	186.00	94.21	72.67	26.1	30.40	42.66	52.80
SE	± 65.20		± 0.70		± 1.00		± 3.60	

Vege- Vegetative stage
Flow- Flowering stage

DISCUSSION

The initial source of mineral nutrients for plant use is the soil and the seed reserves. Nutrient uptake by the plant starts shortly after germination and is influenced by water absorption. Studies have shown that irregular water supply easily results in diurnal fluctuations in nutrient uptake (Olson and Kemper, 1968).

Nitrogen is a principal constituent of protein; it assists in the regulation of cell functions, respiration and photosynthesis. It is also responsible for succulent, fleshy green leaves (Janick, 1980). In this study, it is possible that there were no significant differences in both developmental stages since the plant actively continued with the growth functions.

The fat levels remained fairly constant over the developmental stages but could be considered to play an important role to counter transpiration loss by the leaves. They are also responsible for the accumulation of the fatty subcutaneous layer on the leaves and are known to generally accumulate in seeds (Janick, 1980).

Ascorbic acid and beta-carotene are vitamins and these break-down with time and age of the plant due to loss of succulence (water soluble ascorbic acid) and prolonged action of light which breaks down beta-carotene; this is likely to have caused the significant drop in their levels (Robinson , 1987).

Calcium is likely to have increased at the start of fruiting stage because the element is relatively immobile in plants especially the older leaves (which were apparently being harvested). Also the element is required in increased proportions in the plant for cell wall formation during fruiting (Agri-News, 2003; Janick, 1980).

Iron helps in chlorophyll formation, absorption of other nutrients and is essential for the synthesis of proteins contained in the chloroplasts. It is a constituent of ferrodoxin and other electron carriers in the photo system II phase of electron transport. However, some ions are rapidly metabolized after uptake, hence need regular checking to avoid deficiencies, iron transported to the shoots is often complexed with organic acids (Grusak, 1994; Rorison, 1969) hence becoming unavailable, this may have contributed to the decline in iron levels.

Moisture levels also reduced but not significantly, possibly due to plant age and increase in crude fibre content in the leaves.

Zinc is important for internode elongation; development and function of growth regulators, chloroplast formation and seed development. Zinc is also associated with water uptake and water relation in the plant (www.indianagriculturalresources-soilmanagement.html; Janick, 1980; Rorison, 1969). These functions are likely to have enhanced the uptake of this element by the plant. As the plant ages, the fleshy plant tissues become stiffer and fibrous (Rorison, 1969) and may result in increased crude fibre content in the leaves.

Carbohydrates and protein levels increased or decreased with time across the accessions. Proteins are a factor of nitrogen, while carbohydrate levels were affected by its' constituent compounds.

Studies by different researchers have however shown how various factors such as plant age, season, soil fertility e.t.c. affect nutrient levels of African nightshades (Schippers, 2000). Studies by Mwafusi, (1992) and Onyango, (1993) showed that there existed differences in nutritional levels between the various African nightshade variants and that these levels changed with time as the plant proceeded from vegetative to reproductive stage and hence supported the observations in this study.

Since vitamin A, vitamin C (ascorbic acid), calcium and iron are reportedly lacking in most Kenyan diets (KENRICK, 2003; Williams and Wilkens, 1993; Shils and Young, 1989 and Burrows, 1975), consumption of 100g of African nightshade would meet over and above the requirements for vitamin C, > 70 % of the Vitamin A, 45- 50% of iron and 30-35% of calcium for an active man, irrespective of the stage of harvest (Table 26). The same nutritional requirements for vulnerable groups (Lactating /expectant mothers and children), would be met through supplementation. The significance of this is that, African nightshade can thus be utilized for nutrition intervention as they are available through out the year (Table 3) and are nutritionally superior to the commonly consumed exotic vegetables (Table 4).

However, further studies need to be done to ascertain the presence of glycoalkaloids (in the edible parts) during the production as reported in other studies (Schippers, 2000) and whether these anti-nutrition compounds influence the bioavailability of those nutrients present in the African nightshades.

Comparatively, the nutritional level of S.04.2 was superior as compared to all the other accessions in this study.

CONCLUSION AND RECOMMENDATIONS

The results of the study emphasize on the fact that African nightshade plays an important role in our diet. It shows that the vegetable exhibits a wide genetic diversity between its variants; as they differed in morphological features such as leaf size and shape as well as nutritional levels and hence serve as a potential area to be tapped into.

With promotion on its cultivation and utilization plus the accrued benefits, most rural communities can manage their nutritional dilemma that has been caused by decreasing food choice and inadequate prioritization of a balanced nutrition as the crop is available in ample levels almost throughout the year. This action would also eventually put them out of danger of continued genetic erosion and ultimate disappearance.

It is further recommended that S52 which had the largest leaf size and highest leaf yield and S.04.2 that had superior nutritional levels be selected for improvement and promotion.

Further research is however recommended to sensitize people on the importance of the vegetable in terms of nutrition and genetic conservation plus studies be done on the toxic compounds that accumulate on the edible parts of the crop (Schippers, 2000) and whether they affect the bioavailability of inherent nutrients.

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NUTRITIONAL VALUE AND UTILIZATION OF INDIGENOUS VEGETABLES IN UASIN GISHU DISTRICT

Lizzy A. Mwamburi
Department of Botany, Moi University, P.O. Box 1125, Eldoret. Kenya

ABSTRACT

Traditional vegetables are a source of nutrition and contribute substantially to protein, mineral, amino acid and vitamin intake. In Uasin Gishu district where rain-fed agriculture has traditionally been the predominant system of agricultural production, the cultivation of indigenous vegetables is marginalized and their consumption is generally considered of 'supplementary' nature in the diet. This implies that they are not regularly eaten and that their consumption is still firmly rooted in practices and knowledge of rural people. This study documents the various traditional vegetables sold in Uasin Gishu, representing an enormous wealth of agrobiodiversity with potential to contribute to improved incomes, household food security and enhanced nutrition.

INTRODUCTION

As urbanization advances in Kenya, people are depending on only a handful of crops that are easily available, cheaper and energy giving such as maize, potatoes, wheat, vegetable oils and fats. The narrowing base of global food security is limiting livelihood options for the rural poor, particularly in marginal areas. Addressing their needs requires the development of a much wider range of indigenous crop species. Many of these species occupy important niches, adapted to fragile and risky conditions of rural communities. They have a comparative advantage in marginal lands where they have been selected to withstand stress conditions and contribute to sustainable production with low-cost inputs (FAO, 1985; Mnzava, 1989; 1993). They also contribute to the diversity-richness and hence the stability of agro-ecosystems.

The narrowing food base has also resulted in less variety in food with limited nutrition . The result has been increased incidences of nutrition-related diseases, obesity, weak bones, anemia, hypertension and heart diseases. Many children suffer from protein-energy malnutrition (PEM) related diseases. PEM is most common among young children and pregnant women in the developing world. Infants and young children are most susceptible to PEMs characteristic growth impairment because of their high energy and protein needs and their vulnerability to infection. It is usually caused by energy-deficient diets (that may also lack protein) coupled with infections that raise nutrient requirements while limiting the intake and utilization of food. Malnutrition magnifies the effect of every disease. It is the prime cause of low birth weight and poor growth in the developing world. The extent of the problem of malnutrition in Africa as compared with developing countries as a whole is shown in Tables 1 to 3.

Malnutrition can have serious effects, right from conception. Vitamin A deficiency is associated with increased child mortality, and is a prime cause of child blindness (Okigbo, 1990). Iodine deficiency leads to slow mental growth and mental development and to goitre. Anaemia, largely due to iron deficiency is the most widespread nutritional problem (Table 3). It can impede learning and productivity and is a leading cause of maternal mortality in developing countries. Calcium deficiency is a leading risk factor for osteoporosis, a condition where bones become fragile and brittle. Inadequate vitamin C can lead to scurvy and has been linked to poor absorption of iron and increased risk of certain non-communicable diseases.

Table 1 - Chronic undernutrition[a] in sub-Saharan Africa and developing countries, all ages

Countries	Percent affected		Number (millions)	
	1969-1971	1990-1992	1969-1971	1990-1992
Total, developing countries	35	21	917	839
Sub-Saharan Africa	38	43	103	215

Source: FAO, 1996b.

[a] Population with energy intake (kcal/caput/day) on average below 1.54 times the basal metabolic rate (BMR) over one year. The estimates are averages for sub-Saharan Africa.

Table 2 - Underweight children[a] in Africa and developing countries

Countries	Percent affected			Number (millions)		
	1975	1990	1995	1975	1990	1995
Total, developing countries	42.6	35.8	34.6	195.6	193.4	199.8
Continental Africa	30.4	27.3	27.0	22.9	31.6	34.8

Sources: WHO, 1995b; WHO Global Database on Child Growth.

[a] Children aged 0 through 60 months with weight for age below -2 SD of the median United States National Center for Health Statistics (NCHS) reference (for continental Africa and sub-Saharan Africa).

Table 3 - Micronutrient malnutrition in Africa and developing countries, 1990s

Form of malnutrition	At risk (millions)	Affected (millions)
Iron deficiency or anaemia	-	206
Iodine deficiency disorders (IDD)	181	86
Vitamin A deficiency (children under five years)	52	1.04

Sources: WHO, 1994; WHO/UNICEF/ICCIDD, 1993; WHO/UNICEF, 1995

To counter these nutritional problems, it is important that the most commonly consumed foods be nutritious. Traditional vegetables are a source of nutrition and contribute substantially to protein, mineral and vitamin intake. They are compatible in use with starchy staples and represent a cheap but quality nutrition to the poor urban and rural areas where malnutrition is widespread. This makes them useful in nutrition intervention programs. They may be dried and conserved during the rainy season when they are plentiful for use during times of scarcity. In this way they contribute to household food security. The vegetables also offer variety in diet and in production systems, therefore broadening the food base (Okigbo, 1977).

The under utilization of traditional leafy vegetables has had a negative impact on nutrition, health and economic status of both urban and rural populations. This study attempts to address this problem as it crosscuts all of the Kenyan society with emphasis on groups that are vulnerable to under-nutrition. It expected that results obtained from this study will draw on the insights gained to produce educational material that effectively addresses the needs of vulnerable groups by increased the use of traditional crop diversity.

The Current Status Of Traditional Vegetables In The Farming Systems In Uasin Gishu

In Uasin Gishu district where rain-fed agriculture has traditionally been the predominant system of agriculture, indigenous vegetables are considered of 'supplementary' nature in the diet, implying they are not eaten regularly. Their cultivation is therefore marginalized and consumption is still firmly rooted in the practices and knowledge systems of rural people. Lack of attention has meant that their potential value is under-exploited restricting development options for the poor. This study documents the various traditional vegetables in Uasin Gishu district in a bid to show their role in food security and as a buffer against periods of food shortage.

Agricultural development and cultivation in Uasin Gishu district is primarily based on subsistence crops, edible wild plant species, and the cultivation of a few food crops; mainly wheat and maize. Uasin Gishu district has relatively fertile soils, a wet climate and a well-distributed rainfall in most areas. In normal times, there is abundant food supply to meet human requirements. The staple foods are maize, beans and maizemeal usually supplemented with a sauce made from a range of different species. These are mainly traditional vegetables which are either indigenous or which were introduced a long time ago and are now being cultivated; their leaves are used as a necessary accompaniment to the staple food. However, dietary utilization of non-domesticated plants has received little attention and a dramatic narrowing of food base in many traditional societies has occurred (Juma, 1989; Kabuye, 1993).

Most of the traditional leafy vegetables (Table. 4) are only available during the rainy season. These vegetables are often intercropped and rarely occupy a significant proportion of the farm. The process is that, traditional vegetables that can grow during the dry season are harvested during the growing rainy season - a type of crop rotation sequence. The behaviour pattern suggests that the vegetables could be available throughout the year, as long as the conditions are favourable (Chweya and Eyazanguirre, 1999). Supply of the vegetables is highest 2 months after the onset of the long rains, when tender plants are uprooted for use. Supply then drops until the next short rainy season, when the vegetable is either planted as a pure stand in small plots or interplanted with maize. Given that not much in terms of inputs as in the way of fertilizers and pesticides are needed (Cunningham *et al*., 1992), this approach would certainly increase the overall production of food crops.

Some of the traditional crops have been domesticated, while others are still being harvested as wild or semi-wild plants. Domesticated vegetables are grown in small plots adjacent to human settlements, as a survival strategy. These vegetables make a substantial, though rarely appreciated, contribution to food security. Management practices are basically traditional. There is no definite spacing applied and weeding is done alongside the main crop. Soil is mainly fertilized using kitchen or animal waste.

FOOD VALUE OF TRADITIONAL VEGETABLES

Given the economic situation of most people in Uasin Gishu district, the predominant diet is a vegetarian one. Traditional vegetables have been identified as a critical nutritional source, especially in children (Kakitahi, 1984). Traditional vegetables have high contents of proteins, calcium, phosphorus, carotene and vitamins A, B and C (Table 5), complementing the nutritional value of basic staple foods. In addition, the following traditional vegetables supply small amounts of starch; *Corchorus* spp., *Solanum* spp. and *Vigna unguiculata*. *Amaranthus spp., Basella alba* and *Bidens pilosa* supply some dietary fibre, while *Cucurbita maxima* supply oil. This oil is mainly unsaturated fatty acids, oleic and linoleic. Amino acids are found in *Solanum* spp. And oxalates are present in *Commelina benghalensis* and *Solanum indicum*, while ascorbic acid is found in almost all the vegetables. All these food values are essential to meet human requirements, including normal growth and protection against malnutrition.

CULTURAL USES OF TRADITIONAL VEGETABLES

Cultural uses of traditional vegetables are associated with different beliefs. There are many ethnic, language and cultural groups in Uasin Gishu due growth of main towns. It is however, interesting to note that certain plants appear to be important in more than one community and have found use as traditional medicine in several communities (Table 6). For example, the leaves of *Bidens pilosa* are used to treat wounds and boils; the juice to treat various ear and eye problems; a decoction for rheumatism, stomach disorders and intestinal worms and roots for malaria. *Solanum nigrum* and *Commelina spp* have also found use as medicine in most communities in the district.

Table 4. A list of traditional vegetables found in Uasin Gishu District

Scientific name	**Common English name**	**Local name**
Amaranthus dubuis	Amaranthus spinach (L)	Lidodo/Doodo/ Mborochet/Terere
A. gracecizane	Pig weed (L)	Tsimboka/Ekwala/ Chepkerta
Basella alba	Vine spinach (L)	Nderema/Nderemiat/Murerema
Bidens pilosa	Black jack (L)	Esisi/Sere/Muhehenje/ Munyugunyugu/Munzee/Ologohe/ Onyiego

DIETARY EFFICACY OF AFRICAN INDIGENOUS VEGETABLES IN THE CONTROL OF MICRONUTRIENT DEFICIENCIES FOR POVERTY ALLEVIATION AND NUTRIENT SECURITY

By Dr. Mary Khakoni Walingo, Maseno University.P.O. Box 333, Maseno, KENYA E-mail: khakoni@yahoo.com

ABSTRACT

The increasing prevalence of chronic diseases and micronutrient deficiency in developing countries is burdening the national and household resources. This in turn interferes with resource distribution among competing claims scarce national and household resources. Governments are spending more of the limited national resources on micronutrient supplements and fortification programs. Even then, controversies are rife about the effect of nutrient supplements (chemical) on human health, making dietary intervention the safer source for addressing micronutrient deficiencies. Dietary intervention is cheaper and nutritious, with a higher capacity for intervening where micronutrient deficiencies prevail. Diet has been known to be a risk factor for chronic diseases. Changes in dietary patterns, attitudes and beliefs about food, coupled with experiences and interactions, have induced major modifications in national and household diets, with resultant higher prevalences of chronic diseases and micronutrient deficiencies. Indigenous, more plant-based diets are being replaced by high-fat, energy-dense diets with increased intake of animal foods. Yet plant-based foods, especially African Indigenous Vegetables (AIVs) are rich in many micronutrients and non-nutrients needed for healthy living, and also medicinal value to the consumer. The AIVs grow fairly easily in the African environment and require fewer inputs in recipe preparation at the consumer level. Raising production of AIVs will enhance the household's economic situation, diversify diets and enhance food security, especially with improved markets and infrastructure. For AIVs promotion and adoption at the consumer level as a health resource of dietary micronutrients, an understanding of the food systems of different cultures is necessary to help determine the entry point. This paper examines the efficacy of AIVs in the promotion of human health. In helping reduce resource expenditure on health services, households can spend more on food and other household needs, while Governments can now spend on other development projects in lieu.

KEY WORDS :African Indigenous Vegetables, micronutrient deficiencies, chronic diseases.

INTRODUCTION

Great efforts are being directed at poverty alleviation strategies for economic and social empowerment of households and communities, after the realization that poverty is the basic cause of malnutrition and underdevelopment. Poverty often results in low food availability, poor health and nutrition, poor living conditions, overcrowding amongst other effects. There is resultant loss of human potential that has great economic and social costs to a nation. The resources and earning capacities of the people are further reduced compounding the social and economic problem. Poverty and malnutrition exacerbate the problems of unsustainable agricultural practices as a result of desperate efforts of poor people to obtain adequate food. Hunger and malnutrition are the most devastating problems facing the majority of the world's poor. Consequences of malnutrition are tragic and include, amongst others, death, disability, stunted physical and mental growth, retarding social and economic development of many nations.

The past three generations in Africa have experienced extensive changes in family food supplies and diets. The range of indigenous domestic foodstuffs has been considerably reduced. Changing diets and lifestyle in developing countries combined with food insecurity, under-nutrition, emerging micronutrient deficiencies and chronic diseases have become a real burden to nations. Now food-based strategies directed at ensuring food security have enormous implications for national food supply. These strategies seek to produce foods of the right nutritional quality and to diversify diets and nutrients base.

African Indigenous Vegetables (AIVs) are necessary for dietary diversification. AIVs are a rich source of many micronutrients needed for healthy living, besides preferring herbal medicinal value to the consumer. These vegetables grow fairly easily and require fewer inputs in recipe preparation at the consumer level. Raising the production and consumption levels of AIVs has the potential to enhance the household's economic situation especially with improved infrastructure and markets.

Kenyan statistical abstracts and economic surveys do not mention vegetables, an indication of lack of government policy on AIVs. Crops are categorized as cereals, temporary industrial crops, other temporary crops and permanent crops [CBS 2001, 2002]. National policy does not consider the value of vegetables in diets. Yet, it is the government policy to improve lives and eradicate poverty through increased productivity, incomes and employment. Increased production of AIVs has potential to increase incomes, employment and nutrient security.

AIVs contribute to nutritional quality of diets and hence nutrient status of individuals. Agricultural modernization and globalization give prominence to crops that offer more potential on the local and international market. There is a wealth of knowledge by women about the AIVs and their health value. Even then there is decreased and increased use of AIVs in households. Decreased use of AIVs has contributed to loss of species from wild habitat and among farmers, and also recipies.

Epidemiology of Micronutrient Deficiencies and Chronic Diseases

Micronutrient deficiency refers to vitamin and mineral deficiency diseases, and is caused more by diets deficient in these essential nutrients. This deficiency is also referred to as "hidden huger". Lack of micronutrients has serious implications for both food and behaviour, and causes inadequate diet quality. Inadequate diet quality should now be included in policies and monitoring systems for hunger alleviation, which have in the past concentrated on 'glaring hunger' i.e. macronutrient deficiency. Micronutrient deficiency interfere with complex metabolic responses such as metalloenzymes, which require metals from the environment to function, the immune function and others. The general outcomes of micronutrient deficiency are presented in Fig.1.

The most common micronutrient deficiencies of current public health concerns are vitamin A deficiency (VAD), iron deficiency and iodine deficiency disorder. Vitamin A deficiency is often associated with protein-energy malnutrition, and is commonest among children. Records indicate that about 250 million children in developing countries are at risk of VAD, of whom about 3 million are clinically deficient. Vitamin A is commonly available in low-cost foods such as green leafy vegetables, yellow fruits and vegetables. About 30 million (23.8%) new borns every year suffer Intra-Uterine Growth Retardation. VAD results in blindness and impairs resistance to infection, affects growth, child survival, physical and mental capacity of affected individuals. These individuals have increased risk of developing diet-related non-communicable diseases later in life.

Iron deficiency anaemia affects over 2000 million people worldwide and about half of the anaemia is caused by dietary iron deficiency. Among infants and children anaemia is associated with retardation of physical growth, intellectual and psychomotor development, and reduced resistance to infections. Anaemia causes reduced work capacity and fatigue in adults, exacting a high economic burden on the economy. A reduced work capacity among adults implies a reduction in national and household productivity, increasing malnutrition and food insecurity. The global picture of micronutrient deficiency is detailed in Table 1. The causes of micronutrient deficiency are dietary inadequacy and impaired absorption or utilization of nutrients due to infections and infestations, which increase the metabolic need for nutrients. Poverty is an underlying cause for micronutrient deficiencies through inadequate access to food, sanitation, safe water, lack of nutrition and health education in food handling and preparation. Micronutrient deficiencies are obstacles to socio-economic development of many communities as they impact greatly on health with high social and public costs, decrease learning ability hence loss of human potential, decrease productivity due to decreased work capacity, and reduce resources leading to underdevelopment of other sectors of the economy. This creates a vicious cycle of malnutrition, poverty and underdevelopment [Fig.2].

AIVs prefer the solution to micronutrient deficiencies. Overcoming micronutrient deficiencies is a precondition for sustainable development as it enables the re-direction of resources from micronutrient treatment to other development activities. Community and family vegetable and fruit garden are important in increasing production of micronutrient-rich foods that are useful in preventing micronutrient deficiency.

Diet has a great role to play in the prevention of chronic diseases. Prevalent chronic diseases are presented as obesity, type II diabetes, methters cardiovascular diseases, cancer, osteoporosis and dental carries. Obesity is increasing with increasing mortality rates, with associated co-morbid conditions. Fibre has been identified as a food factor relevant in the control of obesity, i.e. increased dietary non-starch polysaccharides from plant foods (whole grain cereals, legumes, fruits and vegetables). Type II diabetes mellitus is associated with weight gain, overweight and obesity due to major changes in the diet consumed, coupled with reduced physical activity. Dietary fibre and non-starch polysaccharides from fruits/vegetables, legumes and whole grain cereals are recommended for the control of diabetes.

Unhealthy dietary practices have also contributed to increased prevalence of cardiovascular diseases. Other causal factors include physical activity, increased tobacco consumption, overweight, obesity, high blood pressure, diabetes and dyslipidaemia. For dietary factors, increased consumption of saturated fats, salt, refined carbohydrate and low consumption of fruits and vegetables increase risks of cardiovascular disease. Fruits and vegetables have vital phytonutrients, potassium and fibre that reduce CVD.

Cancer incidence stood at 10 million new cases and 7 million deaths in 1996, and is predicted to double by 2020 in developing countries, with an increase of 40%. Dietary factors are estimated to account for about 30% of cancers in Western countries and 20% in developing countries. Rates change as people adopt different dietary patterns. Fruits and vegetables have probable protective factors. Population nutrient intake goals for preventing chronic diseases concern amount and source of total fat and total carbohydrates. Diets rich in vegetables, fruits, and whole grain cereals may sustain a total fat intake of up to 35% without the risk of unhealthy weight gain, and supply about 15-30% energy. The total carbohydrate should be 55-75%, after taking into account that consumed as protein and fat. Other chronic diseases are dental diseases and osteoporosis. The main feature in osteoporosis is vitamin C deficiency. In both disease states consumption of fruits and vegetables confer decreased risk. Vegetables and fruits thus offer great economic opportunities as functional foods in the prevention and control of chronic diseases and micronutrient deficiencies

Agrodiversity Practices Of Aivs

Agricultural development has created a great change in food and nutrition. There is increased reliance on domesticated crops resulting in loss or diminished diversity of indigenous food crops. There is reduced food choice and nutrient diversity. An understanding of the food systems of an environment is useful in the determination of the food security of a people and the interactions within the food system. Food systems are embedded in environments which differ according to a variety of factors such as social, health, economic, climate, agro-ecology culture, climate and policy. The food system is altered when people change to cash economy and purchase of processed foods with implications for nutrition and health status of people.

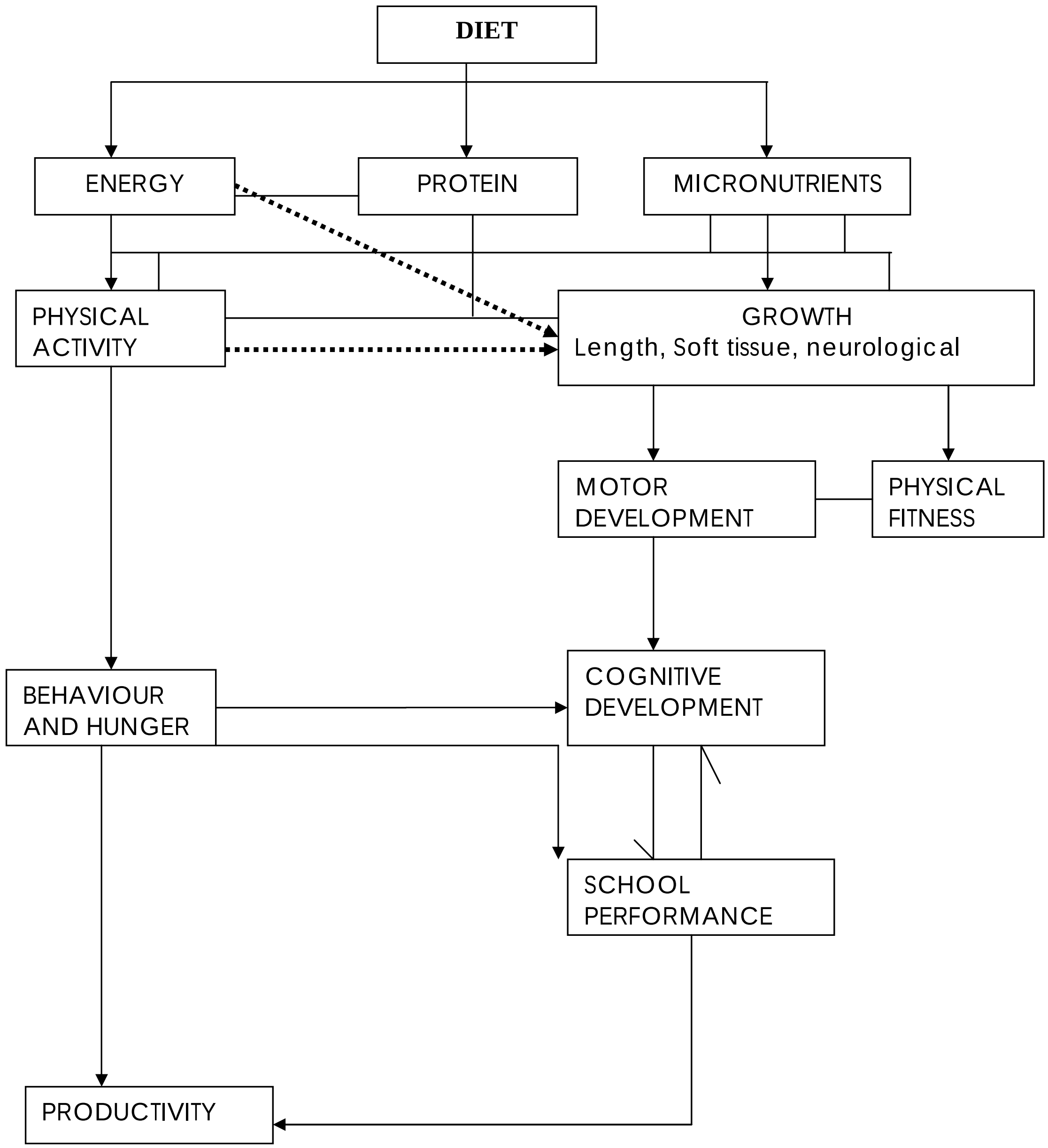

Fig. 1: Schematic diagram of the nutrition, biological and functional outcomes of micronutrient deficiency.

Table 1: Global Estimate of the number of People at risk and affected by selected Micronutrient Deficiency by Region.

	VITAMIN	DEFICIENCY[1]		IRON DEFICIENCY [2]	IODINE DEFICIENCY [3]	
	REGION	At Risk	Affected Xeraphthalmia		At Risk	Affected (Goitre)
1.	Africa	52	1.0	206	181	86
2.	Americas	16	0.1	94	168	63
3.	South-East Asia	125	1.5	616	486	176
4.	Europe	-	-	27	141	97
5.	Eastern Mediterranean	16	0.1	149	173	93
6.	West Pacific	42	0.1	1058	423	141
7.	TOTAL	251	2.8	2150	1572	655

Sources: [1] WHO/UNICEF (1995); [2] WHO (1992); [3] WHO/UNICEF ICCIDD (1994)

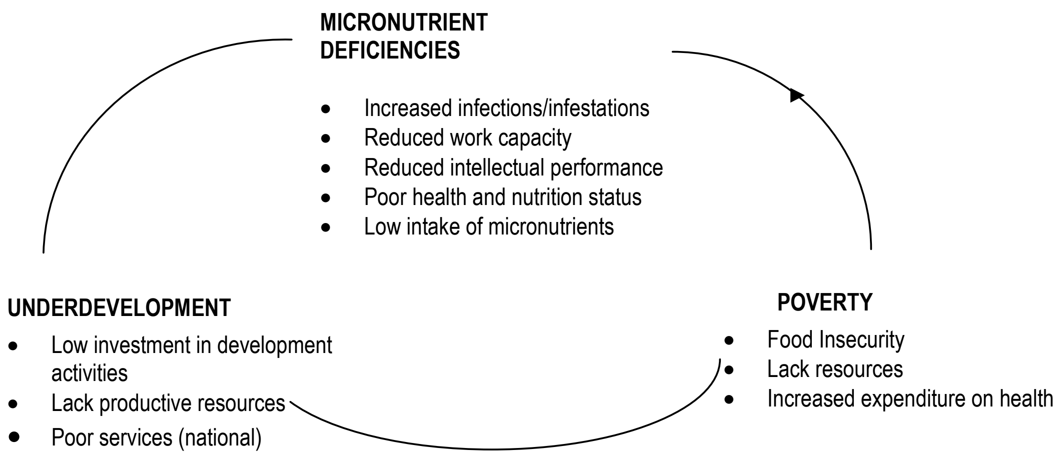

Fig.2: Vicious cycle of poverty, underdevelopment and micronutrient deficiencies

African farming systems had a wide variety of crops, many of which are still un-documented. Unfortunately poor attitudes towards traditional foods have contributed to the reduction in variety of indigenous food crops. Introduction of high-yielding variety of food and fruit crops is diverting the farming systems from mixed crop cultivation to mono-crop cultivation leading to loss of agro-biodiversity and increased risk to food insecurity. Decreased use of AIVs contribute to loss of species from the wild habitat.

Erosion of traditional values and knowledge, loss of genetic diversity and inequity in society has rapidly imperilled the native landraces and overall sustainability of agricultural system, leading to decline in indigenous crop diversity. Diversification reduces dependence on a few crops bringing about greater economic returns per unit of land and more employment reducing biotic factors. It also broadens the household's nutrition and food security base. Diversification increases the households' food and nutrient base, increases household incomes through marketing of products, and enhances accessibility of these foods all year round. Diversification of food and nutrient base of households assures micronutrient and food security, with implications for the health and nutrition status of a people. Nutrient value of AIVs varies between and within species. AIVs contribute to nutritional quality of household's diet. AIVs production is seen as a woman enterprise so its growth may empower women economically besides enhancing nutrient quality of diets. AIV production is labor intensive. Men prefer less labor-intensive exotic and market-oriented vegetables. However, AIVs are valuable sources of micronutrients, thrive in diverse ecological systems, can be grown as intercrops with staples, diversify household food resource base, provide employment and play a valuable role in cultural affairs. AIVs also contain non-nutrient factors that are believed to have curative and preventive advantage.

AIVS are highly perishable, and nutrients are lost during processing, requiring processing techniques that reduce losses and increase shell-life. Acceptability of AIVs at the individual consumption level is low. Dietary consumptions, lack of variety, requiring food diversification in farming systems as a policy framework.

Dietary Modifications

Globalisation has not spared cultural foods and their mode of preparation. Plant-based foods, especially the AIVs are a major source for cheap micronutrients in the human body. They are also a major source in fibre, whose recommended daily intake averages 30 grams/day and is necessary for the prevention and control of cancers of alimentary canal (i.e. colon).Diets evolve over time and are influenced by many factors and complex interactions such as commodity prices, cultural influences, intermarriages, psychological status, beliefs and preferences, lifestyle factors, growth and development. The perception of food varies from one group of people to another. Generally diet has been known to play a key role as a risk factor for chronic diseases and micronutrient deficiencies, amongst other risk factors. However, there have been global changes in lifestyle, civilizations interactions amongst others that have induced major modifications in diets.

Plant-based diets have been replaced, to a larger extent, by high-fat energy-dense diets with substantial content of animal foods. FAO Food Balance Sheets have revealed less consumption of plant foods and higher consumption of animal foods in the 1990s. It has also revealed a shift in the consumption of traditional, locally available foods to more western diets, a precarious situation for food security. Food consumption surveys have revealed consumption of 120-140g/day fruits and vegetables, 100g/day roots and tubers and 40g/day pulses in Asia, and 215g/day green leafy vegetables in Vihiga Kenya. Consumption of fruits and vegetables rose from 344g/day in 1982 to 369g/day in 1992 in China [Walingo 1998].

A small world population consume the recommended average of 400g/day of fruits and vegetables. However to increase consumption levels amongst populations production has to be enhanced and transport facilities availed to allow movement of fruits and vegetables to areas where national production does not meet demand – Special consideration has to be made to understand how balance of payments can be affected by an inflated demand of low-energy dense commodities.

Table 2 gives a summary of the perceived role of AIVs in health. The importance of fibres in the diet is now evident through research. Besides fibre, African indigenous Vegetables prefer herbal medicinal value e.g. spider herb has been used to treat stomachache and relieve constipation is a rich source of calcium and iron. Black nightshade, rich in vitamins A and C minerals and protein content is 29.3% has been used to treat hypertension and fever. Generally African Indigenous vegetables contain provitamin A, vitamin C and B complex, which are important in enhancing the body's immune function.

Infection rates are reportedly higher among individuals whose vitamin status is lower than the recommended allowances. Low consumption of AIVs resulting from dietary modifications reduces the intake of these essential vitamins, and also minerals. Low dietary consumption of AIVs is associated with attitudes, prejudice and closely related to changing cultures as people associate with other cultures. Now more animal and junk foods are being consumed, with deleterious affects on human health. The media has played a significant role in changing diets. Consumption of AIVs has been associated with the poor and rural "primitive" societies. Now effort is being made to enhance both the production and consumption of AIVs in all households.

Table 2: Perceived Role of AIVs in Health

Species	Medicinal Value
Amaranthus dubius	• Increased blood, prevent anaemia • Increase milk production in lactating women • Make a body strong, Prevents prostrate cancer.
Solanium nigrum	• Increase milk in lactating women • Increase blood i.e. prevent anaemia • Used to treat hypertension and fever
Manihot esculenta	• Make a body strong • Increase milk in lactating women
Vigna unguiculata Vigna unguiculata seed	• Increase blood prevent anaemia • Provide energy • Increase blood
Launaea cornuta	• Increases milk in lactating women • Makes body strong
Fruit & seed	• Prevent cancer of prostrate
Cleome gynandra	• Relieve constipation and stomach-ache

Composition of selected AIVs and Exotic Vegetables

Comparison of proximate principles and energy of selected AIVs and exotic vegetables reveals higher levels in AIVS than in exotic vegetables, for all proximate principles (energy, protein, fat, carbohydrates and fibre), though levels of proximate principles are lower than other foods like cereals, and beef. The AIV prefer further advantage since besides the leaves, the flower/tuber and seeds of the plant are also edible and add more nutrition value.

AIVs have higher concentration of calcium, phosphorus, phytin phosphate, iron and magnesium than cabbage and lettuce for example. Corchorus olitorius, Oxalis corniculata, spider herb are rich sources of calcium and iron, micronutrients important in the control of osteoporosis and iron deficiency anaemia.

AIVs have higher levels of vitamin A, thiamine riboflavin, niacin, ascorbic acid than exotic vegetables. The superior micronutrient quality of AIVs makes them important and appropriate in the prevention of nutrition-related diseases like hypertension, iron deficiency. Adequate policy support coupled with enhanced plant breeding and agronomic practices will improve production and consumption of AIVs. Controversies are rife about the effect of chemical nutrient supplements on human health. Dietary intervention in terms of quality is more appropriate intervention in the control and prevention of nutrient-related diseases. Such an intervention is cheaper, nutritious and cost-effective, besides improving variety in household diets. AIVs have non-nutrient contents than prefer medicinal advantage, increasing the possibility of using AIVs as functional foods.

SUMMARY

AIVs are important sources of cheap micronutrients that add nutrient quality to food. AIVs are necessary in the prevention and control of micronutrient deficiencies and chronic diseases. These vegetables help broaden the households' nutrition base by adding variety to diet. They also diversify the food base and food security. Raising production of AIVs will enhance households' economic base and provide employment.

RECOMMENDATIONS

1. Change people's attitudes so that they are more receptive to AIVs in daily diets.
2. Increase knowledge of the nutritional value of AIVs.
3. Develop processing technologies that will prevent excessive nutrient losses.
4. Diversify recipes of AIVs through research of existing recipes and food combinations that are time saving.
5. Organize markets for AIVs.
6. Avail good quality seed and train farmers in seed processing.
7. Strong government policy in promotion of AIVs.

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EFFECT OF NUTRIENT SOLUTION, SILICON AND MANGANESE CONCENTRATIONS ON COWPEA (*VIGNA UNGUICULATA* L. WALP) LEAF WATER LOSS

C. Owino-Gerroh, Department of Horticulture, Maseno University P.O Box 333, Maseno, Kenya
Horst, . W J. Institute fur Planzenerhrung, Universitat of Hannover, Herrenhauser Str. 2 Hannover, Germany.

ABSTRACT

The effect of silicon (Si) and manganese (Mn) on cowpea leaf water loss was studied in nutrient solution in a growth chamber at the Institute of Plant Nutrition, University of Hannover, Germany. The plants were grown for four weeks after transplanting the seedlings. Both leaf transpiration and resistance were determined for seven days under different light regimes using a Locor porometer. The addition of Si significantly increased leaf transpiration and resistance. The reverse was true when Mn was added to the solution. The addition of Si to the solution containing Mn significantly increased leaf transpiration and decreased resistance. The addition of Mn to solution containing Si had no effect on both leaf transpiration and resistance. These findings were attributed to better plant growth and suppression of the negative effect of Mn when Si was added to the nutrient solution. Mn normally suppress plant growth due to its toxic effects.

INTRODUCTION

As demand for more land for crop production increases, lands which were formerly considered unsuitable are increasingly being put into production. Moisture stress normally scores high as the major factor limiting the suitability of the land under consideration for crop production, the world over. Cowpea (*Vigna unguiculata* (L.) WALP) is a very sensitive crop to moisture stress and even a mild drought stress condition significantly reduced yields (Purseglove,1991). Manganese (Mn) toxicity is a major factor limiting plant growth and crop yield in acid and water logged soils, but may also occur under extreme climatic conditions such as drought or heat and steam sterilization of soils (Horst *et al*., 1991). Large differences has been reported between cowpea cultivars resistance to Mn toxicity (Horst, 1993). Besides plant genotype, several developmental, environmental, nutritional factors and including leaf age (Horst, 1982), temperature (Marsh *et al*., 1989), light intensity (Weissemeier and Horst, 1992), silicon (Si) nutrition (Horst and Marschner, 1978), and nitrogen form (Langheinrich *et al*., 1991) influence cowpea resistance to Mn toxicity.

Silicon is the second most abundant element on the earth surface, yet its role in plant biology has been poorly understood and the attempts to associate Si with metabolic or physiological activities have been inconclusive (Lewin and Reimann, 1969; Epstein 1994, 1999, 2001). Although Si has not been listed among the generally essential elements of higher plants, it has been demonstrated to be beneficial for the growth of plants particularly graminecous plant(Epstein, 2001; Ma *et al*., 2001). It (Si) has also been shown to alleviate both biotic and abiotic stress in other plants (Liang *et al*. 1994; Epstein, 1999, 2001; Ma *et al*., 2001) In this paper, the effect of Si and Mn accumulation in cowpea (*Vigna unguiculata* L Walp) leaf water loss is addressed.

MATERIALS AND METHODS

After germination between the filter moistened with 1 mM Ca $S0_4$, Cowpea (*Vigna unguiculata* (L) Walp) cvs. Tvu 91 and Tvu 1987 seedlings were transferred to a constantly aerated nutrient solution in round plastic pots of 2.0L capacity in a growth chamber. The chamber conditions were controlled at 30/25 ° C day/night temperatures, 75% relative humidity and photo flux density of 270 μ mol m-2 s-1 photosynthetic radiation at mid-plant during a 12 hour photoperiod. The composition of the basic nutrient solution was (μM): $Ca(N0_3)_2$ 1000, KH_2 $P0_4$ 100, $MgS0_4$ 325, FeEDDHA 20, NaCl 10, H_3 $B0_8$ 8, $MnSO_4$ 0.2, $CuSO_4$ 0.2, Zn SO_4 0.02, Na_2MoO_4 0.05. The seedlings were grown in two types of nutrient solutions. To half a portion of the prepaid basic solutions, 0.2μM$MnSO_4$ was added while the other received 50μM . These two solutions were further subdivided to two equal portions. To each half of each of the two subdivided portions was added 0 and 1.4 Mm Si (Si as potassium silicate K_2SiO_3). To the solutions that received Si treatment, 70 uM K^+ was also added. The pH of this solution was then adjusted to the pH of solution without Si (pH 5.8) using 0.5 M H_2 $S0_4$. To compensate for the additional K supplied to the solution with silicon, the nutrient solution without silicon received an additional 70 uM K^+ as K_2S0_4. The pH of the solutions were then kept at constant of pH 6.0 ± 0.1 by titration with 0.5 M H_2 $S0_4$. The nutrient solutions were renewed after every three days. The experimental design was a 2 by 3 factorial experiment in completely randomized design with five replicates. The seedlings were a to grown for four weeks. In the fourth week, leaf transpiration and diffusion resistance were determined on daily basis as affected by light regime using a loco porometer.

RESULTS AND DISCUSSION

The effects of Si and Mn concentrations on leaf transpiration and diffusion resistance of cowpea varieties Tvu 91 and TVu 1987 are shown in Fig. 1 and 2. The addition of Si increased and decreased transpiration rate and diffusion resistance respectively while the opposite was true in the solution which received higher concentration of Mn. The addition of Si significantly ($P \leq 0.05$) increased cowpea leaf transpiration and decreased diffusion resistance in solutions containing Mn. In solutions containing Si, the addition of Mn produced similar results for the two varieties but the effect of Si and Mn was more pronounced in variety Tvu 91 where higher transpiration rates and decreased diffusion resistance were observed. The observed effect of Si on cowpea leaf transpiration rate and diffusion resistance could be attributed to better growth performance. Cowpea plants grown in solution containing Si appeared healthier, their leaves were better disposed to light interception and were also rougher in compassion to those without Si. Si deficient plants were prone to wilting and senescenced earlier.These results are in consistent with those of Adatia and Bestford (1986) on cucumber where stimulation of growth was observed on addition of Si

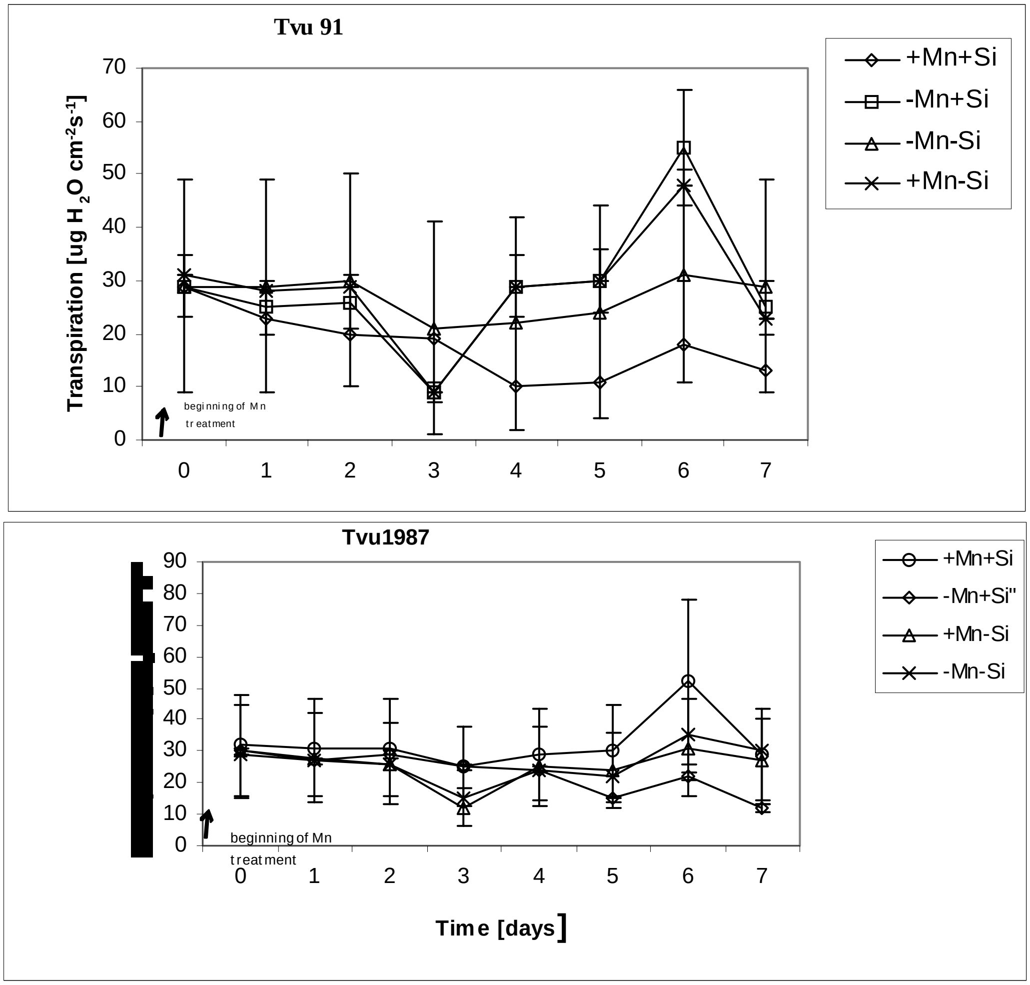
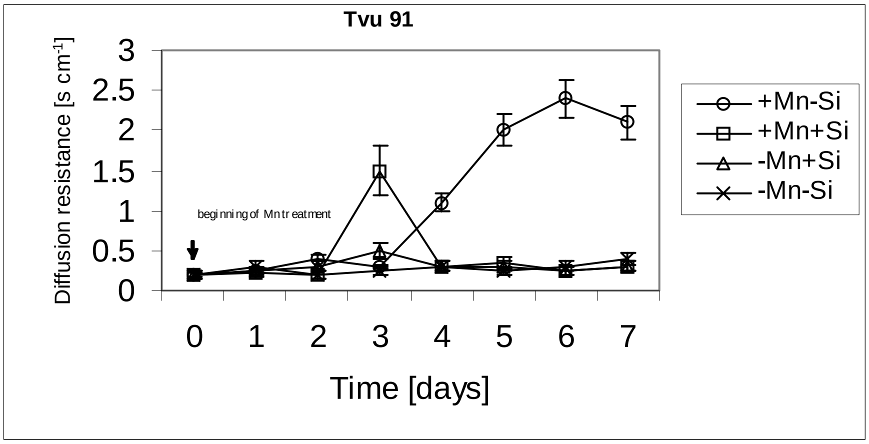


Fig.1a Effects of Mn and Si supply on transpiration of cowpea cultivars leaf as affected by light regimes



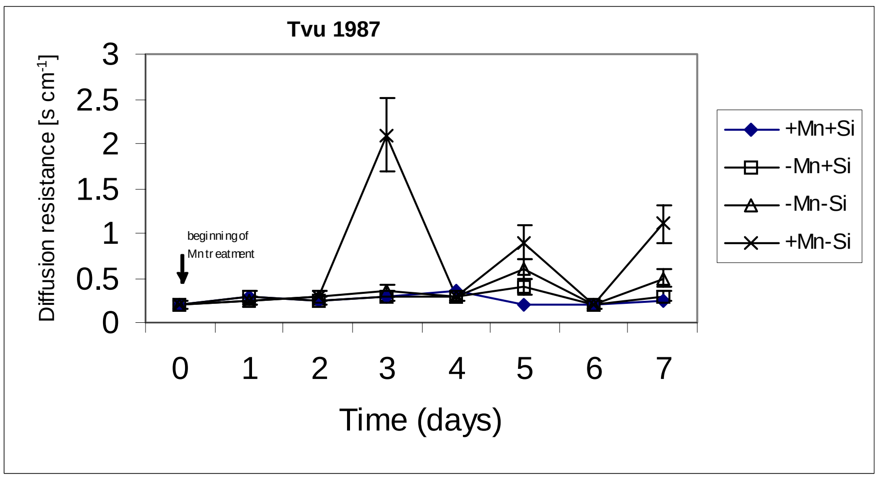


Fig.1b Effects of Mn and Si supply on cowpea cultivars leaf diffusion resistance as affected by light regimes

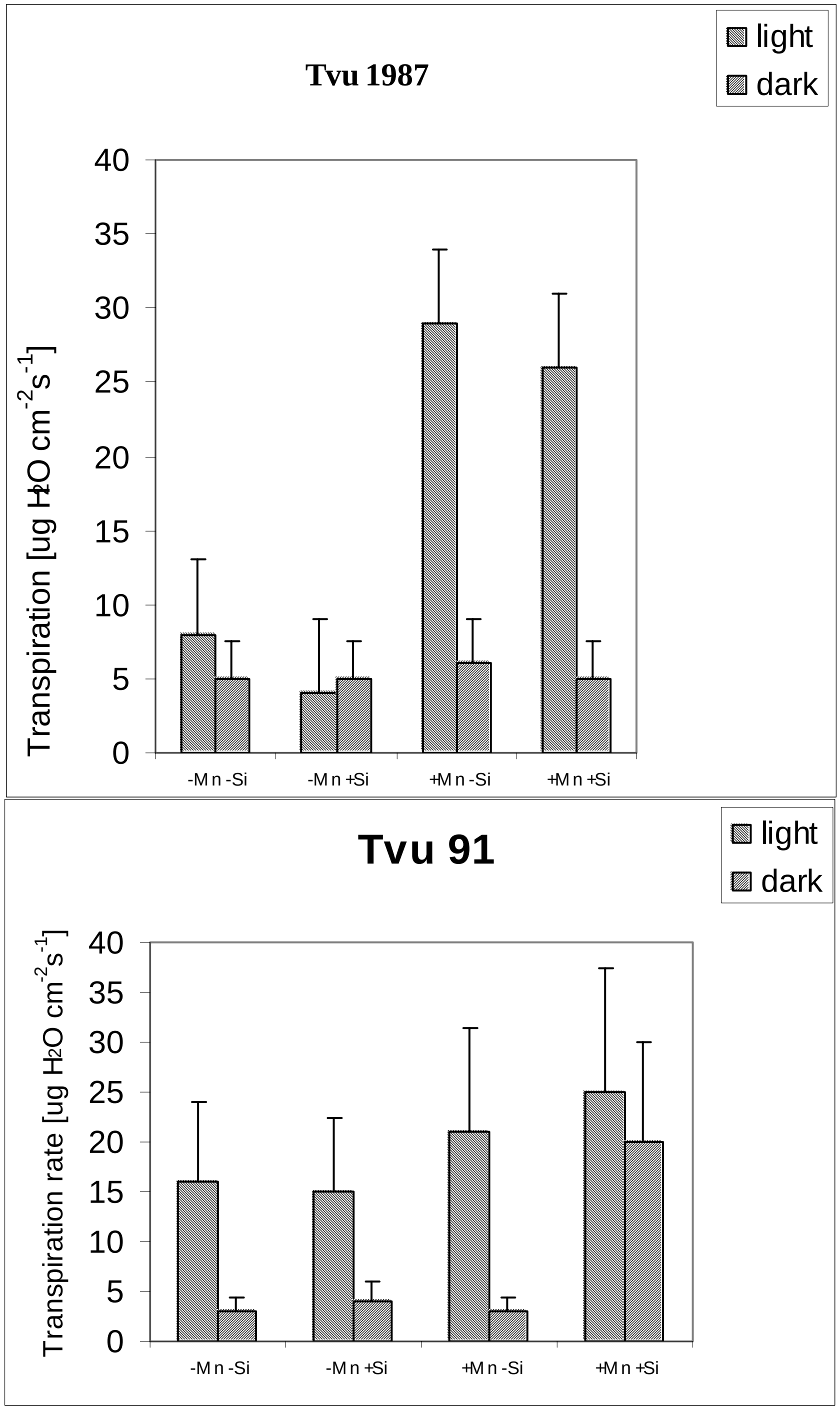
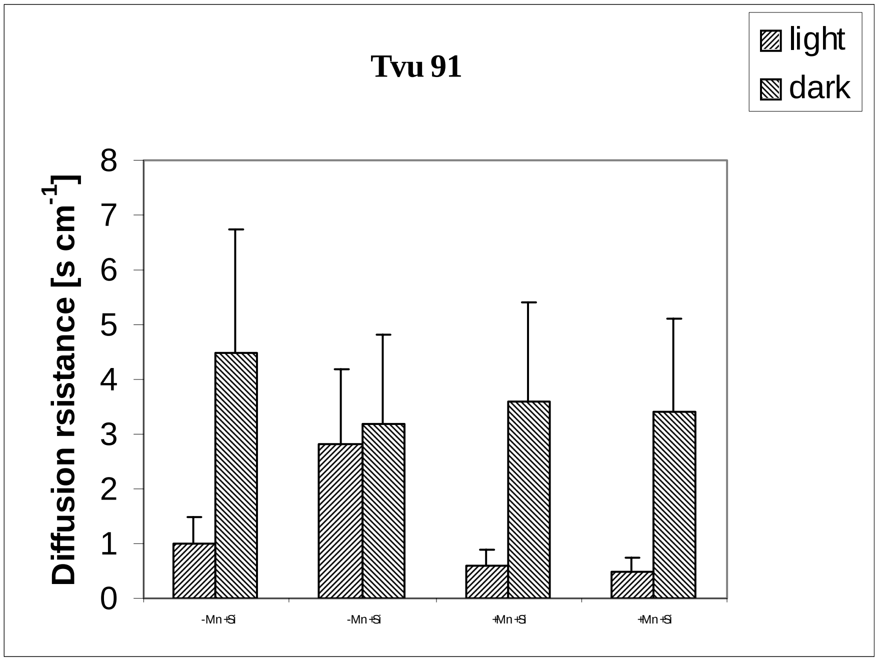


Fig. 2a Effects of Si and Mn supply on cowpea cultivars leaf transpiration as affected by light regime.



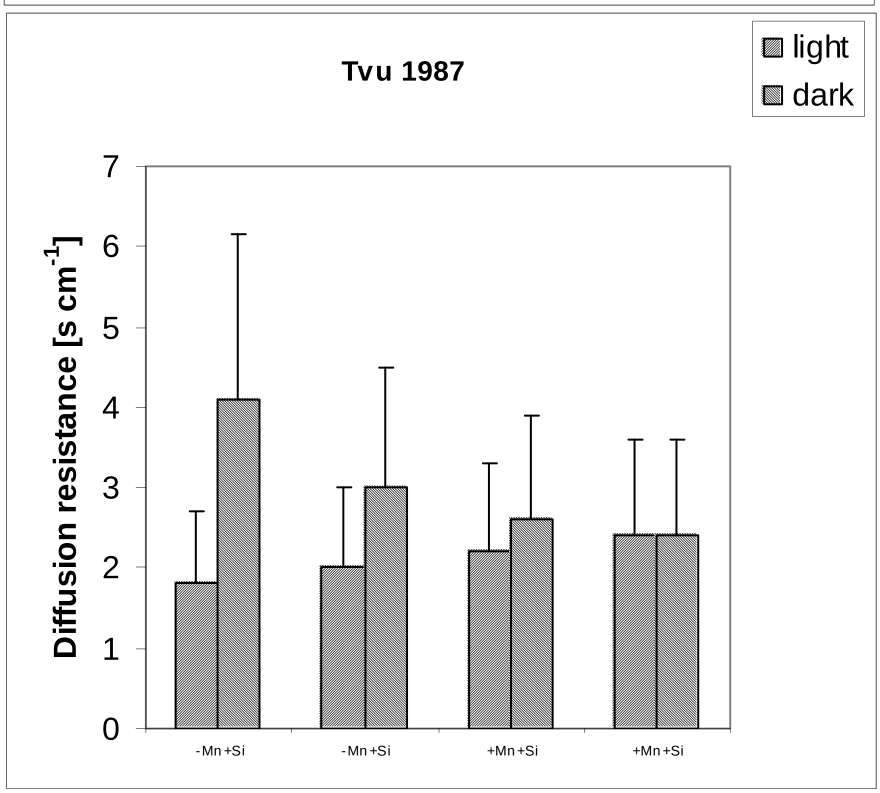


Fig.2b Effects of Mn and Si supply on cowpea cultivar leaf diffusion resistance as affected by light regimes

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RESEARCH CHALLENGES FOR DEVELOPMENT OF SMALL-SCALE HORTICULTURE IN THE HIGHLANDS OF MT KENYA

H. Kaburu M'Ribu
Department of Agriculture and Natural Resources-
Kenya Methodist University
PO Box 267
60200 Meru, Kenya

INTRODUCTION

Mount Kenya region comprises of the mountain itself and the various highlands around it, which form part of the central highlands east of the Rift Valley. It stretches across parts of three provinces and several districts. It is characterized by many hills, ridges, rivers and streams. It supplies water to millions of people and forms the upper catchment of the Tana and Engare-Uasonyiro rivers. The region covers various ecological zones ranging from montaine climate with sub-zero temperatures at the mountain top to hot and semi-arid zones in the lower highland areas. Rainfall and humidity levels are high in the upper zones especially in the eastern side of the mountain whereas semi arid conditions may be found on the northern and western sides. The region is one of the natural repositories of plant genetic resources. Traditional land tenure systems have created a culture that revolves around land ownership. Land has been central to the social welfare of ethnic communities, clans and families. With changes from the original communal ownership to private individual ownership, land has been continuously subdivided into smaller units parallel to the emergence of new families. Subdivision appears to continue unabated and in some areas, the holdings may have exceeded the minimum economic size for agricultural production. The situation has been aggravated by urbanization in previously rural areas.

Small-scale horticulture farming is a major activity in this region. It is desirable that appropriate production practices are developed for the existing systems in the region. The ideas presented in this paper represent observations and surveys carried out in Meru and Embu on the eastern slopes of the mountain to establish the relative position of fruits and vegetables in the agricultural systems, to observe the production, marketing and utilization practices and to assess the sustainability of agriculture in these environments. The paper attempts to outline the various opportunities available for research to develop horticulture in the region.

Production Systems

In traditional systems, farming was regarded as a way of life, primarily carried out to provide subsistence to the community. Production was strongly influenced by the basic requirement for food as a security measure for survival. With development of commercial agriculture, farming has been recognized as a major contributor to development of the economy. Mt Kenya region has high agricultural activity and is one of the major sources of food in the country. It represents a model of the intensive land use systems characteristic of the small-scale agriculture in Kenya. Various farming systems have been developed. Many farmers grow various horticultural crops. These crops are however generally considered secondary to grain crops and they are often disregarded if financial or labour constraints occur. In the past, most fruits, vegetables and spices were collected from the wild (M'Ribu et al, 1993). Perhaps because there was no history of planting them, there has been very little effort to grow them. Most of the commercially grown crops are of exotic origin and are often viewed as 'for sale only'. A few local crops are grown primarily for home consumption.

This region has high traditional agroforestry activity and many tree species are found. Fruit species have generally been treated in the same way as other tree species. Indeed fruit trees are generally used as fodder trees. They often sprout on their own in the farm and are cared for in situ or transplanted to other locations. They are thus scattered as single plants in various parts of the farm. Fruit trees are however, not allowed to grow on boundaries as other trees do. Because of the general attitude on fruit trees, they receive little attention in terms of agronomic care or crop protection. This leads to poor quality. As the fruit industry has continued to develop, there is now a tendency to plant new improved varieties. This has led to a surge in demand for grafted seedlings. Vegetables crops are grown in scattered small plots or in few lines in gardens. Most crops of exotic origin are primarily for sale. They are normally grown as seasonal crops under rainfed conditions. Crops meant for commercial purposes may be irrigated in the dry season. It is not known how the small plots influence crop management, especially with respect to diseases and pest management.

Species Diversity

Various local and exotic vegetable and fruit species are grown in scattered small farms. Several species may be found on the same farm. Approximately 4-6 vegetable and 5-7 fruit species, respectively, were frequent and up to fourteen vegetable and eight fruit species have been observed on individual farms (Kaburu et al. 2001). There was no farm with less than three species of fruits or vegetables. For many crops, only one or a few cultivars are planted, such that some crops are indeed known by cultivar names. It would be interesting to find out how the great diversity of species influences commercial production.

Banana (*Musa spp* L), avocado (*Persea americana* Mill.), papaya (*Carica papaya* L), mango (*Mangifera indica* L), passion fruit (*Passiflora edulis* Sims) and macadamia nut (*Macadamia tetraphylla*) are the most widely grown fruits. These are observed across several zones and constitute the major part of the commercial fruit industry in the region. Other fruits include pineapple (*Ananas comosas* L), guava (*Psidium guajava* L), citrus (*Citrus spp.*), loquart (*Eriobatiga japonica*), tree tomato (*Cyphomandra betaceae*) custard apple (*Annona spp*) and white sapote (*Casimiroa edulis*). These are grown as isolated small plots and often only one or a few plants of a particular species may be found. Banana is an old crop, which has been grown across various zones in the area. It has recently gained popularity because of markets in Nairobi. Availability of tissue culture seedlings has greatly enhanced production of the crop. Avocado, mango, papaya, passion fruit and pineapple have been grown in the area for several centuries as minor crops. They are also grown widely in other parts of the country. They have come into commercial production following the new developments in the export market in the last thirty years. Farmers are now planting pure orchards of improved varieties of these crops.

Several local fruits are grown or cared for when they sprout on the farm. Among them, 'Mburu' (*Vitex spp.*), 'Matuja' (*Myrianthus holstii*), 'Mbiru' (*Vangueria spp.*), and 'Ndoroma' (*Ximenia spp.*) are widely consumed and marketed locally. It appears that these can be easily selected and grown as commercial crops. Other fruits include 'Ndura/Maura' (*Ximenia spp.*), 'Ndoo/Ngambura' (*Dovyalis spp.*), Ngawa (*Carissa edulis*), 'Ngoe/Muriru' (*Syzyguin spp.*), 'Mukomboki' (*Sambucus africana*), 'Munoa' (*Pachystela brevipes*) and 'Muroro' (*Flacourtia indica*). These need to be properly identified and characterized. Kales (*Brassica oleracea acephala*), cowpeas (*Vigna unguiculata* L.), pumpkins (*Cucurbita maxima* Duch.), onions (*Allium cepa*), tomatoes (*Lycopersicon esculentum* Mill.), cabbages (*Brassica oleracea capitata*) and carrots (*Daucus carota*) are commercially grown by many farmers. Kales, cowpeas, pumpkins and onions are grown in small plots both for home consumption and for sale whereas tomatoes, cabbages and carrots are primarily for sale. Other commercial vegetables include French beans, peas, pepper, Russian comfrey and several Asian vegetables grown for export purposes.

Among the local vegetables, amaranth (*Amaranthus viridis* L), 'Managu' (*Solanum nigrum*), 'Tsisaga' (*Gynandropsis gynadra*), yams (*Dioscorea spp*.) and cocoyam (*Arum spp*.) are popular in the highlands. Adequate research on amaranth, 'Tsisaga' and 'Managu' has been carried out and the seed is now commercially available. On the other hand, despite the surge in demand for yams and cocoyams, they have not been well researched. Various clones are grown under a range of environments. It appears that suitable clones can be selected for the different environments. Yams are particularly suitable for vulnerable slopes. A number of other species of local vegetables are consumed.

Most indigenous vegetables are not commercially grown perhaps because they were originally collected from the wild. Although many of these were in use for generations, they have tended to disappear in the past four decades following new settlements and clearing of land for cash crops (M'Ribu et al, 1993). This means that they are not well known by the younger people who were not exposed to them. Indeed, in some cases they are often considered as weeds, primitive or not appealing to taste (Chweya 1997; Kaburu et al, 2001). Many wild and semi-wild species are utilized as vegetables in various parts of the world (Chweya 1997; Thorp 1997; Yongneng and Aigou 1999). Small-scale farmers may grow traditional varieties for various reasons (Thorp 1997). There is need for these species to be properly characterized and developed as crops in their respective areas. The new interest in these crops indicates that various species can be developed as commercial crops. Planting and use of the crops gives opportunity for improving food security, improving health status and enhancing the conservation of species diversity (Maundu 1993). There is need for development of appropriate recommendations for production as well as marketing for these species.

It is evident that there are many local fruits and vegetables that can be developed in this region. In some areas they may be considered as weeds or just trees whereas in other areas they are popular crops. Most of these have not been properly identified or characterized. They need to be identified, characterized and where possible, developed as crops for the respective areas. The fact that they are edible, they have been consumed for generations and they grow locally implies that they have high potential as crops in the area. It appears that a number of breeding lines can be selected and the crops can be developed further.

Production Constraints

The traditional land tenure system has led to severe shortage of land. Because of heavy human settlement, farm holdings have continued to decrease in size as the small farms are subdivided for inheritance. This is aggravated by the fact that new families have to allocate part of the farm for the homestead. Thus the small-scale sector is characterized by intensive cultivation on the available land. This has put a lot of pressure on the land. Many growers have tried to increase their production by off-season cultivation through irrigation and by practicing multiple cropping systems. Small irrigation schemes are therefore common; however, no specific recommendations are in place with regard to water use efficiency, protection of the water resources or the influence of irrigation on soil properties in the highlands. In addition, encroachment on water resources has led to some of the original small steams drying up. The small-scale sector is characterized by low soil fertility caused primarily by intensive cultivation, heavy rainfall, low use of inorganic fertilizers and lack of organic inputs. Heavy rainfall leaches nutrients or washes the topsoil down the slope. Because of poverty, many farmers use very little or no inorganic inputs. On the other hand, very little organic matter is available in the farms. This region is characterized by intensive livestock production through zero grazing which uses up all plant material available on the farm and elsewhere. Although zero grazing is expected to assist by providing manure to the farm the available quantities may be too low to improve soil fertility.

The highlands are characterized by heavy rainfall, which often comes in heavy storms that cause heavy runoff down the slopes. The highlands have thus been rendered vulnerable to heavy soil erosion and landslides. Shortage of land has forced farming activities in fragile areas that were previously not used for agriculture. Cultivation has been extended to steep slopes and other vulnerable environments without adequate conservation measures. Clearing of woodlands and vegetation cover on vulnerable slopes, riverbeds and along small streams and natural waterways has aggregated the problem. In addition, poor road design and lack of coordination between relevant authorities in agriculture, road maintenance and water conservation contribute to heavy soil erosion.

The hilly terrain presents a handicap to transportation. Indeed it is impossible to access some farms through motor transport. Transportation of potted seedlings fertilizers, manures and farm produce is therefore difficult. The planting and harvesting seasons are particularly difficult due to poor roads. Lack of proper planting materials, especially for fruits, has contributed to low production. Vegetable seeds are readily available for many commercial vegetables. However the prices are relatively high for the farmers. There are no seeds in the market for most of the local vegetables. Various types of plant nurseries are available in the area but they are not able to meet the demand for seedlings during the planting season. There is a lot of hawking of planting materials during the rainy season. However the quality of these seedlings with regard to type or health status cannot be ascertained and growers have often been conned.

Damage by pests and diseases can be very serious. Because of high humidity, fungal infections and damage by pests are common. Whereas many farmers use some control measures on vegetables, fruits are normally not protected. Both pesticides and cultural control methods are used. Pesticides are, however, relatively expensive. Farmers therefore use them sparingly. Crops grown for commercial sale are well protected whereas those for home consumption are not. Because of limited knowledge in pest control practices, inefficient methods are often used. There is need for development of farmer-friendly crop protection practices.

Post Production Activities

Availability of horticultural produce is characterized by gluts and shortages at various times of the year following the seasonal patterns. Because of the low scale of production, fruit and vegetable products are practically absent from the local diets most of the year. Although these products are nutritionally essential, they are neglected. Many people indeed do not believe they need them. A recent survey in the region indicated that over 67% and 50% of the farmers consider maize and beans, respectively, as enterprise crops whereas less than 10% consider vegetable crops or fruits as enterprises (M'Ribu, unpublished data). Lack of horticultural products has aggravated the food situation in many rural areas and has also influenced the product range in the urban markets. It has led to poor levels of nutrition and consequently poor health.

Produce marketing is a major constraint because of seasonal over-production, difficult terrain and lack of market outlets. Many small-scale farmers do not have adequate access to market information and therefore are not able to effectively follow market trends. Individual farmers do not have adequate produce to influence the market without collective bargaining. They may therefore be forced to go for very low prices or lose their products altogether. This causes unpredictable supply and pricing patterns. The market is characterized by a narrow range of products. Lack of information on utilization methods has hampered adoption of new farm products, which initially appear to have low market potential even though they have a high potential for improving the local food situation. Poor information has also led to erratic supply of some good products because only few people may use them. Because of the prevailing poverty, many peasants think more of products that have immediate market potential rather than meeting their long-term needs or overall nutritional requirements. They are unaware of how to dispose of the exotic products if the marketing processes fail. At harvest, peasants rush to sell their produce in order to get quick cash. They may indeed sell their products even though they need them. In this way the normal process of first having enough to eat and selling the surplus has been reversed. The negative influence on the economy is not immediately obvious. It is therefore important that farmers are made aware of various methods of utilization of products and the value of associating production to their nutritional requirements and health status.

Storage facilities are inadequate and processing industries are not well developed. A lot of wastage is thus incurred during gluts whereas serious scarcities occur off-season. Post-harvest losses have hampered production, such that many farmers are not even able to meet their own needs throughout the year. It is apparent that development of low-cost home-level techniques for food preparation, preservation and storage would reduce losses and enhance food availability for longer periods of the year. Diversification of the product range would also assist in reducing risks and ensure a better distribution over time.

CONCLUSION

The Mt Kenya region poses various challenges and opportunities for horticultural development. The various production systems existing in the region need to be studied to ascertain their economic worth and contribution to the welfare of the highland communities. Production of existing commercial species can be enhanced through development of appropriate packages for the various environments. There is great potential for development of the local fruit and vegetable species through breeding and research on appropriate production recommendations. Constraints associated with marketing of produce should be investigated. Farmers should be sensitized on development of storage facilities, appropriate methods of utilization and enhancement of consumption of horticultural produce in the region. There is need for research and collaboration among various organizations targeted towards long-term development of the horticultural industry in the region.

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RESPONSE OF TOMATO (*LYCOPERSICON ESCULENTUM)* TO MEDIA MIXTURE RATIOS OF SAND, LOAM AND MANURE.

By Kyele S.K and Abukutsa Onyango M.O, Department of Horticulture, Maseno University, P.O. Box 333, 40105, MASENO. E-mail: stevenkyele@yahoo.com, mabukutsa@yahoo.com

ABSTRACT

Tomato crop *Lycopersicon esculentum* is a highly nutritious vegetable and its distribution depends on climatic and edaphic factors. This fruit vegetable is scarce in Arid and Semi-arid areas where irrigation cannot be practiced. Other areas that experience shortage of tomatoes are in densely populated areas due to land pressure and low income earners mainly in rural areas and crowded urban centers like in the shanties. Developing Gunny bag culture can be of great use in these areas. The objective of the study was to investigate the effect of media mixture ratios of Loam, Sand and manure in growth and yield of tomato in gunny bag culture. The study was conducted at Maseno University Farm from May – August 2003. Seeds were tested for germination capacity in a laboratory and seedlings established in a 1m x 4m nursery. Four treatments were done by varying sand: loam: manure ratios and mixing them as follows, T_1 (control) 1:2:1, T_2 – 1:1:1, T_3 –1:1:3 and T_4 – 3:1:3 respectively. Data analysis was done by Analysis of variance (ANOVA). Parameters taken were plant height, leaf area, number of leaves, fruit weight and fruit size. On growth, development and yield of the plants significant effect was observed from the treatment with T_2 1:1:1 being significantly better than in other treatments including T_1 1:2:1 (control). From the results it was recommended that T2-1:1:1 ratio was the best for use in this technology. The significance of the study was that with establishing the best media ratio composition in gunny bag culture, tomatoes will be grown in Arid and semi-arid areas, densely populated areas and in crowded urban centers. This will reduce malnutrition problems.

INTRODUCTION

The Tomato (*Lycopersicon esculentum*.)

This is a Member of the *solanacea* family believed to have originated from tropical America mostly Mexico. It was introduced into Europe in early fifteenth century and spread to the Philippines via South America and to Malaysia by about 1650 AD. It was introduced in U.S.A. at the end of 18th century *(Atherton and Rudich, 1996)* The crop is believed to have arrived in West African parts via Portuguese traders or was brought across the continent from Egypt and Sudan *(Atherton and Rudich, 1996).* Tomato is an aninnual herb with hermaphrodite flowers, which are self-compatible and highly self-pollinating in cooler climates. To a small extend insects have been reported to help cross pollinate the crop *(Grubben et.al, 1977*)

It requires temperatures of about 20^{0}c – 25^{0}c during the day and 13^{0}c –17^{0}c at Night. Night temperatures above 17^{0}c may lead to malformed fruits which lower yields *(M.O.A, 1980)*. A wide range of soils is suitable for tomato cultivation. It should be well drained and not too heavy. Silty loams or clayey loams with a high organic matter content are preferred. The pH should be between 5 – 7 and suitable elevations are in the range of 0 – 2000m above the sea level. (*M.O.A, 1980)*. In the arid regions like Baringo, Machakos, Narok and lower parts of Taita Taveta, the crop is grown under irrigation. High rainfall zones such as Western, Nyanza and Rift Valley provinces plus Central and Coast areas are not the best for production because they are prone to fungal disese attack (*M.O.A, 1996)*.

Lycopersicon esculentum is grown in a wide range of climates including growing in the fields, protected green houses and heated green houses (*Williams, 1991).* Tomato is very important in that it is used as a vegetable. It is also processed to produce purees, juices, sauces, canned fruits and ketchups (*Tindall, 1983).* \In terms of nutrition the vegetable has appreciable quantities of nutrients, vitamins and mineral like vitamin a and c,and calcium. Phosphorous. This vegetable has many varieties which have been plantbred Selection is based on the purpose of the fruit whether for fresh market or for processing. Other basis of selection are colour, plant growth habits like determinate or indeterminate, disease resistant, adaptation to season and whether it is a hybrid or inbred, time to maturity, yield among others. *(Onyango, 2003 personal communication).*
Some of fresh market varieies include Money maker, Marglobe, Marmande, elgon dume, bonny best, ponderosa, hotset, Best of all and Beauty. The processing varieties include:- Roma, VF, m-82, Cal – J, Sam marzano, heinze 1350, VF 134 -1-2, Rutger hybrid, petomech and Mecheast, Cal – J and Heinze 1350 are both for fresh Market and processing *(M.O.A., 1980), (M.O.A. and J.I.C.A., 2000).*

Media and Gunny Bag culture.
Crops can be grown in the field without significant alteration of the soil. However when the same crop is planted there is failure. This is brought about by aeration which is not adequately provided for, compaction and contamination from weedseeds, pathogens and pests. *(Preece and Read, 1993), (William et.al, 1991), (Nelson 1991).*

A good soil media should serve as a reservoir for plant nutrients, hold water and make it available to the plant, provide exchange of gases between roots and the plant *(Nelson, 1991).* Also Nelson, 1991 adds that to ensure good water capacity and aeration, water and air should have a balance. A recommended mixture to obtain these functions should contain topsoil or loam, peatmoss (manure), and sand or perlite at equal volumes or at a ratio of 1:1:1 (*Relley and Shry, 1977), (Nelson, 1991).* Another ratio of sand: soil: manure at 1:2:1 was a recommended by Williams et.al, 1991. If clay soil is to be used instead of loam soil then the sand ratio is increased *Williams et. Al 1991), (Nelson, 1991).* If sand is used alone then it provides an excellent support and gaseous exchange but has insufficient water and nutrient supplying capacity. Clayey soils on the other side has high nutrient and water holding capacity. It provides excellent support but has poor drainage hence poor nutrition (*Nelson, 1991).* Organic matter on manure used will improve the soil structure, water retention capacity within the root zone, increase aeration, lower bulk density, increase (CEC) and hold other major nutrients like Nitrogen, phosphorous, sulfur and most trace elements. *(Tisdale et. al, 1993).* The life span of the Gunny bag can extend beyond 3 years depending on the shelf life of the crop planted (*Daily Nation, 2003).*

Table 2: Showing approximate composition of various manure when ready for farm use in percentages.

Type of Manure	% N	% P_2O_5	% K_2O
Cow/Horse	0.5	0.2	0.5
Sheep/Goat	0.7	0.2	0.7
Pig	1.0	0.2	0.8
Poultry	1.5	1.5	0.8

Rotten cow manure is the best to use. Though others are stronger they should be used in smaller quantities. The reason being that like poultry manure they produce high amounts of ammonia which causes root and foliage injury. This also lowers the pH below recommended pH 5 – 7. *(Nelson, 1991).* Gunny bags culture now involves putting this media mixture in Gunny bags of 0.5m width and 1m height. In the middle of the bag a column of pipe or containers which are perforated and filled with gravel is put to facilitate water percolation. *(Care Kenya, 2000. Personal communication).* In such containers, the suitable plants are small, relatively in expensive and easy to work with when planting. Small newly rooted cuttings produce the best results. However large containers with good-sized opening suit large plants *(Relley and Shry, 1997).* However, after media mixing there are some amendments, which need to be done. To begin with, the pH should be adjusted 6.2 – 6.8 pH by using dolomtic limestone. Where neutral to alkaline soils are used no adjustment should be done. Double superphorsphate should be applied for one year. Third micro-nutrients should be applied where possible *(Relley and Shry, 1997).*

Effect of media ratios on growth and yield of tomato.

Tomato crop is a heavy feeder and requires enough supply of macro-nutrients like Phosphorous, Nitrogen and potassium. Nutrients like phosphorous diffuse through the soil very slowly. Plants therefore get adequate phosphorus by extending their roots into the soil where it is depleted. The rate of growth is depended by the degree of compaction of the soil and phosphorus uptake was found to decline as the bulkdensity of the soil was increased by compaction *(Menary and Kruger, 1966.)* Quoted by Atherton and Rudich, 1996).

For producing high yields, soil needs to be well structured and to accept water and rainfall without crusting, eroding or shipping. It should hold moisture at reasonable levels to avoid wilting. The pH level should be within the range 5.5 – 6.8 in the tropics. The (CEC) cation exchange capacity should be high above 5 meq/100g Studies have shown that micro nutrient deficiencies are rare in cases where manure is used (Nelson, 1991). In a nutshell, Gunny bag culture is a new technology. Very little has been documented about it. This idea was brought by a German non-governmental organisation but was dealing with Kales. It's target was the people living in densely populated areas and people in arid and semi-arid areas. It was for the same reason that prompted the need for investigating the effective of media mixtures in growing of tomatoes for use in these communities.

OBJECTIVE

To investigate the effect of media mixture ratios of loam, sand arid manure in growth and yield of tomatoes.

MATERIALS AND METHODS

The Research was conducted at Maseno University farm between April – August 2003. Beds were thoroughly tilled and raised to fit 1m x 4m exactly. Furrows were made 20cm apart and 1cm depth. A double superphorsphate fertilizer was put at a rate of 10g per furrow. Seeds were sown along the furrows and lightly covered with soil. Routinely watering and all crop management practices were done to get a healthy seedling.

Scouting for pests and diseases was done to make sure that the seedlings were not attacked by them. Thinning was done leaving a 7cm distance between plants in a row. This ensured sturdy seedlings to emerge and were less susceptible to fungal diseases. Much care and more watering, scouting and weeding was continued until the seedlings were 4 – 6 true leaves or 15 cm height. At this stage hardening was started by reducing the shading, frequency of watering for two weeks before transplanting.

During this hardening period the bags were prepared. To start with, 1kg plastic tins were perforated and filled with gravel. Then the mixture of the media was put according to the treatments to fill the bags leaving a space of 4cm from the top. When the bags were $^{1}/_{3}$ full, the plastic tins were centrally arranged at each Bag stacked together up to the top of the sack. This was to facilitate vertical infiltration of water to the lower parts of the Bag media.

A support system was constructed by forming a cross structure above the experiment for staking. On the 4cm space left on the top a layer of gravel was placed on the bag to the fall 4cm height. This gravel covers the soil and act as mulch. It also prevent water splashing and reduce the erosive power of hand applied water. Another use was that the gravel made water applied to spread evenly from the top. Watering of the bags started 2 weeks before transplanting to prepare media and ensure it had uniform moisture.

Transplanting was done 5 weeks after germination. The seedlings were transplanted with a ball on it at 4 – 6 leave stage. Using a sharp stick, holes were made around the bag. Tomato seedling were then planted at 37cm spacing along a line. The first line was 10cm from the ground level and the other line was 90cm from the ground level then planted and firmed well. The young seedling were immediately tied up to the staking system by use of sisal twines. The planting was done on a late afternoon. The early training avoids the drooping of seedlings and hence the collapse of the succulent stem. Watering was continued 3 times a week but the frequency of watering was adjusted as water requirement increased and the changes in the environmental conditions. Scouting for pests and diseases was highly emphasized and any occurrence of these sprayed against. The experimental design was a completely randomized design (CRD) with (4) treatments replicated 3 times.

Table 1: Treatment description

	RATIO OF THE MIXTURES		
	SAND	**LOAM**	**MANURE**
T_1 (control)	1	2	1
T_2	1	1	1
T_3	1	1	3
T_4	3	1	3

NB: T_1 was used as control because it has been recommended for use in container plants by (William et. al, 1991)

Double superphorsphate was applied in each bag at the same time of media of mixing. After the firs fruitset 4 weeks after transplanting 100g of CAN was applied. Growth measurements were made on Number of fruits per cluster, leaf area per plant and fruit weight per plant. Data collection commenced 24 days after transplanting and continued for 9 weeks. It was analyzed statically by Analysis of variance (ANOVA) and separation of means using LSD, to establish which treatment mean was different from the other. One bag represented an area of 1m^2. There were twelve plots (bags) as per the plan. In each plot there were two planting lines of circumference of 110cm and only three plants were placed in each line. This made total plants per plot to be six. It therefore made it possible living in densely populated areas to place them on the verandahs and balconies. This to an extent can solve the problem of dwindling land as opposed to the geometrically growing population.

Secondly, sufficient results from the study provides a way of increasing production of tomatoes. This makes the vitamins and minerals present in them available. These include calcium, phosphorous, Beta carotene and ascorbic acid hence it improves our diet. Third. The media components are cheap as they can be collected from the rivers and on the roadsides. It then helps to make a step to alleviate poverty. Fourth, the project is helpful in that, once the correct ratio is established then it makes it easy for arid areas to use them as the water requirement is low i.e. a 5 litre container is enough after establishment for one bag. One bag of tomatoes is enough for a one nuclear family.

RESULTS AND DISCUSSION

Germination Test

The germination test results in the Laboratory showed a high germination percentage of Tomato seeds of 80%. Germination in the nursery was high as over 85% of the seeds germinated. This collaborated with the laboratory germination results. These findings were in line with recommendations by Atherton and Rudich, 1996 which says that Tomato seeds will retain their viability at normal temperatures and at fairly wide range of relative humidity. James, Bass and Clark 1964 report figures showed 90% and 59% germination after 15 and 30 years respectively. However the spread or uniformity of germination expressed as time between germination of 10% and 90% of the seeds was too short. This was completed after 14 days. The conclusion was that there was low degree of variability, which is important to a tomato producer.

Number of fruits cluster per plant

On the case of numbers of fruit clusters per plant, there was no significance effect ($p > 0.05$) at 24, 30, 37 and 44 days after transplanting. However there was significant effect ($p \leq 0.01$) at 63 day after transplanting as shown in the Table 2.

Also the results of numbers of fruit clusters per plant at 63 days after transplanting which showed a significant effect were as shown below. Figure 1 and plates 3 and 4. In addition the significance effect at 63 days after transplanting of number fruit cluster per plant on different media ratio was on line with (Artherton and rudich, 1996). This ascertained that holding other factors constant then nutrients availability greatly improve the quantity and yield of tomatoes including fruit set. The possible explanation for the manual used had started decomposing hence availing nutrients for growth.mineral deficiencies generally retard flower development i.e. low level of nitrogen in a solution culture results in delayed flower opening (Fisher 1969). Treatment 1 [control]had media ratio of sand:loam:manual at1:2:1 it was used as control because it was recommendable for use in potted plants (Williams et al,1991) however the results were contrary as T2 –1:1:1 media ratio had more fruits in cluster per plant than the T1-1:2:1(control). However,T3-1:1:3 and T4 –3:1:3 were homogenous with T1 (control) 1:2:1, in that there was no significance difference. In T3- 1:1:3, ratio of manure was increased.

Table 2: Effect of media ratio on number of fruit per plant at various growth stages.

TREATMENT Sand:loam:manure	**24 DAT**	**37 DAT**	**30 DAT**	**44 DAT**	**63 DAT**
T1 control 1:2:1	1.05	3.11	4.89	5.78	5.33
T2- 1:1:3	1.11	2.78	4.78	6.55	8.33
T3-1:1:3	0.33	1.67	3.78	5.66	6.00
T4-3:1:3	0.66	2.11	4.22	6.00	6.33
Significance	NS	NS	NS	NS	P≤ 0.01
LSD 5%	-	-	-	-	1.170

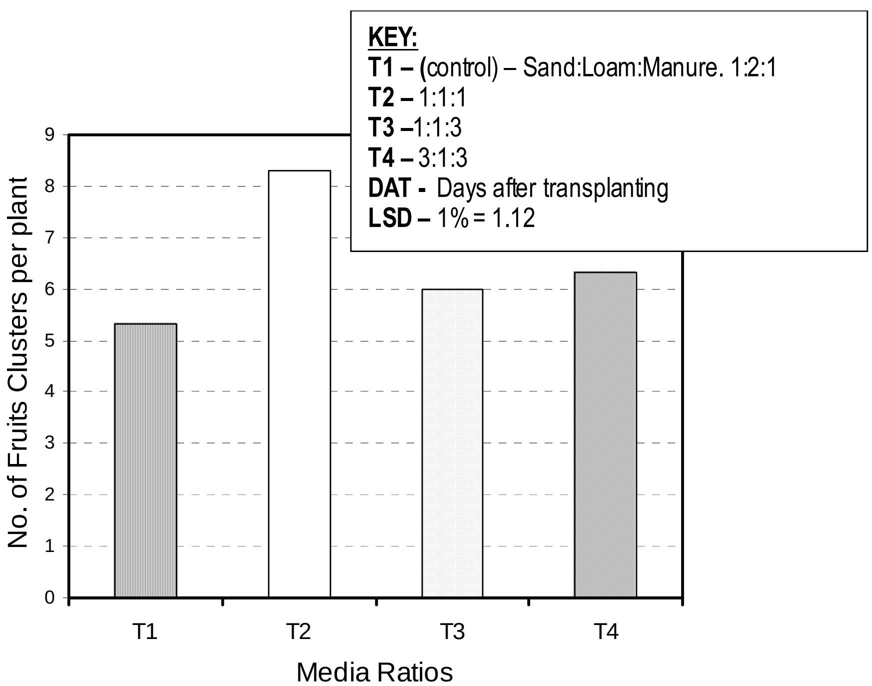

Figure 1. Effect of media ratios on number of fruit clusters per plant at 63 days after transplanting.

And the possible explanation was growth inhibition by pH range of tomatoes PH 5-7. This was possibly due to release of ammonia by decomposing manure. This might have caused root and foliar injury which reduced the growth hence number of the clusters (Nelson, 1991). T4--3: 1:3 had high sand and high manure content and the possible explanation was the ammonia effect discussed earlier but which was reduced due to improved aeration brought about by high sand percentage in the media hence much of ammonia was leached. This high drainage led to water stress disorders like blossom end , cat-facing and wilting were noted in T4 -3:1:3.

Fruit weight per plant.

Fruit weight per plant, a destructive parameter taken on 63 days after transplanting was significantly was significantly affected ($P \leq 0.01$). This was as shown in the Figure 2. Using LSD only T3-1:1:1 was different from T2-1:1:1 all the other treatments had no significance difference.

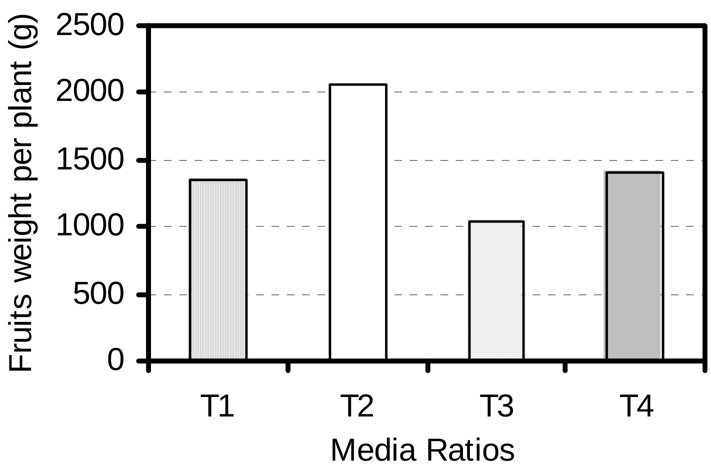

Figure 2. Effect of different media ratio on Fruit weight per plant at the 63 days after transplanting

T1- (control) 1:2:1 performed poorly in terms of fruit weight probably because of increased competition resulting from use of more topsoil. This affected the absorption of nutrients and water therefore affecting other metabolic activities, which led to small fruit yield and less fruit weight. T3-1: 1:3, which had high manure content, had the lowest plant weight. The possible reason of this was the ammonia release from decomposing manure, which affected the root absorption capacity, and leaves functioning. This lowered the yield and consequently the plant weight as less photosynthates were manufactured. T4-3:1:3, showed good growth but of average weight because of the water stress problem brought about by high drainage from use of high sand ratio. This made same fruits to develop defects like the blossom end rot and cat facing. In T2-1:1:1, there were best results as shown in the figure 2 below as the media was balanced.

Leaf area

Results on leaf area showed significant effect ($P \leq 0.05$) at 63 days after transplanting. The trend in which the leaf area varied was as shown below in Table 3 and figure 3

Table 3: Leaf area

TREATMENT	Leaf area cm^2
T1- Control Sand: loam: manure 1:2:1	4494.00
T2-1:1:1	6038.50
T3-1:1:3	3467.83
T4-3:13	4561.17
Significance	P≤0.05
LSD 5%	2435.06

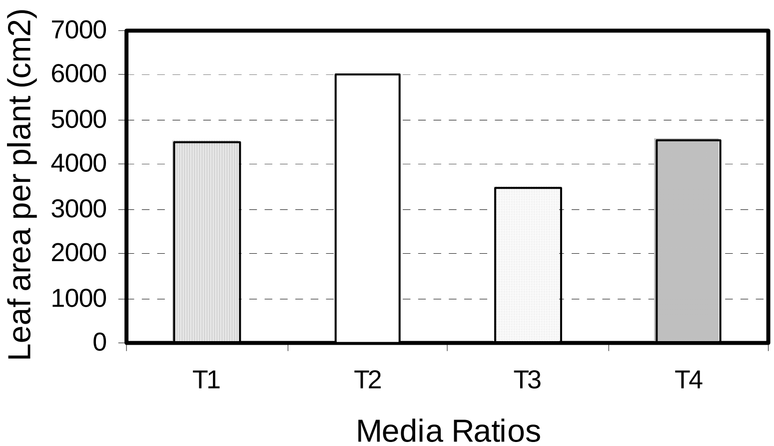

Figure 3. Effect of media ratios on leaf area at 63 days after transplanting

By using the LSD only T2-1: 1:1 was different from the control T1-1: 2:1. All the other treatment showed no significance from the control. Also T2-1: 1:1 was also different from the other treatments T3-1: 1:3 and T4-3: 1:3.

CONCLUSION AND RECOMMENDATION

Media composition of Sand: Loam: Manure at a ratio of 1:1:1 respectively significantly increased the performance of the tomatoes in terms of leaf area, number of clusters per plant and fruit weight. This was seen in T2 – 1:1:1. Since T2 – 1:1:1 showed the best performance in terms of the parameters taken even than the control T1 – 1:2:1, I would therefore recommend T2- 1:1:1 for use in gunny bag culture.

Suggestion for future Research

Due to time limit, harvesting was done four times and then discontinued for lack of time therefore cumulative yield from each plant was not completed. Time allowing, one can continue with taking yield per plant or per plot up to the dearth of the crop. This will help in calculating the total production per plot in a given area and then compared with the field conditions. Secondly, because of lack of time some other important parameters like the pH and soil temperature reading of the media ratio were not taken. With enough time one can take them and investigate how they interfere with the growth and yield of tomatoes.

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PATHOGENICITY AND FUNGICIDE EFFICACY ON FUSARIUM WILT OF PAPAYA SEEDLINGS (*CARICA PAPAYA* L.)

Palapala Valerie, Koech Joel and Gudu Samuel
Department of Botany, Moi University, P.O. Box 1125, Eldoret
E-mail: simsim@africaonline.co.ke

ABSTRACT

Papaya is an important horticultural fruit crop in Kenya grown for nutritional and industrial purposes. Attempts to raise seedlings for planting in many nurseries in and around Chepkoilel Campus farm, Moi University has failed due to high incidence of Fusarium seedling wilt. The aim of the study was to determine the influence of some environmental and edaphic factors on the pathogenicity and epidemiology of this pathogen and the efficacy of commonly used fungicides (Benlate, Bayleton and Ridomil) in the control of Fusarium in-vivo and when drenched in the soil. The effects of medium buffer, pH, temperature and soil chemical and physical composition on the incidence and growth of the pathogen was determined. Soil samples from Marigat (near neutral pH 7.02) and Chepkoilel campus farm (acidic soil, pH 4.6) and a mixture of both soils were used in the study. Temperature, soil texture, pH and phosphorus levels had significant effects on the disease incidence. Wilt incidence was high (70%) in seedlings grown in acidic soils (pH 4.6) than those grown on near neutral (pH 7.02) soils (35%). There was a significant negative correlation($r = -0.95$) between soil pH and disease incidence adequately explaining the observed high disease incidence at Chepkoilel. A high negative correlation was observed between phosphorus and disease severity. Fungicides tested displayed both fungistatic and fungicidal activities. Though mycelium growth was inhibited at low fungicide concentrations, cells remained viable. However, Benlate was found to be more effective as a soil drench while Ridomil had the highest inhibitory effect on biomass production of the pathogen. 25^0C was the optimum temperature for growth of *F. oxysporum.* Low soil pH experienced at Chepkoilel was the major predisposing factor for the high incidence of Fusarium wilt disease. This study demonstrates the role of soil pH and other environmental conditions in development of Fusarium wilt infection and indicated the effectiveness of the fungicides against the isolates of the pathogen.

INTRODUCTION

In Kenya, although papaya can survive in diverse agro-ecological zones, the major growing areas lie between sea level and 1500m above sea level (a.s.l.). Papaya is susceptible to attack by many pathogens, especially those causing rots and wilts of seedlings, associated with poor soil drainage (Garner *et al*, 1976) and viruses including papaya ringspot virus (Fritz *et al*, 1992). It is sensitive to variation in soil types and thrives well in easily drained sandy to moderately heavy soils (Botha, 1987). Seedlings growing on wet soils readily develop fungal stem rot, a condition normally aggravated by low fertility level in the soil. An attempt to establish different papaya cultivars at the Moi University, Chepkoilel Campus farm, standing at an altitude of about 2000m a.s.l. and with a pH of between 4.5 and 5.5 has failed due to 99% crop loss resulting from stunting and wilting of seedlings (Gudu, Personal Communication) whose causative agent was not immediately known. Since there has been no report of severe seedling wilt of papaya in Kenya, it was interesting to identify the causative agent of the observed seedling death.

Fusarium oxysporum is both a soil saprophyte and a facultative parasite. It causes vascular wilt disease in a variety of plants including chickpea (Haware *et al*, 1986), cucurbits (Chattopadhyay and Sen, 1996), chrysanthemums (Gardiner *et al*, 1989) and bananas (Bentley *et al*, 1995). Identification of the species is widely based on morphological characteristics and normally the pathogenic forms are classified into forma specialis based on host range (Snyder and Hausen, 1940). Forma specialis are further divided into races based on pathogenicity to particular cultivars of the host plant. Correct identification of Fusarium has become quite important due to the toxin producing capabilities of some species, especially the fumonisin producers (Chelkowski *et al.* 1999). Precise identification of *Fusarium* species still remains a problem.

Chemical control is by far the most widely used method in plant disease control including *Fusarium* spp. However, resistance of *F. oxysporum* isolates towards fungicides justifies the current trend in crop protection via breeding for resistance against it. However, benomyl is widely used against most Imperfect Fungi including Fusarium spp. as soil drench and foliar spray. There is as such, need to comprehensively evaluate quantitatively the effects of different chemicals on various growth parameters of the pathogenic organisms consequently the effects of the active ingredients of Bayleton (triadimefon), Ridomil (metalaxyl) and Benlate (benomyl) against *F. oxysporum* were studied, although field and laboratory resistance may not be similar according to Staub (1991), but could give some hints about the potential of these fungicides in controlling the pathogen.

The objectives of this study was to determine the effect of temperature and soil ph on epidemiology of *f. oxysporum* on papaya seedlings and to determine the effects of three fungicides on the growth of *f. oxysporum* via soil drenching and incorporations into artificial growth medium. it also aimed to screen different accessions of papaya for tolerance to *f. oxysporum* wilt pathogen.

LITERATURE REVIEW

The causal pathogens enter the vascular system of the host plant directly after penetration and remain in the conductive tissues (xylem) of the host (Parry, 1990). The wilt pathogens are thought to be distributed passively through the infected plant by transpiration stream. Parry (1990) reported that microconidia reach the perforation plate at the end of a xylem vessel where they germinate and grow through the plate. Disease syndrome is caused by the interaction of the pathogen propagules in vascular tissues of the host. *Fusarium oxysporum* forma specialis (f. sp.) medicaginis (affecting Lucerne) develops through tissue intercalary mainly, its growth directed towards xylem vessels (Parry and Pegg, 1985).

Pathogenic strains are usually designated as forma specialis (f. sp.) with selective pathogenicity existing within species. The forma specialis are known to exist in different races e.g *F. oxysporum* f. sp. *pisi* race 1 and 2 (Tessier *et al,* 1990) and *F. oxysporum* f. sp. *cubense* race 1, 2 and 4 (Bentley *et al.*, 1995). *F. oxysporum* occurs chiefly as a soil saprophyte although seed-borne cases of chickpea (Haware *et al.,* 1986) have been reported. The pathogen survives unfavourable conditions as chlamydospores or hyphae in infected plant debris. The chlamydospores state can live indefinitely in the soil. *F. oxysporum* f.sp *pisi* can survive for six years in the absence of a pea host (Haware *et al.,* 1986).

Various fungicides have different mechanisms of action. The selective toxicity of fungicides depends on target sites and resistance mechanisms (Griffith, 1994). Multi-site fungicides are non-specific and bind to any functional group important in maintenance of protein structures while specific fungicides have one recognized site of action (Lyr, 1977). Triadimefon (Bayleton) metalaxyl (Ridomil) and benomyl (Benlate) bioassays on Fusarium wilt pathogens infecting papaya was studied.

MATERIALS & METHODS

Experimental site

The fungal wilt pathogen infecting *C. papaya* was isolated from diseased seedlings of papaya raised at the Chepkoilel Campus farm located at an altitude of 2180m a.s.l and experiencing a minimum and maximum daily temperature of 15.5 and 22-24°C respectively. The soil pH averages about 4.5 at 0-20cm (Jaetzold and schmidt, 1983).

Fungal isolation and identification

To isolate the pathogen, diseased plants with classical wilt symptoms were randomly sampled from the seedling nursery. After pure cultures were obtained, the isolates were stored on dry slants (Carmichael, 1956) at 4°C. Pathogen identification was done using morphological growth characteristics in culture such as conidia types, shape and size, mycelia and pigmentation in media, sporodochia and presence or absence of chlamydospores as described by Snyder and Hausen (1940) and Booth (1971).

Epidemiology of Fusarium wilt of papaya seedlings

Pathogenicity of *F. oxysporum* on papaya accessions in different soil types was tested. Four accessions (BAR 3, GLS4, MVR2 and MLS 3) were randomly chosen for infection with the pathogen to determine if there was variation in tolerance or susceptibility within the accessions. The effect of soil type on pathogenicity of the pathogen on papaya seedlings was tested by using two major soil types viz: acidic soils (pH 4.6) of Chepkoilel (CCF) and near neutral soils pH 7.02 of Marigat (KMF) with two mixtures and sand (1:2, v/v) for each major soil types, viz: KMFSM and CCFSM soil mixtures.

Effect of soil type and properties

The aim of soil chemical analysis was to assess the overall nutrient status for the two experimental sites; Kenya Agricultural research Institute (KARI) Marigat and Chepkoilel Campus sites to establish if there was any relationship between soil nutrients status and wilt development. Since *F. oxysporum* is a soil pathogen, nutrient status of the soil could have had some influence on its infectivity. The soil sampling and chemical analyses were done according to procedures described by Okalebo *et al.,* (1993).

Determing efficacy of Bayleton, Benlate and Ridomil

The efficacy of active ingredients of Bayleton, Ridomil and Benlate was investigated to determine their effect on fungal biomass production, fungistatic and fungicidal activities on growth of *F. oxysporum*. The effect of soil drenching with fungicide on growth of *F. oxysporum* was done according to the procedures of Singh and Kapoor (1996) with slight modifications. Linear growth increases for each fungicide concentrations (0,10,150 and 1000 ppm) were determined and expressed as percent germination of controls. Means of increase in mycelial diameter of all test fungicides and concentrations on the first, third and fifth day after inoculations were tested for significant differences using Tukey's Honestly significant difference (HSD). Percent colony diameter increases on day 1 and 5 after inoculation were used to determine fungistatic effect of the test fungicides. Fungicide concentrations were transformed into natural log and probits on percent germination of all text done at x=0.05 to determine the effective concentrations at which 50% of the colony (EC_{50}) can be inhibited. The effect of fungicides on radial growth of mycelia in solid medium was determined by using 1 ml of 0, 10, 150 and 1000 ppm benomyl, triadimefon and metalaxyl fungicide concentrations in PDA media in four replicates. Colony diameters were measured periodically every 24 hours for five days. The experiment was repeated thrice and linear growth rates calculated and expressed as percentages of the control after determining percent mycelia germination. Mycelial diameter means recorded on the first, third and fifth day were compared by Tukey's honesty significant method. The EC_{50} for media treatment was determined and fungistatic effect of the test fungicides were evaluated.

The effect of the fungicides on biomass production in liquid medium was also determined. Conical flasks were amended with 0, 10,150 and 1000 ppm fungicide solutions. 5 mm mycelial plugs obtained from 7 day old cultures were used as inoculum. The conidial plugs were incubated at 25°C in orbital shaker at 50 ppm. After 7 days of growth, the resulting mycelia were harvested by filtration and blot dried in 10 layers of facial tissue. All the treatments were set up in triplicates in a completely randomized design and repeated thrice. The fresh weights were recorded. Mean of means for each concentration was used for analysis of variance to determine the effectiveness of test fungicides in inhibiting fungal growth.

RESULTS

Growth cultures were cottony white and the colony pink to pale yellow on PDA media. They were striate, delicate and white with a purple/ violet tinge. Micro and macrocondia were produced on short lateral conidiophores in fructification bodies. Macroconidia were generally sausage shaped, ranging from 35-40 x 3.5 – 4.5 cm with 3-5 septa. Microconidia were generally smooth walled and non-septate ranging from 8 - 9 x 4 - 4 .5 cm. However, the conidia were very sparse in distribution.

Table 1 shows the degree of tolerance of papaya accessions to Fusarium wilt which confirmed that wilting plants were due to the pathogen infection. Re-isolation and culturing was done, and the screened papaya accessions were found susceptible. However, GLS 4 and MLS 3 were relatively tolerant to Fusarium wilt compared to BAR3 and MVR2. The type of soil in which the seedlings were growing determined the degree of tolerance to wilt. However, BAR 3 was less susceptible in Marigat than Chepkoilel soil. GLS4 was most susceptible in Chepkoilel and forest mixture and Chepkoilel soil than in Marigat soil mixture, while MLS3 was more infected in Chepkoilel soil than Marigat soil. Plant development was hampered by wilt infection. Susceptible plants tended to become stunted. A general reduction is leaf size and chlorosis (yellowing) was observed. Wilting of diseased plants occurred after inoculation and successful infection.

Table 1. Fusarium wilt incidence on different papaya accessions raised in different soil types.

PAPAYA ACCESSION	**% Fusarium wilt incidence and severity**				
Soil Types	**CCF**	**CCFSM**	**KMF**	**KMFSM**	**Mean**
BAR 3	100(5)b	40(2)a	20(1)a	60(3)b	55(2.75)b
GLS 4	60(3)A	80(4)C	20(1)a	40(2)a	50(2.5)a
MVR 2	60(3)A	40(2) a	60(3) c	80 (4)c	65 (3.25)c
MLS3	60(3)a	60(3) b	40(2)b	40(2) a	50(2.5) a
Mean	70(3.5)c	55(2.75)b	35(1.75)a	55(1.75)b	53.75(2.69)

- Figures in parentheses represent mean disease severity. Means followed by same letter in column except for means are not significantly different (x=005) according to turkey HSD.
  Note: CCF- Chepkoilel Campus farm; CCFSM- Chepkoilel campus forest, soil mixture; KMF- Kari Marigat farm, KMFSM- Kari Marigat forest soil mixture.

Disease incidence was relatively high in the acidic soils (70%) and lower in alkaline soils (35%). Therefore wilt disease was most severe in Chepkoilel soil (severity score 3.5) than Chepkoilel forest soil and Marigat forest soil (1.75) and least in KARI Marigat farm soils (Table 1). Simple correlation analysis revealed that Olsen P and silt had a non-significant (X=0.05) negative correlation with wilt disease incidence (r=-0.632) (Table 2). Organic carbon, nitrogen, % sand and clay recorded a high but non- significant positive correlation (r=0.632, 0.316, 0.316 and 0.316 respectively). pH had a significant negative correlation (r=-0.949). Chepkoilel soils with lowest pH (4.62) recorded highest disease incidence (70%) while Marigat with highest pH had least (35%) (Table 1). Disease incidence increased with decrease in phosphorous level. Chepkoilel with low phosphorous recorded highest wilt incidence while Marigat with highest phosphorous least.

Table 2. Correlation coefficient (r) between soil parameters and Fusarium wilt incidence.

Parameter	**Correlation coefficient (r)**
% Clay	0.316 ns
% organic carbon	0.632ns
% Nitrogen	0.316 ns
Olsen P	-0.632
PH	-0.949
% sand	0.316 ns
% Silt	- 0.632ns

ns = Not significant at D=0.05.

The fungicides as soil drench were evaluated to determine the effective concentrations of benomyl, triadimefon and metalaxyl that would inhibit mycelial growth of *F. oxysporum.* All the three fungicides produced variation in mycelia growth, % germination and % inhibition of *F. oxysporum* (Table 3). Fungicide type, concentrations and number of days after inoculation had significant effects (x=0.05) on mycelial growth of the fungus although, mycelial growth on the surface of PDA media was inhibited even at low fungicide concentrations. 1000 ppm was the most inhibitory while I ppm the least inhibitory effect on fungal growth.

The fungicides evaluated significantly inhibited (∝=0.05) mycelial growth of the fungus in vitro. However triadimefon was the most effective in reducing mycelial growth while metalxyl was least. However, no significant difference was observed between triadimefon and benomyl with regard to mean growths. Similarly, the effects produced by metalaxyl were not significantly different from benomyl unlike triadimefon effects.

Table 3. The effect of soil drenching with different fungicides concentrations on mean mycelial growth of *F. oxysporum* observed on the first, third and fifth day after inoculation.

FUNGICIDES	CONCENTRATION (PPM)	MEAN DIAMETER OF MYCELIA (MM)			MEAN MYCELIAL DIAMETER (MM)	% INHIBITION
		DAY 1	DAY 3	DAY 5		
BENOMYL	**0**	**7.861**	**30.296M**	**49.86M**	**29.337B**	**-**
	1	4.88h(62.1)	27.0k	45.62k(90.5)	25.833b	9.5
	10	3.50f(44.50)	26.1251	45.125j	24.917b	9.51
	150	1.12c(14.2)	19.0f	39.5f	19.873b	36.16
	1000	7.861 (0.0)	0.28a	0.43a	0.277a	99.99
TRIADIMEFON	**0**	**7.861**	**30.29M**	**49.86M**	**29.337B**	**-**
	1	6.25j (79.0)	26.75j	44.75h(89.7)	25.928b	10.25
	10	5.141 (65.4)	26.14j	43.71g(87.6)	25.343b	12.34
	150	0.0a (0.0)	7.95c	16.5c (63.33)	8.15a	36.67
	1000	0.0a(0.0)	5.86b	12.14b(24.3)	6.00a	75.65
METALAXYL	**0**	**7.861**	**30.29M**	**49.86M**	**29.337B**	**-**
	1	7.63k(97.0)	28.571	45.711(91.6)	25.917b	8.32
	10	6.121(77.8)	22.71h	44.861(89.9)	24.997b	10.03
	150	34.8d (2.7)	16.71e	34.38e(68.9)	8.15a	31.05
	1000	25.5c (2.0)	14.75d	31.83d(63.8)	6.00a	36.17
	MEAN	**4.432 A**	**21.43B**	**37.75C**		

Note: Figures in parentheses represent % mycelium germination means for days 1 and 5.

- Mean diameter for 0ppm not considered.
- Means followed by the same letter(s) in the same column except for mean mycelial diameter are not significantly (∝= 0.05) different according to Tukey HSD.

Variation in biomass production

The different fungicides and their concentration variability had significant effects on the biomass production of *F. oxysporum* in liquid media. Metalaxy1 inhibited biomass production more than benomyl and triadimefon. However, at 1000 ppm all the fungicides produced the highest inhibitory effect while 1 ppm the least.

DISCUSSION

The pH values used in the study were chosen because they represent the range of conditions that occur at both Chepkoilel and Marigat where the papaya seedlings were raised. Generally low pH levels enhanced growth (I%) while pH above 6 inhibited growth of the *Fusarium* sp. The increase in colony diameter at pH 5.0-6.0 may partially have led to the increase in Fusarium wilt severity in papaya seedlings raised at Chepkoilel campus farm with a soil pH 4.5-5.2 than Marigat with a pH 6.7 – 7.26. Fusarium wilt severity and incidence was highest in Chepkoilel soil with low pH (4.62) and phosphrous levels but lowest at Marigat soil with a high pH (7.02) and phosphorus levels. This observation indicates that the wilt pathogen is able to infect papaya seedlings over a wide range of soil pH (4.6-7.02).

A general negative correlation was observed between phosphorus level and disease severity. Chepkoilel soils containing low phosphorus levels (0.103 ppm) recorded the highest disease severity (70%) while Marigat with highest phosphorus level (0.167ppm) had lowest disease severity (35%). Kaushal and Sharma (1998) recorded highest wilt

(92.6%) at high phosphrous dose (40 kg/ha) and least at low phosphorus (20kg/ha). Although there was no statistical difference between wilt incidence at high and medium doses, phosphorus levels enhanced disease incidence over the check in the study. The results in this study indicate that the disease is more prevalent in the acidic soils and rarely in neutral to slightly alkaline soils. Phosphorus addition to soil is also known to affect the disease development as demonstrated by Kaushal and Sharma (1998).

Although mycelium germination was inhibited by very low fungicide concentration, the cells were fully viable. The results obtained in this study indicate that benomyl, metalaxyl, and triadimefon had varying fungistatic and fungicidal activities. Benomyl was more effective in media than as a drench. The fungistatic and fungicidal activity of benomyl could be attributed specifically to benzimidazole fungicide. Higher concentration requirements for benomyl as a soil drench in this study are comparable to the recommended rates of 12 –45 kg (approximately 300ppm) a.i/ha. Metalaxy was relatively less effective against Fusarium wilt than benomyl and triadiamefon except in reducing production in shake culture.

CONCLUSIONS

It can be concluded from this study that soil pH and phosphorus levels have significant effect on development of Fusarium wilt in papaya seedlings. The fungicides benomyl, triadimefon and metalaxyl when applied to growth medium have no significant effects on the growth of Fusarium wilt but have significant effect when used as a soil drench.

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MYCORRHIZAL EFFECTS ON GROWTH AND SUPPRESSION OF ROOT PATHOGENS IN SOME HORTICULTURAL CROPS

Too, E.J., Onkware, A.O. and Koech, J.K
Department of Botany, Moi university. P.O. BOX 1125 Eldoret

ABSTRACT

Infestation by root pathogens can reduce crop growth and production due to inhibition of root development. A major beneficial effect of mycorrhization on host plant growth is due to increase in below ground root surface area for acquisition of essential nutrients of low mobility in the soil solution. Mycorrhization is therefore of special importance for crops which have poorly branched root system. External hyphae can absorb and translocate mineral nutrients to the host from the soil. In most soils, roots are infected with indigenous mycorrhizal fungi (endomycorrhiza-arbuscular mycorrhizae-VAM and ectomycorrhizae-ECM). Elimination of VAM fungi by soil fumigation is reported to have reduced growth of carrot and leek and growth was restored after reinoculation. In legumes growing in phosphorus deficient soils, VAM fungi enhances nodulation, nitrogen fixation and plant growth. Mycorrhizae enhance water supply to the host plant. ECM fungi form extended extramatrical mycelium and rhizomorphs which facilitate rapid and water transport to host plants. This enhances crop growth especially under water stress conditions. Inoculation with VAM fungi has been shown to suppress soil-born fungal and bacterial root pathogens. It increases resistance of tomato to *Fusarium oxysporum* and *Pseudomonus syringae*. VAM fungus *Glomus intraradices* reduced disease development and severity of *Aphanomyces euteiches* in pea roots. Peanut plants inoculated with *Glomus mosseae* showed lower incidence of root rot, decayed pods and death as compared to non mycorrhizal ones. This review presents the importance of mycorrhizal associations with respect to growth and suppression of root pathogens on their host plants.

Keywords: mycorrhizae, root pathogens, nutrients

INTRODUCTION

Mycorrhizae are close mutually beneficial relationship between specialized soil fungi and plant roots (Marschner, 1995). The roots of most soil grown plants are mycorrhizal. On a global basis, mycorrhizas occur in 83 % of dicotyledonous and 79 % of monocotyledonous plants, and all gymnosperms are mycorrhizal (Wilcox, 1991). Non-mycorrhizal plants occur in habitats where the soils are either very dry, waterlogged, severely disturbed or where soil fertility is extremely high or extremely low (Brundrett, 1991).

A summary of common mycorrhizal groups are presented in Table 1. There are two major mycorrhizal groups according to how the fungal mycelium relates to the root structure, the endomycorrhizae and ectomycorrhizae (Marschner, 1995). Endomycorrhizae are fungi that live within cortical cells and also grow intercellularly. There are several distinct types of endomycorrhizae the best known being Vesicular-arbuscular mycorrhizae (VAM), Ericoid and Orchidaceous mycorrhizae. The VAM is the most abundant of endomycorrhizae (Harley and Harley, 1987). It is characterized by branched haustorial structures (arbuscules) within the cortex cells and a mycelium, which extends well into the surrounding soil (Fig. 1)(Marschner, 1995, Harley and Smith, 1983). The VAM fungi belong to mainly four genera, *Acaulospora, Gingaspora, Glomus and Sclerocystis. Glomus* is the most abundant genus (Lamont, 1982).

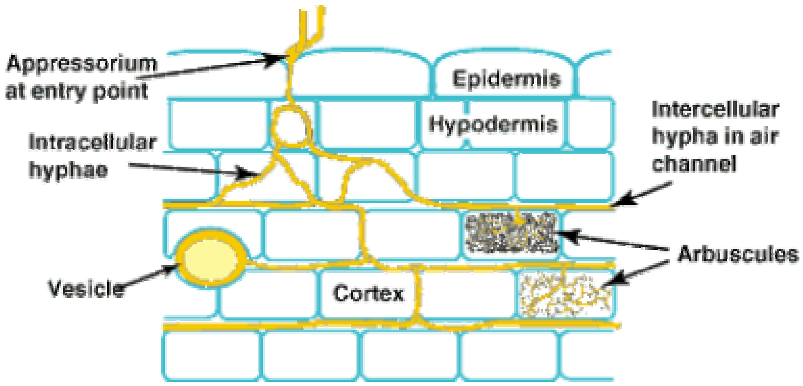

FIG. 1. Plant root cells showing structures of vesicular-arbuscular mycorrhizal fungi

Ericoid mycorrhizae occur in Ericales, either as endomycorrrhizal or ectendomycorrhizal type. Ectomycorrhizae (ECM) are characterized by two main features; an interwoven mantle of hyphae around the root surface (fungal sheath) and hyphae that penetrate the root intercellular spaces of the cortex to form a Hartig net which envelopes the cortex cells and increases surface area at the fungus-root interface (Marschner, 1995). Fig. 2

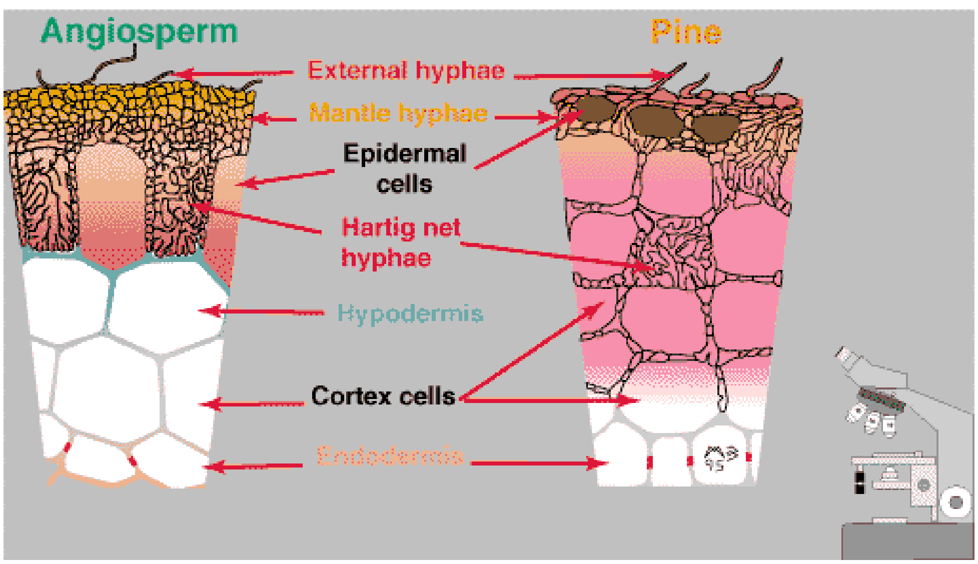

FIG. 2. Plant root cells showing structures of ectomycorrhizal fungi.

Root infection with mycorrhizae is initiated either from soil-borne propagules or from neighbouring roots of same or different plant species. Infection is enhanced by pre-existing network of hyphae in the soil and hence severe soil disturbances such as vigorous soil mixing (Jasper *et al.*, 1989) and tillage (Miller and McGonigle, 1992) severely depresses or delays mycorrhizal infection. Root exudates of host plants have a strongly chemostatic action on ECM (Horan and Chilvere, 1990) and VAM (Gianninazi-Pearson *et al.*, 1989).

Little change in root morphology occurs following infection by VAM fungi (Harley and Smith, 1983) and the root apices continue to grow and root hair production is not suppressed. It is difficult to tell if a root system is mycorrhizal without microscopic examination unless there is characteristic yellowing of infected roots for example in onions and some members of leguminosae (Harley and Smith, 1983) Mycorrhizae are a phenomenon of natural soils, hence can only operate in a range of mineral availability found under natural conditions. Heavy fertilization especially of phosphorus has been reported to inhibit mycorrhizae establishment (Ted, 1985; Baath and Spokes, 1988). Mycorrhizae may also be lost through use of pesticides, which are normally specific for a particular group of organisms such as nematodes and insects. However some of these pesticides have a certain amount of activity against non-target organisms such as mycorrhizal fungi. Fortunately not all pesticides are inhibitory and appropriate compounds can be found to treat most pests without destroying mycorrhizal fungi (Ted, 1985). Once lack of mycorrhizal fungus has been identified as a problem, it is possible to be re-established back into the soil. The usual inoculum is a mixture of soil, spores, fungal hyphae and dead mycorrhizal roots

Role of Mycorrhzae on Plant Growth

Alleviation of Drought Stress

Mycorrhizae may improve host plant growth and development through direct or indirect effects on plant water relations (Marschner, 1995). Enhancement of water supply to the host plant is documented for ECM fungi, which form extended extramatrical mycelium and rhizomorphs (Brownlee *et al*., 1983). Rhizomorphs facilitate rapid and substantial water transport to the host plant (Lamhamedi and Fortin, 1999). VAM fungus *Glomus clarum*, stimulated tomato plant growth under water stress conditions (Dell'Amico *et al*., 2002). Other workers (Busse and Ellis, 1985) reported drought tolerance in soybean inoculated with *Glomus fasciculatum*. Total seed weight of innoculated soybean increased by 10% more than uninnoculated, possibly as a result of reduction in pod arbotion. Nodule development and activity of soybean inoculated with *Glomus mosseae* under drought conditions has been reported to be higher than uninoculated ones (Bethlenfalvay *et al.,* 1987).

Alleviation of Salt Stress

High salt levels in soils and water can limit agricultural production and land development in arid and semi-arid regions. VAM fungi have been shown to decrease plant yield losses in saline soils. Improved growth in terms of high shoot and root dry matter yields and leaf area in tomato colonized by *Glomus mosseae* under salt stress has been reported (Al-Karaki, 2000). Increased fruit fresh yields of tomato under salt stress due to VAM colonization has also been reported (Al-Karaki *et al*., 2001). These results indicate that VAM innoculated plants had greater tolerance to salt stress than uninoculated plants.

Alleviation of Nutrient Stress

The most distinct growth enhancement effect by mycorrhizae occur by improved supply of mineral nutrients of low mobility in the soil solution, predominantly phosphorus (Marschner, 1995) (Table 2). External hyphae can absorb and translocate nutrients from the soil to the roots of the host plant (Tinker *et al.,* 1992). The high effectiveness of the VAM and ECM hyphae in phophorus uptake is caused by their large surface area and accumulation of polyphosphates in their vacuoles (Smith and Gianninazzi-Pearson, 1988). *Glomus intraradices* enhanced growth in terms of increased leaf number, leaf area, shoot, root and fruit mass of *Capsicum anuum* (Aquilera-Gomez *et al*., 1999). Squash plants colonized by *Glomus intraradices* is reported to have had higher amounts of P and K in shoots and higher amounts of N and P in roots as compared to non colonized plants (Aboul-Nasr, 1998).

The effectivity of VAM fungi in providing P to the host plants depends on VAM species (Boddington and Dodd, 1998; Marschner, 1995) possibly due to the larger differences in the length of the external hyphae (Jakobsen *et al*., 1992). External hyphae also possess acid phosphatase activity and hence have access to organically bound P in their hyphosphere (Tarafdar and Marschner, 1994).

In legumes growing in P deficient soils, VAM enhances nodulation, nitrogen fixation and host plant growth (Table 3). Due to high P requirement for nodulation, a high VAM dependency is expected (Marschner, 1995). However, *Rhizobium* symbiosis imposes a strong sink for photosynthates and mycorrhizal colonization adds a new sink. This sink competition causes decrease in root/shoot dry weight and also lowers nitrogenase activity of nodules compared with the legumes grown in P sufficient soils. Effect of *Glomus fasciculatum* on growth and nitrogen form assimilated was assessed on onion (*Allium cepa*). Results indicated that mycorrhizal plants utilized nitrate form more than ammonium form as evidenced by increased nitrate reductase activity (Azcon and Tobar, 1998)

ROLE OF MYCORRHIZAE ON SUPPRESSION OF ROOT PATHOGENS

Innoculation of tomato with VAM fungi has been reported to increase resistance to *Fusarium oxysporum* (Dehne and Schonbeck, 1979) and to *Pseudomonas syringae* (Garcia-Garrido and Ocampo, 1989). Interaction between VAM fungus *Glomus mosseae* and two pod rot pathogens *Fusarium solani* and *Rhizoctonia solani* and subsequent effects on growth and yield of peanut plants were investigated (Abdala and Abdel-Fattah, 2000). Peanut plants innoculated with *G. mosseae* had lower incidence *F. solani* and *R. solani* than non-mycorrhizal plants.

Glomus intraradices has been reported to reduce severity of root rot disease caused by *Aphanomyces euteiches* in *Pisum sativum* (Bodker, 1998). Suppression of root pathogens by mycorrhizal fungi can be attributed to improved P nutritional status of host plants (Perrin, 1990). However, in many cases specific interactions are involved which includes changes in root exudations and rhizosphere microflora. The ECM fungal sheath can also act as a mechanical barrier (Perrin, 1990) or the fungus can produce phenolic compounds with strong inhibitory effects on various pathogenic microorganisms (Kope and Fortin, 1990).

CONCLUSIONS AND RECOMMENDATIONS

The mycorrhizal symbiosis is a natural means by which most horticultural crops have attained enhanced growth and production. This is achieved through improved nutritional status, tolerance to various soil stresses and protection from widespread types of pathogenic microorganisms. There is need therefore to encourage natural spread of mycorrhizae by minimizing heavy fertilization especially of phosphorus and nitrogen. In moderate quantities, these fertilizers encourage rather than inhibit mycorrhizal symbiosis. There is also need to use pesticides that are not inhibitory to mycorrhizal fungi.

TABLE 1. Characteristics of important kinds of mycorrhizae[a]

Fungi Septate	-	+	+	+	+	+	+
Aseptate	+	+	-	-	-	-	-
Hyphae enter cell	+	-	+	+	+	+	+
Fungal sheath	-	+	+ or -	+	+	-	-
Hartig net	-	+	+	+	+	-	-
Hyphal coils in cell	+	-	+	+	-	+	+
Vesicles in cells	+ or -	-	-	-	-	-	-
Fungal taxon	Phycomycetes	Basidiomycetes Ascomycetes Phycomycetes	Basidiomycetes	Basidiomycetes	Basidiomycetes	Ascomycetes	Basidiomycetes
Host taxon	Bryophytes Pteridophytes Gymnosperms Angiosperms	Gymnosperms Angiosperms	Gymnosperms Angiosperms	Ericales	Monotropaceae	Ericales	Orchidaceae

Table 2. Effect of increasing Phosphorus Fertilizer supply on shoot Growth and shoot contents of mineral Nutrients in Nonmycorrhizal (NM) and Mycorrhizal (M *Glomus fasciculatum*) Soybean.[b]

			Mineral Contents per g shoot dry matter					
P supply (mg kg^{-1} soil)	**Shoot dry weight (g)**		**P (mg)**		**Cu (µg)**		**Zn (µg)**	
	NM	M	NM	M	NM	M	NM	M
0	1.25	2.80	0.61	1.73	3.3	10.3	21	44
60	1.61	3.21	0.75	2.09	3.7	7.9	27	35
150	1.85	3.42	0.81	2.08	2.9	6.3	30	36
270	2.78	3.83	1.4	1.79	3.5	4.6	29	33

[b] From Lambert and Weidensaul, 1991.

Table 3. Plant Dry Weight and Phosphorus Content in Leaves, Number of Nodules and Nitrogenase Activity (NA) in Nodules of Soybean Grown at Low and High P Supply[c]

	Low P	High P	Low P + VAM[1]
Shoot dry weight	2.8	3.8	5.6
Root dry weight	1.7	1.9	2.0
P content (mg/plant)	2.9	6.0	5.8
Nodules (no. per plant)	33	30	97
NA (µmol C_2H_4 per plant h^{-1})	4.6	22.8	9.0

[c] From Brown *et al*., 1988.

Table 4. Effect of suppressing and Reintroducing VAM fungi on Growth (plant dry weight in g) of Some Plants[d]

Soil treatment[2]

Plant type	**Nonfumigated**	**Fumigated**	**Fumigated-reinoculated**
Carrot	8.5 (61)	0.4 (0)	7.4 (60)
Leek	4.4 (50)	0.4 (0)	4.0 (67)
Tomato	4.1 (61)	2.5 (0)	5.1 (90)
Cabbage	11.9(0)	14.2 (0)	13.6 (0)

[d] From Plenchete *et al.,* 1983

[2] Values in parenthesis indicate % root colonization by VAM fungi

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EVALUATION OF ROOOTING MEDIA FOR COMMERCIAL NURSERY PROPAGATION OF *VANILLA FRAGRANS* IN UGANDA

R. NAMIREMBE-SSONKKO, A LULE AND F. KYAKIMWA
Department of Crop Science, Makerere University,
P.O. Box 7062, Kampala, Uganda

ABSTRACT:

Commercial nursery propagation of *vanilla fragrans* using short cuttings (3-4 nodes long) is becoming widespreads in Uganda due to the shortage and unavailability of the preferred typical 90-120 cm long cuttings with at least 12 nodes. In search for rooting media for the nursery propagation method, the performance of four rooting media currently used by nursery growers was evaluated at Makerere University Agricultural Research Institute in a greenhouse experiment in 2000/2001. Each rooting medium consisted of 10 kg. Compost, a blend of 30% soil, 30% manure and 40% of either sawdust, gritty sand, coffee husks and crushed charcoal. The rooting medium with 40% sawdust gave the best performance. Sawdust significantly ($p<0.01$) reduced the time to rooting, increased the percentage of rooted cuttings (85%), the number of roots per cutting (21), the percentage of sprouted cuttings (93%), improved the quality (size and more root hairs) of the root system produced and the percentage cutting survival (96%). This performance is attributed to the high moisture holding capacity and good aeration porosity which sawdust provides when used in a mixture. The fast rate of mineralisation of the OM content of sawdust when mixed with soil also provides, within a short time, nutrients like N,P,Ca, Mg which are essential for meristemic growth.

Keywords: *Vanilla fragrans*, propagation; stem cuttings; rooting medium

INTRODUCTION

The fruit of the orchid *Vanilla fragrans* is an important non-traditional export crop in Uganda. Vanilla, an important and popular flavouring and spice is obtained from the fully-grown fruits after fermentation and curing (Purseglove, 1980). The international demand for vanila is estimated at about 5000 MT/year although only 3500 MT/year is produced globally (UVAN, 2003). Uganda is considered a small vanilla producer; with production estimated at 150-180 MT of green beans or 30 MT of top quality cured beans. At these export levels, Uganda is supplying only around 1% of the current world demand, although it has the potential to export at least 100 MT annually or 3-5% of the current world demand. Prices paid for Ugandan vanila range from US$ 50/kg for green beans to US$ 250 for high quality cured 'black' vanilla beans. These prices give very good economic returns to those producers prepared to give the necessary detailed care to the growing and preparation of the crops for markets(kyakimwa 2002). As a result, districts growing vanilla have increased from one sub-country in Mukono in 1989 to 29 districts to date, and the vanilla industries one of the fastest growing sector in the agricultural economy of Uganda (UVAN, 2003).

Despite all the available opportunities in the export market for vanilla and its potential for income generation to small scale growers, current planting are still small and overall production is low (Kyabangi,1995; Nakungu,1998).this is attributed mainly to unavailability of planting materials and failure of propagation of medium to produce high quality plants (Bucyanayandi,1992).

Commercially vanilla is propagated by stem cuttings. The length of the cutting is usually determined by the amount of planting material available. Cuttings of 90-100cm long with at leased 12 nodes obtained from healthy vines facing upwards (Kyakimwa, 2003) are usually preferable and are planted in situ, and they flower and fruit within 2-3 years (Purseglove, 1980; IDEA, 2001).

However, the use of short cuttings,30cm long with 3-4nodes, which flower within 3-4 years, is becoming widespread due to shortage and unavailability of the preferred planting materials. Short cuttings often deteriorate and become weak and liable to disease when directly planted in the field (Ressel, 1976) so they are usually propagated in the nursery (Purseglove,1980: Kyabangi,1995:IDEA,2001). Nursery growers are currently using compost, a blend of soil, manure and either coffee husks, gritty sand, sawdust or crushed charcoal as the rooting medium(IDEA,2001).But the effects of this more commonly used ingredients and mixes on the growth and development of vanilla cuttings are still unknown.

The objective of the study was, therefore, to evaluate the performance of the common rooting media currently used in the nursery for propagation of *vanilla fragrans* stem cuttings in Uganda. The specific objectives were aimed at establishing the effect of the various rooting medium on the : time to rooting, rooting and sprouting percentages of cuttings, number of roots and buds formed per cutting, quality of the root system formed and cutting survival.

MATERIALS AND METHODS

Greenhouse experiments were conducted in 1998/1999 at Makerere University Agricultural Research Institute, Kabanyoro (MUARIK), located at latitude 0.28N and 32.37E,at an altitude of 1200m.a.s.l. The treatments were four(4) rooting media consisting of 10kg compost(i.e. a blend of 30% soil, 30% manure and 40% of sawdust, gritty sand, coffee husks or crushed charcoal) fine smooth sawdust was wetted, heaped and fermented for about three(3) weeks. Coffee husks were obtained from a coffee processing factory and cooled before use. Charcoal was crushed and sieved to smooth dust. Lake sand was washed thoroughly twice with clean water before use.

Three-node cuttings were hung in a well ventilated area for a period of one (1) week to stress the plants and induce the cuttings to root. All leaves and holders were removed from the vine before planting. Holes were made in the rooting media and cuttings were stuck to a depth of 7.5-10 cm leaving at least two (2) nodes above the ground. The media was firmed around the base of the cuttings to give support and was watered immediately. The cuttings were placed in a propagation box (i.e. a metal frame covered with a thick (4mm gauge) clear polythene sheet tied down tightly to trap high humidity under the sheet which reduces transpiration from the cuttings). Netting was erected high above the propagation box to provide 50-70% shade. The cuttings were watered daily and ventilated for half an hour every week to avoid disease.

The treatments were arranged in a completely randomized block design and were replicated four (4) times. Data was collected and recorded once every week for eight (8) weeks on time to root initiation, number of rooted cuttings, number of roots per cutting, quality of root system produced, number of spouted cuttings and cutting survival. Data analysis was done by ANOVA and separation of means by LSD at the 5% level.

RESULTS

Time to formation of callus, which is the first biological process to formation of roots at the base of the cutting, took a markedly shorter time (4 days) on cutting in the sawdust rooting medium and longest (8 days) on cuttings in the gritty sand and coffee husK media (Table 1).

Table 1: The Effect of rooting medium on the growth and development of *Vanilla fragrans* stem cuttings propagated by the nursery method

Rooting Medium	Callus Formation (days)	Rooted Cuttings (%)	Number of roots/ cutting	Sprouted Cuttings (%)	Number Of buds/ cutting	Cutting Survival (%)
40%Sawdust	4	85	21a	92.5a	9.5a	95
40% Charcoal	6	63	10b	72.5ab	7.25ab	92.5
40% Sand	8	65	7b	65.0b	6.7b	87.5
40% Coffee husks	8	57	11b	27.5c	3.25c	90.0
LSD (0.01)		NS	9.67	27.7	2.5	NS
CV(%)		29.9	99	18.7	16.2	4.8

The percentage of sprouted cuttings was significantly (P<0.01) affected by the rooting medium. It was 92.5% in the sawdust medium, and significantly (P<0.01) higher than 65% and 27.7% sprouted cuttings recorded for gritty sand and coffee husk media, respectively. The percentage of sprouted cuttings (72.5%) recorded for crushed charcoal did not differ significantly from that of sawdust or gritty sand (Table 1).

The number of buds sprouted per cutting followed the same trend with 9.5 buds sprouting/cutting in the sawdust medium which was significantly ($P<0.01$) higher than the 6.75 and 3.25 sprouted buds/cuttings recorded on cuttings in gritty sand and coffee husk media, respectively. Cuttings growing in the crushed charcoal medium developed 7.2 buds/cutting, which did not differ from that of cuttings in either sawdust or gritty sand media (Table 1)
Although rooting medium did not have a significant effect $P>0.05$) on cutting survival at eight (8)weeks after sticking, percentage mortality increased over time in the various rooting media (Table 1). It was observed that cuttings growing in gritty sand always died from drying while cuttings from the other media died from rotting.

DISCUSSION

The type of rooting medium used can have a major influence on the rooting capacity of cuttings (Hartman. et. al., 1990). The basic functions of the rooting medium in cuttage propagation are to serve as anchorage and support to the cutting and to serve as reservoir for water and mineral nutrients for plant growth and development. In addition, the medium must have a pH conducive to plant growth, a structure that permits gaseous exchange to provide aeration for the roots and permit water infiltration and movement. Since the supply of minerals available for plant growth may be limited by the size of the container or nursery bed, it is desirable that the rooting medium has a relatively high CEC to serve as reservoir for mineral elements (Nursery Industry, 1980).

In this experiment, the rooting medium had a profound effect on the growth and development of vanilla cuttings. The number of roots formed per cutting, the percentage of sprouted cuttings and the number of buds sprouting per cutting were significantly ($p<0.01$) higher, while the time to root formation was shorter and the quality of the root system was superior on cuttings in the rooting medium with 40% sawdust. The rooting medium with 40% coffee husks gave the poorest performance in all aspects.

Vanilla stem cuttings are adversely affected by the availability of water and nutrients in the medium used during propagation, and these results indicate the importance of the organic fraction of a rooting medium for water and nutrient retention. Wood products of various types including sawdust are an excellent source of OM for soil mixtures for production of container or nursery bed grown plants. Aged sawdust makes an excellent ingredient for container production of nursery stock. It is relatively lightweight, has good moisture holding capacity and good aeration porosity. It does not require addition of N-fertiliser to support microbial development and it is relatively stable (Nursery industry, 1980). It has good organic materials that increase aggregation of the soil (Charles, 1992) and is rich in Ca, N, P and Mg elements, which are essential for meristemic growth (Ridley, 1912; Brady, 1990). Net N and P mineralisation increases from four (4) weeks onwards after adding sawdust to the soil (Ridley, 1912; Brady, 1990; Classman and Munns, 1980) and the fast accumulation of nutrients may be responsible for the significant increase in root and bud formation on cuttings with time in this medium. Nviiri (1990) observed that sawdust mixed with soil is a well-drained, deep and fertile medium suitable for vanilla growth.

In this investigation, cuttings inserted in media with relatively lower water holding capacity (i.e. gritty sand, charcoal and coffee husks) displayed lower values for rooting percentages, and number of roots and bud sprouts per cutting. The ability of cuttings to absorb water from the media is important for overcoming the initial physiological shock after cuttings are taken (Ofori, et.al.,1996). For horticultural purposes, sand contains few if any mineral elements; it has no significant buffering capacity or CEC and lacks water holding capacity, but improves drainage and aeration when used in a mixture (Nursery Industry, 1980;; Kenneth et.al.,1992). Charcoal is extremely high in carbon content but has good drainage and aeration, absorbs heat and has a high moisture holding capacity. It is usually mixed with other components such as sand and loam soil to increase friability. Both sand and charcoal are particularly low in N,S,Mg and P, the elements which influence the number of roots formed on vanilla cuttings (Ressells, 1976), have great diurnal temperature variations and warm up easily resulting in high evaporation, salinity and increase in the osmotic pressure around the root and hence impede crop establishment (Cooke, 12992; IDEA, 1998).

Although coffee husks provide good aeration and drainage to mixtures, they have a very low rate of decomposition, are inadequate in P and Mg (Zaake, *et al*.,1996; Purseglove, 1980) and they produce low pH which result in coagulation and flocculation of the protoplast of cuttings (Demeer, 1928; Moukam and Techato, 1982) leading to a delay in crop growth and development. Coffee husks composted with sand and/or soil and/or wood clips require addition of a high N-fertilizer to speed up the rate of decomposition (Kenneth, et.at., 1992).

In conclusion, the study reveals that *Vanilla fragrans* can be easily and successfully propagated in the nursery using short stem cuttings (30cm, 3-4 nodes) inserted in a medium with a high OM content and a high water holding capacity, like sawdust.

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DEVELOPING A BACULOVIRUS FOR THE MANAGEMENT OF DIAMONDBACK MOTH, *PLUTELLA XYLOSTELLA* L. IN BRASSICAS IN KENYA

Walter Okello Ogutu[1], George Isaiah Oduor[1] and Callistus K.P.O. Ogol[2]
1. CAB International, Africa Regional Centre (CABI-ARC), P. O. Box 633-00621, Nairobi, Kenya
2. Department of Zoology, Kenyatta University, P. O. Box 43844, Nairobi, Kenya

INTRODUCTION

Diamondback moth (DBM) *Plutella xylostella* L. is a major pest of brassica crops including kale and cabbage in Kenya (Michalik 1994; Oruko and Ndun'gu, 2000)). Currently, the strategy most readily available to farmers to manage this pest is the use of synthetic insecticides, a control method that not only is expensive and cause high risk to applicators, farmers and consumers, but has also been noted to be ineffective (Kibata, 1997). There is thus an urgent need to develop alternative pest control methods in order to reduce the amount of chemical insecticides currently in use and damage caused by this pest. Naturally occurring pathogens such as viruses, bacteria and fungi are known to reduce the pest populations in nature (Wilding, 1986). They have also been used in several countries as biopesticides against major pests (Lacey *et al.,* 2001). Studies on granuloviruses (GVs) of *P. xylostella* (a group of baculoviruses) had been reported from Japan (Asayama and Osaki 1970) Taiwan, China (Kadir *et al.,* 1999) and India (Rabindra 1997) but there were no previous published records of *Plxy*GV isolates from Africa. A project to develop non-chemical methods in Kenya explored the use of indigenous pathogens as potential control agents. This paper reviews the status of the work done on this baculovirus towards developing it as a biopesticide for the control of DBM in Kenya.

MATERIALS AND METHODS

1. Survey of brassica farms for endemic DBM pathogens in Kenya

A survey was conducted on brassica farms in the peri-urban areas of Nairobi to identify endemic pathogens of DBM. Larvae showing signs of baculovirus infection were collected for later examination. Restriction endonuclease analysis (REN) of the baculovirus isolates was performed on each of the GV isolates following the protocol of Smith and Summers (1978). The pathogenicity of those isolates showing different REN restriction profiles were determined by discriminate dose assays. LC_{50} bioassays were then carried out on three of those eight isolates and the *Plxy*GV-Tw isolate using methods described by Parnell *et al.,* (1999).

2. Evaluation of the potential of *Plxy*GV for DBM control

To evaluate the potential of the *Plxy*GV to control DBM, small-plot field trials were conducted on the isolate Nya-01 in 1999. The virus was applied as an unformulated suspension using standard knapsack sprayers. The field trial was a replicated randomized-block design carried out on small plots (5m x 5m) on kale (var. Thousand headed). This trial compared two virus doses, (3.0×10^{14} occlusion bodies (OB) ha^{-1} and 3.0×10^{13} OB ha^{-1}), a standard pyrethroid insecticide (Karate®- lamda-cyhalothrin), all applied in a weekly basis and a no treatment control. Further field trials were carried out at Kabete and Thika in 2000. In these trials there were five treatments arranged in randomised replicated small plot design consisting of the above treatments plus one more virus dose (3×10^{12} OB ha^{-1}). The gross plot size was 3.6 x 4.2 m, with a net plot of 2.4 x 3.0 m where sampling was being undertaken. In both trials numbers of DBM larvae present, numbers showing symptoms of GV infection and damage caused by DBM were monitored weekly. In the second trial yield data was also collected. The effect of *Plxy*GV on other lepidopteran pests of brassicas and beneficial insects were also assessed by direct observation for symptoms in the field. To assess more precisely the disease incidence samples of larvae from plots treated with virus at dose rate of 3.0×10^{13} OB/ha/ were collected and reared individually.

3. Persistence of *PlxyGV* on potted plants

A standard unpurified suspension of *Plxy*GV at a dose rate of 3.0×10^{13} $OBha^{-1}$ was used to spray 42 two-month-old plants, after which they were split into 6 groups of 7 plants each. Three groups were placed in shaded areas and three in open areas. Once dry, one plant from each group was collected for immediate bioassay. The bioassay was repeated on plants collected 7 hours, 1 day, 3, 7 and 9 days after spraying. At the time of collection, fifteen 2nd instar DBM larvae were placed on each plant. The larvae were monitored daily until all had either died or developed to adulthood.

4. Laboratory and field evaluation of neem/molasses as adjuvants to improve the efficacy of ***Plxy*GV**

Leaf dip and leaf disc bioassay methods were used to evaluate the unformulated *Plxy*GV, formulated *Plxy*GV, Brigade® (Bifenthrin) and an unsprayed control in the lab at CABI-ARC. The same treatments were again compared in kale plots at Kabete and Thika sites. Each treatment was replicated 6 times in a randomized complete block (RCB) design in plots of size 4.2 x 3.6 m. A polythene sheet was used to surround each plot during spraying time to act as a barrier against spray drift. Weekly sampling of pupae, larvae and *Plxy*GV infected larvae, as well as damage caused by DBM was done on 10 randomly selected plants in each net plot. Yield data was collected fortnightly. Kale leaves harvested from the net plot were sorted into two groups, consisting of marketable and unmarketable leaves, (based on grading criterion used by local farmers and also at the urban markets) and the numbers and weights for each group recorded. These trials were conducted during the 2001 short rains season (October 2001 – January 2002) and the 2002 long rains season (January – April).

5. Laboratory and field assessments of the effect of mixing ***Plxy*GV with Pirimor®**

The efficacy against DBM of the standard *Plxy*GV was compared to a mixture of standard *Plxy*GV and Pirimor®, (a selective and specific pesticide to aphids) and an unsprayed control in the laboratory at CABI-ARC. The treatments were prepared by thoroughly mixing the ingredients in a glass beaker. Twenty leaves of kale were washed with moist cotton wool and left to dry. Five dry leaves were placed in each test solution and left in the beaker for 1 hour.

After drying, each leaf was placed in a round plastic tub (5cm diam. x 7cm height) and into each tub five 2^{nd} instar DBM larvae were introduced. The larvae were monitored daily until all individuals had either died or developed to adulthood. The number of larvae alive, infected and dead was recorded 4, 7 and 10 days after exposure. The efficacies of these same treatments were also compared on field populations of DBM. All the treatments were replicated four times in a RCB design, each gross plot measuring 4.2 x 3.6 m. Observations were made as outlined previously.

6. Effect of using a conventional or V-shaped lance on the efficacy of ***Plxy*GV against DBM**

The efficacy of *Plxy*GV using a conventional and V-shaped lance was investigated in field trial plots at the two sites. The trial consisted of 5 treatments; *Plxy*GV at an application dose rate of 3.0×10^{13} $OBha^{-1}$ and fipronil sprayed using either the conventional or V-shaped lance and an untreated control. Each treatment was replicated four times in a RCB design, each gross plot measuring 4.2 x 3.6 m. The trials were conducted over two growing seasons, 2001 long rains and short rains respectively. Observations were made as outlined previously.

Data analysis

Analysis of Variance (ANOVA) was applied to summaries of insect counts and yield (means and totals, respectively) in GenStat (Release 4.2). Generalized Linear Modeling, assuming binomial distribution, was used to analyze mortality due to *Plxy*GV using logit transformation. Significance of each factor was calculated using analysis of deviance and approximate F-distribution.

RESULTS AND DISCUSSIONS

1. Survey of brassica farms for endemic DBM pathogens in Kenya

During the field survey, 127 larvae with disease symptoms were collected and examination confirmed that 95 larvae were suffering from GV infection (Odour *et al.,* 1998). The REN analysis of the 95 *Plxy*GV isolates showed that 14 had fragment profiles that could be distinguished from any other with both *Eco*R1 and *Pst*1 cuts. Comparison of these 14 Kenyan *Plxy*GV isolates to an isolate of *Plxy*GV from Taiwan (*Plxy*GV-Tw) revealed that, although the profiles had many similarities, there were major band differences between all isolates (Parnell *et al.,* 2002). In the dose response bioassays no significant differences in LC_{50} values between Kenyan isolates and the *Plxy*GV-Tw isolate were observed. Average LC_{50} values for second instar DBM larvae varied from 2.36×10^6 OBs/ml for Nya-01 to 3.95×10^7 OBs/ml for Nya-40. In comparison the LC_{50} for the *Plxy*GV-Tw was 1.55×10^7 OBs/ml. The discovery of numerous genetic isolates (14) in the small number of infected larvae collected is an interesting result. Previously reported work (Kadir *et al.,* 1999) has characterised only two genetically distinct isolates one from China and one from Taiwan. Other studies of DBM pathogens have also only reported finding a single genetically distinct isolate from India (Rabindra 1997) and Japan (Yamada & Yamaguchi 1985). The genetic variation in *Plxy*GV isolates discovered in Kenya might indicate a long relationship between host and virus and could be interpreted as providing additional support to the theory of Kfir (1998) that the origin of DBM lies in Sub-Saharan Africa.

2. Evaluation of the potential of *Plxy*GV for DBM control

The field trials showed that the *Plxy*GV was highly infectious to DBM, spreading rapidly in trial plots and infecting 80-90% of larvae within two to three weeks of application. Both the two virus dose rates of 3.0 x 10^{14} OB ha^{-1} and 3.0 x 10^{13} OB ha^{-1} reduced DBM damage to crops to below that seen in either unsprayed controls or insecticide treated plots (Fig. 1). In the second series of trials the yield data showed that the virus dose rate of 3.0 x 10^{14} OB ha^{-1} gave a mean yield 37% higher than the control and 17% higher than the insecticide treatment although this was not statistically significant (Fig. 2). The virus dose rate of 3.0 x 10^{13} OB ha^{-1} did not result in effective DBM control. However yield data for the virus dose rate of 3x10^{14} OB ha^{-1}, while higher was not significantly better than the insecticide. This may partly be because *Plxy*GV does not control other pests such as aphids that the chemical insecticide does.

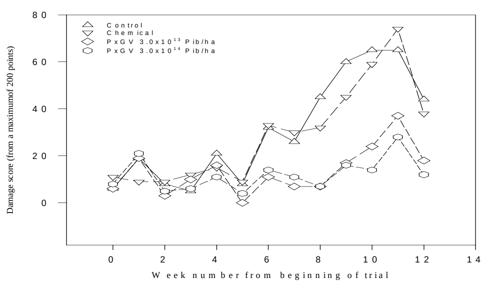

Fig.1 The level of crop damage by DBM in the different treatments observed in the field.

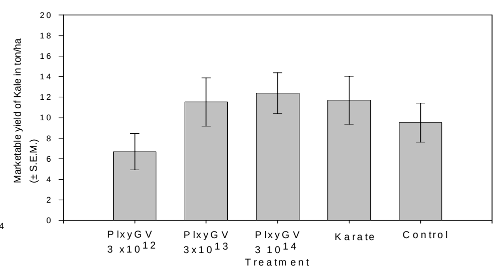

Fig. 2: Effect of Three different PlxyGV application dose rate, karate and no spray control on marketable yield of kale.

The average observed DBM infection rates in virus treated plots showed a clear application-rate trend with the highest dose producing an average of 40% in the field (Fig. 3). Whereas DBM collected from plots sprayed with *Plxy*GV at an application dose rate of 3.0 x 10^{13} OB ha^{-1}, it was noted that the true infection rate was much higher than that observed in the field as shown in Table 1. It was also noted that *Plxy*GV could infect all DBM instars. *Plxy*GV was not observed to infect other lepidopteran pests of kale or any beneficials such as syrphid and spiders in the field. This observation showed and confirmed that *Plxy*GV is host specific to DBM.

Table 1. Percentage *Plxy*GV infections levels of the different larval instars of DBM collected from virus sprayed plots in the field and reared in the laboratory

Larval instar	Infection rate (%)
1st	90
2nd	82
3rd	64
4th	60

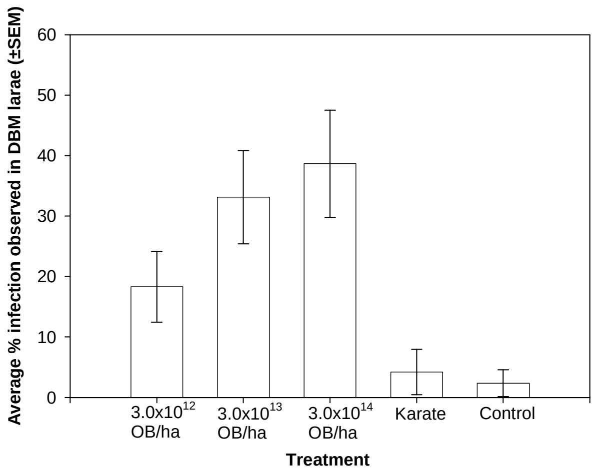

Figure 3. Average *Plxy*GV infection-rate (%) observed in DBM larvae for each of the treatments

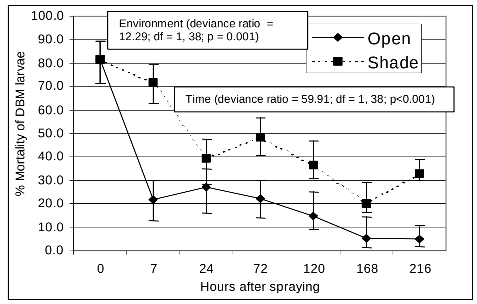

Figure 4. The persistence over time of *Plxy*GV on potted plants under open and shade conditions (95% CI)

The results showed that the activity of the *Plxy*GV on unshaded plants declines rapidly, by two thirds, within 7 hours of spraying corresponding to daylight time (Fig. 4). The slight rise in activity seen on the unshaded plants between 7 and 24 hours is interesting but other authors have reported that after exposure to daylight some recovery of activity may be seen in other baculoviruses after overnight darkness (Jones *et al*., 1993). Plants in the shade also show a decline in efficacy but this is less rapid and the virus retains significant activity even after 5 days (120 hours). These results are similar to those for other GVs and NPVs, (closely related to GVs), used as bioinsecticides in the tropics. For example, Su, (1991) reported that spraying granulosis viruses (GVs*) of P. xylostella* and *Artogeia rapae* of 1 LE/1L—1 LE/2l alone or in combination was also effective for control of both insects and persisted for 14 days in the field. The loss of activity in the shade indicates that the inactivation of the GV particles is not only due to UV radiation but also other abiotic factors e.g. physical loss of particles and chemical inactivation by plant exudates. Jones *et al*., (1993) observed that the rate of sunlight inactivation of the *Spodoptera littoralis* Nuclear Polyhedrosis virus (*Sl*NPV) varies with season, this being especially reduced with increasing latitude.

4.Laboratory and field evaluation of neem/molasses as adjuvants to improve the efficacy of *Plxy*GV

Bioassays of simple formulations of *Plxy*GV gave a much reduced LC_{50} for the formulated virus of 3.62 x10^5 OBs/ml compared to 3.65 x10^7 OBs/ml with the unformulated control (Fig. 5). Therefore molasses and neem formulation increased the efficacy of an aqueous suspension of *Plxy*GV against DBM by 100 fold in the laboratory. In the field there was no significant difference on the overall infection level between the formulated (37%) and unformulated (35%) *Plxy*GV. It was shown that although both formulated and unformulated *Plxy*GV produced higher marketable yields than the unsprayed control only the formulated application showed a significant increase in yield (p=0.03) (Fig. 6). Significant differences between treatments were observed in the marketable yield (p=0.002), with higher yields recorded in Brigade® plots than in the other treatments at both sites (p<0.001). However as Brigade® is a broad spectrum insecticide with both aphicidal and acaricidal activity it cannot be determined if this higher yield was due to better DBM control or a reflection of its ability to reduce secondary pest damage.

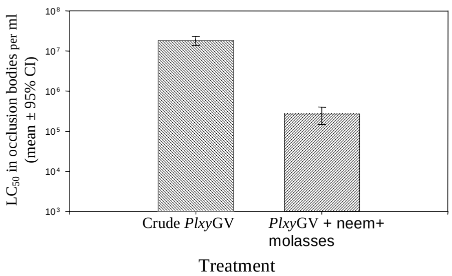

Figure 5 LC_{50} value of the crude *Plxy*GV suspension compared to the LC_{50} value of the neem/molasses formulated *Plxy*GV suspension

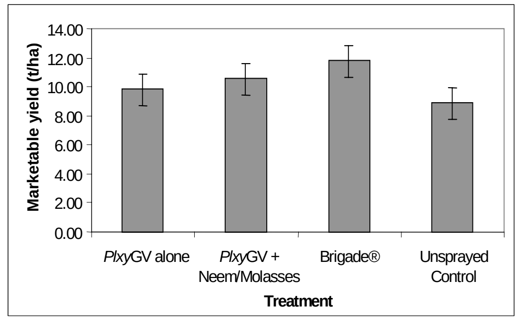

Figure 6. The effect of applying *Plxy*GV alone, *Plxy*GV + neem/molasses, Brigade® and an unsprayed control on the overall marketable yield of kale (Summarised over two sites and seasons) (95% Confidence Interval)

Other workers have shown that the addition of molasses to a GV formulation can increase the viruses' efficacy by a factor of ten and allow for a consequent reduction in the application rate of *Plxy*GV. (Kadir, 1990; Ballard *et al*., 2000). Lacey *et al.,* (2001) noted that research on formulation and application technology has enabled greater persistence and improved efficacy, but further improvements are needed.

They also observed that continuing research on methods of production, such as large-scale use of cell lines that could reduce the cost of production is also warranted. In developing countries such as Kenya, where the cost of synthetic (mostly imported) insecticides is high and that labour is lower, *in vivo* production could provide a viable means of producing large quantities of virus and a source of employment. Technology required to produce baculoviruses as insecticides is relatively simple and cheap enabling local companies in developing countries to produce virus-based insecticides (Moscardi, 1999).

Laboratory and field assessments of the effect of mixing *PlxyGV* with Pirimor®

The results from laboratory studies showed that an application of a tank mix of crude *Plxy*GV inoculum and Pirimor caused a reduction in efficacy on DBM larvae of the *Plxy*GV (Fig. 7). It is suspected that Pirimor® could be acting as a feeding deterrent to DBM. A few direct actions of insecticide on baculovirus activity have been reported (Durand, 1989). In the field, however, there was no significant difference in the level of infectivity whether *Plxy*GV was applied alone or mixed with Pirimor® (p=0.108) (Table 2). There was no effect of *Plxy*GV on the efficacy of Pirimor® against aphids in the field, (p=0.230) (Fig. 8). The overall marketable yields at both sites were comparable, Kabete (11.0 t/ha) and Thika (12.0 t/ ha) and again there was no effect of either ingredients, *Plxy*GV or Pirimor®, on the yield (p=0.681 and p=0.773 respectively). Therefore, it was concluded that these two ingredients, *Plxy*GV and Pirimor®, are compatible and can be used together by farmers to manage DBM and aphids in their brassica fields.

Table 2. Percent infection of DBM in *Plxy*GV alone, *Plxy*GV + Pirimor®, Pirimor® alone and unsprayed plots at Kabete and Thika sites over two seasons

Percent (%) infection (95% confidence interval, shown in brackets)					
Treatment	Sites (Summaries of two seasons)			Seasons (Summaries of two sites)	
	Kabete	Thika	Mean	SR 2001	LR 2002
*Plxy*GV alone	32 (29-35)	33 (30-36)	33 (31-34)	34 (32-37)	29 (26-32)
*Plxy*GV + Pirimor®	36 (33-38)	34 (32-36)	35 (33-37)	36 34-38)	33 (30-36)
Pirimor® alone	5 (4-7)	2 (1-3)	3 (2-4)	4 (3-6)	1 (0-3)
Unsprayed Control	6 (4-7)	2 (1-3)	3 (2-4)	4 (3-5)	2 (1-3)
Mean	15 (14-17)	9 (8-11)	-	14 (13-15)	9 (7-10)

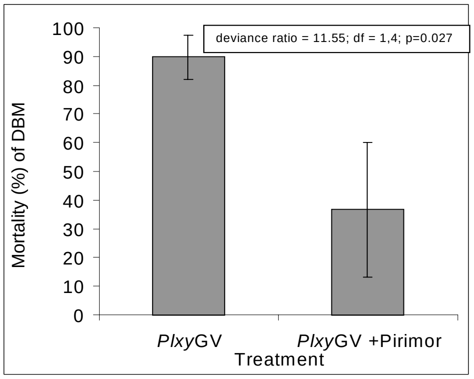

Figure 7. Effect of applying *Plxy*GV alone and *Plxy*GV + Pirimor® mixture on the % mortality of DBM larvae in the laboratory (95% Confidence Interval)

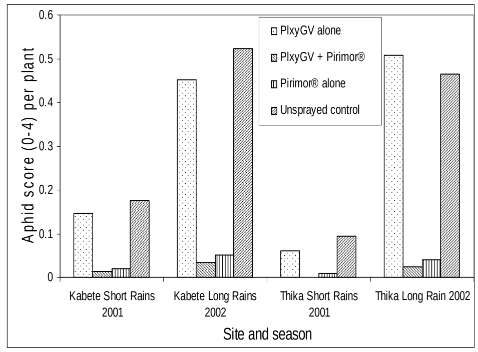

Figure 8. The effect of applying *Plxy*GV alone, *Plxy*GV + Pirimor® mixture and Pirimor® alone and an unsprayed control on the average population (score) of aphids per plant (*Brevicoryne brassicae*) at Kabete and Thika during the two growing season

6.Effect of using a conventional or V-shaped lance on the efficacy of *Plxy*GV against DBM

The results have shown that spray application using a V-shaped lance gives a small but significantly higher infection of DBM than using conventional lance (p=0.05) (Fig. 9). These results support the earlier report that stated that V-shaped lance proved to give good delivery of insecticides especially to the lower surface of broad-leaved and tall crops such as kale (Kibata, *et al*., 2002). DBM numbers during both growing seasons were generally low. Fipronil was shown to be the most effective product giving higher yields (32.7-42.3 t/ha) than the other treatments (28.8-33.7 t/ha) (p<0.001). However, this might reflect to some extent its broader spectrum activity, rather than its control of DBM. The type of lance did not influence the final yield of kale for either *Plxy*GV or fipronil (Fig. 10).

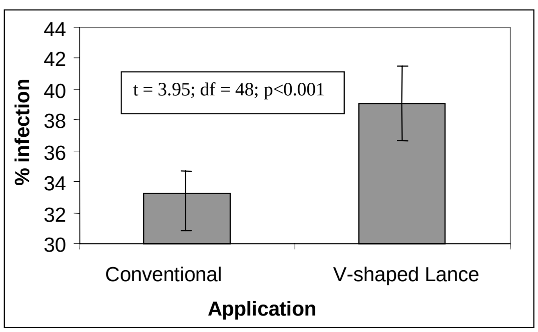

Figure 9. Overall percent infection level of DBM in treated plots using V-shaped lance and conventional lance

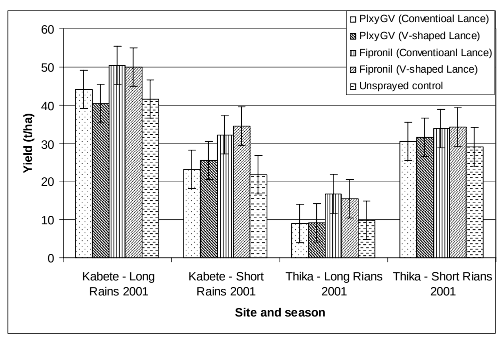

Figure 10. Effect of pesticide application method and pesticide on the yield of kale (marketable and non-marketable).

CONCLUSION

Therefore, the development of a virus endemic to Kenya first isolated in 1997 as a biological pesticide has made very significant progress towards a commercial product. The results of the various studies undertaken including efficacy, persistence, the potential of formulating *Plxy*GV using locally available materials such as neem and molasses and combining *Plxy*GV with Pirimor® (selective and specific chemical insecticide for aphids), and the use of improved appropriate application techniques using a V-shaped lance make *Plxy*GV a viable option for the management of DBM (Ogutu, 2002). A number of researchable issues still remain that could improve the efficacy and utility of *Plxy*GV and these include the development of formulations to improve shelf life, persistence and optimization of infectivity of this baculovirus (Grzywacz *et al.,* 2002; Ogutu, 2002). Despite the limitations of baculoviruses such as sensitivity to UV light, slow action and limited host or target range, the advantages outweigh the disadvantages and if used correctly and with farmer education, baculoviruses have real prospects and a wide scope for pest control in the future both in Kenya and in the other tropical countries as well as worldwide. The use of baculoviruses for insect control within the

IPM context is expected to increase in the coming years, particularly in developing countries and for the control of insects in high-value crops grown on small acreages. These studies have therefore provided a basis upon which development of such alternative control options for lepidopteran and other soft-bodied insect pests of crops including indigenous vegetables can be developed.

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LINKING SMALLHOLDER HORTICULTURE PRODUCTION WITH LOCAL AND INTERNATIONAL MARKETS

By:

Jotham O. Ouko and Joseph Kenduiwa

Horticultural Crops Development Authority, P.O. Box 42601, Nairobi, Tel: 254-020-827260/1,

E-mail:hcdameb@wananchi.com, Website:www.hcda.or.ke

INTRODUCTION

Horticulture contributes enormously to the economies of many developing countries through generation of income, creation of employment opportunities for the rural people and the youth, foreign exchange earnings in addition to providing raw materials to the agro-processing industry. These benefits have made horticulture the focus of the Government of Kenya Policies the current one which is for economic recovery strategy for wealth and employment creation. In recent past, it is only the horticulture sub-sector which has shown positive growth in a declining agriculture sector. The sub-sector is vibrant in Kenya and has had a steady 10-20% annual increases in production, exports and earnings.

The horticulture industry worldwide is very dynamic in terms of production and marketing, trends which are usually dictated by the consumer demands. Horticulture production in Kenya is predominantly from small holders who contribute up to 80% especially for fruits and vegetables. However, recent focus towards liberalized market economy and globalization in addition to international consumer concerns for food quality and safety have threatened the survival of the smallholder, in particular contribution to the export volumes. The internal markets are also being opened up to competition from imports thus creating another threat.

HORTICULTURE PERFORMANCE INDICATORS

- Total hectarage under horticultural crops in 2001 was 236,815 ha.
    - 60.6% under fruits
    - 39.4 under vegetables, herbs and spices
    - <1.0% under flowers.
- Total annual production in 2001 was 3,362,146 MT.
    - 66.01% fruits
    - 33.9% vegetables, herbs and spices
- Total value of marketed horticultural produce in 2001 was Kshs. 42.62 billion
    - 44.7% from fruits
    - 30.2% from vegetables, herbs and spices

- 25.1% from flowers

- Out of total annual production
  - 120,000 MT (3.6%) was exported in 2002
  - 250,000 MT (7.5) utilized in agro processing
  - 2,992,146 MT (88.9%) consumed fresh locally.
- About 80% of total production is from small holders especially fruits and vegetables
- Post harvest losses estimated at 40% of total production
- Value of total exports Kshs 26.725 billion
  - 55.34% fro from flowers
  - 39.20% from vegetables
  - 5.46% from fruits

Export volumes composed of

- 43.0% flowers
- 38.40% vegetables
- 18.60% fruits

- Exports have grown to be the second largest foreign exchange earner after tea
- Horticulture contributes to food self-sufficiency, enhanced nutrition, income generation, employment creation and provides raw material to the agro processing industry.

CHALLENGES FACING THE SMALLHOLDER

Declining Productivity

Production per unit area has continued to decline in addition to poor quality produce being obtained. This has been attributed to pest and disease build up, poor farm management due to high cost of inputs including seeds, fertilizer and pesticides. Farmers are unable to invest on equipment inputs especially for irrigation and post harvest handling. Access to new varieties is also restricted by plant breeder's rights. Principally, they have no access to improved technology, which they can't afford due to lack of credit. All lead to poor returns and discouragement on the part of the farmers. In addition to low yields per unit area, most small holders cultivate small units which are not economical and hence reduced profits.

Declining Government support

The government of Kenya liberalization policies since mid 1990's has caused a lot of shift in the public sector's functions to a role of being a facilitator in provision of services and goods. Private sector participation in supply of inputs and in some cases extension services is being encouraged as the GOK reduces its spending on them. This has been detrimental to the small-scale producer who is unable to pay for services of consultants and is also not protected from exorbitant prices charged for inputs as the government has withdrawn its intervention or stabilization mechanisms.
The farmer has therefore lost touch with the important production and marketing information, which used to be provided by the Ministry of Agriculture extension services as this essential service provision in gradually being shifted to the private sector.

Lack of Market Information

The majority of small-scale farmers production is seasonal as determined by weather conditions. This production is unplanned and leads to gluts as all produce mature at the same time and compete for the same market outlets. Information on out of season production is either lacking or they have no technology to practice it. Supply and demand information is not made available to the farmers to enable them plan their production to take advantage of off-season high prices.

The small scale farmer is also in most cases not informed of the diverse products they are able to produce in terms of crops, varieties and value adding to enable them sale widely. Market linkages are also partial as most producers are at the detriment of middlemen who are able to access the market directly and sale produce on their behalf.

Increasing Post Harvest Losses
This relates to roads, power and telecommunication. Roads in the farming areas are inaccessible and are worse during rainy periods when produce is due to be moved to the markets. This coupled with lack of electricity in rural areas and poor post harvest handling procedures lead to heavy losses either in the farms or market outlets where facilities are inadequate. It's estimated that these losses can be up to 40% of total harvest.

Competition From Imports
The trends towards globalization means opening up markets for competition by removing restrictions or preferable treatments. These have opened up boundaries and in some cases resulted in unfair competition as some countries subsidize their production or have lower production costs, hence can dispose their produce cheaply. The horticulture sub sector has not been spared as an influx of fruits (temperate, oranges etc) vegetables/herbs (onions, garlic, tomato) and processed products (juices, jams, sauces etc) have been observed).

Lack of Credit/Investment Capital
Facilitation of low interest rates borrowing which is friendly to smallholder should be encouraged. Costs of equipment and inputs need financing and most farmers have no collateral required by financial institutions.

Export Market Restrictions
The export market is getting increasingly competitive especially with regard to:
a) Quality standards: variety, grade, size shape, weight, colour, packaging, maturity wholesomeness etc. smallholder production can't meet most of these quality requirements.
b) Sanitary phytosanitary restrictions: Quarantine regulations, hygiene and food safety concerns due to deligence/traceability of produce in the production and processing chain.
c) Pesticide and chemical usage (MRLs) social obligations (labour) to meet these standards increase production/management costs and reduce profits.
d) The small-scale farmer in most cases is unable to comprehend these issues and is therefore unable to penetrate the export market. The overall effect is smallholder isolation as exporters shift to larger units and consolidate their production. Small exporters who have no access to larger units are also phased out hence reduction in export volumes.
e) Lucrative markets with high potential such as Japan, USA, and some parts of Western Europe which account for 80% of world imports of fruits and vegetables therefore remain out of reach of our exports.

APPROACHES TO ENHANCE SMALLHOLDER SUSTAINABILITY
Faced with the challenges listed above, the following are some of the possible approaches which might enable the small-scale producer enhance productivity.

Improved Production and Profits
This can be achieved through:-
a) Using improved production technologies e.g. improved varieties, use of irrigation and recommended production practices. However, these need investment and hence affordable credit or direct funding.
b) Institute proper post harvest handling procedures e.g. harvesting, grading, packaging, transporting, storing and maintaining cold chain in the whole process to reduce post harvest losses.
c) Improve infrastructure
d) Training.

Diversification
Encourage diversification through on
a) Introduction more profitable crops
b) Adding value to produce through packaging and processing (dying juices, marmalades/jams) in small enterprises.
c) Seeking alternative market outlets especially where there is insufficient supply during certain periods and regions with limited market restriction quality and sanitary and phytosanitary requirements.

Linking Production to Markets
The trend presently is to link the farmer to the market before the production starts. Producers should give preference to producing off season production when prices are high in the local market in addition to growing on contract to major known buyers like exporters, green grocers and suppliers to the wholesale markets. These call for formation of large production units, which can be managed as a form jointly to consolidate supervision.

FOCUS SHOULD BE ON

a) Formation of farmers groups for production and marketing purposes and crop based associations.
b) Farmers signing contracts with buyers.
c) Farmers and buyers being loyal to agreements/contracts signed with buyers.
d) Put in place modalities for arbitration
e) Capacity building for farmers groups and associations

Adherence to Export Requirements
Although export market requirements are strict, the small-scale farmers can be guided to produce under conditions which meet export quality standards. In addition to extension staff assisting farmers to understand and practice good agricultural practices which enhance produce quality acceptance to export requirements, buyers should be encouraged to give support to the producers through provision of input and services which can be recovered from produce sales at fees agreed upon prior to starting production.

Affordable Credit Provision
This can be done through:-
encouragement and facilitation of low rate interest borrowing which is friendly to smallholder. Through bilateral agreements and collaboration between credit providers critical issues such as collateral can be agreed upon producers can also be advanced money based on delivery notes from buyers to enable them purchase more inputs and pay for farm labour.

Holistic Approaches/Improved Linkages.
There should be wholesome approaches to assist smallholders by linking production not only with marketing but also incorporating infrastructure, credit, environment and gender issues. Currently, institutions are operating independently without incorporating other stakeholders even if they are operating in the same areas. Linkages through collaboration is therefore highly recommended to have a holistic approach.

Code of Conduct
This is basically a guideline to agreements between a buyer and seller to ensure fair play but also touches on inputs supply, safe use and disposal of pesticide, chemical and record keeping.

Quality Standards for Local market
Minimum quality requirements for produce destined for the local market has been published. Aim is to standardize transactions, improve presentation and probably improve prices in addition to reducing wastages which occur during transport and handling.

Establishment of Horticultural Research Fund

The horticultural research fund has been established to mobilize funding for research from within the sub sector. It is based on deduction from exports which will give support to research needs within the sub sector. A survey has been commissioned to identify research needs in the different growing areas and also document research findings, which are available. This will again assist in identifying if there exists a gap between research and dissemination of research findings.

HCDA'S ROLE IN FACILITATING SMALLHOLDER PRODUCTION AND MARKETING

Support to Smallholders Through Improved Service Provision

In order to enhance development and empowerment of smallholders, HCDA is focusing on the following

- Strengthen its specialized national extension service to cover all potential areas with the aim of promoting production and marketing.
- Organize smallholders into production and marketing groups to improve efficiency in service delivery.
- Support grassroots farmers groups and associations to strengthen their organization and management practices and enhance their bargaining power.
- Encourage contract farming through promotion of code of conduct and create a fair playground between producers and buyers.
- Intensify farmer training to encompass new trends on market needs and production technologies.

Facilitate marketing for smallholders

- Encourage channeling of horticultural produce through HCDA's horticultural produce handling facilities and enhance production and marketing linkages for those with no facilities.
- Provide for rent/hire of horticultural produce handling facilities including coldrooms, packhouses, and trucks for produce packaging, storage and transportation by Stakeholders (exporters, processors, green grocers/supermarkets) with limited infrastructure.
- Contract growers and provide linkages with potential buyers and ensure market requirements of traceability, environment, pesticide residues and consumer safety are met.
- Establish a network for monitoring and disseminating market prices, demand and supply in the major local markets and production areas.

Establishment of Horticulture Resource Centre and Enhanced Marketing Intelligence

- Provide one-point reference center for horticulture information relating to production technologies, research findings, markets, prices, products, policies, etc.
- Subscribe to market information sources
- Collate and analyse market information on existing markets, market demands and supply competitors, processing, packaging and transportation
- Dissemination information to stakeholders

Improved Linkages with Stakeholders

- Establish a network with all stakeholders in the public and private sectors and encourage collaboration.

Establish Consumer Confidence

- Initiate farm certification and accreditation programme to ensure good agricultural practices are put in place
- Undertake farm inspection, evaluation and award certificates as recognition to farmers who meet the basic defined protocols of good agricultural practices.
- Enhance consumer confidence and safety for the certified production in the local and export markets.

Encourage Products and Market Diversification

- Look for new markets outside the current dominant markets in Europe
- Put up facilities which will enhance penetration of lucrative markets in Japan, USA etc.
- Intensify export market promotions
- Encourage local consumptions of products which are predominantly exported through development of recipes and promotion.
- Promote development of new products, packaging and more competitive modes of transport.

Develop and Implement Produce Quality Standards for the Local Market

- Standards with specific reference to quantity and quality to control losses during marketing.
- Enhance adoption of the developed standards.

- Negotiate for uniform cess charges countrywide to encourage adoption of the developed standards.

MARKETING AND TECHNOLOGYTRANSFER CHALLENGES FACING KENYAN EXOTIC VEGETABLE GROWERS AND EXPORTERS.

Victoria E. Anjichi
Moi University, Horticulture Department, Box 1125, Eldoret Kenya, Email Address vashiali@yahoo.com

ABSTRACT

Horticultural farming plays an important role in Kenya's economy. It is a source of food providing the necessary vitamins and minerals to balance diets as well as ensuring food security for the Kenyan population. There has been substantial growth in this sector since 1967 when the first documented horticultural exports of 1,477 tons were made. This volume rose to 98,762 tons in 2001 earning Kenya Ksh 20.2 billion foreign currency. Out of this volume, 34,770 tons were exotic vegetables mainly French beans, runner beans, snow-peas, and Asian vegetables. This sector imports over 90% of the seed used to grow these exotic vegetables. This seed is imported from various countries including Denmark, Holland, Israel, and USA. There are major technology transfer challenges facing growers and exporters of these crops as a result of this. Several other challenges also affect this sector and these are highlighted in this paper. This paper presents the results of a survey carried out on various exotic vegetable growers, exporters, seed supplies, and other stakeholders. The survey sought to find out the marketing and technology transfer challenges that face this promising and rapidly expanding sector. The current trends in this sector were also analyzed. Available literature, including journals and newspapers articles were also reviewed to ascertain these. Recommendations and suggestion are given on how to address these challenges.

Keywords: technology transfer challenges, exotic vegetables, export crops.

INTRODUCTION

Horticultural farming both for local consumption and for export plays a major role in Kenya's economy. It is a source of food providing the necessary vitamins and minerals to balance diets as well as ensuring food security for the Kenyan population. Covering an area of 236,815 ha in 2001, (Ministry of Agriculture annual 2001 report) the horticultural sector provides employment for over 2 million Kenyans most of them women and youth based in the rural areas. Export vegetable crops grown in Kenya include French beans, runner beans, snow-peas, brinjals, Asian vegetables and baby corn. The Kenyan horticultural sector has undergone substantial growth since 1968 when the first documented exports of assorted horticultural produce was 1,477 tons (Mulonzya, 2002). This volume rose to 99,212 metric tons in the year 2000 making Kenya a model country in sub-Sahara Africa. Expansion of the fresh produce industry in the 1990's has been spurred by an increased knowledge base in horticulture over the last 15 years when Bachelor of Science degree programs in Horticulture started to be offered by Kenyan Universities. This remarkable growth is also attributed to a dynamic private sector, which has developed and profitably marketed a wide range of horticultural products to diverse international markets. Production of a wide range of horticultural products is possible in Kenya due to the varied differences in altitude making it possible to grow tropical, subtropical and temperate crops in the various Kenyan Agro-Ecozones. Structural and macro-economic reforms, plus the introduction of more liberal-trading environment have provided a major boost for Kenya's horticultural investment prospects. Several major challenges face this horticulture sector and among them unavailability of appropriate and affordable good quality seed especially for the small holders (Kiptum, 2000). This study sought to find out the source of the locally available vegetable and summer flower seed, the various distribution channels to the small scale horticultural farmers. Several Seed companies who are major suppliers of horticultural seed in Kenya were interviewed with a view to find out what type of horticultural crops seed they market and where they source this seed from. Vegetable growers, exporters, and some transporters were interviewed with a view to finding out marketing and technology transfer challenges that face them as a sector.

MATERIALS AND METHODS

Three major horticultural crops seed suppliers were interviewed. These are, Kenya Seed Company (Simlaw Seeds), East African Seed Company, Hortitec (K) Ltd, and a major stockist for Regina Seed Company, North Rift region (Wilchemson's Ltd). These were interviewed with regard to type of horticultural seed they market and origin of their seed stock. The distribution outlets for this seed in the horticultural crops growing areas of Kenya were analysed in parts of North Rift region. Several seed stockists in the district and divisional headquarters of Uasin Gishu, Keiyo, and

Trans Nzoia Districts were interviewed to check on their horticulture seed stock. Interviews were also carried out on vegetable crops growers and exporters. Ministry of Agriculture Extension staff were also interviewed to find out the challenges they face as government extensionists who reach out to farmers frequently, in the course of their duty. Available literature including journals and newspaper articles were also reviewed to find out the challenges facing this sector.

RESULTS AND DISCUSSION

Availability of vegetable seed.

Kenya is an established exporter of horticultural crops. The range of vegetables exported from Kenya is shown in Table 1. French beans, runner beans, snap peas, and Asian vegetables top the list of exported vegetables.

Table 1 Types of Vegetables Exported from Kenya in 2002.

VEGETABLE CROP TYPE	ABUNDANCE
French beans	+++
Runner beans, Snow peas, Asian Vegetables	++
Baby Carrots, Baby corn, Leeks, Broccoli	++
Aubergines, Salad Onions, and others	+

+++ extent of abundance

Availability of seed/seedlings of the above vegetable crops was found to be fairly abundant at the stockist shops within the districts of study.

Distribution and Marketing of Vegetable Seed.

Some companies involved in selling vegetable seed in Kenya are shown in Table 2. They are registered seed importing companies which comprise of both local (Kenya Seed Company), and foreign companies. Of these companies, Kenya Seed Company (Simlaw Seed), does some breeding of vegetable seed in Kenya. Most of the other companies only import flower and vegetable seed for sale to small scale and medium scale farmers. The large scale horticulture growers such as Homegrown and VegPro do their own seed importation. There are over 42 registered seed merchants in Kenya who import various types of horticultural seed from various sources. Over 90% of all available horticultural seed in Kenya is imported.

Most of the small scale horticultural growers interviewed were not aware that most of the horticultural seed they use is imported. These interviews revealed that the four major horticultural crop seed suppliers import their stock from various countries as listed below. The major countries of import according to this survey are Holland, Denmark, France, Israel, Japan and USA.

Table 2 Major Companies Involved in Selling Vegetable and Summer Flower Seed.

NAME OF COMPANY	HORTICULTURAL SEED TYPE	IMPORTED FROM
Kenya Seed Company	Assorted Vegetables	Holland, Denmark
East African Seed Company	Assorted Vegetables	Holland, France
Hortitec (K) Ltd	Vegetable & Summer flower Seed	Holland, USA,
Regina Seed Co.	Assorted Vegetable Seed	Holland, Japan, France
Others i.e. Amiran	Especially Greenhse veg. Varieties	Holland, Israel

This study showed that over 90% of the available horticultural crop seeds in Kenya are imported from other countries, some of them temperate and others Mediterranean. This has serious implications since the phenotypic value of a crop is influenced by both the genotype of the crop as well as environmental interaction (positive or negative). Therefore seed of excellent genetic value cannot perform the same in Denmark as in Kenya because of the environmental differences between these two countries. Over the years, Kenya has made tremendous breakthroughs with regard to breeding of cereal crop seed i.e. maize, wheat and sunflower. The country has a working system for breeding, multiplication, distribution, and marketing these major food crop seeds. It is therefore possible in Kenya, to put in place a system for breeding, multiplication, distribution and marketing of horticultural crops seed, since this sector has become a major foreign exchange earner as well as an employer of many rural Kenyans, especially women and youth who live in the rural areas. Dependence on imported seed could lead to salient introduction of diseases which may not be easy to detect at the time of importation. Some of these issues were previously raised (Wabule, 1995), however there has not been much progress towards implementation of such measures. In our recommendations, we at Moi University, Horticulture Department, are trying to answer the question "How can we, the trained cadres of Horticulture specialists, focus and direct our efforts to work with farmers and policy makers in overcoming the persistent deficiencies in Kenyan horticulture in order to catalyze greater food security, rural well-being and sustainable development?" It is essential that policy makers together with the other stakeholders should address this serious problem if horticulture is to be boosted in this country. Table 3 is a summary of the challenges faced as reported by the interviewed export vegetable farmers.

The following recommendations are given to improve the fate of export vegetable growers in the north rift region:

- Have the growers to sign binding contracts with the buyers so that the growers are guaranteed a good price and a steady market.
- The growers should, where possible diversify their production so that they can spread their risks in case of poor price performance of a particular crop type.
- Holistic approaches to production whereby the seed importers incorporate universities and researchers to try out the performance of the new seed in various locations in this region, the use of funds from the horticultural research fund will assist in this; environmental conservation issues should also be incorporated, gender issues etc.
- There should be an annual "**National Horticultural Day**" where the entire nation of Kenya will focus its attention on the significance of horticulture in the economy of this nation.

Table 3. Marketing and Technology transfer Challenges faced by growers.

RANK	CHALLENGES REPORTED BY INTERVIEWEES
1.	Lack of accurate market information with regard to actual prices of produce leading to possible exploitation by middle men
2.	Declining Government support. The private sector is increasingly taking over support to export vegetable growers such as supply of inputs on credit, extension advisory services, all at a fee to the grower.
3.	Increasing post harvest losses due to ignorance of the required grades by the growers.
4.	Lack of credit facilities where farmers can borrow capital for laying down of essential horticultural infrastructure such as irrigation facilities, cold storage, etc.
5.	Unreliable middle-men who fail to come whenever the prices overseas start to drop leading to losses since the local markets in this region do not use much of french beans
6.	Declining productivity per unit of land due to a wide range of uncertainties such as inability to provide adequate irrigation as required,

The following table (Table 4) shows the list of challenges reported by the Ministry of Agriculture extensionists as they work with export vegetable farmers in the north rift region.

RANK	CHALLENGE REPORTED
1.	Unavailable technical information on some export vegetable crops grown by the farmers since the farmers get the imported seed from the middle men who have secured a market, and the farmers just grow these for them.
2.	Inability to assist with regard to post harvest losses especially when the middlemen fail to come and pick the produce.
3.	The farmers do not see the importance of extensionists since there is no tangible benefits they get from us.

Tremendous effort is being done by Kenya Seed Company to breed and avail some horticultural seeds. The tomato varieties "Kentom" and "Zawadi" are the fruit of these effort. However, there's an urgent need for this effort to be complemented by other institutions. It is recommended that close collaboration be urgently established between Kenya

Agricultural Research Institute (KARI), Institutes of higher learning offering degrees in Horticulture i.e. Moi University, Egerton University, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Maseno University, Horticultural Crops Development Authority (HCDA), Fresh Produce Exporters Association of Kenya (FPEAK), Kenya Plant Health Inspectorate Service (KEPHIS), Ministry of Agriculture extension services, and farmer group representatives. These will chart a way forward whereby horticultural crops breeding programs and coordinated horticultural crop performance trials can be planned and carried out in the various Agro Eco Zones of this nation. Also, an institution (preferably a university) should be appointed and enabled to hold an initial Annual Horticultural Seed trial/performance where stakeholders will see the performance of various horticultural seeds. Attendants can pay an entrance fee which will help sustain this event in subsequent years. Interested Seed Companies can avail samples of their seed to be included in these annual performance trials. Farmers who have unique horticultural seed will also be encouraged to bring it forth for display/ popularization. Finally, it is recommended that coordinated horticultural crop adaptation trials be carried out in various Agro Eco Zones of Kenya before seed is availed for sale. Various qualified agronomists, plant breeders, who are also lecturers in our Universities offering degrees in horticulture, working with a team of post-graduate students could be assigned the task of performing such trials within specific localities of this nation. This will avail information on the performance of the numerous varieties of horticultural seed available on the market. It will lead to farmers selecting proven varieties for increased yields, making horticultural farming profitable and ensuring food security. It will complement the work currently being done by some companies such as Regina Seed Co. (Riungu, 2001). Spot visits to various divisional headquarters revealed that these have adequate supplies of vegetable seed especially at planting time (onset of rainy season). There are several appointed seed stockists all over the divisions in Uasin Gishu District, Keiyo District, and Trans Nzoia Districts.

CONCLUSIONS

The Kenyan horticulture sector is a dynamic and vibrant sector which requires frequent updating of technical knowledge. It is important that the ministry of Agriculture puts in place a mechanism to regularly update the technical knowledge of the technical staff. According to this study, over 90% of the horticultural crops seed that is available on the Kenyan market is imported from Holland, Denmark, France Japan, USA, and Israel. In conclusion, the Kenyan horticultural crops seed industry is deemed to be at cross-roads because horticulture activities in Kenya are increasing rapidly whereas there is no supporting plant breeding programs to ensure their sustainability. Kenyan horticulture crops could be viewed as “orphan crops” with no parental backing in the form of breeding programs. It is strongly recommended that a further study be done to compare the benefits of breeding crops locally versus depending on imported seed.

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PERFORMANCE OF PASSION FRUIT (*PASSIFLORA EDULIS* SIMMS.) VARIETIES AS INFLUENCED BY PLANTING MATERIALS

Isutsa, D. K[1]. and Mumera, F. B[2]., [1]Department of Horticulture, Egerton University,
P. O. Box 536, Njoro. [2]National Plant Breeding Research Centre,
P. O. Private Bag, Njoro-Kenya. Tel. +254-51-42251, Fax +254-51-62527, Email: dki1@africaonline.co.ke

ABSTRACT
Lack of adequate field-testing may curtail use of micropropagated (tissue-cultured) passion fruit (*Passiflora edulis* Sims.) planting materials. Currently, tissue culture (TC) of *P. edulis* is not practiced in Kenya on a commercial scale, and its implications remain unknown. There is no information on the performance of micropropagated *P. edulis* in Kenya. The objective of this research was to compare field performance of conventional and TC yellow and purple passion fruit varieties, when grafted or not grafted. The experiment was set up in a completely randomised design, with four replications. Each treatment had 40 plants, spaced at 2 m x 3 m per plant. Vegetative and reproductive growth variables were assessed every two weeks from 14 weeks after planting (WAP). Data were subjected to analysis of variance, using the MSTAT-C statistical programme, and Duncan's Multiple Range Test was used to separate significantly different means. All plants grew normally. The effect of planting material on growth was significant throughout the observation period. Yellow conventional and yellow TC plants had more leaves and greater height than all the other plants. Yellow conventional versus yellow TC plants, and yellow conventional-grafted versus yellow TC-grafted plants did not differ significantly in all growth variables assessed. At the beginning of assessment, purple TC plants were significantly more vigorous than purple conventional plants in height, number of leaves and laterals. With reference to reproductive growth, yellow conventional and yellow TC plants did not bear any flowers, whereas yellow TC-grafted plants had the highest number of flowers and fruits throughout the season. Fruit quality did not vary with planting material. These results show that micropropagation alone does not alter field performance, although it slightly increases plant vigour. These findings should pave way in the adoption of micropropagation to regenerate passion fruit planting materials on a large scale in Kenya.

INTRODUCTION
Passion fruit (*Passiflora edulis* Sims.) has become an important fruit crop in Kenya, since it was reported as a viable new industry in the early 1970's (Owen, 1971). Passion fruit growing is rapidly expanding to replace low value and other cash crops, facing a variety of recalcitrant constraints and has great potential in Western, Nyanza and Rift Valley provinces of Kenya (Anonymous, 1997). The income from exported passion fruits exceeded K.Sh. 161 millions in 2002, representing a 36% increase over the previous year (HCDA, 2003). Among the cultivated varieties, purple passion fruit (*Passiflora edulis* var. *edulis*) is the most important in the Kenyan juice industry (Anonymous, 1997), but they are also consumed in jam, jelly, dessert, yoghurt, ice cream, and other food products, or exported (Anonymous, 1997). On the other hand, certain yellow passion fruit varieties are important as rootstocks for protecting the purple passion fruit varieties against soilborne diseases such as nematodes and Fusarium wilt (*F. oxysporum* f. *passiflorae*) (Amugune et al., 1993; Nakasone and Paull, 1998).

Most commercial passion fruit producers worldwide use seedlings to establish plantations (Nakasone and Paull, 1998). Propagation by cuttings and grafting on yellow passion fruit rootstocks are occasionally practiced. Poor quality seeds and lack of disease-free planting materials are ranked among major constraints preventing adequate production and supply of passion fruits in Kenya (Anonymous, 1997). The practice of micropropagation on a commercial scale and performance of micropropagated passion fruit plants under Kenyan field conditions have not been reported widely, save for Amugune et al. (1993), or included in past research priorities for Kenya. Both yellow and purple passion fruit varieties have been successfully micropropagated and field-tested elsewhere (Scorza and Janick, 1976; Moran-Robles, 1978; Kantharajah and Dodd, 1990; Drew 1991; Dornelas and Vieria, 1994; Kawata et al., 1995; Faria and Segura, 1997; Huang et al., 1997). In Spain, Faria and Segura (1997) reported that micropropagated yellow passion fruits exhibited normal development and blossomed abundantly, but they did not compare them to conventional plants. This research was aimed at evaluating field performance of micropropagated *P. edulis* plantlets in comparison to conventional seedling plants.

MATERIALS AND METHODS

Planting Materials

Seeds were extracted from disease-free yellow and purple passion fruits, which are the most economically important in Kenya. The fruits were obtained from the Kakuzi (Kenya) limited and the National Horticultural Research Centre, both in Thika-Kenya. Seeds of each variety were germinated in sterilized sand on a laboratory bench maintained at 25 ± 1^{o}C and 16 hours of 35 µmol·m^{-2}·s^{-1} (Kantharajah and Dodd, 1990). Shoot apices, measuring 0.5 cm long were excised from the seedlings and established on modified Murashige and Skoog (1962) basal salts medium supplemented (per litre) with 5 mg 6-benzylaminopurine (BAP), 30 g sucrose, and 8 g agar (Kantharajah and Dodd, 1990). The pH was adjusted to 5.7, before pouring the medium into 100-ml jars and autoclaving for 18 minutes at 121^{o}C and 100 kPa. Cultures were maintained under the same conditions as for germination. Shoot tip and internodal segments, measuring 1 cm long were subcultured for proliferation on a medium similar to that used for establishment, and maintained at 25 ± 1^{o}C and 16 hours of 90 µmol·m^{-2}·s^{-1} (Faria and Segura, 1997). The resulting stage II microshoots rooted best ex vitro in a sterilized sand: soil (2:1, v/v) mixture in a cool, humidified propagation box maintained at 75% relative humidity, 25 ± 2^{o}C, and 16 h of 90 µmol·m^{-2}·s^{-1} (Faria and Segura, 1997). Subsequently, plantlets were transplanted into the same sand: soil mixture as that used for ex vitro rooting and acclimatized in a greenhouse. Conventional plants were grown in the greenhouse throughout until field-transplanting stage. Half of the yellow passion fruit plants were grafted using purple conventional scion shoots.

Experimental lay out

The field trail was conducted at Lare that is located in agro-ecological zone (AEZ) lower highland 3 (LH3) at an elevation of 2160 m. The site receives 832 to 931 mm of rain annually and achieves 8 to 24^{o}C temperature (Jaetzold and Schmidt, 1983). The land at the site has high soil fertility, according to Jaetzold and Schmidt (1983). It was expected that performance in this site could be reproduced in regions with similar environmental conditions. The experiment was laid in a completely randomised design, with six treatments (planting materials). Each treatment was replicated four times and assigned 40 plants. Plants were established and maintained according to the recommendations of Nakasone and Paull (1998). Plants measuring 30-cm in height were transplanted in November 2002 into 60 cm x 60 cm x 60 cm holes, spaced at 2 m x 3 m. Farmyard manure (5 kg) and 100 g diammonium phosphate were applied to each hole, and plants were irrigated immediately after. Soon after planting a trellis was established to support passion fruit vines. Two main shoots were trained on a string up to a wire in opposite directions. All other shoots were pruned off. Laterals on the two main shoots were left to hand down and bear fruits. Weeds were controlled in rows by shallow cultivation.

Calcium ammonium nitrate fertilizer was top-dressed at a rate of 70 g/vine at the beginning and middle of the growing season. Irrigation with 15 litres water per week was performed to sustain growth when rains failed. Plants were assessed at bi-weekly intervals for height, number of leaves, laterals, flowers, yields and quality. Data were subjected to analysis of variance, using the MSTAT-C programme and Duncan's Multiple Range Test was used for mean separation.

RESULTS

Vegetative growth in height, number of leaves and laterals

All plants (conventional and tissue-cultured) grew and yielded normally, and showed no aberration. The height of plants differed significantly throughout the observation period of 24 weeks after planting (WAP), when main shoots on the tallest plants had started growing along the trellis wire (Table 1).

The yellow conventional or TC plants had significantly greater height, more leaves and laterals than all the other planting materials (Tables 1, 2, and 3). The effect of tissue culture on the height, number of leaves and laterals of the yellow variety (conventional versus TC) plants was not significant (Tables 1,2 and 3). The same result was observed on the effect of grafting the yellow variety (conventional-grafted versus TC-grafted) plants, with scions from conventional passion fruit plants.

Table 1. Effect of planting material on height (cm) of passion fruit varieties in the field

Planting material	Time (weeks after planting) 14	16	18	20	22	24
Yellow conventional, own-rooted	130.3^{a}	171.5^{a}	209.5^{a}	254.0^{a}	300.8^{a}	316.0^{a}
Yellow tissue-cultured, own-rooted	139.8^{a}	174.3^{a}	223.8^{a}	264.3^{a}	316.8^{a}	324.5^{a}
Yellow conventional grafted	84.5^{b}	93.8^{bc}	105.0^{b}	121.3^{b}	156.5^{b}	192.5^{b}
Yellow tissue-cultured grafted	79.5^{b}	95.8^{bc}	102.0^{b}	105.5^{b}	164.8^{b}	201.5^{b}
Purple conventional, own-rooted	74.8^{b}	82.3^{c}	84.8^{b}	99.5^{b}	124.5^{c}	175.5^{b}
Purple tissue-cultured, own-rooted	89.8^{b}	99.0^{b}	105.0^{b}	118.0^{b}	151.5^{b}	193.3^{b}

[Z]Means followed by the same letter within columns are not significantly different at $P \leq 0.05$.

Table 2. Effect of planting material on number of leaves of passion fruit varieties in the field

Planting material	Time (weeks after planting) 14	16	18	20
Yellow conventional, own-rooted	15^{ab}	19^{ab}	24^{a}	30^{a}
Yellow tissue-cultured, own-rooted	17^{a}	19^{a}	26^{a}	27^{ab}
Yellow conventional grafted	13^{bc}	15^{c}	18^{b}	21^{c}
Yellow tissue-cultured grafted	14^{abc}	17^{bc}	18^{b}	22^{bc}
Purple conventional, own-rooted	12^{bc}	14^{c}	16^{b}	19^{c}
Purple tissue-cultured, own-rooted	16^{a}	18^{ab}	19^{b}	23^{c}

[Z]Means followed by the same letter within columns are not significantly different at $P \leq 0.05$.

Table 3. Effect of planting material on number of laterals of passion fruit varieties in the field

Planting material	Time (weeks after planting) 26	28	30	32	34
Yellow conventional, own-rooted	11	15^{a}	15	18^{a}	17
Yellow tissue-cultured, own-rooted	13	15^{a}	17	16^{a}	18
Yellow conventional grafted	4	8^{b}	10	14^{ab}	18
Yellow tissue-cultured grafted	3	10^{ab}	13	15^{a}	21
Purple conventional, own-rooted	1	7^{b}	11	10^{b}	14
Purple tissue-cultured, own-rooted	5	11^{ab}	12	14^{ab}	20

[Z]Means followed by the same letter, within columns are not significantly different at $P \leq 0.05$.

At the beginning of assessment, purple TC plants were significantly more vigorous than the purple conventional plants in height, number of leaves and laterals (Tables 1, 2 and 3).

Thus, they grew faster than the conventional plants. However, by the end of the observation periods, the two types of planting materials were not significantly different in vegetative growth attributes assessed. Thus, the conventional plants caught up with the micropropagated plants in all growth attributes.

Reproductive growth of flowers

With reference to reproductive growth, the yellow (conventional and TC) variety plants did not bear any flowers, whereas yellow TC-grafted plants had the highest number of flowers throughout the season (Table 4). At the end of 34 WAP, yellow conventional-grafted, yellow TC-grafted and purple TC plants did not differ significantly in the number of flowers (Table 4). However, the purple conventional plants had significantly fewer flowers than the purple TC plants (Table 4).

Table 4. Effect of planting material on number of flowers of passion fruit varieties in the field

Planting material	Time (weeks after planting) 26	28	30	32	34
Yellow conventional, own-rooted	0	0	0[c]	0[b]	0[c]
Yellow tissue-cultured, own-rooted	0	0	0[c]	0[b]	0[c]
Yellow conventional grafted	2	5	23[b]	64[a]	115[a]
Yellow tissue-cultured grafted	5	25	59[a]	73[a]	190[a]
Purple conventional, own-rooted	0	2	24[b]	35[a]	39[b]
Purple tissue-cultured, own-rooted	3	21	35[ab]	71[a]	140[a]

[Z]Means followed by the same letter or no letter, within columns are not significantly different at $P \leq 0.05$.

Yields and yield components

The effect of planting materials on yields was significant (Table 5). The trend in yields was similar to that in number of flowers, whereby yellow conventional and yellow TC plants did not set any fruits (Table 5). Yields ranged from 0 to 794 fruits/plant, corresponding to 0 to 32 kg/plant and 0 to 53,344 kg/ha (Table 5). Types of planting material bearing the highest number of fruits were: yellow TC grafted. The difference in number of fruits on purple conventional and purple TC plants was not significant (Table 5).

Fruit quality

Fruits ripened first in Lare 11 months after planting. There was no major difference in timing by the various planting materials in the Lare farm. Quality attributes (fresh weight, diameter, and total soluble solids) of all fruits were similar (Table 6). The attributes were measured on ripe fruits that had turned dark-purple. The fresh weight, diameter and total soluble solids ranged from 41 to 44 g/fruit, 4.9 to 5.2 cm and 13.0 to 15.1%, respectively.

Table 5. Yields of planting materials in three agro-ecological zones in the Kenyan highlands

Planting material	First year yields [z] (fruits/plant)	(kg/plant)	(kg/ha)
Yellow conventional, own-rooted	0[d]	0[d]	0[d]
Yellow tissue-cultured, own-rooted	0[d]	0[d]	0[d]
Yellow conventional grafted	469[c]	18[c]	30,673[c]
Yellow tissue-cultured grafted	794[a]	32[a]	53,344[a]
Purple conventional, own-rooted	542[bc]	22[bc]	36,007[c]
Purple tissue-cultured, own-rooted	655[b]	26[b]	44,009[b]

[Z]Means followed by the same letter or no letter, within columns are not significantly different at $P \leq 0.05$.

Table 6. Quality of purple passion fruits produced at Lare

Planting material	Attribute [z] Fresh weight (g/plant)	Fruit size/diameter (cm)	Total soluble solids (%)
Yellow conventional grafted	44	5.0	15.1
Yellow tissue-cultured grafted	42	4.9	14.9
Purple conventional, own-rooted	41	4.9	13.0
Purple tissue-cultured, own-rooted	43	5.2	14.5
Reported (Nakasone & Paull, 1998)	36	3.5-7	15.0

DISCUSSION

Few reports concerning field performance of tissue-cultured passion fruit in comparison to conventional passion fruit appear in the literature. The increased vigour of tissue-cultured purple variety and the yellow TC grafted agrees with findings of Huang et al. (1997) in China, which reported that tissue cultured own-rooted and tissue-cultured grafted were longer and larger than other plants of *P. edulis* x *P. flavicarpa* hybrids. Enhanced plant height, leaves and laterals could translate into higher and profitable yields, which can offset costs of producing tissue-cultured passion fruits (Huang et al., 1997). The increase in vigour of tissue-cultured plants could be attributed to the optimal conditions (both nutritional and environmental) provided in vitro (Faria and Segura, 1997). In commercial production of passion fruits, particularly the expensively tissue-cultured ones, profitability is crucial to sustain the enterprise.

In our study, the type of yellow passion fruit we used failed to produce flowers. Perhaps, environmental conditions at the study site did not promote flowering. This result agrees with the fact that yellow passion fruit thrives best in lowlands and with cross-pollination, since it is self-incompatible (Nakasone and Paull, 1998). This means that this variety could only be used as a rootstock under similar environmental conditions. The number of fruits set varied depending on the planting material. All the purple variety plants set fruits, as all yellow variety plants did not (Table 5). In Spain, Faria and Segura (1997) reported that micropropagated yellow passion fruit plants (*P. edulis* var. *flavicarpa*) exhibited normal development and blossomed abundantly in the field, although they did not mention conventional plants or prevailing environmental conditions during testing. The difference in flowering and fruiting can be attributed to prevailing environmental conditions. The yields realised corresponded to the flowers set; plants that had set more flowers at the end of 34 WAP also yielded more fruits than the others (Tables 4 and 5). Thus, the number of flowers set indicates the potential yields to be expected (Nakasone and Paull, 1998). Therefore, the best planting materials are those with the potential to set more flowers and hence more fruits.

The lack of a significant difference in fruit quality attributes suggests that type of planting materials exerted more impact on growth and yields than on fruit quality attributes. The quality attributes observed in our study (Table 6) agreed with standard ones established elsewhere (Nakasone and Paull, 1998). Observations revealed that tissue culturing and grafting do not alter field performance of the yellow variety, but TC increases the vigour of the purple own-rooted variety. These results further prove that passion fruit varieties respond differently to micropropagation (Amugune et al., 1993); thus they would require testing each genotype to determine its optimal requirements, or field performance. Field-testing is important, because it generates information on growth, pests, yields, somaclonal variants, and farmers' perception, which form the basis for making recommendations on adoption of micropropagation technology to generate planting materials on a large-scale. Field trials also indicate the strength, safety, and reliability of micropropagation relative to conventional techniques (Faria and Segura, 1997). Thus, similar evaluation studies of micropropagated passion fruit plants are worthy undertaking under Kenyan agro-ecological conditions.

One avenue to sustaining production and arresting the short supply of passion fruits in Kenya is increasing the availability of disease-free planting materials to growers. Planting more passion fruits would increase acreage, boost production, and generate income (HCDA, 2003), which in turn would ensure food security, improved mineral nutrition, and raised living standards of growers, unable to produce other cash crops due to constraints beyond their control. The increase in production should also translate into enhanced foreign exchange earnings for the country (HCDA, 2003), thus a boost to socio-economic development of Kenya. However, passion fruit production for local and export markets is bound to expand if other constraints such as field pest and disease management can concurrently be dealt with besides ready availability of planting materials. Diseases and insect pests are constraints that remain a big threat and hindrance to realization of the full potential of passion fruits (Nakasone and Paull, 1998). This research, however, was not able to quantify the contribution of diseases and insect pests to the performance of the passion fruit plants due to the great variation in the fields. Nevertheless, efforts were made to manage the pests, but complete control proved impossible.

CONCLUSION

Our results show that micropropagation alone does not alter field performance, but it enhances the vigour of passion fruit plants. Micropropagation is, therefore, recommended for regeneration of own-rooted or grafted plants of both the yellow and purple passion fruit varieties in Kenya. These findings on field performance support adoption of micropropagation to regenerate passion fruit planting materials in Kenya on a commercial scale.

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SOCIO- ECONOMIC BASE-LINE INFORMATION OF SMALLHOLDER FRENCH BEANS PRODUCERS IN KENYA

Ibrahim Macharia[1], Varela Ana[1], Bernard Lohr[1], Seif Abdurabi[1].
[1] *International Centre of Insect Physiology and Ecology (ICIPE), P.O. Box 30772, Nairobi, Kenya*

ABSTRACT

This study presents baseline data and information about French bean farmers participating in a training programme geared towards compliance with EU regulations on pesticides use and hygiene standards. Interviews and direct observations survey techniques were used for collecting most of the data from purposely-selected farmers, in six-sampled district. Results showed that a typical French beans enterprise is 0.3 acres, which constitutes 8.6% of the total farm area. Most farmers rely on pesticides only for pest control. Scheduled spraying is done by 98% of the farmers with an application after every week; only 2 % scout the crop before spraying. Average pesticide expenses including labour for application was KShs. 6,367/ acre or roughly 8% of the crop value. Labour for harvesting and handling was found to be the highest cost component; accounting for 21% of all production costs (9,694/ acre). Average gross margin per season was KShs 33,758. The most important insect pests were bean fly, thrips and mites. These pests were mentioned as major constraints by 81%, 46% and 44% of the farmers, respectively. Rust was reported to be the most

economically important disease, particularly during the rainy seasons. Other diseases mentioned included, in decreasing order, blight, fusarium wilt and leaf spot. Farmers believe they cannot produce French beans without use of chemicals as they expect crop losses of 100% if no pest control measures are applied. Generally none of the farmer had any legally binding contract or agreement with the buyer.

Keywords: Integrated Pest Management, pesticides, French beans, baseline information, Kenya

INTRODUCTION

In the international markets French beans (*Phaseolus vulgaris L)* is an important vegetable both in the volume traded as well as for its importance of providing income to many small, medium and large-scale farmers in developing countries. The use of pesticides has played a vital role in French bean production. However, Over the years, pest control practices in vegetable production has become a major issue and the European Union, the main market for Kenyan produce, has introduced maximum pesticide residue limits and standards in hygiene that might endanger the future of export French bean production unless farmers can be made to comply with these rules.

In Kenya, most of the commonly available and used pesticides in export horticulture are either not approved for use or are used wrongly. Worse still, for many uses, there are no alternative products registered, thus rendering farmers defenseless. Pesticide impact on health and environment necessitate the training of farmers on safer ways of controlling pests and proper handling of the crop. The implementation of Good Agricultural Practice is the best way of achieving a reasonable and acceptable assurance of food safety from small-scale farmers. Another important aspect is that farmers will be out of the market if they do not comply with European Union (EU) regulations on use of pesticides, pesticide residues (MRLs) and hygiene standards. In response to these challenges a Project funded by United States Agency for International Development Mission to Kenya (USAID) was initiated in ICIPE. Its role is to train front line horticultural extension officers (Trainer of Trainers, ToT) drawn from private and public sectors that are expected to train farmers in their respective areas through a participatory and interactive training programme. The data and information presented here were collected from farmers` groups undergoing group training. The information will be used as baseline for later used assessing the training impact on target beneficiaries.

Back ground on French beans production sector in Kenya

French beans are grown in different agro ecological zones by both small scale and large-scale farmers. Swanberg (1995) reported that almost 100,000 people earn major income directly from the export of French beans and this number is believed to have doubled. Central Province is the major growing area with a share of 72 % (Table 1). A two-year average for fresh export by sea and air to all countries (2000 and 2001) shows that French beans account for 10.6 percent of the total value with flowers taking the lion share of 41.7 percent (HCDA statistics, 2000- 2001). Thus, French benas are the most important export vegetable of Kenya. Varieties grown include, Monel, Paulista, Amy, Samantha, Teresa, and Julia. Major insect pests and diseases of economic importance include, bean fly, thrips, aphids, pod borers, whitefly, Fusarium wilt, rust and anthracnose (MoARD, 2000). Other constraints limiting production includes, high inputs costs, exploitation by brokers and seed mix-up (MoARD, 2000). As stated earlier, most farmer use pesticide and fungicides not approved for use and their handling is also questionable.

Table 1: French beans production statistics for the Provinces of Kenya (average 1998-2000)

Province	Area (ha)	Production (t)	Yield (t/ha)	Production share (%)
Central	3,946	22,736	5.76	71.8
Western	344	1,429	4.15	4.5
Rift valley	602	1,904	3.16	6.0
Nairobi	32	248	7.75	0.7
Eastern	906	2,300	2.53	7.2
Nyanza	376	3,012	8.01	9.5
Total	6,206	31,629	5.09	100

Source: Ministry of Agriculture and Rural Development, (1999, 2000)

METHODS

A training of trainers course (ToT) was conducted at ICIPE where extensionists from the private and government sector were made familiar with all problems affecting the bean crop as well as the market requirements as the GAP and hygiene. Before the graduates of this course started training their farmers groups, six groups were purposively selected from a total of twelve for this base-line study. Farmers for interviews were randomly sampled from a sampling frame provided by the trainers, taking into consideration those farmers who were harvesting or had just harvested the crop to ease collection of input – output data. This criterion did not apply in Nakuru District, where cultivation of the crop had stopped. The farms surveyed fell under the category of mixed farming system. Combinations of interview and observation techniques were used to collect most of the data and information. The main instruments applied were farm walk and discussions with the farmer using a semi-structured schedule. Main respondents were mostly heads of the households, their wives and adult members living in the compound. During the visit, the trainers and the researcher introduced themselves, the purpose of the visit and the planned activities. The first step was to ask the farmer about the main farm activities and the location of his or her French beans plot. After the initial discussions, the researcher asked the farmer to show the farm, especially the areas for further French beans production. During the walk to the plot, there were discussions on farming activities and familiarisation with the farm, the farmer and the actual situation of the crop. On reaching the plot the farmer explained the area, incidences of pests, the inputs used, previous and expected harvests, selling prices, harvesting and handling, estimates of loss if no pests control measure were done (both on high and low infestation and during different seasons).
In an open-ended question, farmers were also asked to describe the pests they knew, this was confirmed by a sample from the field and visual pictures in a French beans manual. Finally farmer willingness to cost share the training was investigated. Base period for the evaluation was production season between November 2002 and May 2003. A total of 60 farmers were interviewed. Only 47 were used for most of the analysis, the rest did not have the crop in their farm at the time of survey.

RESULTS AND DISCUSSIONS

Production practices

Important aspects of French beans production, separated according to production area, are presented in Table 2.. On average, typical french beans holding was 0.3 acres, which constituted 8.6% of the total farm area. All French beans received inorganic fertilisers, while only 57% of growers used manure. Almost every farmer used irrigation, particularly during the dry spell. Generally, gravity furrow and sprinkler irrigation were used.. Most farmers used a wide range of chemicals for pest control, the most frequently named insecticides included, Dimethoate (+Rogor) (57%), Karate (L-Cyhalothrin) (23%) and Fastac (Cypermethrin) 15%. For diseases, the frequently used products were, Thiovit 80WP (Sulphur), Pencozeb (Mancozeb) (15%) and Plantvax 20 EC (Oxcarbaxim) (13%). In contrast to manufacturers' recommendations, farmers used their own mixing rates.

These were in most instances below the recommended rates. Scheduled spraying was the method of choice for 98% of the farmers with an application approximately once every week. Scounting for pest presence was uncommon, only 2% of the farmers monitor the pest before spraying. This monitoring is based on symptoms but not actual presence of the pest. The major source of pesticides (100% farmer) was the local agrochemicals shops, although the outgrowers of some exporters were offered pesticides on credit. Farmers expected crop losses of 100% if no pest control measures were applied. This is a clear indication that farmers believe they can't produce this crop without the use of chemicals. The most important insect pests mentioned were bean fly (*Ophiomyia phaseoli, O. spencerella, and O. centrosematis (Diptera: Agromyzidae))* (81% of the respondents), followed by thrips (*Megalurothrips sjostedti and Frankiniella occidentalis (Thysanoptera: Thripidae)* and mites (*Tetranychus spp.)*, 46% and 44% of the growers, respectively. Rust (*Uromyces appendiculatus*) was reported to be the most economically important disease, particularly during the rainy seasons. Other diseases mentioned from the most important to least included, blight (*Pseudomonas savastanoi pv. phaseoli)*, fusarium wilt (*Fusarium oxysporum f. sp. phaseoli*) and leaf spot (*Phaeoisariopsis griseola)*. Generally, the farmers knew insect pest better than diseases in terms of description and the symptoms they cause.

Experience in French bean production is high in Nyeri (5.8 years) and lower in Kajiado (0.8 years). It is important to note that Nakuru (7.4 years) had the highest average year of experience, dating back to 1991 for most of the farmers. According to 71% of the farmers, marketing is the major problem in French beans production, followed by pests (43%), high input costs and problems with water supply during the dry spell. Many farmers commented that, with proper marketing and good prices, they could be able to cater for the other problems because their production will be economically able.

Regarding knowledge level in pest identification and crop management, highest scores 63% was found in Kajiado, while Transnzoia (46%) had the lowest overall score. This confirms earlier evidence of higher number of years of education in Kajiado. Important to note, also Kajiado had only two farmers who were growing the French beans at the time of interviews.

Marketing

Generally none of the farmer had any legally binding contract or agreement with the buyer. Some buyers assisted farmers with inputs like seeds, fertilisers, and pesticides. The costs are then deducted during the payments. Poor coordination between exporters and farmers was cited to have increased uncertainity at farmers` level. Farmers also complained of delays of payment, which reduces their purchasing power for farm inputs. Few farmers sold to brokers apart from one group in Meru Central, who had a number of brokers acting for companies like Vegpro, Homegrown etc. Normally these brokers (middle persons) issue packaging cartons and gather the produce from a wide range of growers and sell to the agents of the exporting company.

Table 2: Descriptive characteristics in selected training districts of Kenya, 2002.

Characteristic	Meru C (N=17)	Kirinyaga (N=13)	Kajiado (N=2)	Nyeri (N=10)	Transnzoia (N=5)	Average (N=47)
Total farm size (acres)	3.9 (0.6)	3.3 (1.0)	6.5 (3.5)	2.4 (0.45)	3.7 (3.9)	3.5 (0.4)
French beans holding (acres)	0.3 (0.1)	0.26 (0.1)	1.1(0.9)	0.19 (0.0)	0.39 (0.1)	0.3 (0.05)
Home consumption share (%)	1.5	3.6	1.0	1.4	3.7	1.97
Farmers age	36.3 (1.7)	35.8 (3.9)	27 (5)	41.3 (3.5)	37.2 (3.9)	36.9 (1.5)
Year in education	9.7 (0.9)	8.8 (0.9)	12 (0)	8.7 (1.17)	10.2 (0.9)	9.4 (0.49)
Farmer experience in growing French beans (years)	3.5 (0.5)	3.1 (0.5)	0.8 (0.1)	5.8 (1.6)	1.12 (4.2)	3.9 (0.61)
Knowledge of major pests recognition and crop management (scores)	18.7 (0.7)	16.4 (1.3)	21.5 (3.8)	17.6 (2.1)	15.6 (1.0)	17.6 (0.7)
Percent of farmer using manure	24	61	50	80	60	57
Percent of farmer using pesticides	100	100	100	100	100	100
Percent using furrow irrigation	50	70	0	20	20	32
Percent using sprinkler irrigation	50	7	100	50	20	45
Percent using pipe irrigation	0	23	0	30	60	23
Percentage who do schedule spraying	100	100	100	90	100	98
Percentage who do monitoring	0	0	0	10	0	2
Farmer estimates loss if their is no control	100	100	100	100	100	100

1 acre =0.405 Hectares. We use acre for the analysis because it is the standard measure used by most farmers.

Production economics

Production costs of French beans varied widely between the Districts (Table 4). Labour for harvesting and handling at the farm level was the highest cost component. It took nearly 21% of all production costs. Pest control measures accounted for just 14 %. This was higher in Meru C (KSh 7,485) and lower in Kajiado (KSh 1,668). Cost of the seeds varied from one district to the next. This depended highly on the source e.g. those from companies, which later collect the produce are cheaper. Labour cost per man-day was higher in Meru C and lower in Transnzoia.

Average pesticide expenses, including labour for application, was KShs.6,367 (Table 4), or roughly 8% of the crop value. Apart from pesticides being costly, they also have hidden costs, e.g. some farmers stated, that they in one time had health problems and visited hospital or bought medicine (23%). Interviews also showed that most users get exposed to pesticides during mixing and spraying. Use of some pesticides (e.g. Karate) caused a variety of eye and skin problems.

The average gross margin per season was KSh. 33,758 (Table 5). Assuming the benefits are constant over the year and the farmer can have three crops per year, a most likely assumption of benefit would be KShs 27,684/year, when the actual acreage is considered. The standard errors of the gross margins were consistently very large, almost twice the mean at Meru Central, and still half for the overall gross margin. This is caused by a very skewed distribution of the benefit with some producers registering high losses and others earning a very large income

Table 4: French bean production cost (in KShs/Acre) at farm level in selected training districts of Kenya (in 2002)

Aspect	Meru C (N=17)	Kirinyaga (N=13)	Kajiado (N=2)	Nyeri (N=10)	Transnzoia (N=5)	Mean (N=47)
Labour for land preparation	1,531	1,200	1,250	1,944	1,186	1,479 (162)
Cost of seeds	8,911	5,733	9,700	6,752	7,425	7,448 (737)
Labour for planting	861	1,557	750	1,654	880	1,219 (172)
Labour for weeding	2,156	2,601	1,000	2,437	1,793	2,251 (139)
Cost of irrigation	6,808	12,482	12,000	7,431	7,480	8,802 (1,180)
Manure	4,629	1,727	3,500	11,440	640	4,803 (2167)
Fertiliser	4,291	2,946	3,912	6,425	1,379	4,047 (397)
Labour for top dressing	747	609	575	540	538	635 (101)
Insecticides and fungicides	6,073	3,995	1,093	4,788	2,012	4,581 (1,100)
Labour for Insecticides and fungicides application	1,412	3,357	575	1,228	569	1,786 (366)
Harvesting and handling	8,019	4,044	11,875	20,089	8,420	9,694 (1,815)
Total	45,444	40,257	46,230	64,733	32,325	46,751 (6,193)

78 KShs = 1 US dollar according to 2003 exchange rate

. Important to note also, G.M also varied considerably between the districts possibly due to differences in prices. Per unit cost was extremely variable and high for Kirinyaga (KSh 37,623 KShs/t) and lower for Nyeri (KSh 16,901 KShs/t) with an average of 23,611 KShs/ ton. Average yields ranged from 3.83t/acre in Nyeri to 1.0t/acre (Kirinyaga), with an actual average of 0.5t/acre. The study also showed that although farmers are willing to pay for the training this will depend on what they will be trained on and that costs should not be high because of their limited income.

Table 5: Mean French beans production costs and related income in selected training districts of Kenya, 2002.

District	Meru (N=17)	Kirinyaga (N=13)	Kajiado (N=2)	Nyeri (N=10)	Transnzoia (N=5)	Mean (N=47)
Total cost per season (KShs)	45,444	40,257	46,230	64,733	32,325	46,751 (6,193)
Average yields (t)	1.64 (0.69)	1.07 (0.17)	2.37 (0.60)	3.83 (0.88)	1.68 (0.47)	1.98 (0.34)
G. M per season (KShs)	8,703 (13,950)	11,375 (7,684)	56,269 (31,120)	90,307 (41,958)	55,034 (18,679)	33,758 (11,378)
Per unit cost (KShs/ t)	27,709	37,623	19,506	16,901	19,241	23,611

78 KShs = 1 US dollar according to 2002 exchange rate, all cost figures are calculated per acre

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AFRICAN LEAFY VEGETABLES: PRODUCTION AND CONSERVATION FOR EFFICIENT UTILIZATION

J.C. Onyango[1] and M.O.Abukutsa Onyango[2], Department of Botany[1] and Horticulture[2],
Maseno University, Private bag – 40105, MASENO. Kenya

ABSTRACT

African leafy vegetables (ALVs) have been grown for centuries in the African continent. In East and West Africa, *Solanum* sp. and *Cleome* sp. have been known to cure several diseases, leading to their preferential collection and subsequent preservation at the Royal Botanic gardens, Kew in the nineteenth century at the time when colonial scramble for Africa was at its peak. African Scientists and governments have neglected their own heritage in flight to other research materials where Donor Agencies could easily give out research funds based on their priority crops. In search for adaptive genetic materials to the African situation in terms of poverty alleviation and provision of food at the table, the African elites and governments are starting to appreciate our heritage. The development of ALVs will not only contribute to poverty alleviation but also to the provision of food at the table for most rural families. The problems of hunger in most African countries are not lack of food *per se* but poverty – the ability to buy food for the household needs. The University Botanic Garden, Maseno and African Leafy Vegetables projects have led in the initiative for production, popularization and seed production of the ALVs in Western Kenya region. The response is encouraging as we observe the increasing demand for these vegetables from the University staff and local communities on a daily basis as opposed to demand for kale and cabbages. The University Botanic Garden now has clean seeds for several of these vegetables at subsidized prices to farmers. The research on the ALVs is being undertaken at various levels, including both undergraduate and postgraduate teaching and research in collaboration with other Consultative Group for International Agricultural Research (CGIAR) member organizations, such as IPGRI and ICRAF. Work on the low in-put cultural practices is being undertaken, however, this has to be evaluated with the labour in-put at farmer's level to maximize production. The strong points in this approach is the appreciation and incorporation of indigenous knowledge from the local communities involved in the research.

INTRODUCTION

African leafy vegetables are sometimes described by Western world Scholars as weeds. Dating from settler's time some herbicides was developed to control growth and reproduction of these vegetables in farm lands. These herbicides were successfully used on tea plantations in East Africa to control weeds from Solanaceae and Amaranthaceae families. This opinion lead to almost extinction in biodiversity of these species and lose of the indigenous knowledge. Today some members of Solanaceae family have been recognized for their high levels of secondary plant metabolites especially the alkaloids. Currently research is being conducted on the characterization of these alkaloids for different purposes. Some work at Maseno university Botanic Garden is based on the potential use of this family for medicinal purposes among other plants. There are also investigations on the nutritive values and ways of reducing the bitter tastes of some *solanum* cultivars. Recently another study has been strated on the inter-cropping of *Solanum scabrum* with tea seedlings as a means of providing soil cover and food to small scale tea farmers in Kericho district.

MATERIALS AND METHODS

The vegetables research at Maseno have been guided by close collaboration with the farmers in the university catchments area and in this endeavour the Botanic garden's research has undertaken effective task of producing clean seeds of the six priority ALVs to the farmers. These are *Solanum scabrum, Solanum villosum, Corchorus olitorius, Cleome gynandra, Crotolaria brevidens* and *Amaranthus blitum*. The seeds are sold at subsidized price to collaborating farmers, mostly in Western Kenya. African Leafy Vegetables (ALVs) have unique advantages within farming systems. They grow quickly and can be harvested within a short period of time. This makes them useful in nutritional intervention programmes. During high precipitation seasons when leafy vegetables are plentiful, some communities preserve them by drying for use in times of scarcity. In this way the preserved vegetables contribute to house hold food security and are more easily marketed as a technology to the communities (Chweya and Eyzaguire 1999). The strategy for conservation of traditional vegetables is to prevent their falling into disuse because of economic demographic and cultural factors. Hence our conservation through use approach is to work with the farmers within the existing production and consumption systems to maintain local knowledge about their diversity and uses, to document the genetic diversity of key priority species, and to demonstrate the potential for improvement and their competitiveness against other exotic vegetables species such as cabbage and spinach

RESULTS AND DISCUSSIONS

The field observations on the growth of these vegetables shows that they reach harvestable stage within three to four weeks after planting depending on the cultural practices used. The vegetables can be harvested for up to three months giving a total cumulative harvestable leaf of 6 tons per hectare. In economic terms this production level is high enough to meet the intensive labour input and raise the rural family's economic status especially in respect to food security (Onyango and Onyango,2002). Demand for these African Leafy Vegetables is high and the production inputs are low although with high labour input, they can therefore be categorized as an alternative technology towards alleviation of poverty in rural parts of Kenya. However, the journey to poverty reduction and food security will be long in Kenya, since it needs changes in practice and perception from policy makers, extension workers and researchers. What is needed now is not the workshops for campaigns on the benefits and importance of technologies but the actual provision of clean seeds and hands-on-work geared towards production. In most cases researchers and extension workers spend a lot of time and resources trying to educate the populace with inherent indigenous knowledge about their heritage. At times this results in conflict of innovation and understanding at the detriment of technology transfer. It is therefore imperative that the indigenous knowledge bestowed on the communities by their cultural practices should be given due consideration as new technologies are being transferred.


Farmer's field visit by research team at Maseno


ALVs vendor selling at Kiboswa market (Kisumu, Kenya)

CONCLUSION

Our experience has proved that most farmers in Western Kenya are very responsive to new technologies especially if they can be seen to be working (Onyango *et al.*, 1999). The benefits of ALVs to rural households have been recognized and internalized in this region. What remains is commitments by researchers and availability of research funds to develop appropriate technologies for the vegetables production, especially those that can reduce the labour requirements at production level. This should be taken simultaneously with introduction of ALVs production courses at tertiary education institutions. Maseno University is already having these programmes at all levels of its higher education. The university Botanic garden will continue on its role as repository centre for the *ex situ* plant conservation. However, this will be based on the principles of conservation for sustainable utilization as opposed to the protection of germplasms. Sustainability will be achieved through usage of clean seeds from the garden by farmers to produce the vegetables in their back yard gardens or large plantations for commercial purposes. This is already the case with some farmers in Yala division and Kisii district production areas.

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IMPORTANCE AND SCOPE OF PREVENTIVE PEST MANAGEMENT FOR QUARANTINE COMPLIANCE OF KENYAN EXPORT HORTICULTURE PRODUCE AT EUROPEAN DESTINATIONS

C. J. Kedera[1,] W. Songa[1], B. Kuria[1], R. S. Ntoyai[1], S. Sithanantham[2], S. Lux[2], J. Nderitu[3], G. Kibata[4] and C. Muholo[2]
[1] Kenya Plant Health Inspectorate Service (KEPHIS), P.O Box 49592 – 00100, Nairobi, Kenya.
[2]International Center of Insect Physiology and Ecology (ICIPE), P. O Box 30772 - 00100, Nairobi.
[3]University of Nairobi (UoN), P. O Box 30197 GPO, Nairobi.
[4]Kenya Agricultural Research Institute (KARI) - NARL, P. O Box, 14773, Nairobi, Kenya.

ABSTRACT

In Kenya, there is keen interest in and concern for compliance with regulations of European Union, which accounts for about 90 percent of the Kenyan horticultural export. Besides complying with the stringent regulations regarding pesticide residues and related practices, the Kenyan export horticulture industry now needs to also address another concern about interceptions at the European destinations, due to insect infestations (hidden or escape) in the export fresh produce from Kenya. The number of interceptions in these destinations during 2002, mostly due to hidden insect infestations in the produce was 77, which is far greater than the range (6-25) in the proceeding three years (1999 – 2001). Overall, during 1999-2002, the African bollworm (*Helicoverpa armigera*) (39 interceptions) and the leaf miner, (*Liriomyza* sp.) (36 interceptions) accounted for about two thirds of the interceptions. Three other pests, namely the fruit fly (*Ceratitis* sp.), the whitefly (*Bemisia tabaci*) and thrips (*Scirtothrips* sp.), were also cause for concern, but only next in importance (with 12, 8 and 7 interceptions, respectively). A stakeholders' consultation workshop held in April, 2003 identified the need for evolving /refining/validating preventive practices so to minimize and even avoid such interceptions in future. Two complementary initiatives have been visualized for empowering farmers with capacity to identify and monitor these pests at farm level and to also undertake preventive control interventions. The initiatives are interactive and seek to link the relevant specialists, research institutions and the key players in the industry, so to meet this urgent need for enhancing the compliance levels by catering to the relevant capacity building and knowledge gap filling requirements.

INTRODUCTION

The Kenya horticultural industry has grown tremendously over the last three decades to be the most important agricultural foreign exchange earner after tea. The industry earned the country 20 billion in foreign exchange in the year 2001. Kenya growers were the highest suppliers of cut flowers into the European market, 25% ahead of Israel, Zimbabwe, Ecuador, Colombia and Zambia. Export production from small scale and medium scale holdings currently accounts for 60-70 % of all fruits and vegetables. In addition, it employs in excess of two million people directly or indirectly. The industry enjoys an average yearly growth of 20%. The European Union (EU) accounts for about 90% of total horticultural exports from Kenya. For Kenyan produce to maintain and even improve its market share in a highly competitive market, the industry has to keep up high standards of production, processing, packaging and handling to meet quality requirements. There is therefore need to strictly comply with these regulations to ensure continued marketing of Kenyan horticultural and floricultural produce.

THE MANDATE OF KEPHIS

KEPHIS is mandated to implement the Plant Protection Act (Cap 324), The Suppression of Noxious Weeds Act (Cap 325), The Agricultural Produce (Export) Act (Cap 319) and The Seed and Plant Variety Act (Cap 326).

Therefore, the activities of KEPHIS include:

- Preventing introduction into the country of harmful foreign weeds, pests and diseases through adherence to strict quarantine regulations and procedures.
- Grading and inspection of agricultural produce.
- Testing and monitoring for the presence of harmful residual agrochemicals on agricultural produce, soil and water systems; to ensure compliance with the maximum residue limits (MRLs) requirements.
- Certification of the quality of seeds and fertilizers.
- Diagnosis of diseases and pests on damaged plants and providing advisory service to the farmers on appropriate management practices.
- Plant variety protection thus enabling access to elite germplasm.

PHYTOSANITARY MEASURES APPLIED ON HORTICULTURAL EXPORTS

Phytosanitary certification is undertaken to ensure that all exported plant products are in conformity with the requirements of the importing country. Inspection may be carried out during the growing period of the plant or after harvesting.

Phytosanitary inspections during active growth

KEPHIS Plant Inspectors normally visit commercial growers and farmers of various agricultural and horticultural crops during the active growing period. They ensure compliance with the phytosanitary requirements of the importing country on freedom from specified diseases or pests during the growing period and compliance to safe use of pesticides.

Inspection at exit points

KEPHIS undertakes inspection of the plants and plant products at the points of exit. Inspection of all material for export is done to ensure compliance to the recommended quality standards. It may be visual, microscopic or a combination of both on plants/plant products at airports, seaports, mail and border posts. Usually, samples are inspected according to the type and volume of the commodity. Inspection levels are determined by the assessed risk of the commodity. When inspecting fresh produce, the following standards are checked:

- Freedom from pests/pest damage
- Produce quality
- Produce grading (size, color, shape etc.)
- Packaging (clearly labeled, clean and well ventilated)

A phytosanitary certificate is issued if the plant products meet the required conditions, as specified on the import permit issued by the importing country.

INTERCEPTIONS OF KENYAN PRODUCE

Despite the impressive performance of the Kenyan horticultural industry in the past, there is emerging risk of decline in the amounts exported due to the substantial cases of recent interceptions of Kenya produce, especially in the EU, due to failure of the export produce to meet EU's phytosanitary requirements (**Table 1**). Rejection of the produce at EU destinations is done when the consignment fails to meet any of the minimum set standards. During 1999-2002, the following two are the major reasons for rejection of Kenyan horticultural export produce:

i) Presence of harmful organisms in the consignments e.g. Leaf miner (*Liriomyza sp.),* Bollworm (*Helicoverpa armigera*), Thrips (*Scirtothrips* s*p.*), White fly (*Bemisia tabaci*), Fruit fly (*Ceratitis cosyra*, *C. rosa*)
ii) Lack or non-compliance of phytosanitary certificates accompanying produce.

Table 1. Interceptions of Kenyan export horticultural produce (country –wise), 1999 – 2002

	Country	Number of interceptions				
		1999	2000	2001	2002	Total
1	Netherlands	2	6	0	32	40
2	UK	4	15	8	18	45
3	France	-	4	-	22	26
4	Finland	-	-	3	-	3
5	New Zealand	-	-	-	3	3
6	South Africa	2	-	-	-	2
7	Poland	-	-	-	1	1
8	Country not mentioned	-	-	-	4	4
	Total	**6**	**25**	**11**	**80**	**124**

Table 2. Causes for interception of Kenyan horticultural produce in European destinations (2000 -02)

	Reason for Interception	Destination	No. of interceptions
	QUARANTINE PEST INTERCEPTIONS		
1.	*HELICOVERPA ARMIGERA*	Netherlands	31
		UK	8
		Total	39
2.	*Liriomyza sp.*	UK	25
		Netherlands	11
		Total	36
3.	*BEMISIA TABACI*	Finland	2
		UK	6
		Total	8
4.	*Ceratitis sp.*	France	12
5.	Thrips	UK	7
	Other compliance problems		
6.	Discrepancies in quantity indicated on phytosanitary certificate	France	2
7.	No phytosanitary certificate	France	5
		UK	3
		Netherlands	1
		Finland	1
		Total	10
8.	Non compliant phytosanitary certificate	France	6
		Netherlands	1
		Total	13
9.	Produce rotting due to delay in transit	Poland	1
	GRAND TOTAL		**122**

In **Table 2**, the total number of interceptions is lower than in **Table 1** because New Zealand (4) and South Africa (2) have been excluded, as they are not European destinations. A significant increase in the number of interceptions by the importing countries has been recorded for the year 2002, compared to the preceding 2 years (2000-01), which may be partly or mostly attributed to improved communication and direct notification to KEPHIS, unlike in the past.

KEPHIS INITIATIVES TO REDUCE THE INTERCEPTIONS

KEPHIS has made a follow-up with the affected farms/exporters to ensure adherence to phytosanitary requirements of importing countries. The size of samples inspected has been increased, so as to improve the chances of detection of any pests and diseases infesting produce. KEPHIS has also participated in agricultural shows and exhibitions, such as

Hortifair, to enlighten farmers and exporters on the issue of interceptions and the need to adhere to phytosanitary requirements of importing countries. Additionally, KEPHIS has been working closely with stakeholders in the horticultural industry such as Fresh Produce Exporters Association of Kenya (FPEAK), Kenya Flower Council (KFC), Horticultural Crop Development Authority (HCDA), Kenya Agricultural Research Institute (KARI), Ministry of Agriculture (MoA) so as to reduce incidences of interception of Kenyan horticultural produce. This will help the country maintain and improve its market share in the international market.

STAKEHOLDERS' WORKSHOP ON INTERCEPTIONS

The workshop to bring experts to listen to the stakeholders' concerns and to develop an action plan for empowering the producers was held in April, 2003 to be aware of and adopt scouting and preventive management practices at farm level, besides filling in priority knowledge gaps through time-bound and problem solving research, involving inter-institutional partnerships. The highlights and recommendations of the workshop are given below: -

Lectures and exhibits/specimens:

The importance of five pests – *Helicoverpa* (fruit borer/pod borer/bollworm), Leaf miners (*Liriomyza* sp.), whiteflies (*Bemisia*), thrips and fruitflies was focused as concerns from interceptions during 2000-2002 (Tables 1 – 2). The need to disseminate the available knowledge as well as to fill in knowledge gaps was recognized as of urgent importance. Correct identification of the life stages of these pests, known and promising methods to preventively manage these pests and the scope for utilizing biological control agents / products were pointed out. The experts availed their time during the practical sessions to provide suitable demonstrations/explanations to smaller group/individuals. Brief lecture outlines were also availed by the experts for reference by participants.

DISCUSSIONS ON FURTHER NEEDS AND THE WAY FORWARD

The stakeholders recognized the following, as priority technical/information needs to be addressed:

i) Access to information on how to identify and monitor/scout for these pests in individual farms and what preventive practices are readily available to adopt for each of the five priority pests.
ii) Access to up-to-date information relating to EU guidelines on permitted pesticides, which pesticides best suited for which of the five priority pests and limits regarding waiting period/residues for each of them.
iii) Need to enhance information access as well as to train trainers holistically across the major stakeholders – the producers, the enforcement officials and the extension/development agents.

The participants discussed and endorsed the following actions as the way forward:

i) Recommend KEPHIS to continue to involve experts, such as from KARI, Universities and ICIPE in link with FPEAK, KFC and HCDA to prioritize the information needs and knowledge gaps, so as to cater to them through time-bound action plans.
ii) Plan and implement an urgent initiative aimed at building awareness and capacity to minimize the hidden infestation of *Helicoverpa* and *Liriomyza* at farm level, based on existing information and by filling critical gaps within a short time frame (12 months)
iii) A complementary and well structured initiative aimed at expanding the range of options available to preventively manage each of the five priority pests of quarantine importance, so to empower the producers to chose and adopt according to their local needs and resources.
iv) FPEAK along with KFC and HCDA to help secure/support funding for both the initiatives. KEPHIS to provide the lead in linking with experts' team to jointly plan and seek implementation.

THE EXPERTISE AND KNOWLEDGE REQUIRED ON TECHNOLOGY OPTIONS FOR THE PRIORITY PESTS

In a regional seminar on pest management convened by the Food and Agriculture Organization (FAO), *H. armigera* has been identified among the priority targets among vegetable crops grown in Africa. (Ikin *et al.,* 1993). Among the common vegetable crops in Kenya, this pest occurs as 'fruit borer' on tomato, okra and capsicum, as 'pod borer' on French bean and snow pea (Sithanantham *et al.,* 2002). The yield loss caused on tomato in Kenya is about 30 percent. Besides direct yield reduction (due to reduced set of fruits/pods), it also causes cosmetic damage (by feeding injuries on the pods/fruits, including holes (Kibata, 2002). The European Plant Protection Organization (EPPO) has listed *H. armigera* as pest of quarantine importance to Europe, which is the major destination for Kenyan horticulture produce.

THE FOLLOW-UP INITIATIVES:
Short term initiative to maximize farm level compliance to export (EU) guidelines to prevent hidden pest infestations in Kenya's fresh produce

Objective: Plan and implement **an urgent initiative** aimed at building awareness and capacity to minimize the hidden infestations of *Helicoverpa* and *Liriomyza* at farm level, based on existing information and by filling critical gaps **within a short time frame (12 months**)

Purpose: To cater to the stakeholders' needs for urgent technical support as recommended during the workshop convened by KEPHIS on 9 April 2003.

Potential collaborators supporting the export horticulture industry: KFC, FPEAK, and HCDA
Major concerns to be addressed:

i) Lack of ready to use information materials for TOT and dissemination towards building up awareness among practitioners/growers.
ii) Need for filling in critical research gaps in a short time for improved detection/elimination/preventive management of the pest
iii) Lack of inter-institutional experts' initiative to jointly cater to these urgent needs of the growers in linkage with the industry and promotional/enforcement agencies

Specific objectives of the initiative:

i) To quickly and extensively disseminate available knowledge through TOT and local language bulletins across the cross section of growers.
ii) To fill in critical gaps in research knowledge in preventive management of the priority pests and provide the enforcement /extension/NGO/private growers with comprehensive recommendations.

Guidelines to be adopted in planning the initiative:

1. The knowledge empowerment should focus on all the stakeholders, so as to make holistic impact.
2. Awareness among growers on the need and scope to comply with EU regulations should be built very urgently and should focus on both training of trainers as well as dissemination materials.
3. Critical local knowledge gaps should be filled by short-term (6-9 month) research attachment programs under co-supervision by specialists.
3 Inter-institutional collaboration in information sharing and in training of trainers to be encouraged.
4. Exporters' association should be more proactive in supporting backup research/training activities.

Strategy for implementing the short-term initiative:

- Develop an action plan for a short-term (12 months) joint initiative to prepare appropriate training and dissemination materials as well as to fill in critical knowledge gaps for *Helicoverpa/Liriomyza*
- Entrust to task team of experts (TTE) who are currently active in the priority themes
- Secure and avail the needed funding support to implement the initiative

Activities proposed and time frame:

Activity	By whom	Where	Beneficiary
1. Package and publish information on pest identification/symptomatology	TTE	Desk	KEPHIS/TOT
2. Prepare and distribute appropriate training/ dissemination materials	KEPHIS/FPEAK	Desk	KFC/FPEAK
3. Identify critical knowledge gaps and undertake quick research to fill them	Experts (TTE)	Lab/field	KFC/FPEAK
4. Compile full information on all aspects of compliance and share it.	KEPHIS/FPEAK	Workshop	All stakeholders

Medium term initiative to assemble a wider range of IPM options

Purpose:

To assist the export horticulture stakeholders with enhanced level of compliance and adopting preventive practices that can safeguard the confidence in European Union for Kenyan horticultural produce.

Problem being addressed:

- The fresh produce export from Kenya is coming under stringent restrictions effective April 2003 regarding adoption of good crop production and protection practices, especially in complying with the pesticide usage (zero tolerance to pesticide residues) or compliance to Maximum Residue Limits [MRLs]. This fragile market is also confronted with an additional challenge of rejection of consignments of export produce due to live insects of quarantine concern being detected at European destinations. These insects escape the inspection officers both at the farms and exit points since they appear as hidden infestations during the early developmental stages.
- A recent stakeholders workshop convened by KEPHIS, jointly with FPEAK, KFC, ICIPE, KARI and University of Nairobi on 9th April 2003, drew attention that compared to an annual interception rate of 10 - 20 cases during 1999 - 2001, the interceptions and rejections due to live insect pest infestations in Kenyan produce at EU destinations during 2002 were as high as 80. This could be attributed to pest development characteristics along side the lack of improved management practices at the farm level.
- The first priority pests identified among the interceptions were the African bollworm (*Helicoverpa*) affecting snow peas, French bean, *Dianthus, Pelargonium*, and leaf miners (*Liriomyza*) affecting snow peas, *Passiflora, Alliums* and *Gypsophila*; for these two pests both dissemination of current knowledge on identification/detection and preventive practices, besides adding the range of safer management options are required. For the three next priority pests - whiteflies (on *Euphorbia*), fruit flies (on mangoes) and thrips (on *Vernonia* and *Astromeria*), the current knowledge on identification and preventive practices need to be developed and disseminated. The workshop recommended the need for urgent technical measures to safeguard the confidence among EU importers on quarantine safety as well as pesticide use compliance standards of the Kenyan produce. The Kenyan research institutions should get involved in pest risk assessment early enough so as avert interceptions due to pests in the produce exported to the EU.

The way forward visualized:

- The problems and actions that were identified at this workshop as important are:
    - To extend the knowledge on correct identification of the pests of quarantine importance to trainers and producers as a means of maximizing prevention and minimizing hidden infestations in export produce.
    - To disseminate the current knowledge on practices that could be undertaken as preventive interventions against the quarantine priority pests to be practiced at the farm level.
    - To expand the basket of the preventive management options, so as to enable the producers to select and use them according to their individual situations
- It was also recommended that the institutions concerned should jointly plan and assist implementing a set of time-bound activities and these need to be backed up by scientific underpinning by relevant experts/specialists from institutions like ICIPE, KARI and Universities, where related research is ongoing.

The proposal to address the problems

- Major themes / outputs:

- Dissemination activities - training of trainers and preparing suitable training materials - on pest identification/detection and available preventive control practices for all the five target pests organized.
- Time - bound and knowledge gap filling research to improve monitoring / detection methods and to expand the range of preventive options for the two first priority pests undertaken.
    - Technical capacity of key researchers in relevant technology development in KARI and Universities and master trainers in technology dissemination in KEPHIS, FPEAK, KFC and NGOs enhanced.
    -

CONCLUSION:

This paper has focused on the urgency of the problem of regulated pests to be avoided from the horticultural produce being exported to European destinations from Kenya. It also summarizes the efforts made by KEPHIS and other institutions to bring about awareness of this problem among the stakeholders. Vision developed for intervening in this problem is also summarized. It is hoped that suitable funding will be secured from concerned agencies for supporting the implementation of the vision.

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SPORTS TURF USAGE: SURVEY OF MAJOR UTILITY AREAS WITHIN NAIROBI, KENYA

John Bosco Njoroge[1] and Moses Kasini Kivungi[2]

[1] *Jomo Kenyatta University of Agriculture and Technology, Department of Horticulture, P.O. Box 62000, Nairobi, Kenya*

[2] *Muthaiga Golf Club, Greens Section, P.O. Box 41651, Nairobi, Kenya.*

ABSTRACT

Knowledge of basic information on status of sportsturf fields and usage of turf is important for identifying the key issues that need to be addressed in order to provide high quality fields both for sports and recreation. This paper presents an overview of the current status of sportsturf usage in major sports fields within Nairobi city, Kenya and points out some of the important challenges that need attention by researchers and other people involved in turgrass industry. Seven sports fields offering playing grounds for soccer, golf, cricket, rugby and hockey were surveyed through interviews and questionnaires. Information sought included, the types of grass species used, soil profile construction method, cultural practices observed, level of technical expertise, source of information for management and problems encountered. It is noted that, the industry is still young in Kenya and documented information is lacking. From the information gathered, the practice in most golf courses was more strict and keen on quality maintenance of fields that could be attributed to the nature of the game and the expectations placed on them by the more informed and serious users as compared to other sports fields. There is a general lack of schedule of maintenance activities in tandem with expected sports events. Long time experience and advice contributed largely to the knowledge for maintenance of fields and not factual

scientific evidence. All in all there is a strong feeling that the number and types of users of sports fields is going to increase which will demand more playing fields that guarantee quality sportsturf for intense usage.

INTRODUCTION

Worldwide, the turfgrass industry is considered to be one of the least recognized facets of agriculture but quickly growing in importance. Historically, documented information on aspects of turfgrass and its usage is scant and where it has been, is very brief and biased towards lawns for example (Jex-Blake, 1950). Recently, there has been an increase in the population of people participating in athletics and other sports such as soccer, golf, rugby, hockey and cricket. Similarly there is an increase in the number of national and international sporting events that seek hosting in the country. Despite these developments, serious efforts to improve the surfacing condition of the existing sports fields to internationally accepted standards levels are lacking. Cancellation of matches either local or international due to poor playing quality of fields translates as direct loss of revenue for the government. Advantages of natural turf over artificial turf as a surfacing material in sports fields have been widely reported. For example a study by Stanford Research Institute International (SRI) over a six-year period on health effects of artificial turf reported that natural grass was safer to play on than artificial surfaces (SRI, 1974). Similarly, survey results by NFL (National Football League) players association that found that artificial turf is more likely than grass to cause the kind of serious injuries that shorten careers (AcaDemon.com., 2002).

While other horticultural commodities are routinely surveyed, the green industry has not been included because it is rarely considered as an important component of horticulture. As such little studies have been done to examine trends in the growth of the industry and the technical aspects of turfgrass management especially sportsturf under application in Kenya today. Such information would be invaluable in determining how to re-address the problems afflicting the growth and expansion of this vital industry to the economy by highlighting areas of concern for decision makers, researchers and other stakeholders. This article is an overview of the current status of sportsturf usage in some of the major sports fields in Nairobi, Kenya. The information was sought by direct communication to those in the field through structured questionnaire.

MATERIALS AND METHOD

The name, location and kind of sport in the surveyed fields are shown in Table 1. Information on the following aspects of sportsturf was obtained through questionnaires and personal communication; (i) types of grass species used (ii) soil profile construction (iii) drainage measures (iv) method of installation

Table 1: The name, location and kind of sports in the surveyed sports fields

Sports field	Location	Distance from city center	Kind of sport(s)	Time first constructed
Muthaiga golf club	Kiambu road, Muthaiga	12 km	Golf	1953
Royal club	Ngong road, Kenyatta Estate	10 km	Golf	1906
Windsor golf club	Kiambu road, Garden Estate	30 km	Golf	1992
Kiambu golf club	Kiambu road, Kiambu Town	25 km	Golf	1915
Kasarani sports center	Thika road, Kasarani	20 km	Soccer	1982
Nyayo sports center	Mombasa road, Langata	5 km	Soccer	1980
Parklands club	Limuru Road, Parklands	10 km	Cricket, Hockey & Soccer	1905
Nairobi Gymkhana	Forest Road, Parklands	8 km	Cricket, Hockey & Soccer	1980

(v) Irrigation, mowing and fertilization practices, (vi) intensity of use, (vii) level of technical expertise, (viii) source of information for management and any research or test activities, (ix) problems encountered and (x) opinion and comments about the future.

Table 2: Type of turf gras species sed for surfacing the surveyed golf sports fields.

Sports field	Type of grass species used	Construction materials		
		Upper (Rootzone)	Middle	Bottom
1. Kasarani	*Pennisetum clandestinum* (Kikuyu grass)	Soil / Sand mixture	Soil / Sand mixture	Gravel / Stones
2. Nyayo stadium	*Pennisetum clandestinum* (Kikuyu grass)	Soil / Sand mixture	Red soil	Red soil
3. Parklands sports club	Mixed grasses: *Axonopus compressus* (carpet grass), *Digitaria dactyloides* (couch grass), Kikuyu grass and Star grass	Red loams	Black cotton soil	Black cotton soil
4. Nairobi gymkhana	*Cynodon transvaalensis* (Royal cape) *Bouteloua gracilis* (blue grama, 'madi river'), 'Masindi'	Red loam soils	Charcoal + fine aggregate	Gravel

Table 3: Type of grass species used for surfacing and type of material used in profile construction of surveyed sports fields

Sports field	Type of grass species used	Construction materials		
		Upper (Rootzone)	Middle	Bottom
1. Kasarani	*Pennisetum clandestinum* (Kikuyu grass)	Soil / Sand mixture	Soil / Sand mixture	Gravel / Stones
2. Nyayo stadium	*Pennisetum clandestinum* (Kikuyu grass)	Soil / Sand mixture	Red soil	Red soil
3. Parklands sports club	Mixed grasses: *Axonopus compressus* (carpet grass), *Digitaria dactyloides* (couch grass), Kikuyu grass and Star grass	Red loams	Black cotton soil	Black cotton soil
4. Nairobi gymkhana	*Cynodon transvaalensis* (Royal cape) *Bouteloua gracilis* (blue grama, 'badriver'), 'Masida'	Red loam soils	Charcoal + fine aggregate	Gravel

Table 4: Profile construction materials used golf courses

Sports field	Layer: Upper (Rootzone)	Middle	Bottom
Muthaiga			
Greens	Riversand	Ballast/Aggregate	Heringbone pipe drains
Tees	Red loams	Black cotton/Murram soils	Black cotton soil
Fairways	Red loams	Black cotton/Murram soils	Black cotton soil
Roughs	Black cotton soil	Black cotton/Murram soils	Black cotton soil
Windsor			
Greens	Riversand	Ballast/Aggregate	Heringbone pipe drains
Tees	Red loams	Red loams	Red loams
Fairways	Red loams	Red loams	Red loams
Roughs	Red loams	Red loams	Red loams
Royal			
Greens	Red loams	Sand/Fine aggregate	Gravel, Pipe drains
Tees	Red loams	Riversand	Gravel
Fairways	Red loams	Red loams	Black cotton soil
Roughs	Red loams	Red loams	Black cotton soil
Kiambu			
Greens	Sand/Soil/Compost	Fine aggregate	Gravel, Pipe drains
Tees	Red loams	Red loams	Red loams
Fairways	Red loams	Red loams	Red loams
Roughs	Red loams	Red loams	Red loams
USGA Specs			
Greens	Riversand	Ballast / Aggregate, Blinding Layer	Gravel, Pipe drains
Tees	Red loams	Red loams	Red loams
Fairways	Red loams	Red loams	Red loams
Roughs	Red loams	Red loams	Red loams

The questionnaire aimed at capturing the actual situation and operations on the ground in the major sportsfields. It is believed that the selection gives a good representation of the main sports in Kenya and the main fields where they are held. The information obtained was tabulated in to different categories according to the kind and nature of the sport for comparative analysis. Comparisons were done between the actual practices recorded in the survey and those practiced elsewhere according to recommendations especially those set by the Sports Turf Research Institute (STRI) of UK and those set by the United States Golf Association (USGA), (Adams and Gibbs, 1994).

the main turfgrass used in the fields others being *Axonopus compressus* (carpet grass), *Cynodon transvaalensis* (Royal cape) and even *Digitaria dactyloides* (couch grass). Few native grass species are known by green keepers that can be candidates for use in the sports fields. Evaluation of native grasses for their potential as turf grasses is important as indicated by the studies of Mintenko (2002). Profile construction is one of the major activities in creating turfgrass playing surfaces. The methods are varied but can be largely divided into three according to materials used, all soil system, soil / sand system and all sand system. The method chosen will determine the quality of the field in terms of drainage and playability of the turfgrass. Type of construction materials used in the surveyed golf courses is shown in Table 4.

RESULTS

Turfgrass species and Profile construction

The type of turfgrass species used for surfacing some of the major sports fields within the city of Nairobi are shown in Table 2 and Table 3. The survey shows that only about five species of turfgrass species are used in the six surveyed sports fields. About 75% of the golf courses use only two different species of turf grasses in which only one is a local species. The golf greens demand special playability hence the features of turf grasses selected must be adequate and for these purpose *Cynodon dactylon* (Bermudagrass) has been the traditional choice, while *Pennisetum clandestinum* (Kikuyu grass) was commonly used to surface in the tees, fairways and the roughs. However, new species that are fine textured to ensure uniform grass cover, fast, true and firm surfaces are being sought for, as observed in the introduction of bent grasses in Muthaiga golf greens. In non-golf sports, *Pennisetum clandestinum* (Kikuyu grass) was 80

Routine management practices and information sources

Management practices are meant to upkeep turfgrass at good playing quality levels at all times. Some of the important routine management practices carried out in the surveyed sports fields are shown in Table 5. Irrigation and mowing seem to be the most important practices observed in golf courses and cricket sports field. Fertilization rates differed among the different golf courses depending on type of rootzone material used. For sand based system of rootzone material such as in Muthaiga and Windsor, the frequency of fertilization is higher as compared to soil / sand based systems of Royal and Kiambu golf courses. In the non-golf sports fields mowing and irrigation get more attention as compared to fertilization. The application of fertilizers in the non-golf sport fields was infrequent and the fertilizer formulations widely varied. Topdressing in most fields was done using the existing rootzone material and in some cases additional materials such the longonot sand with special nutritional value was incorporated to benefit turgrasses.

Problems and Challenges

Most of the problems faced relate mainly to poor managerial methods and lack of finances. Activities are not scheduled on time and therefore actions are spontaneous and hurriedly done to meet the immediate need before lapsing into inactivity. Lack of finances to repair equipment in time and buy the necessary inputs results to fields being unattended for long periods of time aggravating an already bad situation. Weeds such as *Trifolium repens* (white clover), *Polygonium aviculare* (knot grass) and *Taraxacum officinale* (dandelion) are common in most sports fields for example in Parklands and Kasarani sports field, which greatly lowers the playing quality of turf. In areas characterized by heavy rains and fertilization such as at Windsor golf, algal growth and patchiness was a common problem. Poor water quality for irrigation especially that from boreholes was reported and manifested itself in differential coloration of the turfgrass leaves. Level of technical expertise to manage the greens was low, as most green keepers have no formal technical training in turfgrass. This is evidenced by respondent presented by almost all the green keepers interviewed in the different golf courses and other sporting fields.

Discussion and Conclusions

A glimpse of the status of some of the major sports fields mostly located within Nairobi area has been shown using information collected from the field. The survey shows that few local species of grasses have been identified as potential candidates for use as turf and there is over-dependence on imported species. Apart from a few of the golf courses, the soil profile construction methods are not designed to recommended standards thereby lowering their playability and increasing maintenance costs.

There exists a big gap in research on turfgrass under local conditions hence more attention is needed towards producing scientific information that can guide green keepers and reduce their reliance on research information

produced under very different conditions. Such information should include screening of native grasses with potential for use as turf, turf improvement for specific uses through breeding programs, morphological and physiological evaluation of turf under different cultural practices and experimentation with different designs for profile construction using locally available materials such as that by McNitt and Landschoot (2003), among other works. This should involve agronomists, plant scientists, and drainage designers among other professionals. Except hockey, all the other games were evaluated to have a high potential for growth in the number players and frequency of games in a year. If the

Table 5: Profile construction materials used surveyed golf corses

Sports field	Irrigation	Mowing	Fertilization	Topdressings
Muthaiga golf club	Wet season: Non Dry season: 5 / Wk	1 / Day Hgt: 7 - 9 mm	1 / Wk, NPK (17:17:17)	2 / year, Sand
Windsor golf club	Wet: Non Dry: 1 / Day	1 / Day Hgt: 5- 10 mm	1 / Wk, NPK (17:17:17)	3 / Year, Sand
Royal golf club	Wet: Non Dry: 2 / Day	1 / Day Hgt: 4- 5 mm	1 / 3 Months, NPK (17:17:17)	3 / Year, Sand + Compo: + Longonot sand
Kiambu golf club	Wet: Non Dry: 2 / Day	3 / Wk Hgt: 4- 5 mm	2 / Month, NPK (20:20:20)	3 / Year, Sand + Soil + Compost
Kasarani Sports Center	Wet: Non Dry: 2 / Wk	Wet: 1-2 / Wk Dry: 1 / Month, Hgt: 2"	3 / Yr. N.P.K. 1-2 bags / Application	Sand + Soil
Parklands sports club	Wet: Non Dry: 1 / 2Wks	Wet: 1 / Wk Dry: 1 / Month	None	Red loam soil
Nairobi Gymkhana	Wet: Non Dry: 1 / Day	Wet: 1 / Wk Dry: 1 / Month	1 / Wk C.A.N.	Cricket: Black cotton Hockey: Red loam soil

economic situation improves as projected, there will be increased leisure time and disposable income which would allow more citizens to enjoy green industry products not only from lawns and parks but also from sports fields. Survey of the trends in growth of the industry is important and should be extended to other regions of the country. This will help to give a wider picture of the situation and develop sound research and training programs to ensure high quality standards of the fields is maintained and more jobs are made available.

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THE EFFECT OF ROOT ORIENTATION ON MACADAMIA SEEDLING CHLOROSIS

Stephen M. Ngugi, Kenya Agricultural Research Institute,
National Horticultural Research Centre, P.O. Box 220, Thika

ABSTRACT

Macadamia is the most important nut crop in Kenya and as a result there is great demand for healthy macadamia seedlings. One of the constraints that limit the production of macadamia seedlings is chlorosis, which affects about 40 % of the rootstocks. Once affected its difficult to eliminate even through nutritional intervention. a study was set up at National Horticultural Research Center, Thika to investigate the effect of root orientation on macadamia seedling chlorosis. Five root orientations: gooseneck, twisted, crank handle, spiral and control(well oriented) of macadamia variety, emb-1 were examined in a pot experiment. the conventional media of soil:manure:sand in the ratio of 10:3:1 v/v respectively, was used in the study. data on the expression of chlorosis was collected from transplanting to grafting stage. from the results the highest incidence of chlorosis was observed with the spiral root orientation, which was significantly higher than all the rest of the orientations. the results indicated that the root orientation can

INTRODUCTION

Chlorosis was identified as a major constraint limiting the production of macadamia seedlings at the National Horticultural Research Centre, Thika. More than 40 % of the seedlings were being affected at the rootstock stage. A stakeholders meeting was held in 1995 at the Horticultural Development Project, Thika. It was recommended among other things that an investigation be carried out to establish the effect of root orientation on macadamia chlorosis. This study was set up therefore to study the effect of root orientation on macadamia seedling chlorosis.

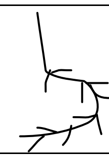
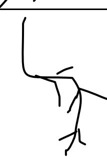
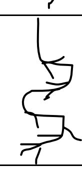
METHODOLOGY

In July, 1999 the experiment was set up at the Horticultural Development Project (HDP), Thika. The seedlings, 4 to 6 hard leaves, of EMB-1 were obtained from the HDP nursery and transplanted in the conventional media; soil: manure: sand (10:3:1 v/v). At transplanting five root orientations representing the treatments were adopted as illustrated below.
Ten seedlings were used in each treatment and were laid out in a completely randomised design. The seedlings were weeded and watered regularly as needed. Data collection on chlorosis was carried out on a monthly basis.
The data was collected using a scale of 1 – 4 as follows:-

- Non chlorotic
- Slightly chlorotic (only new shoot affected)
- Medium chlorotic (upper half yellow 3-5 leaves)
- Chlorotic (entire seedling yellow)

RESULTS

Data collected on chlorosis was analysed using SAS Statistical programme. The results are indicated on Table 1.
As can be observed, the highest chlorosis was expressed by seedlings whose roots had a spiral orientation. Incidentally these seedlings were the most twisted and the only ones which were significantly different from the control (well oriented). It appears therefore that root orientation can significantly affect the level of chlorosis expression in macadamia seedlings and the more twisted the greater the susceptibility to chorosis. The uptake of iron from the soil solution and its subsequent translocation in the plant is apparently significantly affected by the root orientation.

Type of root orientation	Root presentation
Gooseneck	
Twisted	
Crank handle	
Spiral	

Control (correct orientation)	

Table 1. Effect of root orientation on chlorosis expression in macadamia seedlings

Treatment (root orientation)	Chlorosis Expression Means
Gooseneck	1.28 C
Twisted	1.40 BAC
Crank handle	1.50 BA
Spiral	1.59 A
Control (correct orientation)	1.38 BC

Note:
Values with similar letters are not significantly different at p=0.05 according to LSD

PHYSALIS PERUVIANA SEED GERMINATION AS AFFECTED BY FRUIT RIPENESS, SALT WATER PRIMING, AND ACID SCARIFICATION

Ombwara F.K, L. S. Wamocho, E. N. Mugai.
Horticulture Department, JKUAT,
P.O. Box 62000, NAIROBI.

ABSTRACT

The Goldenberry (*Physalis peruviana* L.), though South American in origin, is found widely distributed around the world. In Kenya, it is commonly found growing wild in forests and wastelands, as well as in small plantings. *Physalis* fruit production is limited, with little documentation regarding appropriate means for commercial production under local conditions. Small quantities of fruit are often sold in markets and by street vendors. These fruits are mainly harvested from the wild. Processed fruits are marketed as Gooseberry jam, which is seasonally produced. *Physalis* has great nutritional value, and potential for development as an important horticultural crop. The plant's productivity in poor soils, its ease of cultivation, and low requirement for water and fertilizer add to its attraction for commercial exploitation. Propagation is easily carried out through seed and vegetative cuttings. Seed production forms a critical component of promoting the development of *Physalis* as a horticultural crop. This experiment was conducted to compare the germination performance of seed derived from fruit of varying stages of development, and subjected to different treatments. Two seed sources were used, ripe green and yellow ripe fruits. Germination was compared between untreated seed, seeds subjected to salt solution priming, and acid scarified seeds. Experimental treatments involved priming with a 3% solution of sodium chloride or scarification with 9N solution of sulfuric acid. Untreated dry seeds formed the control. Data analysis highlights the advantage of scarification in enhancing germination of *Physalis* seed.

Keywords: Seed priming, osmoconditioning, scarification.

INTRODUCTION

The Goldenberry (*Physalis peruviana* L.), though widely distributed around the world, is a solanaceous plant of South American origin. In Kenya, it is commonly found growing wild in forests and wastelands, as well as in small plantings. Small quantities of fruit are frequently sold in markets and by street vendors. These fruits are mainly harvested from the wild. Processed fruits are also marketed as Gooseberry jam, which is seasonally produced. *Physalis* has immense nutritional value, comparing favorably against commonly consumed fruits. It thus has potential for development as an economically and socially important horticultural crop.

The plant's productivity in poor soils, its ease of cultivation, and low water and fertilizer requirements add to its attraction as a subject for commercial exploitation. Being easily propagated by seed, improving seed quality is a critical component in promoting *Physalis* as a horticultural crop. This study was conducted to determine the suitability of two different seed pre-treatments as a means to enhance the germination levels of *Physalis* seed.

Problem Statement

Though readily produced, *Physalis* seed is reported to have relatively low germination levels. Since seed represents the most effective means of propagation of the plant, it is necessary to improve the germination characteristics to enhance *Physalis* production.

Research Objective

The objective of this study is to improve the germination performance of *Physalis* seed, using inexpensive, readily available methods, appropriate for local conditions. The two methods investigated were priming using sodium chloride, and acid scarification.

Literature Review

Physalis is a well adapted plant under local conditions. It is found distributed throughout Kenya, from the coastal areas to the highlands. The plant's productivity in poor soils, its ease of cultivation, and low requirement for water and fertilizer make it an attractive potential crop (McCain, 1993). The fruit is of good nutritive value, and can provide a rich source of dietary requirements, including vitamins and mineral nutrients (Morton, 1992).

Table 1. Physalis Food Value Per 100 g of Edible Portion

Moisture	78.9 g
Protein	0.054 g
Fat	0.16 g
Fiber	4.9 g
Ash	1.01 g
Calcium	8.0 mg
Phosphorus	55.3 mg
Iron	1.23 mg
Carotene	1.613 mg
Thiamine	0.101 mg
Riboflavin	0.032 mg
Niacin	1.73 mg
Ascorbic Acid	43.0 mg

Source: Morton, 1987

The propagation of *Physalis* is readily carried out either through seedlings or vegetative cuttings (Morton, 1987). Although plants grown from cuttings flower early and yield well, they are less vigorous than those grown from seedlings (Riley, 1983). Morton (1987) reported low germination figures for *Physalis*, requiring a relatively high seed rate when planting. Criollo and Ibarra (1992) reported higher germination percentages in ripe fruit (73.4%) than in green fruit (41.6%). They also recorded improved germination levels in seeds from fruits that were subjected to fermentation storage. This was beneficial for periods of up to one week after harvest, increasing germination percentages to 75%. Extended fermentation storage however, resulted in a decline in seed germination.

Priming, or osmoconditioning, has been defined as a controlled hydration treatment that allows pre-germinative metabolic activity to proceed, while preventing radical emergence (Bradford, 1986), or a pre-sowing seed treatment used to enhance germination and increase seedling emergence uniformity (Cantliffe, 2003). Seed priming has been used successfully to increase germination in seeds of a number of species, including the tomato (Őzbingöl *et al*, 1998), okra, spinach (Masuda and Konishi, 1993), and a range of other vegetable seeds.

Osmoconditioning is carried out by the incubation of seeds in an osmoticum, such as aqueous salt solutions, solutions of low molecular weight organic compounds such as glycerol, or solutions of high molecular weight compounds such as polyethylene glycol (PEG). These osmotica limit water uptake, hydrating the seed but preventing radicle emergence (Bray, 1995). Such a treatment, often followed by dehydration of the seeds, has been demonstrated to improve the subsequent germination of numerous vegetable seeds (Alvardo *et al,* 1987). Osmotica having water potential deficits equivalent to –1.2Mpa have been demonstrated to have beneficial effects on germination of tomato seed (Mauromicale G and Cavalla, 1997). This can be generated by the use of a 3%solution of NaCl .

Scarification is defined as the alteration of the seed coat to render it permeable to gases and water, as a prerequisite to germination (Janick, 1981). Various agents have been employed including hot water, strong acids, and mechanical abrasion. Such treatments often mimic the effects of the digestive system, in seeds which are` normally dispersed by means of animal ingestion and subsequent excretion, i.e. endozoochorus dissemination..

MATERIALS AND METHODS

Fruits from greenhouse grown *Physalis peruviana* were used in this experiment. Ripe fruits, were harvested. These `were those fruit readily detached from the parent plant by shaking the plant stem. Such fruit are of different levels of ripeness, as described by Johns and Stevensen (1985).

Freshly harvested fruits of *Physalis peruviana* were visually segregated into 3 groups, Green, Breaker and Golden ripe. These were subjected to colorimetric analysis, using a Nippon Denshoku NF 333 Spectrophotometer. The resulting L*a*b* values were used to numerically define the three categories of fruit.

Table 1: Mean Fruit CIELAB values

	L*	a*	b*
Green	58.57	-4.28	44.30
Breaker	57.09	1.59	44.29
Golden	56.76	6.45	40.62

Fruit ripeness was` defined on the basis of the recorded a* values, since both L* and b* values demonstrated insignificant differences in the three groups of sampled fruit.

Green fruits having a* values less than -3.00, and Golden ripe fruits with a* values greater than 6.00 were used as a source of experimental seeds. Wet seed extraction was carried out, after which the seeds were allowed to air dry to 13% moisture content.

Treatments involved independently subjecting seeds from the two sources to the following treatments;

1. Seed priming for 48 hours using 3% NaCl solution (-1.2MPa),, followed by drying back.
2. Seed scarification using 9N solution of H_2S0_4 for 12h
3. Control, non-treated seeds

GERMINATION TESTING

50 seeds per treatment, replicated 4 times were subjected to top paper (TP) germination tests in petri dishes. These were maintained in an incubator at 25°C. Radicle emergence was scored as germination. The experiment was conducted over 17 days, before termination.

Observations

The first seed (Green, scarified) germinated after 4 days. All other treatments commenced germination on Day 5.

Data Analysis

Data was analysed by computer using Genstat Discovery program. Germination data was subjected to angular transformation to compensate for the binomial distribution of the raw data.

DISCUSSION

Seed priming with NaCl had a detrimental effect on germination in all treatments. Scarification however provided significant increase in germination of Gold ripe fruits, at 10% level of significance. This response possibly demonstrates an evolutionary adaptation to endo-zoochorus seed dissemination. This means of dispersal involves animal ingestion and excretion of the seed. Such delayed seed germination ('dispersal in time'), is described as a component of a plant's germination strategy (*Figueroa and Armest,. 2001)*

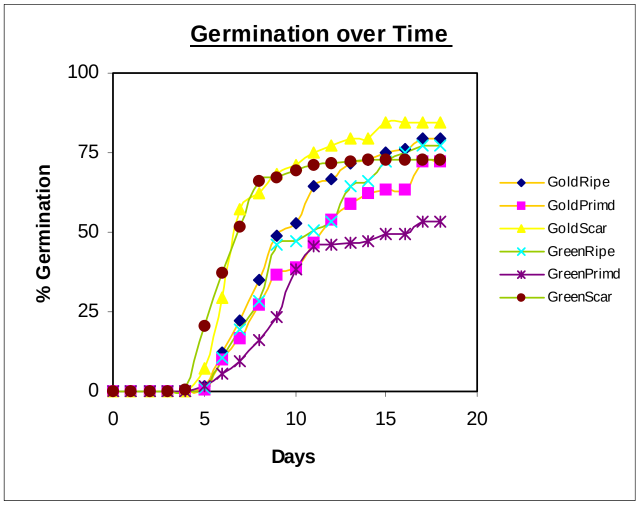


Table 2: Germination

SOURCE	TREATMENT	GERMINATION (%)	TRANSFORMED MEANS
Gold Fruit	Priming	72.5	59.1
	Scarification	84.5	72.4*
	Control	79.5	63.9
Green Fruit	Priming	53.5	47.4
	Scarification	73.0	58.9
	Control	77.0	62.1

se 10.66 and CV.17%

CONCLUSIONS AND RECOMMENDATIONS

Seed from green fruit `had consistently low germination levels, indicating their poor quality as a seed source. NaCl priming proved to be detrimental to seed germination, and hence is not an appropriate method of pretreatment for *Physalis* seed material. Gold ripe fruits demonstrated the highest germination levels, and these increased significantly with acid scarification. Golden ripe fruits represent the most suitable source of seed material, and their germination performance can be significantly enhanced by seed scarification.

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THE EFFECT OF SULPHUR DIOXIDE ON THE REPRODUCTIVE GROWTH AND NITROGEN CONTENT IN THE SEEDS OF TWO KENYAN BEAN (*PHASEOLUS VULGARIS* L.) CULTIVARS.

By Josephine Mumbe Mulei, Department of Botany,
Moi University, P.O. Box 1125, Eldoret, Kenya. Email – mumbemutuku@yahoo.com

ABSTRACT

Two Kenyan bean (*Phaseolus vulgaris* L.) cultivars, GLP-2 and GLP- 585, were studied for their response to SO_2 treatment. The two cultivars were sown in pots and fumigated with four levels of SO_2 gas i.e. 0.0, 0.1 ppm, 0.2 ppm, and 0.3 ppm. The various reproductive growth parameters were measured. These included number of flower buds per plant, number of flowers per plant, number of pods per plant, pod dry weight per plant, number of seeds per pod, number of seeds per plant and the weight of 100 seeds. The protein content in the seeds of the two cultivars was also determined. The SO_2 treatment significantly reduced the number of flower buds and flowers per plant, number of pods per plant and seeds per pod at SO_2 –doses of 0.2 and 0.3 ppm in treated plants as compared to controls in each of the two cultivars. The dry weight of pods in treated plants was significantly reduced as compared to that in controls at the SO_2-doses of 0.2 and 0.3 ppm in GLP-585, and 0.3 ppm in GLP-2. There was a significant reduction in the weight of 100 seeds and number of seeds per plant in treated plants as compared to the controls in each of the two cultivars. Percentage reduction in the two parameters was highest at SO_2-dose of 0.3 ppm. The two cultivars differed significantly in the number of seeds per plant, weight of 100 seeds, number of seeds per pod and pod dry weight per plant at the different SO_2 concentrations. The number of flower buds per plant differed in controls and SO_2-dose of 0.1 ppm while the number of flowers per plant differed in controls only. Cultivar GLP-585 showed a higher value in all the parameters except the weight of 100 seeds. There was a decline in percentage nitrogen with increase in SO_2 concentration in the seeds of the two cultivars. However there were no varietal differences in the seed nitrogen content. The two cultivars responded differently to SO_2 treatment, with cultivar GLP-2 being relatively more sensitive as compared to cultivar GLP-585.

Key words:. Sulphur dioxide, *Phaseolus vulgaris*

INTRODUCTION

The common bean (*Phaseolus vulgaris* L.) is the best known and the most widely cultivated species of *Phaseolus (*Purseglove, 1968). All the ethnic groups of Kenya show high preference for beans as opposed to other pulses. Beans are an important food crop because they provide proteins, which are a limiting nutrient in the third world countries (Leaky, 1970). They are rich in the amino acid lysine and tryptophan, which are found in less quantity in maize and other cereals (Kenya farmer, 1983). Bean plants are adapted to a wide variety of soils, ranging from light sand to heavy clay (Raj, 1978). They are capable of fixing atmospheric nitrogen, hence increasing the level of soil nitrogen (Purseglove, 1968).

Investigations in the past decade have shown that several species of economically important plants are particularly sensitive to air pollutants, including sulphur dioxide, (SO_2) and nitrogen dioxide (NO_2), (Pande, 1985). The SO_2 gas is one of the undesirable pollutants in the air occurring in industrial environments. Emission level of sulphur dioxide, a major phytotoxic air pollutant has been increasing in spite of the concern for air quality (Govil, 1985). Rapid industrialization in developing countries is the cause for increase of SO_2 level in the air. It is believed that 10^6 tons of

SO_2 per year are added into the global environment, of which about half is of anthropogenic origin (Habwaschs, 1983). In any given community, industrial plants are the principal source since many industrial operations emit significant quantities of sulphur dioxide (Vesilind *et al*., 1990). Some significant industrial emitters of SO_2 include nonferrous smelters, oil refining and pulp and paper manufacture. Plant growth and yield is the end product of a series of biochemical and physiological processes related to uptake, assimilation, biosynthesis, and translocation. Experimental studies have revealed that SO_2 affects most of these processes leading to a considerable loss in crop productivity (Davis, 1972; Bleasdale, 1973; Mudd, 1975; Lockyer, *et al*., 1976; Hallgren, 1978; Agrawal *et al*., 1983; Malhotra and Khan, 1984).

Early research on the effects of SO_2 on growth and yield of crops indicated that yield reductions ordinarily did not occur unless the SO_2 concentrations were quite high (>1.0 $\mu L\ L^{-1}$) and such levels caused substantial foliar injury (Ewald and Schlee, 1983). However, in recent years, numerous studies have indicated that yield reductions in the field are not always dependent on severe tissue destruction which is associated with very high SO_2 concentrations but may be caused by long-term exposure to levels of SO_2 that may occur regionally in some areas (Miller, 1987). Ample evidence indicates that even concentrations of SO_2 below 0.15 ppm can be damaging to plants. This observation is different from earlier conclusion that only high concentrations of SO_2 are injurious to crop plants (Ashenden and Mansfield, 1978). Godzik and Krupa (1982) compiled a comprehensive review on the effects of SO_2 doses on the growth and yield of various crops including cereals, from both field observations and controlled fumigation experiments. Substantial yield reductions in several species of pasture grasses (Bell and Mudd, 1976; ashenden and Mansfield, 1977; Ashenden, 1978; Crittenden and Read, 1978; 1979 and Bell, 1982), cereal and horticultural crops (Godzik and Krupa, 1982) in response to long-term exposure to low and moderate levels of sulphur dioxide have been reported. These investigations revealed, however, that plant species differ in the degree of injury, which they sustain from the same level of exposure (Pande, 1985). This has stimulated many workers to identify species and cultivars of plants which have greater degree of tolerance to SO_2 pollution (Evans and Miller, 1972; Miller *et al*., 1974 and Ayazloo *et al*, 1982.

Problem statement and justification

In Kenya there are several industries that emit air pollutants in to the atmosphere, including sulphur dioxide. These include the pulp and paper industry in Webuye, Bungoma district among others. The potential damage and yield loss to beans and other crops as a result of SO_2 pollution has not been widely studied in these areas. Studies by Black and Unsworth (1979) indicated some reduction in growth and yield of field beans due to SO_2 pollution. The genotypic potential of Kenyan bean cultivars (*Phaseolus vulgaris* L.) to withstand SO_2 injury need assessment in order to obtain tolerant types. This may enable selection and breeding of cultivars, which are tolerant to this air pollutant. The present study was designed to determine the effect of different levels of SO_2 on two popular Kenyan bean cultivars. The objective was to study the effect of SO_2 treatment on the reproductive growth parameters, yield and the protein content in the seeds of the two cultivars, and also to establish whether the two cultivars respond differently to SO_2 treatment.

MATERIALS AND METHODS

The study was carried out on two Kenyan bean cultivars namely Rose-coco (GLP-2) and Red haricot (GLP-585). The seeds were procured from Simlaw Seeds Kenya Ltd., and their GLP numbers were confirmed at the National Horticultural Research Station in Thika. The study was carried out at the Chepkiolel Campus of Moi University, which is situated 9km northeast of Eldoret town. Soil pH ranges from 4.0 to 5.7 (Jaetzold and Schimdt, 1983). The seeds were sown in 12-cm standard plastic pots containing 2kg farm soil. The soil used in this experiment is ferratic cambisol in the petroferric phase with a pH of 5.5 in water (W/V 1:2:5) as recommended (Furp, 1987). After germination the plants were set under nursery conditions in a split plot experiment in a randomized complete block design with ten replicates. Five days after germination, the seedlings were thinned to one plant per pot before top-dressing with triple super phosphate (TSP) at the ratio of 0.2g per pot. Weeds were handpicked whenever necessary. There were sixty plants per cultivar per treatment.

The treatment involved fumigation with three levels of sulphur dioxide gas in $1m^3$ polythene fume chambers. The average daily temperature of the chambers ranged between 29-33^oC . The sulphur dioxide levels were 0.0, 0.1, 0.2 and 0.3 ppm, and they were generated chemically by reacting a measured quantity of sodium sulphite ($Na_2 SO_3$) with excess dilute sulphuric acid (H_2SO_4) (Rao and Leblanc, 1966; Sardi, 1981). The polythene walls of the chambers were buried in the soil to prevent the escape of SO_2 from the lower end. The plants were fumigated for 6 hours between 9 am and 3 pm on alternate days between 25 and 95 days after planting. The control plants were also covered with polythene chambers during fumigation in order to simulate conditions of treated plants. The plant samples were collected from treated plants and control at regular intervals. The first sampling was done 30 days after planting and the rest were done at an interval of 15 days. At each sampling time, ten plants per cultivar per treatment were sampled and the following parameters were recorded: number of flower buds and flowers per plant; number of pods per plant; number of seeds per pod; pod dry weight per plant; number of seeds per plant (seed out-put); and weight of 100 seeds. Pods and seeds were separated and dried at 60°C to a constant weight. The total number/weight of each of these parameters was obtained and the values were averaged to obtain a mean score for each parameter. The nitrogen content in the seeds of the two cultivars was also obtained. This was assessed using the Kjehdal method (Hinga *et al*., 1978) and three replicates were taken. The data was subjected to multivariate analysis of variance. Differences were obtained as significant at $P \leq 0.01$. Separation of means was done using Least significant difference (LSD) test.

RESULTS

The two cultivars showed a significant difference in their reproductive growth and yield components when a global F-test was done except in their pod number per plant. The SO_2 treatments were also significant in all the parameters, while interaction effects were significant in number of flowers per plant and weight of 100 seeds. A protected LSD-test was conducted to determine the specific treatment means in which the two cultivars differed. It was observed that the seed out-put (i.e. number of seeds per plant), weight of 100 seeds, number of seeds per pod and pod dry weight per plant, differed significantly at all SO_2 – doses in the two cultivars (Table 1). The number of flower buds per plant and the number of flowers per plant in the two cultivars differed only in controls and the SO_2-dose of 0.1 ppm in the former.

When an F-test was conducted on the various reproductive growth parameters of each cultivar in which the various SO_2 treatments were considered, it was noted that the SO_2 treatment effects were significant in each cultivar. A protected LSD-test was conducted to separate means. The number of flower buds and flowers per plant was significantly reduced at SO_2-doses of 0.2 and 0.3 ppm in treated plants as compared to controls in each of the two cultivars (Table 2). The number of pods/plant and seeds per pod was also significantly reduced at SO_2-doses of 0.2 and 0.3 ppm in each of the two cultivars. The percent reduction in the two parameters was higher in GLP-2. The dry weight of pods in treated plants was significantly reduced as compared to that in controls at the SO_2 doses of 0.2 and 0.3ppm in GLP-585 and 0.3ppm in GLP-2. There was a reduction in pod dry

Table 1: A comparison of the reproductive growth parameters of the two cultivars at different SO_2 concentrations.

Sulphur dioxide concentration (ppm)

	0.0		**0.1**		**0.2**		**0.3**		**LSD**
Cultivar Parameter	GLP-585	GLP-2	GLP5-585	GLP-2	GLP-585	GLP-2	GLP-585	GLP-2	1%
No. of flower buds per plant	18.90a	13.90	16.20a	12.10b	12.50a	9.40a	7.70a	8.00a	3.59
No. of flowers per plant	14.50a	11.10b	13.00a	10.60a	9.90a	7.70a	5.9.0a	6.20a	2.87
Pod dry weight per plant	13.44a	12.13b	12.53a	11.10b	9.44a	8.00b	7.98a	6.22b	0.69
No. of seeds per pod	5.74a	4.34b	5.26a	3.95b	4.11a	2.84b	3.44a	1.81b	1.12
Seed output	40.40a	27.40b	32.50a	21.00b	20.80a	11.70b	10.30a	7.50a	6.20
Weight of 100 seeds	33.40a	48.50b	30.10a	43.60b	27.60a	39.30b	24.80a	33.10b	2.29

Note: Means with the same suffix within treatments (i.e. each stage of growth versus each SO_2 concentration) are not significantly different at $P \leq 0.01$. The weight of 100 seeds and number of seeds per plant (seed-output) were significantly reduced in treated plants as compared to the controls in each of the two cultivars. All the doses were significantly different from the controls, as well as from each other. The reduction in the two parameters was highest in GLP-2.

Analysis of variance test conducted on protein content in the seeds of the two bean cultivars and the various SO_2 treatments revealed significant differences in the SO_2 treatments, but not the cultivars. Therefore there were no cultivar effects with respect to nitrogen content in the seeds of the two bean cultivars.

Effects of SO_2 treatment on seed nitrogen content in each cultivar were also examined. Analysis of variance test showed significant differences between treatments. A protected
LSD-test was conducted to separate the treatment means. It was noted that all the SO_2 doses significantly reduced nitrogen content in the seeds of each cultivar (Table 3). There was a decline in percent nitrogen in the seeds of each cultivar with increase in SO_2-dose (Fig. 1).

Table 2: Effect of SO_2 treatment n the seed yield and yield components of the two bean cultivars

		Sulphur dioxide concentration (ppm)				LSD
Parameter	Cultivar	0.0	0.1	0.2	0.3	1%
No. of flower buds/plant	GLP-2	13.90±3.10a	12.10±3.80ab (12.9)	9.40±2.70b (32.4)	8.00±3.40b (42.4)	4.30
	GLP-585	18.90±4.00a	16.20±2.60a (14.3)	12.50±3.40b (33.9)	7.70±2.50c (59.3)	2.80
No. of flowers per plant	GLP-2	11.10±2.40a	10.60±2.40ab (4.5)	7.7±2.10b (30.6)	6.20±2.70b (44.1)	3.20
	GLP-585	14.50±2.40a	13.00±2.30a (10.3)	9.90±3.00 (31.7)	5.90±2.30c (59.3)	2.60
No. of pods per plant	GLP-2	6.30±1.30a	5.30±1.20ab (15.9)	4.10±1.00bc (34.9)	3.30±1.20c (47.6)	1.40
	GLP-585	7.00±1.20a	6.20±1.60ab (11.4)	5.00±1.30bc (28.6)	3.60±1.30c (48.6)	1.70
Pod dry weight(g/plant)	GLP-2	12.10±1.90a	11.10±1.40ab (8.5)	8.00±1.10ab (34.0)	6.20±0.90b (48.7)	5.00
	GLP-585	13.40±1.60a	12.50±0.90a (6.8)	9.40±1.60b (29.8)	8.00±1.30b (40.5)	1.60
No. of seeds per pod	GLP-2	4.30±01.30a	4.00±0.80a (9.0)	2.80±0.80b (34.6)	1.80±0.80b (58.3)	1.10
	GLP-585	5.70±0.80a	5.30±1.10a (8.4)	4.10±1.00b (28.4)	3.40±0.70b (40.1)	1.10
Seed out-put (seeds/plant)	GLP-2	27.40±8.20a	21.00±3.80b (23.4)	11.70±3.40c (57.3)	7.50±2.20c (72.6)	5.80
	GLP-585	40.40±5.70a	32.50±6.60b (19.6)	20.80±4.90c (48.5)	10.30±2.10d (74.5)	6.60
Weight of 100 seeds	GLP-2	48.50±1.60a	43.60±0.60b (10.1)	39.30±0.60c (19.0)	33.10±1.30d (31.8)	2.50
	GLP-585	33.40±1.30a	30.10±1.40b (9.9)	27.60±0.80c (17.4)	24.80±0.70d (25.7)	2.40

Note: Mean±Standard deviation
The figures within parenthesis indicate the percent reduction in reproductive growth parameters with respect to control.
Means with the same suffix across the rows are not significantly different at $P \leq 0.01$.

weight per plant with increase in SO_2 concentration in each cultivar. However, the percent reduction was higher in GLP-2.

TABLE 3: Effect Of So2 Treatment On The Percent Nitrogen Content In The Seeds Of The Two Bean Cultivars.

	Sulphur dioxide concentration (ppm)				LSD
Cultivar	0.0	0.1	0.2	0.3	1%
GLP-2	4.33±0.15a	3.83±0.25b (11.5)	3.50±0.10c (19.2)	2.93±0.15c (32.3)	0.33
GLP-585	4.20±0.10a	3.73±0.21b (11.2)	3.07±0.15c (26.9)	2.77±0.31c (34.0)	0.39

Note: The figures within parenthesis indicate the percent reduction in seed nitrogen content with respect to control.
Means with same suffix across the rows are not significantly different at $P \leq 0.01$

DISCUSSION

Although there was no significant effect on most of the reproductive parts at the SO_2-dose of 0.1 ppm, the yield was highly reduced at all levels of SO_2-dose (Table 2). In the two cultivars, high number of pods/plant and seeds/pod were recorded in control plants than in treated plants. The control plants also showed higher vegetative growth and grain yield compared to the treated plants. It is believed that the adverse effects of SO_2 treatment on vegetative parts and yield components resulted in reduced seed yield per plant.

Loss in seed number, seed weight and seed yield to SO_2 fumigation was observed in *Phaseolus aureus* (Sharma and Rao, 1985). Sulphur dioxide was found to reduce the yield in wheat and lettuce (Olszyk, *et al*., 1986; Bytnerowicz *et al*., 1987). A considerable loss in the flower and fruit set due to sulphur rich coal burning was reported by Gupta and Ghouse, 1986, 1987; Malibari *et al*., 1991. The two cultivars differed in quantity of injury as measured by yield and yield components, except in number of flowers and flower buds. Cultivar GLP-585 had a higher pod dry weight per plant, more seeds per pod and higher seed out-put. However, the weight of 100 seeds was more in cultivar GLP-2, and this is probably because this cultivar tends to have bigger seeds than cultivar GLP-585.

The decrease in seed nitrogen content with increase in SO_2 concentration may have been caused by inhibition of protein synthesis or enhanced protein degradation (Robe and Kreeb, 1880). A decrease in the total protein content upon SO_2 fumigation has been reported for a number of plants (Fischer, 1971; Nandi *et al,* 1980; Malhotra and Khan, 1984).

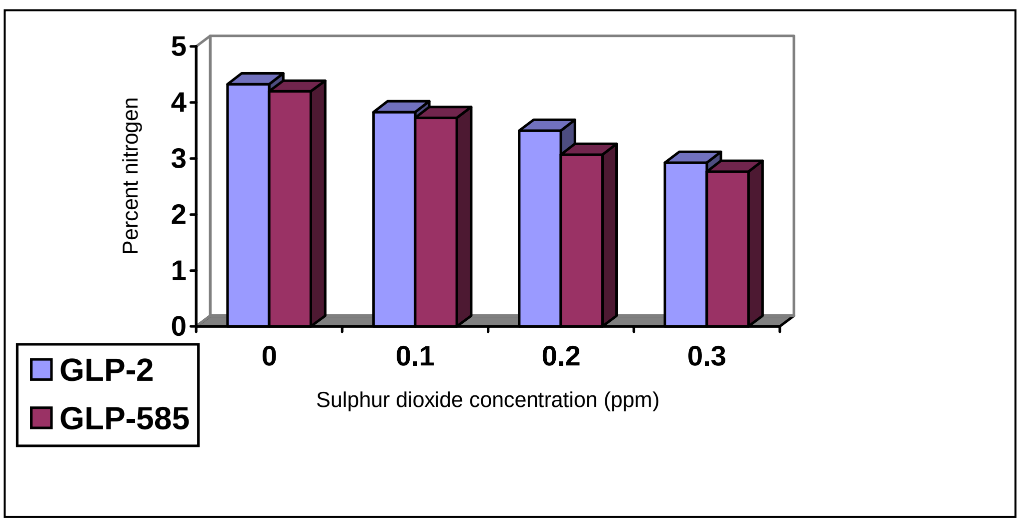

Fig.1. The average percent nitrogen content in the seeds of control and SO_2-treated bean cultivars GLP-2 and GLP-585

Godzik and Linskens (1974), observed an increase in the pool of free amino acids, and a decrease in the amount of protein in SO_2- treated *Phaseolus vulgaris* L.

CONCLUSION AND RECCOMENDATIONS

It can be concluded, based on the results of this study that exposure to SO_2 may result in a number of deleterious responses. Sulphur dioxide was found to cause adverse effects on the yield components and grain yields of the two cultivars. All the yield components decreased with increase in SO_2 concentration. Therefore SO_2 may hamper plant growth through interference with various metabolic processes including nitrogen metabolism. The SO_2 caused grain yield reductions in the bean cultivars used in this study. It may also be concluded that the relative sensitivities of the two cultivars to SO_2 treatment differed remarkably. Cultivar GLP-2 exhibited the greatest reduction in most of the measured parameters and could be considered more susceptible to SO_2 treatment than cultivar GLP-585.

In Kenya, little work has been done on screening for SO_2 resistance in bean varieties, which are an important source of protein. From the results obtained in this study, it is notable that there were significant cultivar differences in SO_2 sensitivity within *Phaseolus vulgaris* L. These cultivar differences may be very important in bean improvement research especially in breeding for SO_2 tolerance. Determination of susceptibility or tolerance could determine the suitability of a certain cultivar in a given area, depending on SO_2 concentration in that area. In this study only two bean cultivars were considered due to time limit. However, prediction of responses of beans to SO_2 treatment could come from a larger investigation involving more bean varieties and repeated over regions and years. It is also necessary to investigate the atmospheric concentrations of SO_2 gas in farmlands near industrialized areas of Kenya like Nairobi and Webuye and see if the concentration of this gas has reached proportions that can cause any appreciable damage to beans and other crops. A field or potted experiment with beans around industrialized and non-industrialized towns can confirm whether the environmental concentration of SO_2 gas warrant research attention.

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OPPORTUNITIES FOR AUGMENTATIVE BIOLOGICAL CONTROL OF CATERPILLAR PESTSON VEGETABLE CROPS IN EASTERN AFRICA

[1]S. Sithanantham, [1]J. Baya, [1]C.M. Matoka, [1]A Kalyebi, [1]L. Migiro, [1]C. Muholo, [1]G. Momanyi, [2]C. Kariuki, [2]S. Njihia, [3]G. Kibata, [4]D. Mohammed, [5]J. Ogwang, [6]B. Pallangyo and [6]E. Nsami
[1]International Centre of Insect Physiology and Ecology (ICIPE), P.O. Box 30772 –00100 GPO Nairobi, Kenya; [2]National Agricultural Research Centre, KARI, P. O. Box 30148, Muguga, Kenya; [3]National Agricultural Research Laboratories, KARI, Nairobi, Kenya; [4]Ethiopian Agricultural Research Organisation (EARO), P.O. Box 37, Ambo, Ethiopia; [5]National Agricultural Research Organization (NARO), P.O. Box 7084, Namulonge, Uganda; [6]National Biological Control Centre, Kibaha, Tanzania.

ABSTRACT

In Eastern Africa, vegetable crops production for domestic and export markets constitutes an important income generating enterprise for multitudes of smallholder farmers. Caterpillar pests, mainly the African bollworm, (*Helicoverpa armigera,* Hübner) and the Diamondback moth (*Plutella xylostella* L.) – constitute important production constraints, as they affect yield and quality of the marketable produce. The vegetable farmers are under increasing pressure from the consumers, especially among the European Union countries, which are the major importers of the East African horticultural produce, to shift away from chemical pesticides and to adopt 'safer' alternatives such as bio-control based Integrated Pest Management (IPM) options in managing these pests. Recent and on-going research in the region is providing promising indications of the potential for egg parasitoids (mainly *Trichogramma* and *Trichogrammatoidea* spp.), besides baculoviruses (Nucleopolyhedrovirus {NPV} for *H. armigera* and Granulovirus {G.V.} for *P. xylostella*) and *Bacillus thuringiensis* {*B.t.*} products. An on-going regional network project, is exploring the potential to enhance the utilization of native egg parasitoids as augmentative bio-control agents. It is visualized that these could be easily and cheaply mass-produced and delivered locally. Scope for cheaper mass production methods, choice of warm-temperature adapted species/strains and integration with pesticide use are being evaluated. In Kenya, native strains of the two baculoviruses (NPV, GV) have been assembled and characterized, with promising results from initial laboratory and field evaluations. The potential for a new *B.t.k* product has also been found to be promising in Kenya. Greater stakeholder involvement and policy support initiatives are recommended for awareness creation to popularize their wide availability so as to initiate their utilization and wide adoption by the needy end-users.

Introduction

Caterpillar pests, especially the African bollworm (*Helicoverpa armigera*) and the Diamondback moth (*Plutella xylostella*) are important constraints to production of several vegetable crops in Eastern African. While *H. armigera* occurs as fruit borer (e.g. tomato, capsicum, okra) and as pod borer (e.g. French bean, snow pea), *P. xylostella* causes foliar damage (e.g. cabbage, kale). These two pests have been recognized as key constraints to vegetable production across Africa (Ikin *et al.,* 1993). Vegetable farmers generally find it difficult to sustainably manage these pests by using chemical pesticides alone. Very often they find that pest control costs become less affordable over time, apparently due to problems such as pest resurgence and pesticide resistance development caused by inappropriate and often excessive use of synthetic chemicals (Sithanantham *et al.,* 2001a). In this paper, the scope for utilizing augmentative biological control methods towards managing these pests more sustainably is presented in the context of recent and current research in Eastern Africa.

Utilizing native egg parasitoids

The potential for utilizing native egg parasitoids for augmentative biological control of the major caterpillar pests in Africa has been documented (Sithanantham *et al.,* 2001a,b). Initial surveys in Kenya showed the occurrence of some species (Haile *et al*, 2000). More recent collections across four countries in Eastern Africa have confirmed the occurrence of 3 species of *Trichogramma* in 31 accessions and 2 of *Trichogrammatoidea* in 140 accessions, besides some scelionid accessions (Baya *et al.,* 2003) recovered from *H. armigera* eggs (**Fig 1**).

Evaluation of adaptation of selected native species/strains to temperature stresses has also been undertaken (Abera *et al.,* 2002; Haile *et al.,* 2002; Kalyebi *et al.* 2003). They have worked out that temperature rather than humidity regimes are important in affecting the performance by *Trichogramma* and it is possible to select strains that perform better under warmer temperatures. Host specificity and relative preference of some of the strains to target lepidopteran pests has also been studied (Muholo *et al.,* 2003). The potential for enhancing mass production efficiency of *Trichogramma* through choice of suitable medium for rearing the larval stage of the host (*Corcyra*) has been explored (Migiro *et al.,* 2003). To enable integration of augmentative biocontrol in the use of synthetic pesticides, the relative safety of commonly used pest control products has been assessed (Momanyi *et al.,* 2003) (**Fig 2**). The guidelines for non-target risk assessments which are also important as they influence public opinion and simple methodological improvements are being pursued (Sithanantham, 2003). The potential demand for *Trichogramma* utilization has been assessed to be positive. Technical support has been extended for promoting local commercial production. Field evaluations to validate the economic benefits and to optimize the releases have been planned.

Potential for native baculoviruses

The baculoviruses which offer promise in Africa include Nucleopolyhedrovirus (NPV) which is popularly used elsewhere for *H. armigera* biocontrol, while Granulovirus (GV) has shown considerable potential for field control of *P. xylostella* (Sithanantham and Maniania, 2001). In Kenya, NPV surveys have been undertaken and several isolates have been assembled (Baya *et al.,* 2001). Small plot tests and pot culture assessments have shown the potential of one of the native NPV strains (which is found to be the SNPV subtype) from Kenya in controlling the pod damage by *H. armigera* on pigeonpea and snowpea (Baya, 2000) (**Fig.3**). Field evaluation also showed that one of the native NPV strain is a promising biocontrol agent for *H. armigera* and can help reduce the pod damage in pigeon pea (Minja *et al.,* 2003). There is also scope to enhance the virulence through NPV strains, as found to be the case of MNPV subtype from South Africa, which appears more virulent than the Kenyan strain (SNPV subtype) (Ogembo *et al.,* 2003).

Studies have also been made on the potential of PxGV for controlling *P. xylostella*. Several strains have been assembled and characterized, both by bioassays and by molecular methods (REN) (Parnell *et al.,* 2002). Field evaluation of PxGV for control of *P. xylostella* has also been pursued. Currently, the private company Dudutech is involved in commercial production of PxGV virus in Kenya. Cherry *et al.* (2003) have analyzed the current use and future prospects for microbial insecticides in Africa.

Scope for bacterial and fungal strains /products

Scope appears to exist for utilizing more efficient strains/products of the bacterium, *Bacillus thuringiensis* and the fungus, *Metarhizium anisopliae*. Several native strains of these fungi have been recently assembled in Kenya and evaluated leading to indications that superior strains can be found (Thumbi, 2002). Onion thrips are found to be satisfactorily controlled by Metarhizium application as filed sprays (Maniania *et al*., 2003). There is also scope for utilizing an additional *B.t.k* product from China (Green guard), besides those already available as registered products namely: Dipel, Thuricide and Xentari (Sithanantham *et al.,* 2004). It is remarkable that there is an upcoming interest in establishing a *B.t.* production factory in Kenya, which is another step forward in making the product cheaper and more extensively available for use locally.

Stakeholder participatory initiatives:

The potential for augmentative biological control to become widely adoptable can be enhanced by promoting stakeholder participation at different stages/steps of popularization. It has been shown that when combined as a component of Integrated Pest Management (IPM), the uptake is encouraged (Sithanantham and Matoka, 2001). It is also critical that the private sector is fully involved as a partner, as they have the capacity and interest to invest and mass-produce the biocontrol agents. Recently, Dudutech, a private sector commercial biopesticide producer has come forward to commercially mass-produce *Trichogramma*, Granulosis virus (PxGV), besides some predators. ICIPE is providing training and technical backstopping for the *Trichogramma* production to this enterprise, so to encourage them to invest in and market the product. The involvement of model IPM farmers' group to help enhance awareness for the use of biocontrol agents is also important.

Initiatives for enabling policy support environment:

There is need to provide adequate policy support for commercial production of biocontrol agents. Simplification of the requirements like registration is important and there are good prospects that biopesticide legislation being conceived in

Kenya will cater to this concern. In horticulture industry there is growing awareness of the need to shift to biocontrol as chemical use is being discouraged.

WAY FORWARD

The potential for augmentation biocontrol of the caterpillar pests of vegetable crops is very promising in Africa. Interdisciplinary collaboration and inter-institutional cooperation are critically needed for enabling adequate availability and awareness among farmers for promising them means of sustainable crop protection of vegetable crops in the region.

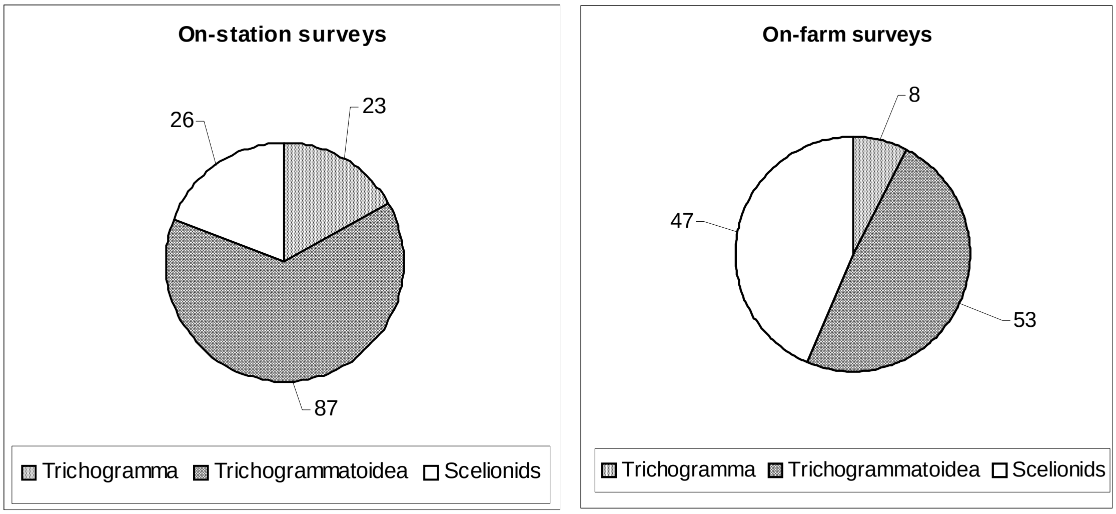

Fig. 1. Diversity of egg parasitoids assembled from onfarm / onstation surveys, 2001-2003

Source: Baya *et al*. (2003)

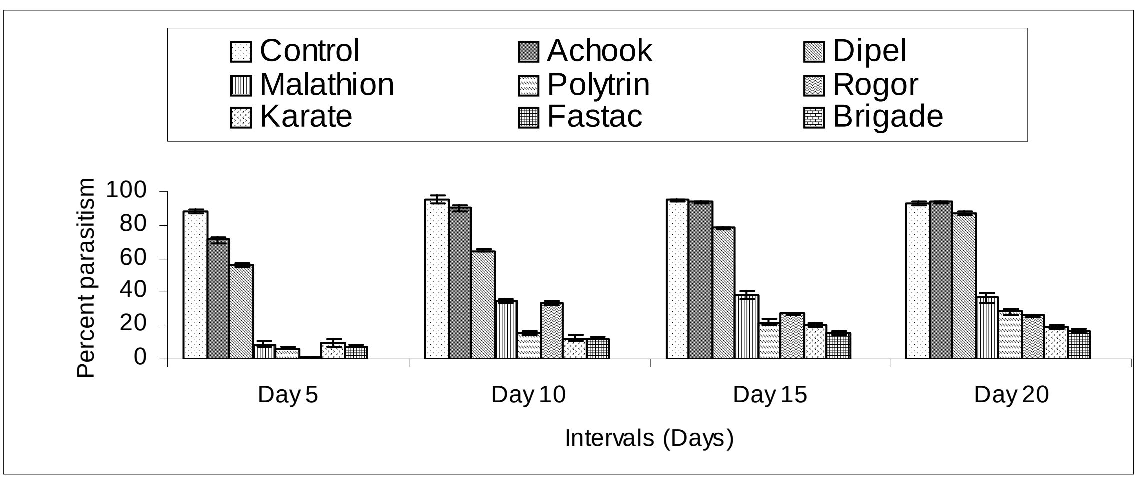

Fig. 2. Relative toxicity of commonly used insecticides to *Trichogramma* adults – lab. study, 2002 - 2003
Source: Momanyi *et al*. (2003)

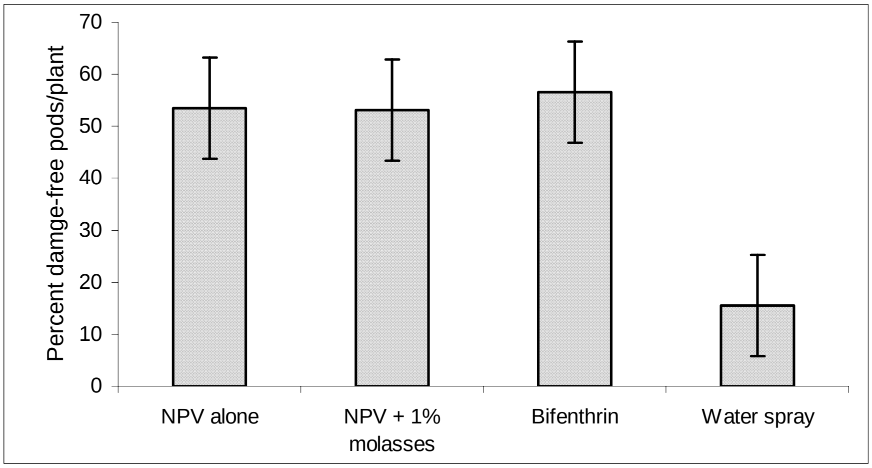

Fig. 3. Efficacy of Kenyan HaNPV strain K-1 in reducing the pod damage by *H. armigera* on artificially infested pot-grown snowpea plants, ICIPE, Kenya
Source: Baya (2000)

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EFFECT OF SEED PRIMING ON GERMINATION AND SEEDLING PERFORMANCE OF DELPHINIUM *(CONSOLIDA ORIENTALIS)* CUT FLOWER.

NDUNG'U BONIFACE NGAROGA
Moi University, Chepkoilel Campus, Crop Science and Seed Technology Department, P.O Box 1125 Eldoret, Kenya.

ABSTRACT

A study was conducted to determine the effect of priming delphinium (*Consolida orientalis*) seeds in different levels of potassium nitrate (KNO_3) concentration: 1% KNO_3 (10 gm per litre), 1.5% KNO_3 (15 gm per litre), and 2% KNO_3 (20 gm per litre), on germination rate, germination percentage and performance of the subsequent seedling. The control treatment was dry non-primed seed. The effects of the treatments were evaluated by germination tests in the laboratory in a completely randomized design (CRD) since all the experimental units were homogeneous.

Priming delphinium seeds in: 1% KNO_3, 1.5% KNO_3, and 2% KNO_3 resulted in an increase of 34.37%, 28% and 39% in the total germination percentage respectively relative to the control. The time to 50% germination (T50), improved linearly with increasing KNO_3 concentration compared to control while the shoot length and seedling dry weight increased linearly with decreasing KNO_3 concentration. Therefore osmotic pre-sowing treatment of delphinium seeds with KNO_3 is significantly advantageous in improving the germination rate, percentage, and the performance of the subsequent seedling.

Key words: delphinium cut-flower, priming ,export crop,

INTRODUCTION

Priming refers to the process in which the seeds are soaked in an osmotic solution that allows them to imbibe water and go through the first stages of germination (stage I and II) but does not permit radicle protrusion through the seed coat (Heydecker, 1973; Akers and Holley, 1986). Delphinium (*Consolida orientalis)*, commonly known as larkspur is one of the most important summer flower propagated both by seeds and cuttings. It takes four months from planting to mature and produce flowers which have desirable ornamental qualities and a long bloom season (Allan, 1993). Delphinium flowers are used as dried or just fresh cut flowers. It is mainly used for export market with a minor element of local consumption in big cities for offices and special occasions like weddings and funerals.

Parera and Cantliffe, (1994) states that rapid and uniform field emergence were the preliquisites to increase yields, quality and ultimately profits especially in annual crops. However germination of delphinium is erratic and thus delays or fails because delphinium seeds have a dormancy period. It begins two weeks after sowing and may continue for another two or three weeks (Allan, 1993). Dormancy is defined as the disability of seeds to germinate under favourable conditions (Yongqing, 1996). This dormancy poses a lot of problems especially in timing of the planting schedules so that flowers can coincide with the main European export market which is from October to May (winter season and heating greenhouses is very expensive hence raising the cost of production of cut flowers and making imports cheaper). Local market is also best at this time due to special occasions which apparently falls between November and May. They include Christmas, New Year, Valentine and Easter holiday. Today, erratic germination of delphinium seeds poses great problems as flower producers demand 100% germination of seeds placed in plug cells. The consequence is unfilled plugs; inefficient use of greenhouse space and need to refill the empty cell- a costly, time consuming operation.

Soaking seeds in water prior to planting has been an old farm practice to reduce the time between planting and emergence. In the last two decades priming of seeds has become a common treatment to improve seed germination, performance both in the field and in the greenhouses and is credited with increasing the rate and uniformity of emergence of many vegetable and flower species under a broad range of environment (Parera and Cantliffe, 1994,Bray, 1995). Therefore the major objectives of this study was to determine the effect of seed priming on the germination and performance of the subsequent seedling. Other specific objectives included determination of germination rate and total percentage germination of delphinium seeds primed at various osmotic potentials of potassium nitrate (KNO_3) and also determination of the osmotic solution concentration that best improves delphinium seeds germination , emergence and seedling performance.

MATERIALS AND METHODS

The experiment was conducted in the laboratories of Crop Production and Seed Technology Department, Moi University Chepkoilel Campus, Eldoret, Kenya. The altitude of the site is about 2100 M above sea level (a.s.l) and lies between 0°30'N and 35°35'E. This area receives a unimodal rainfall pattern with and average annual rainfall of 900-1100 mm and records a mean maximum temperature of 23°c. The seeds were obtained from Hortitec Seed Company limited.

The seeds were treated using osmotic solution of KNO_3 at three levels of concentration. A control experiment constituted dry non-primed seeds. Each of the four treatments were then replicated four times using complete randomized design (CRD). Osmotic solutions were prepared by dissolving appropriate weights of KNO_3 in distilled water to make the desired concentrations: 1% KNO_3 (10 grams KNO_3 / litre of distilled water),1.5% KNO_3(15 grams KNO_3/ litre of distilled water),2% KNO_3(20 grams KNO_3/ litre of distilled water),control (dry non primed seeds). For each treatment, around 200 seeds were randomly picked and placed in each of the three 90mm diameter petri dishes lined with two filter paper discs (whatman No. 2). The appropriate priming solutions were added to partially submerge the seeds. The Petri dishes were then covered with two layers of filter paper discs and put in dark germination cabinet at room temperatures for 24hours;after which the seeds were washed in running tap water, drained and blotted on absorbent paper to remove surplus surface water.

At the end of the priming period, 4 replications of 30 seeds from each priming treatment were arranged in 90mm diameter petri dishes lined with 3 wet discs of whatman No. 2 filter papers, and the top cover of each petri dish replaced. These petri dishes were then placed in a germination cabinet at temperatures set between 20°C and 23°C. Germination counts were carried out after every 24 hours for a period of 14 days from the date of sowing and the total number of germinated seeds expressed as a percentage of the total number of seeds sown (30 seeds). Germination was considered to have occurred when visible radicle emergence occurred. The rate of germination was determined and computed using the equation of Orchard, (1977) by the time the seeds took to reach 50% germination percentage. The average seedlings dry weight at the end of germination period in six randomly selected seedlings was also determined. Seedling length five days after termination of germination counts, (19th day after sowing), the lengths of 6 randomly selected seedlings were then measured.

RESULTS

It was observed that priming delphinium seeds in KNO_3 resulted in significant improvement of the time (in days) taken to reach 50% germination (T50) and the total germination percentage in all the treatments relative to the control. Priming the seeds in 1%, 1.5%, and 2% KNO_3 improved the rate of germination T50 to 9.5025 days, 9.9583 days and 10.28 days respectively compared to the control which took 10.8954 days. 1% KNO_3 was the most superior, followed by 1.5%KNO_3 and finally 2%KNO_3.

The total germination percentages were also significantly improved, with 2% KNO_3 (74.17%) proving to be the best, followed by 1%KNO_3 (71.66%) and finally1.5%KNO_3 (68.33%) as compared to the control with a total germination of 53.33%. Seed priming treatments significantly increased the seedling dry weight and the shoot length. Priming seeds in 1%, 1.5%, and 2% KNO_3 resulted in significant increase in seedling dry weight of 54%, 41.66% and 25% respectively compared to the control. The seedling shoot length also increased by 62.32%, 58.83% and 37.67% respectively though there was no significant difference among treatments. 1%KNO_3 proved to be the most effective in improving seedling performance after priming as far as seedling dry weight was concerned.

Table 1: effect of priming on germination percentages.

Treatments means	Control 53.33	1.5% KNO_3 68.33	1% KNO_3 71.667	2 % KNO_3 74.17	L.S.D 9.91
Control 53.33		*15	*18.33	*20.84	
1.5 % KNO_3 68.33			3.337	5.84	
1 % KNO_3 71.667				2.503	
2% KNO_3 74.17					

Each mean is an average of three replicates. Mean separation by LSD at 5% level.
*= Significantly different

Table 2: Effect of priming on the rate of germination (T50)

Treatment means	1% KNO_3 9.5028	1.5% KNO_3 9.9583	2% KNO_3 10.2896	Control 10.8954	LSD 0.766
1% KNO_3 9.5028		0.4558	*0.7871	*1.2929	
1.5% KNO_3 9.9583			0.331	*0.9371	
2% KNO_3 10.2896				0.6058	
Control 10.8954					

Each mean is an average of three replicates. Mean separation by LSD at 5% level.
*= Significantly different

Table 3: Effect of priming on seedlings shoot lengths (mm).

Treatment means	Control 10.75	**2% NO_3 14.8**	1.5% KNO_3 17.075	1% KNO_3 17.45	L.S.D 2.66
Control 10.75		*4.05	*6.325	*6.7	
2% KNO_3 14.8			2.275	2.65	
1.5 % KNO_3 17.075				0.375	
1 % KNO_3 17.45					

Each mean is an average of three replicates. Mean separation by LSD at 5% level.

Table 4: Effect of priming on seedlings dry weight (in grams).

Treatment means	Control 0.006	2% KNO_3 0.0075	1.5%KNO_3 0.0085	1% KNO_3 0.00925	LSD 0.0022375
Control 0.006		0.0015	*0.0025	*0.00325	
2% KNO_3 0.0075				0.00175	
1.5%KNO_3 0.0085				0.00075	
1% KNO_3 0.00925					

Each mean is an average of three replicates. Mean separation by LSD at 5% level.
*= Significantly different.

DISCUSSION

These results depicts the effects priming has in advancing the rate of seed germination and thus concurring with a major objective of priming of rapid and uniform seedling germination (Brocklehurst and Dearman, 1983). This improved performance in primed seeds can be attributed to the fact that priming brought the seeds to the brink of germination but did not allow completion of germination process. The prolonged phase II period in which the seeds are maintained during priming permits initiation and / or completion of essential pre-germination metabolic events but which are insufficient to allow radicle emergence (Bray, 1995). The improvement in the rate of germination and emergence percentages of primed delphinium seeds could have been due to the increase in available metabolites ready to be utilized for germination and growth processes, such as proteins, RNA, ATP, and enzymes which are normally associated with imbibation or early stages of germination (Zhang and FU, 1985; FU et al., 1988; Bewley and Black 1994).

Improved delphinium seeds performance after priming may also be attributed to the fact that during priming, the seeds imbibe a limited amount of water resulting in partial hydration state which is particularly important in delphinium which is hard seeded and this condition gives the primed seeds a head-start when sown and hence a faster rate of germination and emergence.

These results on priming delphinium seeds in KNO_3 solution, compares with reports on priming in KNO_3 of 'Jalapeno' pepper seeds which resulted in dramatic increase in the rate of germination relative to the control (Halpin-Ingham and Sundstrom, 1992). The effects of priming delphinium seeds in improving seedling shoot length and dry weight could have been due to a faster rate of germination and a faster seedling development as has been reported by Parera and Cantliffe, (1994).

CONCLUSION

This study has confirmed the beneficial effects of priming delphinium seeds with KNO_3 of improving the rate of germination (T50) and total germination percentages as well as early seedling growth as measured by seedling dry weight and shoot length compared to the non primed seeds. The concentration of the priming solution is of concern. Although priming seeds with 2% KNO_3 was the best in improving the rate of germination, it was the least in improving the subsequent seedling performance(measured by seedling length and dry weight) and therefore low concentration of KNO_3 is more desirable. It can be concluded that priming seeds with 1% KNO_3 is the most beneficial because it was the best in improving the rate of germination (T50) and dry weight of the subsequent seedlings.

RECOMMENDATIONS

I highly recommend KNO_3 as an effective primer in improving the rate of germination , germination percentage and performance of the subsequent seedling as revealed by this study and should thus be adopted by commercial propagators to reap its benefits. Germination percentage of delphinium seeds even after priming with KNO_3 is still low (68-74%) and I would therefore like to recommend that further studies be carried out to investigate the effects that other salts such as NaCl and $MgSO_4$ and high molecular weight compounds such as PEG have on the germination rate , percentage and the performance of the subsequent seedlings because they may be of more beneficial effects.

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WOMEN GROUP APPROACH IN DESSEMINATION, EVALUATION AND ADAPTABILITY OF TISSUE CULTURE BANANAS IN MACHAKOS DISTRICT.

Musyoki. R, Karanja. D, Omari. F, *KARI-Katumani, P.O. Box 340 Machakos*

ABSTRACT

Innovation of tissue culture technology has made it possible to mass propagate elite bananas varieties. In Kenya, the laboratories that are producing these clean planting materials are located in urban centers while the resource poor farmers are found in the rural areas. These farmers have limited means to travel and purchase the seedlings. Also the seedlings that are hardened are bulky and therefore not easy to transport them over along distance. In order to reduce transportation costs and enhance adaptability, a need was realized to devise systems of delivery of the seedlings in time to farmers while ensuring sustainability. In Machakos district, women are known to come together to form what is locally known as 'Miethya' groups. These women work together as a team to uplift their family standard of living. Five groups engaged in farming activities were selected in Kathiani division for introduction and evaluation of tissue culture bananas. Four varieties, (Giant cavendish, Willliam hybrids, Grande nein and Chinese dwarf) were planted in farms of three of the selected groups (Kithetheesyo, Kauti and ABC Itulu) and their performance evaluated. Williams took the shortest time to maturity (314 days) followed by Chinese dwarf (337 days), Grande nein (346 days) and Giant cavendish (347 days). There was no significant difference in growth, vigor and health of plants but differences were noticed in height and sucker production. Chinese dwarf was found to be the shortest (64.4 cm) and with the least suckering ability of an average of 1.5 suckers per stool. Two groups (Kiembeni and Ndwae Ngutwae) were used to evaluate the ability of women farmer groups to handle miniature tissue culture bananas, their hardening and marketing. Initially high losses were experienced but with time, practice and experience, the losses were reduced from 27% to 7%. This led to not only more seedlings being available in the area but also more income for the groups to raise their standards of living.

INTRODUCTION

Banana belongs to the family *Musaceae* in subgenus *Eumusa* which gives rise to the majority of the edible bananas. Bananas and plantains are crops of vital importance to millions of people in the developing countries. The total world production of these crops is approximately 70 million tons per year (Kungu *et al.,* 1991), and 90 % of the fruits are used for domestic consumption. Bananas and plantains are the third world's most important starchy stable foods after cassava and sweet potato (FAO, 1987). Moreover, compared with other staples they are the most economic source of carbohydrates in terms of production cost, both per hectare and per ton to millions of people with minimum diets throughout the above region (Kahangi, 2001).

In Africa, banana production is about 24 million tons as compared with the total world production of 88 million tons. In Kenya, the total area under banana in 1993 was estimated at 79,600 hectares with production of 818,000 metric tons (Kungu *et al*.,1991; MOA, 1996). In the country, banana production is mostly by small-scale farmers with an average yield of 10 tones as opposed to potential of 40 tones per hectare. The low production is attributed to limited supply of planting material through convectional propagation, pest and diseases. The small-scale farmers mainly grow the crop across a wide range of agro-ecological zones from coastal lowlands to midlands and the Kenya highlands.

During the research programme priority setting in Katumani when a number of participatory rural appraisals (PRAs) were done in Machakos, Kitui, Mwingi and Makueni districts (Audi *et al.,* 1996, Kitheka *et al*., 1997), it was found that Yatta division in Machakos was the leading banana producer, followed by Kathiani and then Kangundo. Kathiani was found to have many strong farming groups whose main aim was to uplift their standard of living through farming and many of these were women groups.

Due to its importance in Kenya, the KARI priority setting group of 1998 ranked banana 1st among fruits and 8th among other food crops because of the part it plays in food security at household levels and as a means of raising incomes (Musyoki, 2000). Kitheka *et al*. (1997) found that various constraints limited banana production and these included:

- Lack of adaptable cultivars – most cultivars grown had low yielding potential and not well adopted to major growing areas
- Lack of clean planting materials – inadequate sources of continuous supply of clean planting materials had slowed expansion of banana production and encouraged exchange of infected suckers among farmers
- Poor agronomic management practices – improper orchard management practices such as inadequate fertilizer use, irrigation, pruning and inappropriate crop population had contributed to low yields
- Diseases and pests – major diseases that affect banana production in Kenya and greatly contribute to low production are the panama disease, yellow and black sigatoka. The pests include banana weevil, borrowing nematode and banana thrips.
- Post harvest practices - poor post-harvest handling leads to huge losses, which reduce the number of marketable fruits and consequently to eventual low prices.

To address the first constraint of lack of adaptable cultivars, KARI in collaboration with other institutes, introduced and evaluated superior banana varieties like Giant Cavendish, Valery, Williams hybrid, Dwarf Cavendish and Grande nein, among others. These varieties are still being evaluated in various parts of the country for yield, drought tolerance, pest and insect resistance, taste, post-harvest handling and ratooning ability. The country started to solve the problem of lack of clean planting materials by establishing tissue culture laboratories. The laboratories have been able to mass propagate and produce clean planting materials. However, these laboratories are located in urban centers while the resource poor farmers are found in the rural areas with no means to travel and purchase the seedlings. Also the seedlings that are hardened are bulky and therefore not easy to transport over distances, increasing transportation costs. This problem is compounded by the fact that though many laboratories can produce good materials, they have no capacity to ensure that the materials reach all the farmers who require them.

It was therefore the objective of this project to develop an efficient and yet effective channel of ensuring that the banana planting materials were available to farmers at the minimum cost possible and in good time. From earlier studies, it was established that many farmers were still not aware (Kitheka *et al.,* 1997) of the importance and availability of tissue culture banana seedlings. Thus there was need to disseminate this information through demonstrations, trainings, field trips and production of simple reading material.

METHODOLOGY

Groups And Farmer Selection

Among the main banana producing areas in Machakos district, Kathiani was chosen for this study because of strong 'miethya' groups that were mostly engaged in agricultural activities. Five groups were selected on bases of their involvement and activeness. Three groups were used for establishment of demonstration farms and field trials where various tissue culture banana varieties were planted and evaluated for adaptability. The other two groups were used for hardening of the tissue culture banana miniature plantlets before selling them to farmers for planting. The criteria used for selecting the groups were:

- The group had to be already organized with members, elected leaders and with governing rules and by laws
- The main object of the selected group was to be poverty alleviation through collective activities
- The group had to have experience with tree nurseries and/or other communal agricultural activities
- The group members should have been willing to set aside common land to be used for group farming, which was near water source for nursery irrigation (especially for groups to handle the nurseries).

The members of each of the three groups were asked to select one farmer in whose farm the on-farm trial demonstration field was to be established. The farm was to be accessible to other farmers, researchers and visitors at any time. Farmers in the three groups were trained on various banana agronomic aspects. Four tissue culture banana varieties (Giant cavendish, Grand nain, Williams hybrid and Dwarf cavendish) were planted depending on farmers' design and preferences. After planting, the following data were collected and taken for evaluation; - plant height in centimeters, vigour, health and time to flowering in days. Plant vigour and health was determined by using a scale of 1 to 5 where 1 was the most weak or diseased plant while 5 was the healthiest or vigorously growing plant.

The two groups selected for miniature tissue culture banana handling must have been running a nursery for fruit tree/agro forestry tree seedling production and adequate water for nursery irrigation available. Each group produced two members who were trained together with two Agricultural extension staff at Jomo Kenyatta University of Agriculture and Technology (JKUAT) to be trainers of other members. After training other group members on field and nursery banana production, the groups prepared a nursery shade and seedlings bought on 'loan' each costing KSh.20. Each group raised and managed their nursery by themselves. The members provided the land, forest soil and labour for watering. Other inputs provided on 'loan' included fertilizer and polythene bags. By the end of 6 weeks the seedlings were ready for field planting.

RESULTS AND DISCUSSIONS

Group Selection

The groups selected for banana field trial evaluation were kithetheesyo, Kauti and ABC Itulu while for tissue culture nursery established were Kiembeni and Ndwae Ngutwae. Women were the majority (86%) in the first three groups while in the other two there were no men (Table 1). In all cases, the groups indicated that they intentionally kept men out to avoid their influence in decision-making. However the few who were recruited it was done under special circumstances. Like in the case of Kauti, two male members were recruited after death of their wives who were active members of the group. In all cases, constitutionally men were not supposed to hold any office.

Table 1: Groups selected and segregated by gender.

Group	No. Members	Men	Women
Kithetheesyo	25	2	23
Kauti	26	5	21
ABC Itulu	28	3	25
Kiembeni	32	0	32
Ndwae Ngutwae	24	0	24

Before the initiation of the project it was important to know who does what at what stage of banana plant development at household level. This was to help in information dissemination during the training and to ensure gender balance. It was observed that children forms part of household labour in most agricultural activities (Table 2) and most of the farm activities were shared by men, women and children. Children were found to participate more in weeding and crop harvesting. Men were found not to be involved in beans and pigeon pea planting and beans harvesting. Women carried out all the farm operations from land preparation, planting to harvesting.

Table 2: GENDER DIVISION OF LABOUR ON FARMING ACTIVITIES

Activity		Men	Women	Children
Land preparation		√	√	√
Planting beans		+	√	+
	Maize	√	√	√
	Pigeon pea	+	√	+
	Bananas	√	√	+
	Weeding	√	√	√
Harvesting	Beans	+	√	√
	Maize	√	√	√
	Pigeon pea	√	√	√
	Banana	√	√	+

Table 3: Gender division of labour in banana production

ACTIVITY	**MEN**	**WOMEN**	**CHILDREN**
Digging of planting holes	√	+	+
Selection of planting materials	√	√	+
Planting of suckers	√	√	+
Desuckering	√	√	+
Pruning	√	√	+
Harvesting	√	√	+
Transport to market	+	√	+
Marketing	+	√	+

Unlike other agricultural production activities, it was observed that children were not involved in banana production at any level (Table.3). Digging of planting holes for bananas was considered a man's job though women could dig when men are not available to do the job. Both men and women could do selection and identification of suckers to be planted. Harvesting of the mature bunches was usually done by both men and women, though it's considered to be a man's job. Transporting and marketing of the banana was solely women's work as well as marketing. This means that money obtained after marketing the bananas was available to the women unlike in other farm proceeds which are received and kept by men.

TYPE OF CULTIVARS PRODUCED

Most of the banana cultivars produced in the area were of the local types and the farmers were not aware of the improved tissue culture bananas. However a few were aware of bananas they were calling 'kaisrael' which after probing, turned out to be one of the improved banana varieties (Grande nein). The variety was obtained from the National Youth Service (NYS) Yatta and originally came from Israel hence the name.

Type of bananas produced were:

- Mutavato - Ndivi
- Sweet banana - mulalu
- Kamunyuu - Katithi
- Kasukali - Kikanda
- Mulalu wa kiganda - Kisukali kya kikanda

The above varieties were ranked according to overall importance that put in factors like yield, taste, marketability, drought tolerance, pest and disease resistance. This was done by use of pair-wise ranking matrix method. Mulalu ranked high because of its bunch sizes, big fingers, good taste, highly marketable and used as dowry price. However it logged easily during windy period and required probing. This was followed by Katithi, Ndivi, Kasukali, Kamunyuu, kikanda, mutavato, sweet banana, mulalu wa kikanda, kisukali kya kikanda in that decending order.

FIELD ESTABLISHMENT

The tissue culture varieties selected for field establishment included William hybrids, Giant cavendish, Grande nein and Chinese dwarf. These were established in three fields each from each of the three groups. The farm owners were requested to choose the planting design one preferred. Two farmers chose to plant their bananas along the terrace furrows (which is the common practice of planting bananas in their farming systems) and the other chose to plant on the bench terrace (Table 4). All the farmers were intercropping bananas with legumes.

DATA COLLECTION

During establishment, the following data was collected. These included: - number of suckers per plant, plant health, vigor and height, field management level and time to flowering.

Table 4: NUMBER OF BANANAS PLANTED AND THEIR PLANTING DESIGN

Group	No. Planted	Planting design
Kithetheesyo	34	Along the terrace furrow, rain fed with supplementary irrigation
Kauti	42	Along the terrace furrow and rain fed only
ABC Itulu	42	Plants occupying a bench terrace, and rain fed

Table 5: PERFORMANCE OF DIFFERENT VARIETIES DURING ESTABLISHMENT

Variety	Vigor	M. level	Health	Height cm	N. suckers	Dat. flow
Williams	3.9	2.9	3.9	122.9	5.2	314
G/caverdish	3.7	2.9	3.7	135.4	4.1	347
G/nein	3.7	2.9	3.6	116.3	3.0	346
Chinese dwarf	3.4	2.4	3.5	64.4	1.5	337
Mean	3.7	2.9	3.7	109.7	3.4	336.3
CV	13.6	0	14.0	25.3	37.2	11.2
Prob	ns	ns	ns	*	* *	

M.level – management level, N. suckers – number of suckers,

Dat.flow – date to flowering

Table 5 shows that there was no significant different in plant vigor and health during crop establishment. However, significant differences were found in plant height where Giant cavendish and Williams had the tallest plants with 135.4cm and 122.9cm respectively. Grand nein had 116.3cm while Chinese dwarf had the shortest plants of 64.4cm. Differences were also observed in the suckering ability of various varieties with Williams being the heaviest sucker (5.2), followed by Giant cavendish (4.1), while Grand nein had 3.0 and Chinese dwarf had the least suckering ability of 1.5. There was significant difference in time to maturity (inflorescence formation) with Williams maturing first at 314 days while there was no significant difference in maturity of Giant Cavendish, Grand nein and Chinese dwarf. There was no significant difference in maturity within variety that led to uniformity in production in each variety.

TISSUE CULTURE BANANA NURSERIES

Two groups were selected for tissue culture nursery production, which were Kiembeni and Ndwae ngutwae. Three members from each group and 2 agricultural extension staff were taken to (JKUAT) where they were trained as tissue culture banana trainers. Before the nurseries were established the group members were trained on handling of tissue culture materials, nursery structure construction and the nursery management. Each group constructed a nursery shade before tissue culture miniature plantlets were delivered to them. The varieties that were delivered were Giant Cavendish, Williams, Grand nein, Valery, lacatan, Chinese dwarf and Kisii matoke (Table 6) as requested by each group.

Table 6: Tissue Culture Varieties Supplied to Groups

Group	Varieties	No. supplied	No.died	No.sold to members	No sold to others
Kiembeni	Giant Cavendish	300	52	102	186
	Grand neine	300	66	52	222
	Lacatan	150	23	16	111
	Kisii matoke	150	36	42	72
		900	177	212	591
Ndwae ngutwae	Williams	200	52	96	52
	Valery	200	23	62	115
	Kisii matoke	200	61	21	118
	Chinese dwarf	200	132	56	112
		800	268	235	397

Kiembeni and Ndwae ngutwae received 900 and 800 miniature tissue culture banana plantlets respectively. In three weeks time after potting, Kiembeni group had lost 20% and Ndwae Ngutwae 33.5% of the supplied seedlings equivalent to KSh 10,620 and KSh. 16,080 respectfully. After 8 weeks the remaining seedlings were ready for transplanting. The groups arranged the sales in such a way that each seedling was sold to a member at Ksh.40 while to a non member at Ksh.60, so that the members could be encouraged to plant more. This gave Kiembeini a gross income of Ksh.43, 940/- and Ndwae ngutwae Ksh.33, 220.

LEARNED LESSONS

The heavy losses experienced in the two nurseries were due to:

- Plantlets were not planted immediately after delivery and that led to quite a substantial loss of materials
- Mishandling during planting could have led to this loss due to lack of practice and experience
- The farmers had not learned watering regimes and some plantlets were lost due to water shortage/water logging
- The materials took about 6 months to be sold out thus making them to over grow. This could have been due to the quantity delivered was too large to be handled by the groups
- Many buyers were skeptical about the seedlings, some saying they were flowers while others said they were genetically modified plants (GMOs), thus many potential buyers kept away in fear

After realizing the problems encountered during the sale of the first delivery, the following measures were taken to alleviate them. The miniature plantlets obtained from JKUAT were reduced to 400 per group, which have been found to be the amount each group can dispose within 3-4 months. A promotional campaign of the tissue culture bananas was made through chiefs' barazas and agricultural shows where people were educated on the importance of these materials and their availability in the area. Also, the farmers became more aggressive in selling their materials and could take them by 'kyondo' to markets, particularly during the market days. After subsequent 5 deliveries it was found that losses due to death reduced from 20.0% for Kiembeni to 6.3% while that of Ndwae ngutwae reduced to 8.7% from 33.5% (Fig 1).

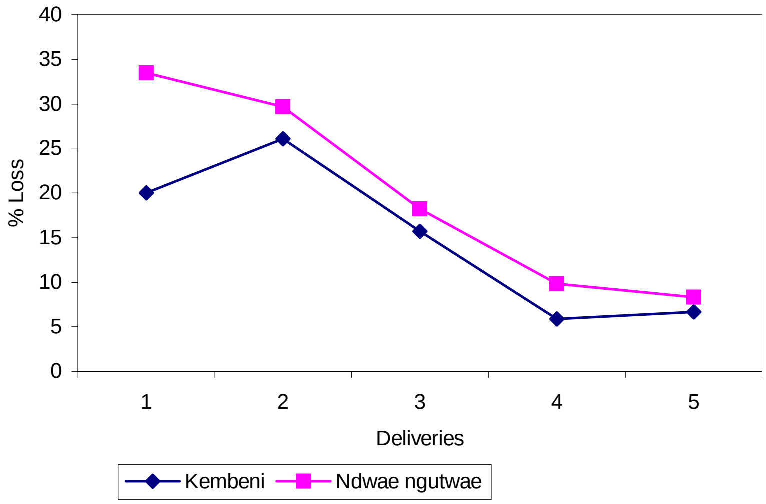

Fig 1: T/C Banana losses due to death at various deliveries

ACHIEVEMENTS BY THE GROUPS

- Clean banana planting materials are available in the area, which has led to increased number of banana stools and consequently increased banana production in the area.
- There is increased income to the resource poor farmers (who are mostly women) as a result of nursery proceeds from seedling sales and is expected to raise with increased banana production.
- Kiembeni group has managed to purchase a piece of land measuring 0.25 acres on which the nursery is located. Ndwae ngutwae are also looking for a suitable land to purchase.
- The group members were trained on other issues besides tissue culture miniature banana handling and banana production. This included business management, gender issues, team leadership and social group relations. Training on other aspects of crop production was also done
- Other institutions have shown interest in the groups. They include Ministry of Agriculture who has posted an Extension Staff to the area, Agricultural Technology Information Response Initiative (ATIRI) – Katumani that is now supporting the group, International Fund for African Development (IFAD) – renovating water cannel from Muuoni River that will make more water available and JKUAT that has continued to supply tissue culture miniature plantlets when required.
- The group members found out that with training and practice as well as proper handling of the miniature plantlets, the nursery losses can be reduced from about 26% to about 7%, which is the current loss thus, increasing their income base.

CONCLUSION

Banana is one of the most important fruits in the world and in Kenya it plays an important role in the diet of most people. KARI priority setting ranked bananas 8th among other crops and 1st among fruits and it plays an important part in food security. However, production of this crop has been limited by lack of adaptable improved cultivars and lack of clean planting materials. The innovation of tissue culture technology and its ability to mass propagate clean planting materials solved this problem. Most of these laboratories are located in urban areas hence the need to device systems that will enable availability of these materials to resource poor farmers in the rural areas at minimum cost possible.

Use of the farmer group approach was found to be an efficient way of technology development, dissemination and scaling up. Groups were easy to mobilize and the information flow was fast reaching majority within short times. It was also found that whatever the group was taught, the members were left discussing not only among themselves or within the households but also with the larger population. This ensured the spread of the information in the area. With this approach, monitoring and evaluation is easier with higher expectation of sustainability of a project. Although handling of tissue culture miniature banana plantlets is known to be a delicate exercise, it was found that when farmers are well trained and prepared, they could handle and harden them with minimum loses. The groups managed to reduce nursery losses due to death from 26% to 7%. Also these groups made the improved seedlings of tissue culture bananas available to themselves and other farmers in far places, thus improving banana production in the in the country. Transport costs and time spent by farmers while looking for these improved planting material were greatly reduced. From the proceeds of the sales, the farmers were able to improve their income base. During field establishment of tissue culture banana, William matured earlier than all the others. However more data is required to be collected in order to establish the best variety in terms of bunch and finger size, taste and successive ratoon production.

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CHEMICAL AND NON-CHEMICAL THINNING STUDIES IN APPLE

OUMA, G. Department of Horticulture P. O. Box 333, MASENO, Kenya
Blanke M.M, Institute of Horticulture, University of BONN, KLEIN ALTENDORF STATION,MECKENHEIMER STREET 42, 53359, RHEINBACH, GERMANY

ABSTRACT

Thinning trials were conducted in the apple orchards of Klein Altendorf Experimental Station, near Bonn, Germany using 7 year old CV. 'Cox Orange' in 2001 and 8 year old 'Elstar' apple trees in 2002. The objective was to reduce the number of fruits per tree, to improve fruit quality and overcome alternate bearing in these two apple cultivars to improve our understanding of the underlying regulatory. mechanisms. The first mechanism, the effect of ethylene promotion of the formation of the separation of abscission zone, was tested using Ethrel at early flowering stage. At a dose of 1000ml/ha the released ethylene severely, and at 500ml/ha still overthinned the fruits in 2001, while at 300ml/ha flordimex in 2002 achieved the required fruit set by thinning before June drop 62% before and 15% after June drop compared to 49% of the unsprayed control trees. Fruit quality was improved by having 71% of the fruits in the class 1 fruit diameter size range of 75 to 90mm while yield per tree was reduced by 31% by Ethrel at 1000ml/ha but not Ethrel at 500ml/ha which had not effect on yield. Mean fruit weight was unaffected by the treatments. The second mechanism based on the foliar fertilizer ammonium thiosulphate (ATS) was tested by one spray on to flowers at full bloom on older (ATS 1) plus to one-year old shoots (ATS 2) which both ATS 1 and ATS 2 did not have any thinning effect in 2001. The foliar urea-based fertilizer Azolon fluid (7.5 li/ha), applied at full bloom, resulted in 61% fruit set before and 17% after June drop in 2002, slight leaf yellowing, scorching and epinasty 7 days after treatment application which disappeared 14 days later but probably started earlier and a slight reduction in leaf photosynthesis. This mechanism, based on leaf photosynthesis, was tested using 50% defoliation of each rosette leaf at early flowering which reduced fruit set 56% before and 14% after June drop, i.e. similarly successful to the chemical thinning. It is concluded that:Early Ethrel application which causes thinning via release of ethylene (Flordimex at 300ml/ha) is effective, because ACC Oxidase levels are high in the late flowers at that time and basipetal IAA transport is hampered. Photosynthesis plays an important role as early as the start of the apple blossom.

Key words: Apple, alternate bearing, biennial bearing, ethylene, fruit, fruit set, photosynthesis, thinning.

INTRODUCTION

Fruit trees develop many more fruits than they can support through to maturity. Hence fruits are subjected to abscission at three different stages of fruit ontogeny. The first 'early or flower drop' shortly after anthesis is followed by 'June drop' and a further drop before harvest (Dennis, 2000, Luckwill, 1953). Abiotic and biotic stresses such as overcropping can disturb these regulatory mechanisms and cause biennial bearing. Fruit thinning is one of the most important management practices a commercial grower requires to produce apples of high quality including a particular fruit size, (red) colour, firmness and soluble solids. Thinning can also overcome biennial bearing in affected apple cultivars thereby securing regular harvests. The mechanism of thinning may be either through effect on photosynthesis or effect on ethylene biosynthese. The hypothese of the chemical thinning experiments was that the chemical thinners will reduce excessive fruit set from reduced leaf photosynthesis resulting in improved apple yields and quality. The objectives of the studies reported in this paper were to investigate the effect of various chemical thinners such as Ethrel, Ammonium thiosulphate and Azolon etc. on apple fruit set and yield of the alternate bearing sensitive apple CV. 'Elstar' and to compare the above with defoliated trees whose photosynthetic surfaces were reduced.

TABLE 1: TREATMENTS APPLIED IN 2001 AND 2002

2001 **Control**	Stage **Full bloom**	**Conc.** **N/A**	**2002** **N/A**	Stage	**Conc.**
Amid-thin + Ethrel	Full bloom	600g/ha Amidthin + 250ml/ha Ethrel	N/A		
Amid-thin + Telmion	Full bloom	600g/ha Amidthin + 250ml/ha Telmion	N/A		
Ethrel	Early flowering stage	500ml/ha 1000ml/ha	N/A		
Ammonium thiosulphate (ATS 1)	Petal fall	10kg/ha	N/A		
Azmmonium thiosulphate (ATS 2)	Full bloom	7kg/ha	N/A		
Azolon				Full bloom	7.5li/ha
Flordimex (Ethylene releasing compound)				Full bloom	+300ml per ha
Azolon + Flordimex				Full bloom	7.5li/ha + 300mlper ha
Defoliation treatment				Full bloom	N/A
Unsprayed cont.				Full bloom	N/A

MATERIALS AND METHODS:

(a) Apple trees and their cultivation. The experiments were carried out at the Klein Altendorf Experimental Station near Bonn, Germany. The station receives an annual rainfall of 615mm and average daily temperatures of 41^{0}C. The experiments were carried out on 10 year old apple CV. 'Cox Orange' on M9 rootstock, planted at 3.45 X 1.50m in 2001 and in 2002 on 8 year old apple CV. Elstar on M9 rootstock planted at 3.45m X 1.50m.

Measurements:
Fruit set was determined on two uniform branches of 4 trees per treatment four weeks after application. The number of fruits remaining after June drop was counted and also expressed per 100 blossoms. Fruit yield was determined by weighing all the fruits after harvest. Mean fruit weight and fruit size class was also determined. Leaves of the two selected branches of three unsprayed apple trees were partially defoliated.

Partial defoliation of these leaves was $^{1}/_{3}$ from the distal end at the time of the application of the chemical treatments and then extended to one half of the leaf blade 7 days after. Before and after the application of the chemical treatments, photosynthesis and transpiration rates were measured using a gas analyzer CIRAS –1 (PP systems, U. K.) during clear sunny days. Each thinning treatment comprised 12 replicates based on 2 branches per 2 X 3 trees in two rows resulting in 11 degrees of freedom. Data was analyzed using a commercial package (SPSS, USA; Version 9.0).

RESULTS:
4.1: Figures of results

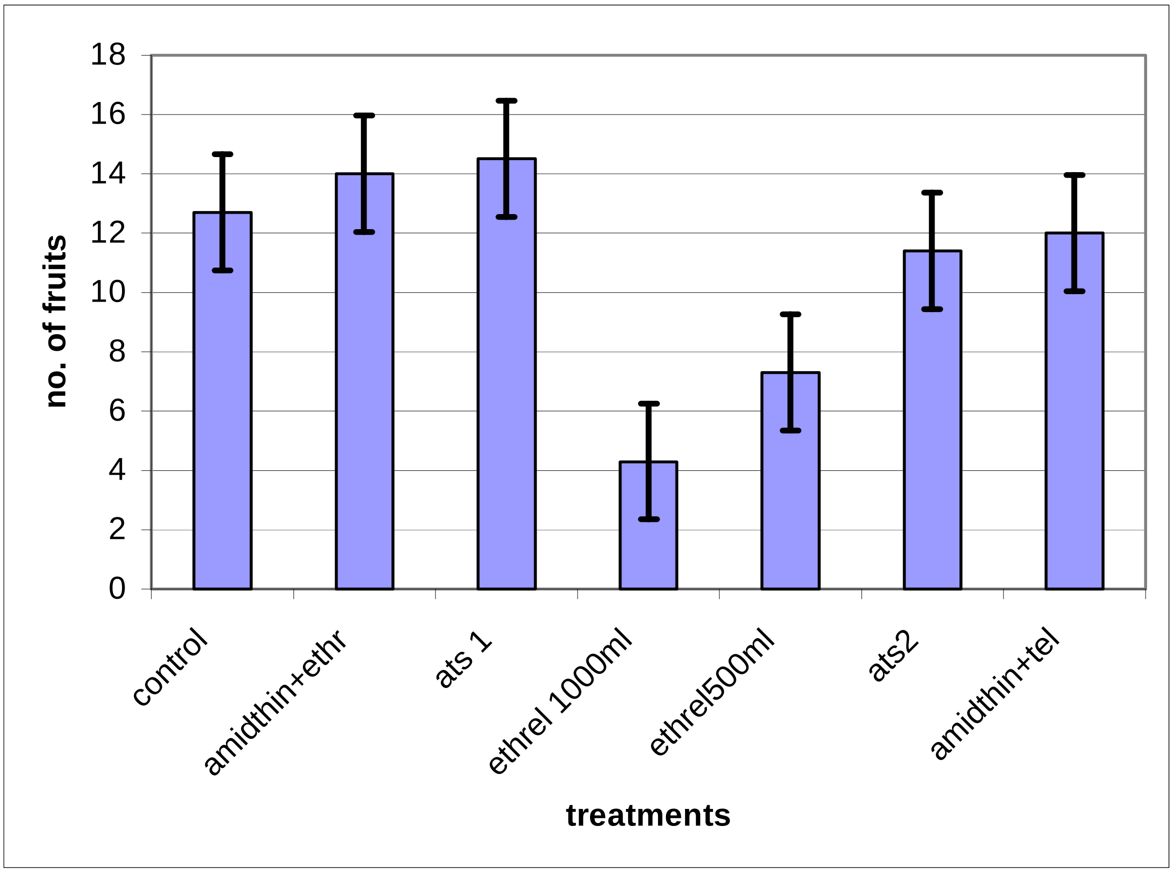

Fig. 1 Effect of treatments on number of fruitlets per 100 blossoms in the year 2001

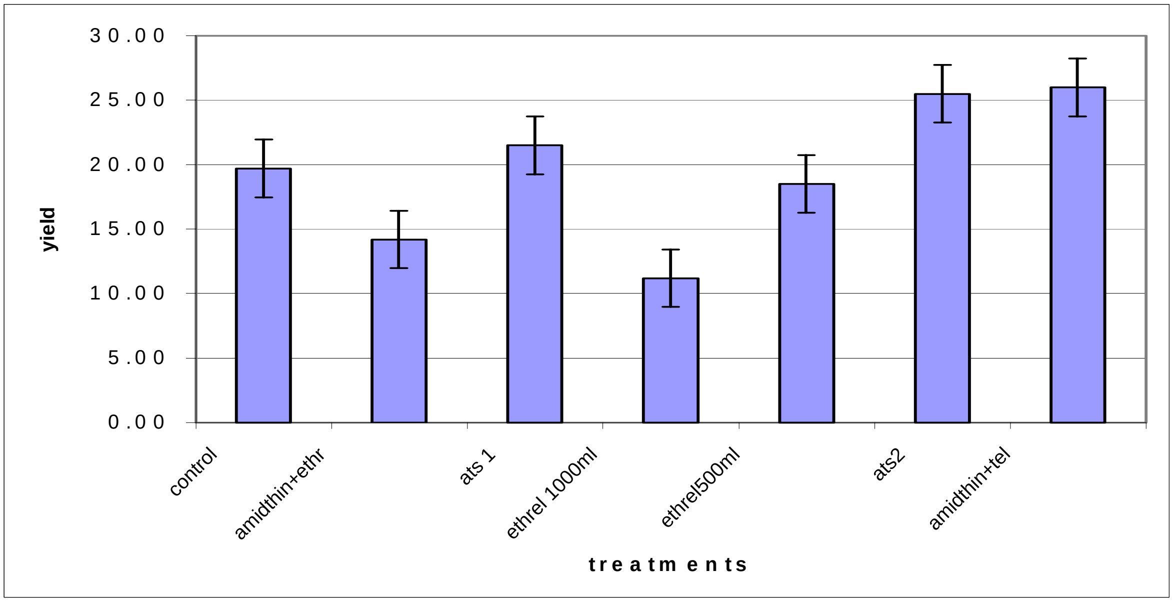

Fig. 2 Effects of treatments on yield of fruits per tree in the year 2001

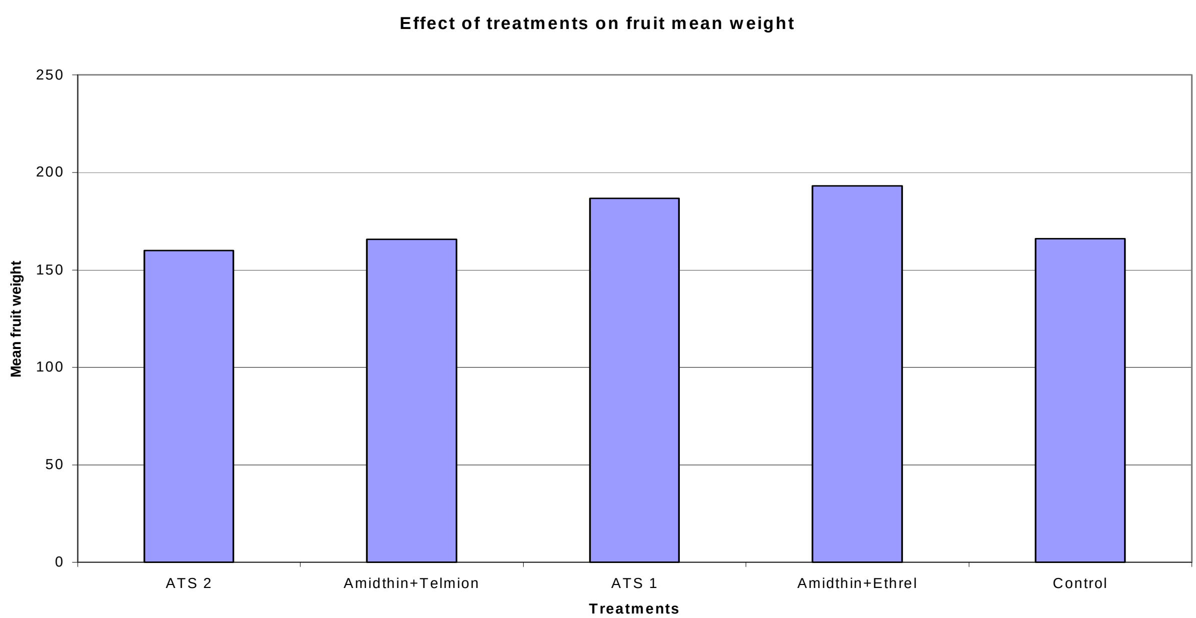

Fig. 3 Effect of treatments on mean fruit weight in the year 2001

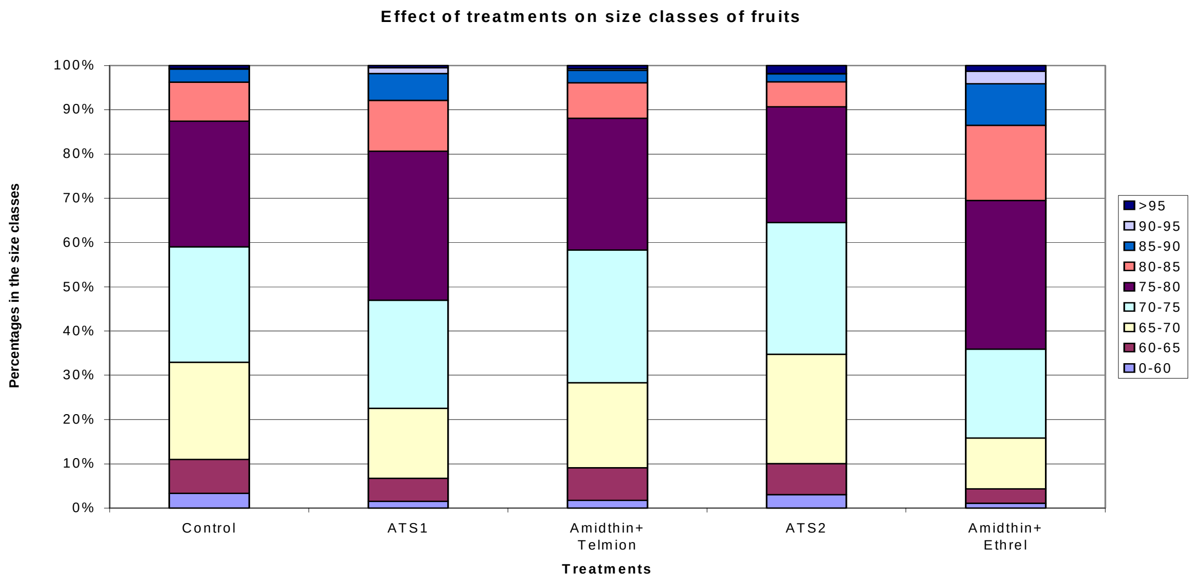

Fig 4 Effect of treatments on the percentages in the size classes in the year 2001

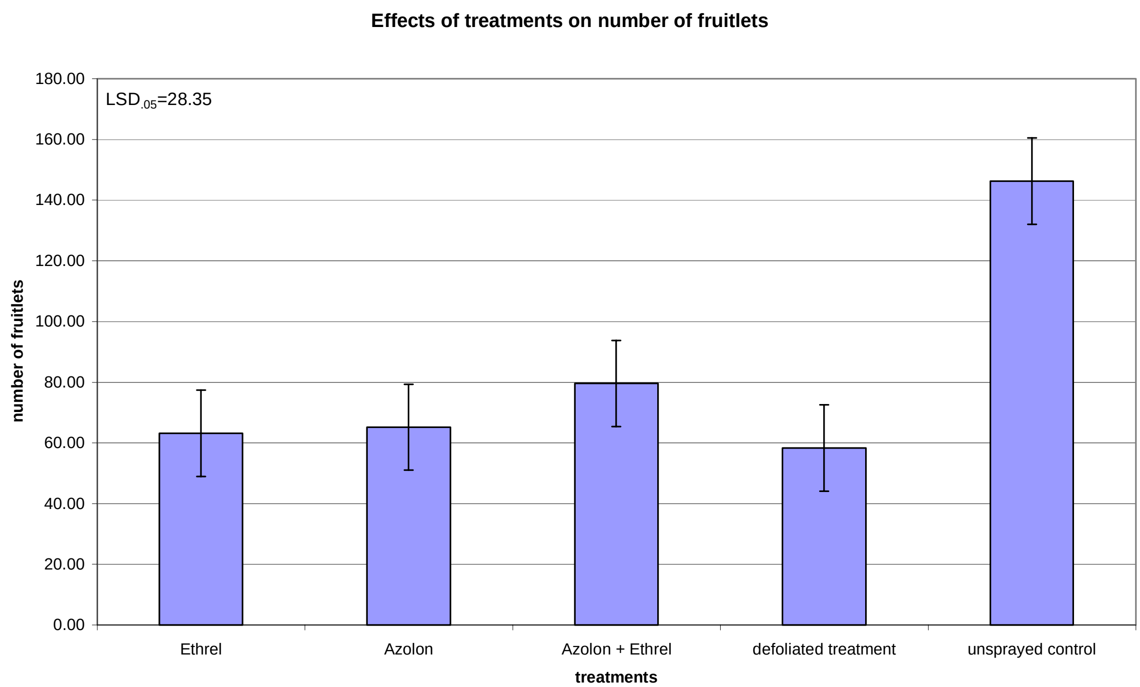

Fig 5 Effect of treatments on the number of fruitlets per 100 blossoms (2002)(first fruitlet count)

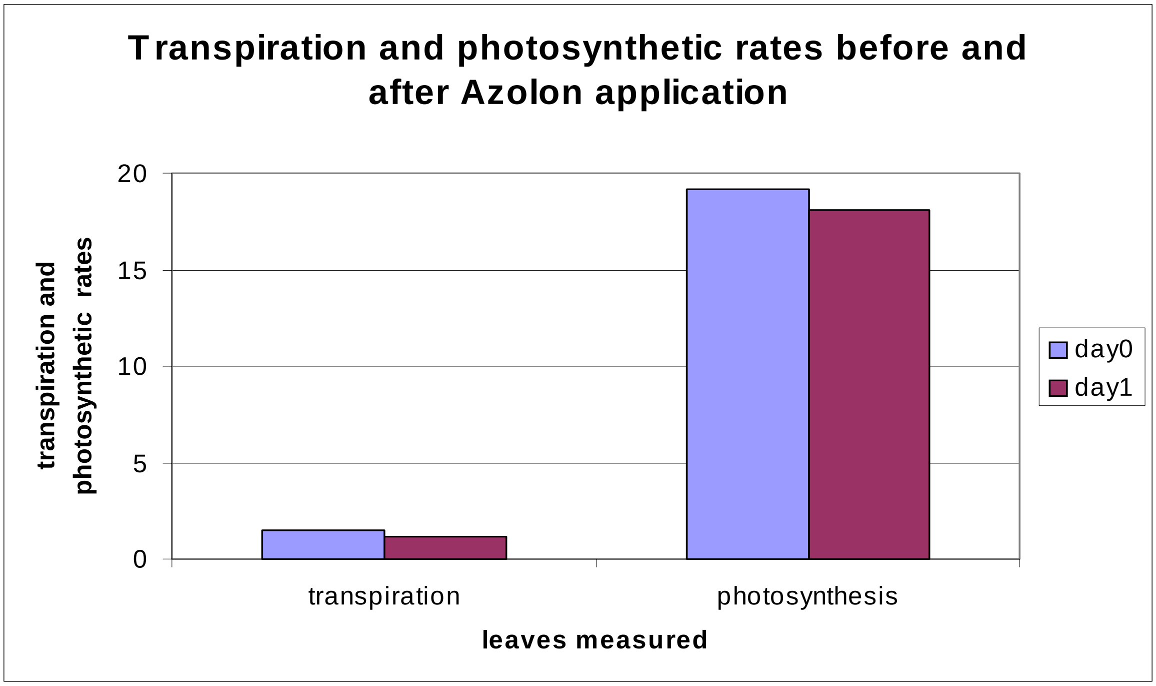

Fig. 6 Effect of Azolon application on transpiration and photosynthetic rates in the year 2002

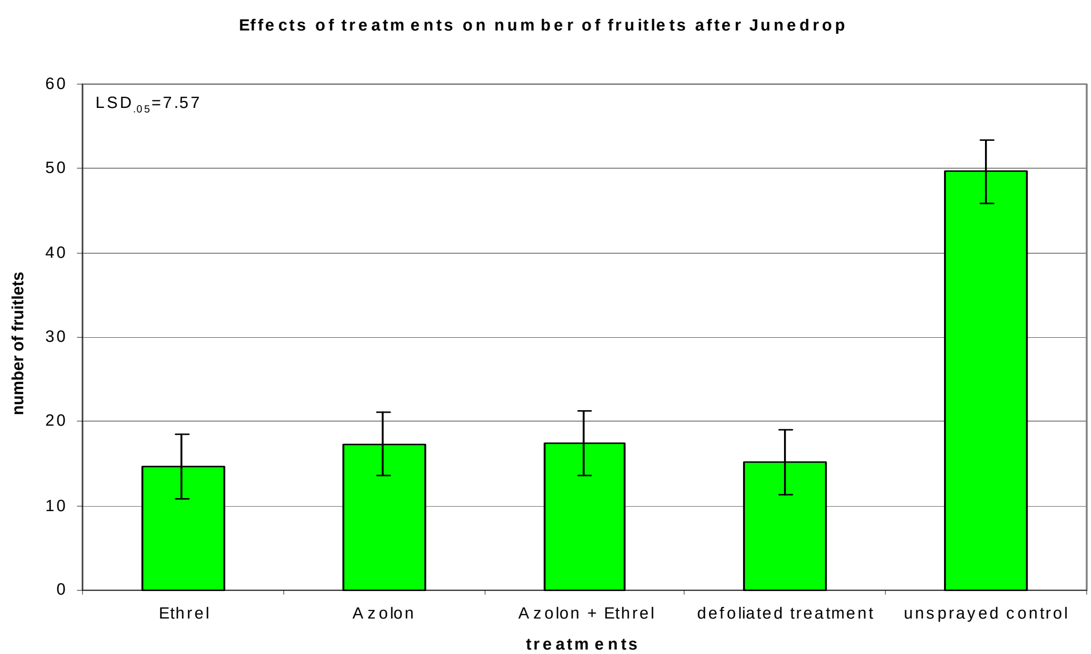

Fig. 7 Effects of treatments on number of fruitlets after June drop in the year 2002

- In the year 2001 Ammonium thiosulpahte (ATS 1 and ATS 2), Amidthin plus Telmion and Amidthin plus Ethrel had no thinning effect (Fig 1).
- Thinning effects of Ethrel 500ml/ha and Ethrel 1000ml/ha were 40% and 67% respectively compared to unsprayed controls.
- Amidthin plus Ethrel reduced yield by 22% while Ethrel 1000ml/ha reduced it by 30%, and Ethrel 500ml/ha had no effect, with respect to unsprayed controls (Fig. 2).
- Only ATS 2 had 44% increase in yield while ATS 1 had no effect.
- Amidthin plus Telmion had 50% increase in yield.
- No treatments affected mean fruit weight.
- With respect to fruit diameter classification, the percentages of fruits in the preferred fruit diameter class I, i.e. 75 to 90mm were 71%, 70%, 68% and 60% for Amidthin plus Ethrel, Amidthin plus Telmion, ATS 2 and ATS 1 respectively (Fig. 4).
- In the year 2002, Azolon fluid had 55% reduction in fruit set in the first fruit set count before June drop while Ethrel had 56% and Azolon plus Ethrel 54%. The defoliated treatment also had 54% fruit set reduction as compared to the controls. After June drop the fruit set counts were 17%, 15%, 14%, 15% for Azolon fluid, Ethrel (Flordimex), defoliated treatment and Azolon plus Ethrel respectively as compared to the unsprayed controls. (Fig. 7).
- Transpiration and photosynthesis rates were reduced by 20% and 5% respectively one day after the application of Azolon (Fig. 6).

DISCUSSION:

The lack of effect of some of the thinners on fruit set could be attributed to environmental factors, cultivar effects, time of application effect and the concentrations used. (Weaver and Pool, 1971a, Weaver and Pool, 1971b). The weather conditions during the time of spraying and immediately after particularly temperature, humidity and wind velocity affect the efficacy of the chemical thinners. Ethrel at the two rates of 500ml/ha and 1000ml/ha had thinning effects which was higher at the greater concentration. This can be explained by the increased ethylene biosynthesis which led to reduced auxin biosynthesis and basipetal auxin transport to the separation zone (Untiedt and Blanke, 2001).

Most of the treatments used in 2001 particularly the nitrogen fertilizers increased yield due to their fertilizing effect which could have increased vegetative growth of the apple trees. The treatments increased fruit size due to their thinning effects which lowered fruit counts thus reducing competition for metabolites among the remaining fruit (Quinlan and Preston, 1968). In the year 2002 the treatments reduced fruit set. Azolon, Ethrel and the defoliated treatments all thinned equally. Following petal fall, fruit growth, leaf area, and shoot growth increases rapidly. There is a high demand for energy produced at these multiple centers of metabolic activity (Quinlan and Preston, 1971). Leaf photosynthesis is the main source of carbohydrates for the developing fruit. Apple fruit abscission after fertilization and during June drop has been attributed to competition for essential metabilites, including photosynthates, among individual fruit lets and between fruit lets and vegetative shoots (Abbott, 1960, Knight, 1980, Quinlan and Preston, 1971). Shading or application of photosynthetic inhibitors such as chemical thinners on leaf defoliation as in the present study, during this critical time, which reduces photosynthesis and thus the carbohydrates available, is the primary factor causing early apple fruit abscission (Arthey and Wilkinson, 1964; Ferree and Palmer, 1982).

CONCLUSIONS:

It can be concluded that:

(a) Early Ethrel application which causes thinning via release of ethylene (Flordimex at 300ml/ha) is effective, because ACC Oxidase levels are high in the late flowers at that time and basipetal transport is reduced.

(b) Photosynthesis plays an important role as early as the start of the apple blossom.

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RESPONSE OF VALENCIA ORANGE FRUITS *(CITRUS SPP)* TO METHODS OF CLEANING

Kioko V. And G. Ouma, Department Of Horticulture Maseno University
E-Mail : Kilundovk@Yahoo.Com

ABSTRACT

Citrus fruits are immensely popular worldwide for their flavour and nutrition. Water loss has remained the main cause of post harvest losses and poor quality for citrus fruits. Since post harvest losses in fresh fruit cannot be stopped but only slowed within certain limits there is need for research to determine alternative and affordable way of controlling fruit cleaning to minimize these losses. A study was carried out with the objectives of finding out how cleaning method affect shrinkage rate of citrus fruits, whether fruit cleaning could be controlled to minimize shrinkage, and whether cleaning method affect the shelf life of the fruits in storage. The study was carried out between May 2003 and August 2003 at Maseno University Department of Horticulture General Laboratory to investigate the effects of cleaning methods on shrinkage rate of citrus fruit. The experimental design was Complete Randomised Design (CRD) with 4 treatments and 3 replicates. The fruits to be cleaned where first soaked for a minute in SOPP soap and later subjected to treatments which included T_2 –fruit washed with brushes, T_3-fruit washed with running tap water, T_4-fruit brushed and waxed and T_1-fruit neither washed nor waxed as a control. Observations were made on shrinkage rate and visual fruit quality daily while fruit shelf life and also cleanliness were noted. The shrinkage rate of 'Valencia' oranges was increased 50% to 150% by cleaning the fruits with smooth bristle brushes. The fruit shelf life decreased by use of both brush cleaning and running tap water cleaning but in contrast was increased by brushing and waxing. The fruit visual quality was enhanced by brushing and waxing the fruits while brushing alone greatly reduced the fruit visual quality. Thus controlling the cleaning process is important to minimize shrinkage of fresh citrus fruit, maintain fresh fruit quality and increase the shelf life of the fruit. The study could be extended to cover parameters such as internal co_2 and respiration rate of the fruit.

INTRODUCTION

Citrus fruits are immensely popular worldwide for their flavour and nutrition. It originated in south East Asia and is now grown in the tropical-subtropical belt from 40° latitude North to 40° latitude South. Citrus has an important place in world fruit production. In addition to fresh fruit, there are many processed citrus products of high economic value of the citrus fruit.

Water loss is the main cause of post harvest losses and poor quality for citrus fruits. Losses in citrus fruit quality affect fresh fruits between harvest and consumption. The magnitude of post harvest losses in fresh market fruits in the developing countries is estimated to be 20-50 percent depending on the type of fruit. To reduce these losses producers and handlers must understand the biological and environmental factors involved in deterioration and use post harvest technologies that delay senescence and maintain the best possible quality. Post harvest losses in fresh fruits cannot be stopped but slowed within certain limits.

All fresh produce are high in water content and are thus subject to desiccation and the degree of water loss depend on the environmental factors as well as the treatments involved in the post harvest handling. Fruit shrinkage due to water loss result not only in direct quantitive losses (loss of salable weight) but also in losses in appearance (wilting) textural quality (flaccidity, loss of juiciness) and nutritional quality.

For many years citrus fruits have been prepared in packing houses for the fresh produce market by washing, treating with fungicides, and applying coating. Currently virtually all citrus fruits are coated despite the flavour degredation that often results.

LITERATURE REVIEW

Taxanomy

Citrus belongs to the family Rutaceae and sub-family Aurantiodeae which contain an orange or lemon like fruit classified as a hesperidium or berry of special structure. These fruits are characterised by a juicy pulp made of vesicles within segments. There are only three genera in this sub-family (citrus, fortunella and poncirus), which produce edible juice vesicles (swingle and Reece, 1967).

Sweet oranges (citrus sinensis)

Sweet oranges are divided into three groups: blood, Navel and common oranges. Blood oranges have a pink to red colour, in flesh, juice and rind. The Navel oranges group has a small secondary fruit that is pushed to the stylar end of the primary fruit giving a belly-button appearance. All other cultivars belong to the common group of oranges. The most important cultivar in the latter group is “valencia” due to its adaptability, abundant juice of excellent colour, good flavour, and paucity of seeds. Oranges store well on the tree and therefore have an extended harvest season (Cooper and Chaput, 1977; Samson, 1986).

Fruit anatomy

Anatomically, citrus fruits are superior ovaries composed of 6 to 20 united carpels, which form locules (Albrigo and carter, 1977; Roth, 1977). The pericarp exterior to the locules is subdivided in to the exocarp (flavedo or exterior peel), mesocarp (albedo or interior peel) and endocarp locule or segment membrane). The juice vesicles which are the edible portion of citrus fruits are therefore of economic value, arise from epidermal or sub-epidermal primordia on the surface of the endocarp and grow to fill the locule cavity (Roth, 1977). The flavedo or exocarp, which is the coloured portion of the peel, contains pigments in chloroplasts and oil glands formed by special cells that produce terpenes and oils. Flavedo epidermal cells produce cutin and waxes and contain actinocytic type stomates (Roth , 1977).

Albedo is the mesocarp or white albedo portion of the peel, consist of colourless cells which are typically parenchymous, highly vacuolated and tube like (Albrigo and carter, 1977). The peel made up of the albedo and flavedo together is called rind; contain more bitter principles and pectin than other parts of the fruit (Albrigo and carter, 1977). The juice vesicles are highly complex, giving rise to juice sacs, which are classified as both “emergences” and multicellular hairs (Roth, 1977).

Fruit harvest

Citrus fruits are harvested when the fruits Brix/acid ratio is about 10 to 16 and the fruits are considered to be of acceptable quality. They are mostly harvested through hand picking or by mechanical method and the harvested fruits transported to packinghouses for fresh market or are diverted to a processing plant (Samson, 1986).

Post harvest handling

Fruits are cleaned, sanitised in water with chlorine or hypochlorus acid of sodium ortho-phenylphenate (sopp) and waxed (Salunkhe and Desai, 1986). Coated fruits are commonly said to be waxed although many coatings contain no wax. One reason for waxing citrus and other fruits is to reduce shrinkage due to water loss (Hardenburg, 1967; Kaplan,

1986), however before fruits are waxed they are washed an operation that increases water loss. Waxing of citrus fruits is used mostly for enhancing appearance and reducing water loss by about 30-40%, especially if the commodity is exposed to less than optimal temperature and relative humidity conditions (Miller and Brown, 1973). An increasing number of customers however, prefer unwaxed fruits, a more effective (and possibly more expensive) alternative to waxing is wrapping individual or multiple units of the commodity with thin polymeric films that restrict water vapuor movement without significantly altering diffusion of oxygen, carbon dioxide, and ethylene (Preece and Read, 1993).
Washing navel oranges with brushes increased the shrinkage rate by 40% when measured after one week of storage at 24° C (Miller and Brown, 1973). Waxing citrus fruits reportedly decreases the shrinkage rate to 70% of that of washed fruit (Hall, 1981). Washing and waxing together according to these figures would restore the shrinkage rate to that of non-treated, field run fruits.

Post harvest physiology
Respiration of oranges was reported to be a function of oxygen tension in the orange of 0-8% oxygen with anaerobic reactions occurring below 2.5% oxygen. Application of waxes to citrus can affect respiration and internal atmosphere composition. The problem with this procedure is that there is a trade off between reduced water loss and the development of anaerobic conditions in the fruit resulting in off-flavours due to increased internal ethanol, acetaldehyde and Carbon dioxide and decreased internal oxygen (Vines and Oberbadier, 1961; Cohen et.al, 1990). Similar results, except for retardation of water loss were observed when citrus fruits were subjected to low oxygen storage (Shaw et.al, 1990). Use of semi-permeable edible coatings on oranges resulted in decreased internal oxygen and increased internal carbon dioxide, increased level of ethanol, methanol and some important flavour volatiles in the juice (Nisperos-carriedo et.al, 1990).

Fresh fruits are living tissues subject to continuous change after harvest. They do vary greatly in their storage potential, which is related to their degree of perishability (Preece and Read, 1993). The dermal system governs the regulation of water loss by the fruit, the rind is composed of surface waxes, cutin embedded in wax and a layer of mixture of cutin, wax and carbohydrate polymers (Preece and Read, 1993). Transpiration rate is influenced by internal or commodity factors and external or environmental factors (temperature, relative humidity, air movement and atmospheric pressure). Transpiration is a process that can be controlled by applying treatments to the commodity (examples are controlled cleaning, waxes and other surface coatings) or by manipulating the environment (Preece and Read, 1993). The present work is undertaken to determine whether fruits washing could be controlled to minimise shrinkage thus reducing dependence on wax for that purpose.

OBJECTIVES

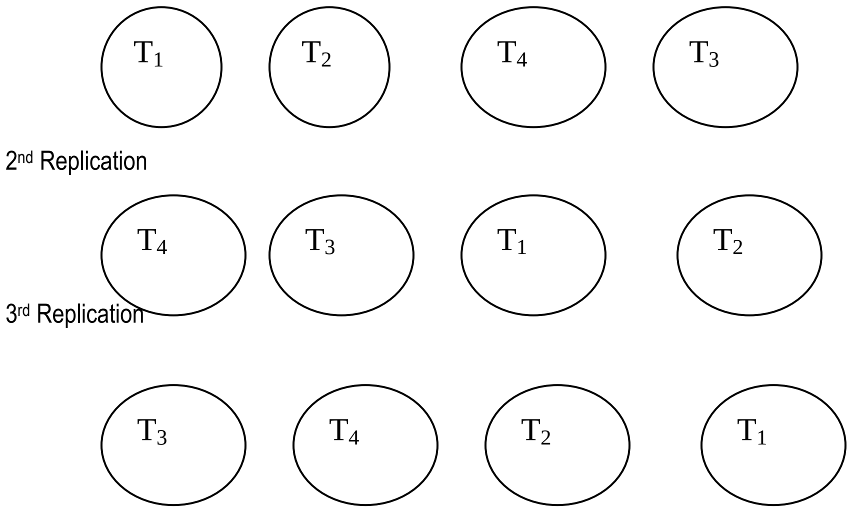
1. To investigate how cleaning method affects shrinkage rate of citrus fruit.
2. To investigate whether citrus fruit cleaning can be controlled to minimize shrinkage, thus reducing dependence on wax for that purpose.
3. To establish if cleaning method affect the shelf life and visual quality of the citrus fruit in storage.

HYPOTHESES
Cleaning method affects shrinkage rate of citrus fruit.

MATERIALS AND METHOD
The study was carried out at Maseno University Department of Horticulture, General Laboratory between May 2003 to August 2003. The Valencia oranges were freshly harvested on 19 June 2003 from Kibos Prison Farm Kisumu. The fruits were divided at random to treatment groups. The fruits to be cleaned were soaked for a minute in SOPP soap, which contained sodium o-phenylphenate and unspecified surfarcantants. The clinser was diluted with water according to the manufacturers recommendation. A group of 5 fruits were hand cleaned with standard packinghouse type brushes for 5 seconds per fruit and cleaned after 15 minutes once again in the same way. The treatment was replicated three times.

Another group of 5 fruits were hand cleaned with running tap water for 5 seconds and immediately dried with a towel and the treatment replicated three times. A third group of fruits was hand cleaned with smooth bristle brushes for 5 seconds then coated with 1mm thick layer of wax on its surface and replicated three times. A forth group of 5 fruits was neither washed nor waxed and served as a control. The cleaned fruits were placed on the benches at room temperature (22^{0}c) conditions in the laboratory.

Storage arrangement in the laboratory
1st Replication



Key
T_1-control
T_2-brush washed
T_3-washed with running tap water and immediately dried with a towel
T_4-brushed and waxed

The experimental design was Complete Randomized Design (CRD) with 4 treatments and 3 replicates. Observations were made on fruit cleanliness, which was determined visually. Fruits were rated clean if ≤1sq. cm of the area appeared soiled. Post cleaning fruit visual quality, which was determined visually. Fruits were rated visually using a scale of 1-5 on daily basis.

1-high quality (well turgid)
2-less turgid
3-mediumly turgid
4-flaccid
5-severly flaccid

Shrinkage rates were reported in units of daily weight loss as percent fruit weight determined by weighing the whole group of each replicate on an electronic weigh balance. Shelf life of cleaned fruits was determined by counting the number of days the fruit stored well before start of senescence process after cleaning. ANOVA was calculated by use of a calculator to determine whether the treatment had a significant effect using f –test at 5%, 1%, and 0.1% levels on all cleaning methods. After significant effects of treatments were determined multiple comparisons were made to separate the means of treatments using the least significance difference (LSD) at 5%level. I.e. students t test at p ≤0.05.

RESULTS AND DISCUSSION

Shrinkage rate
Preliminary results indicated that brush washed "Valencia" oranges lost weight at 1.73% in storage 1 day after cleaning compared to 1.20% for the non washed controls (5 seconds cleaning with smooth bristle brushes, 15 fruits per treatment).

Table 1: The effect of different fruit cleaning methods on percentage water loss (shrinkage rate) 7 days storage after cleaning

Treatment	Shrinkage rate (%)
T1	0.85
T2	1.18
T3	0.79
T4	0.12
Significance level P≤	0.05
$LSD_{5\%}$	0.19

The shrinkage rate of "Valencia" oranges brush washed and waxed was significantly (p<0.05) lower than that of non-washed controls 7 days after cleaning (Table 1). The shrinkage rate of water washed fruits was not significantly (p ≤0.05) different to that of the non-washed controls 7 days after cleaning (Table 1). The shrinkage rate of fruits was significantly (p ≤0.05) decreased by brushing and waxing as opposed to that of brushed fruits 7 days after cleaning (Table 1). The shrinkage rate of "Valencia" oranges hand washed with running tap water for 5 seconds and immediately dried with a towel was increased by 2% to 5% as compared to the non-washed controls 7 days after cleaning (Table 1). Therefore applying wax compensated for the increase in shrinkage rate caused by brush washing. These results are similar to those obtained from "Valencia" oranges coated with polyethylene wax in three Israeli packing houses (Ben-Yehoshua, 1967).

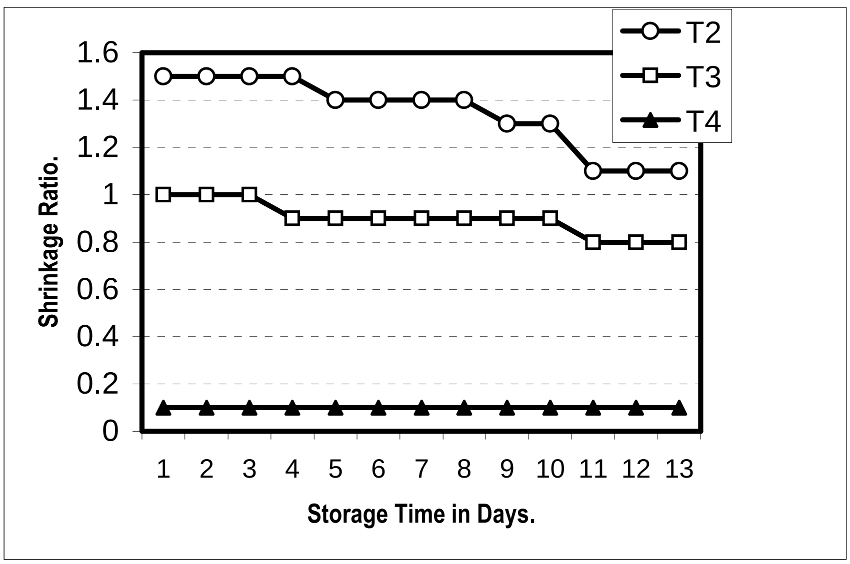


Figure 1. Weight loss rate of washed fruits divided by that of control for all cleaned fruits within 13 days storage period; Key: T1- Control, T2- Brushed, T3- Water washed, T4- Brushed and waxed

The brush washed fruits initially lost weight faster than the controls and thus had a shrinkage ratio >1.0 after storage for 7 days as compared to the non washed controls which lost water in a stable rate and thus had a shrinkage ratio <1.0 after storage for 7 days (Figure 1). The rate of shrinkage, was significantly (p ≤0.05) increased by brushing the fruits seven days after cleaning as compared to the non-washed controls (Table 1).

Fruit visual quality

Fruit visual quality significantly (p ≤0.05) declined after storage for 7 days from scale 1 (well turgid) to scale 5 (severely flaccid) when fruits were hand cleaned with brush as opposed to the controls which had no significant fruit quality change. The fruit visual quality significantly (p ≤0.05) declined after storage for 7 days when the fruits were washed with running tap water for 5 seconds in contrast to the non washed controls. Thus visual fruit quality declined faster for the brushed fruits as compared to water washed fruits. These results explained the properties of fruit washed with minimum abrasion in that the brush washed fruits experienced maximum abrasion, which led to high visual quality decline. Less abrasion was experienced by those washed with running tap water. The visual quality of the brushed and waxed fruit was not significantly ($p \leq 0.05$) different from that of non-washed controls. It thus implied that waxing compensated for the increase in water loss and subsequently any increase in quality loss.

Fruit shelf life

The shelf life of brush-cleaned fruits was significantly ($p \leq 0.05$) decreased as compared to the non-washed controls. Washing "Valencia" with running tap water for 5 seconds and dried with a towel decreased the shelf life of the fruits by 10% as compared to the non washed controls (table 2). But the method was not significantly ($p \leq 0.05$) different from the control with respect to fruit shelf life . The shelf life of brushed and waxed fruits was significantly ($p \leq 0.05$) increased as compared to that of water washed and also the brushed.

Table 2. Effect of different cleaning methods on "Valencia" oranges, on their shelf life 13 days after cleaning

Treatment	Shelf life(in days)
T_1	12
T_2	9.6
T_3	11.33
T_4	13
Significance	$P \leq 0.05$
$LSD_{5\%}$	1.2

The shelf life of fruits washed with tap water was not significantly ($p \leq 0.05$) different from that of non-washed controls (Table 2). The physiological explanation behind these results is that fresh fruits cleaned with maximum abrasion have their condition of openings in the peel (stomates, lenticels) changed due to injuries as a result of the abrasion, which increases the tendency of the fruit to lose water to the surrounding environment. The accelerated water loss causes the fruits to lose their turgidity and freshness then the fruits shrink. Water loss being the main cause of citrus post harvest losses; greatly affect their shelf life.

Fruit cleanliness

Of the brush washed fruits, 73% was acceptably clean compared to an average of 93% of brush washed and waxed fruits. Of the 15 water washed fruits 95% was acceptably clean and 50% of the un cleaned controls were rated clean. Thus brush washing was not as effective as methods currently used in the citrus processing industry. More thorough washing with brushes might have resulted in increased weight loss, quality decline and less fruit shelf life respectively.

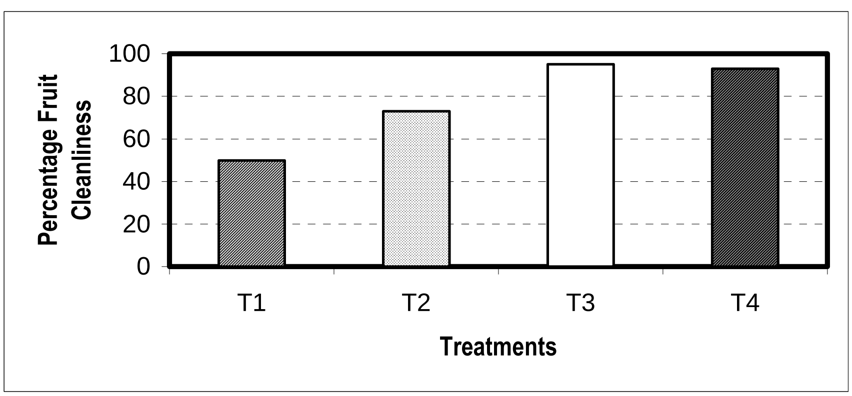


Figure 2. Effect of Cleaning methods on Fruit Cleanliness; Key: T1- Control; T2- Brushed; T3- Water washed; T4- Brushed and waxed

CONCLUSION

Shrinkage rate was virtually the same for non-washed controls. In contrast, brush washed fruits had a higher shrinkage rate than that of those washed with water. The visual fruit quality greatly decreased in brush washed fruits while the decline was less in water washed fruits. Fruit quality was significantly ($p \leq 0.05$) improved in brushed and waxed fruits compared to non-washed controls. The fruit shelf life was longer in brush washed and waxed fruits but short in brush washed fruits. The shelf life was virtually the same for water washed fruits and non-washed controls. Fruit cleanliness was highest with water washed fruits and lowest with the controls. The above results suggest that controlling abrasion during washing can yield citrus fruit with less shrinkage than that of fruit processed by present methods. Unfortunately literature on post harvest citrus treatment generally does not mention cleansers, brush types or brushing time; thus it is of little value as an information base for controlling washing. Whether it is possible to clean fruit to market conditions with minimal abrasion has not yet been demonstrated, however, results point to that possibility.

RECOMMENDATIONS

1. It is recommended that fruits be washed with as minimal abrasion as possible so as to greatly reduce fruit shrinkage and maintain fresh fruit quality.
2. It is recommended that fresh citrus fruit be handled with due care as rough handling may increase water loss and loss of quality due to possible injuries on the fruit surfaces.
3. It is recommended that brush washing of citrus fruit alone is not as effective as methods presently used in the industry and thus not appropriate for use and can be replaced by water washing.

SUGGESTIONS FOR FUTURE RESEARCH

It is suggested that research in this project could be more detailed with the inclusion of the following parameters:
1. Internal carbon dioxide to be determined using a gas chromatograph.
2. Respiration rate of the fruits.
3. Air flux to measure the tendency of airflow through a piece of fruit openings in its epidermis.

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POTENTIAL FOR CULTURAL PRACTICES IN SUSTAINABLE MANAGEMENT OF CATERPILLAR PESTS ON VEGETABLE CROPS IN KENYA

S. Sithanantham[1], J. Makatiani[3], C. M. Matoka[1], R. Raini[3], S.G. Agong[2], C. K. P. Ogol[3], J. Mueke[3] and G. Momanyi[1]
[1]International Center of Insect Physiology and Ecology (ICIPE), P. O. Box 30772, Nairobi, Kenya
[2]Jomo Kenyatta University of Agricultural Technology (JKUAT), Juja, Thika
[3]Kenyatta University (KU), P. O. Box 43844, Nairobi, Kenya

ABSTRACT

Cultural practices are mostly regarded as a compatible option under the Integrated Pest Management (IPM) approaches. Recent research in Kenya on two caterpillar pests–the Diamondback moth (DBM) (*Plutella xylostella* L.) and the African bollworm (ABW) (*Helicoverpa armigera* Hübner) of importance in vegetable crops have shown the potential for cultural practices, especially companion crops, in reducing the losses in yield and/or quality, caused by these pests. It has been found that reducing *P. xylostella* populations infesting cabbage/kale is possible through planting crops like Indian mustard in the vicinity as a useful 'pull' (attractant) crop. Tomato, coriander and Dek (*Cleome gynandra*) appear to be among promising candidates for evaluation as potentially repellent or non-attractive 'push' companion crops for cabbage/kale. The non-target effects of such companion crops, especially on important plant diseases on kale/cabbages, besides the natural enemies of *P. xylostella* have been monitored only empirically and need further assessment. On-station, 'small plot' studies on tomato as a target crop, has shown the potential of short duration pigeonpea as a 'trap' crop for diverting the oviposition by *H. armigera* adults. Further studies to elucidate the mechanisms and to refine them as easily adoptable agronomic practices are recommended so as to include these cultural options as components of Integrated Pest Management (IPM) in the vegetable cropping systems in the region.

Background

The African bollworm, *Helicoverpa armigera* and the Diamond backmoth, *Plutella xylostella* constitute important constraints as caterpillar pests in vegetable production in Africa (Ikin *et. al*., 1993). The diamondback moth has become the most destructive and numerous caterpillar pest on brassicaceous plants throughout the world, and the annual cost for managing it is estimated to be US $ 1 billion (Syed, 1992; Talekar, 1992). Verkerk and Wright (1996) have reported that *P. xylostella* can cause more than 90% crop loss. *H. armigera* has been reported to cause upto 71.5% vegetable yield loss (Mabeza 2000). It is found by vegetable farmers that resorting to sole use of synthetic pesticides is not sustainable (Sithanantham and Matoka, 2001). There is therefore need to evolve safer alternatives and combine them beneficially, as part of an Integrated Pest Management (IPM) strategy, especially in intensive production systems involving supplementary irrigation (Sithanantham *et al*., 2002).

The range of host plants that *P. xylostella* attacks is restricted to members of the Brassicaceae family, which contain glucosinolates that degrade into volatile mustard oils (Salinas, 1986). Members of this family occur in temperate and tropical climates and represent a diverse, widespread and important plant group. Many glucosinolates stimulate feeding in *P. xylostella*, but two of these (3-butenyl and 2-phenylethyl) are toxic to them at high concentrations (Nayar and Thorsteinson, 1963). Sinigrin, sinalbin and glucocheirolin act as specific feeding stimulants for *P. xylostella* hence plant species containing one or more of these chemicals serve as hosts. Non-host plants may contain these stimulants but also contain feeding inhibitors (Gupta and Thorsteinson, 1960). Sulfur-containing glucosinolate or its metabolites, allyl isothiocyanates, act as oviposition stimulants in brassicas (Reed *et al*., 1989).

P. xylostella primary hosts include head crops (namely; *Brassica oleracea* var. *capitata* L. {cabbages}, *Brassica oleracea* var. *botrytis* L. subvar. *cymosa* {broccoli}, *Brassica oleracea* var. *botrytis* L. {Cauliflower} and *Brassica oleracea* var. *gemmifera* {Brussels sprouts}), leafy crops (namely; *Brassica oleracea* L. var. *acephala* {collards}, *Brassica oleracea* L. var. *alboglabra* {kale}, mustard greens and turnip greens) and root crops (namely; *Brassica rapa* var. *pekinesis* {turnip}, *Raphanus sativus* {radish} and *Brassica oleracea* L. var. *gongyloides* {kohlrabi}. Studies on food plant preference of *P. xylostella* have revealed that among several brassicas, *P. xylostella* exhibits a marked preference for cauliflower and cabbage. This is probably due to the fact that both plants possess fleshy and succulent leaves compared to the rest of the brassicas tested and this probably provides olfactory and gustatory stimuli for successful host selection and development (Singh and Singh, 1982). In addition, *P. xylostella* feeds on numerous brassicaceous plants that are considered to be weeds. They maintain themselves on these weeds only in the absence of more favoured cultivated hosts (Talekar and Shelton, 1993).

Cultural control may not by itself reduce the pest population to below economic threshold level, but it is one of the oldest and most effective methods in reducing losses due to insect pests (Glass, 1975). Classical control measures that have been tested and recorded some success are irrigation, mulching, manuring and fertilization, intercropping (Helenius, 1989), trap cropping (Hokkanen, 1991), rotation and clean cultivation among others. The earliest successes of using intercropping as a pest control measure occurred in Russia where intercropping cabbage with tomato reduced damage to cabbage by several pests (including *P. xylostella*) (Vostrikov, 1915). This practice had only limited success in India (Srinivasan, 1984; Chelliah and Srinivasan, 1986), Philippines (Magallona, 1986) and Taiwan (AVRDC, 1985). In Taiwan, 54 crops were tested for their usefulness in intercropping and none had any significant impact on the population of *P. xylostella* on cabbage.

In this paper, recent and current research results involving beneficial association of crops as a potential component of IPM strategy for sustainably managing these pests in Eastern Africa is discussed.

Potential of crop association to benefit pest management

The planting of beneficial crops that could divert or suppress the pest build up and/or possibly promote natural biological control is a potentially promising approach to habitat-based management of pests. The major approaches to beneficial crop associations are as follows:

i) To plant more attractive (trap) crops to divert the onset of infestation
ii) To plant 'repulsive' crops in the neighborhood so to avoid the onset of infestation
iii) To plant taller crops that could act as physical barrier to onset of infestation
iv) To plant profuse flowering plants that can support parasitoids through nectar

Research on potential companion crops for Diamond backmoth (DBM)

Background and Past efforts

Before the advent of modern chemical insecticides, a common practice was to plant strips of an economically less important plant highly preferred by *P. xylostella* within a commercial crucifer field (Kanervo, 1932). The preferred crops, primarily white mustard (*B. hirta*) or rape (*B. juncea*) attracted *P. xylostella* adults, which spared the commercial crop such as cabbage and Brussels sprouts from its attack (Ghesquiere, 1939). Due to insecticide resistance problems, trap cropping is becoming a more realistic alternative especially in developing countries. In Florida, when two rows of collard green (*Brassica oleracea* var. *acephala*) were planted between two cabbage fields, high *P. xylostella* larval infestation was observed on collard than on cabbage on the adjacent fields (Mitchell *et al.,* 1997). The study also showed that collard can play an important role in maintenance of the natural enemy, *Diadegma insulare* (Cress) (Hymenoptera: Ichneumonidae). Major benefits of trap cropping are that they yield commercially valuable commodities and the main crop seldom needs to be treated with insecticides; thus, natural control of pests may remain fully operational in most of the field.

The disruptive factors of host-plant finding and colonization by diverse habitats include the olfactory cues that certain insects rely on for host finding (Stanton, 1983). For example, Buranday and Raros (1973) observed significantly more *P. xylostella* adults and eggs in a plot of cabbage as the sole crop than in a plot of cabbage-tomato intercrop. This is presumably because of the repellent effects of tomatoes. A study by Talekar *et al*. (1986) in Taiwan has also indicated the useful effect of garlic intercropping in reducing *P. xylostella* infestation on cabbage. Other factors are physical barriers to movement (Perrin and Phillips, 1978) and other adverse environmental effects such as shading (Risch, 1981) where the pest tends to remain in the intercrop for a shorter period of time simply because the probability of landing on a non-host plant is increased. Inhibition of visual orientation can be achieved by intracrop diversity as with high-density cropping.

Host-plant finding also often involves olfactory mechanisms, and host-plants grown in association with unrelated plants may be an important component in the defence against herbivores, the non-host plant odours leading to disruption of the host-finding behaviour of the insect based on odour cues. This type of protection is known as "associational resistance" (Tahvanainen and Root, 1972). It derives from the masking effect of the non-host plant odours of the host-plant odour causing a reduction in plant apparency, i.e., making the host-plant less easy to find (Feeny, 1976). This effect has been demonstrated in collards interplanted with tomato or tobacco on the flea beetle, *Phyllotreta cruciferae* (Root, 1973) and *P. xylostella* (Buranday and Raros, 1973) and carrot fly on carrots interplanted with onions (Uvah and Coaker, 1984). In the latter example, reduction in infestation occurred only when the onion leaves were expanding and not when the plants had started to bulb, suggesting that the masking odour emanated from young leaves only. Other aromatic herbs have been claimed to be repellent to vegetable insect pests, mostly by organic gardeners.

Therefore, use of companion crops can make a contribution to Integrated Pest Management systems whose long-term benefits might overweigh some of the short-term economic and environmental costs of present-day chemical control methods and thus provide a beneficial socio-economic option to the Kenyan agriculture. It has been observed that cabbage intercropped with tomatoes had significantly lower *P. xylostella* adults and eggs than in cabbage monocrops (Buranday and Raros, 1973). In Mauritius, cabbage intercropped with garlic, coriander and tomato showed similar results on cabbage (Facknath *et al*., 1998). Other aromatic herbs have also been claimed to be repellent to insect pests of vegetable crops (Hills, 1992), but little experimental work has been done in Kenya to substantiate these claims. Increased plant diversity through companion cropping has also led to an increase in natural enemies' effectiveness (O'Donnell and Coaker, 1975). Therefore, an understanding of how a host plant is located by insects and how they can be disrupted by non-host plants in their vicinity, which provide the camouflage, diversionary or repellent compounds found in diverse ecosystems is vital before utilising companion crops in pest suppression. There have been earlier reports on the potential of Indian mustard and kale/rape seed as more attractive plants that could be used as trap "pull" crops for DBM in cabbage. It has been found that crops like coriander and *Cleome* can be repulsive to infestation by DBM on cabbage (Raini, 2002). However, efforts to compare and combine with repulsive ("push") crops have been limited. Laboratory studies by Makatiani (2003) had shown that fewer eggs were laid on cabbage when the leaves are placed along with those of tomato, coriander or *Cleome* (**Fig. 1**).

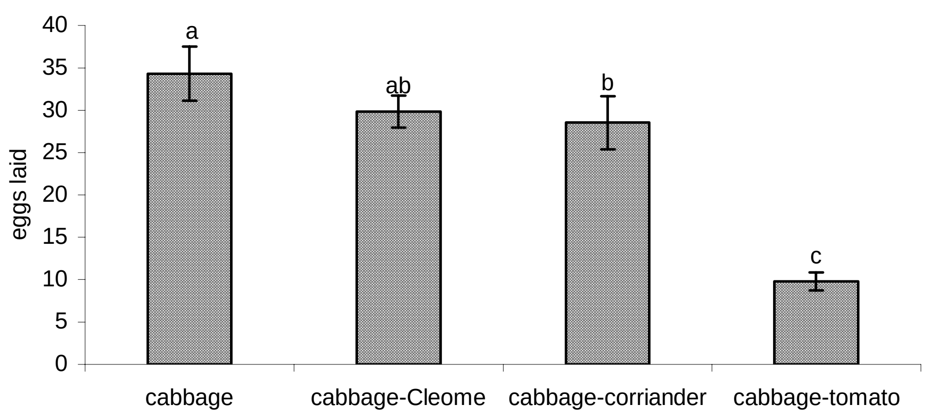

Fig 1: Eggs laid on sole-cabbage and cabbage planted with repulsive companion crops, Juja, Kenya, 2003

Present study

Field trials were conducted during 2001 – 2002 at Juja (JKUAT farm) with cabbage as sole crop (both unprotected as well as protected with a non-synthetic pesticide – Dipel), in comparison with cabbage intercropped (2 rows cabbage: 1 row intercrop) with any of the 'attractant' or 'repulsive' companion crops, in replicated plots. The onset of infestation (egg number), the sustenance of infestation (larval numbers) and crop damage (score for foliar damage) were periodically assessed on ten randomly tagged plants. The extent of eggs laid on cabbage was found to be reduced by 71.4% when planted with tomato as intercrop (**Fig. 1**). The contribution of attractive (pull) crops like Indian mustard, versus the repulsive (push) crop has been verified in terms of reduced larval infestation (**Fig. 2**) and concurrent reduction in crop damage (**Fig. 3**). In addition, it has been found that these companion crops do not adversely affect the crop ecosystem in terms of the activity levels of natural enemies like parasitisation of the larval stage of the pest (**Fig. 4**).

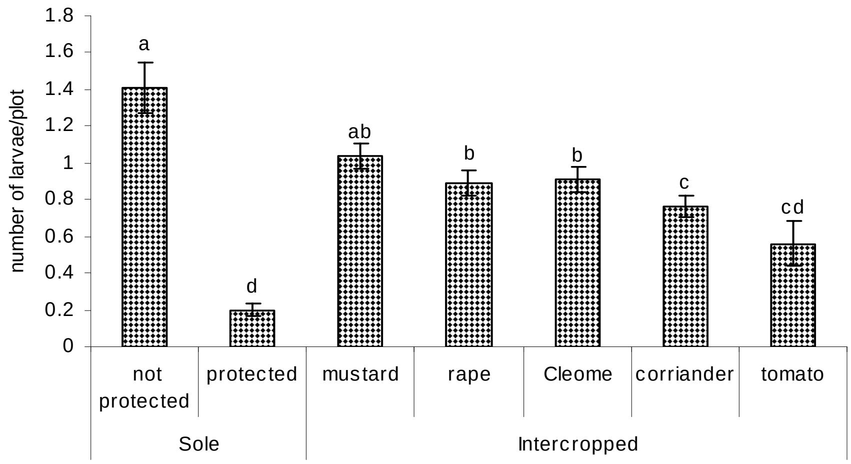

Fig 2: Larval infestation on cabbage inter-planted with five companion crops, Juja

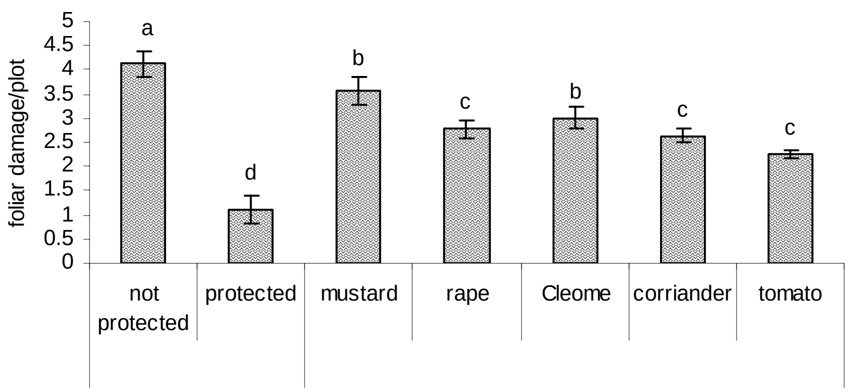

Fig 3: Foliar damage caused by DBM Larvae on cabbage inter-planted with five

The present studies as well as follow up field trial (Makatiani, 2003) have shown the potential for utilizing an attractant "(pull)" crop like Indian mustard and repulsive "(push)" crops like coriander or tomato to minimize DBM infestation on cabbage or kale. Further studies are required to validate the benefits of such a push-pull strategy in bench mark sites, as well as evolving a basket of options to suit the climate / season / crop end use so that the 'push-pull' concept is rendered dynamic and flexible to respond to local needs.

Research with beneficial companion crops for diverting *Helicoverpa* infestation on tomato / okra

Past efforts:

Crops like marigold (*Tagetus* spp.) have been found to attract greater egg laying (oviposition) by *H. armigera* on them when planted in the vicinity of tomato crop (Srinivasan *et al*., 1993). Studies have been undertaken recently in Kenya in which, short duration pigeonpea (ICPL. 87019), found to attract more egg laying by *H. armgiera* than on tomato or okra (Sithanantham, 2003; Kariuki *et al*., 2003).

Present studies:

Small plot experiments were conducted at Mwea during 2002 – 2003, by planting tomato (cv. CalJ) and okra (cv. Pusa sawani) in plots as sole crop and with pigeopea as intercrop. Observations were made on the extent of oviposition in these crops under 'sole' and 'intercrop' situation. The results (**Fig. 5**) showed that intercropped okra and pigeonpea hosted less *H. armigera* eggs per plant, compared to sole crop plots, indicating the potential benefit of intercropping with pigeonpea. Further studies for optimizing the intercrop proportion and choice of suitable varieties for the major climates would be critical for developing this approach to a potential push-pull system of production.

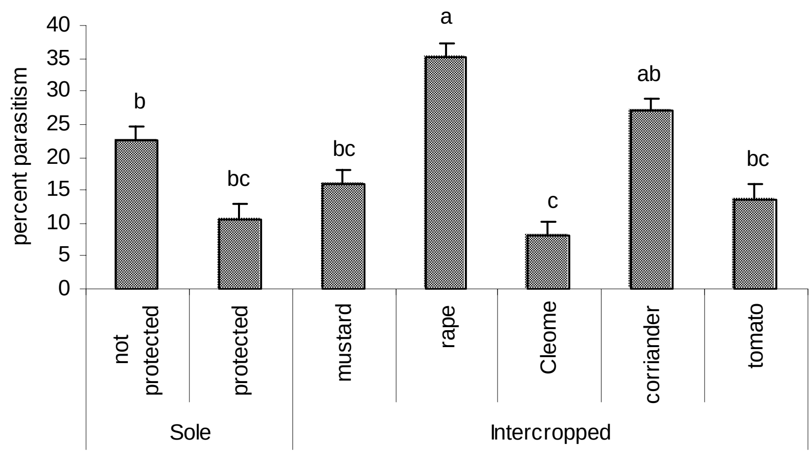

Fig 4: Rate of larval parasitism of DBM on cabbage inter-planted with five companion crops, Juja, Kenya, 2003

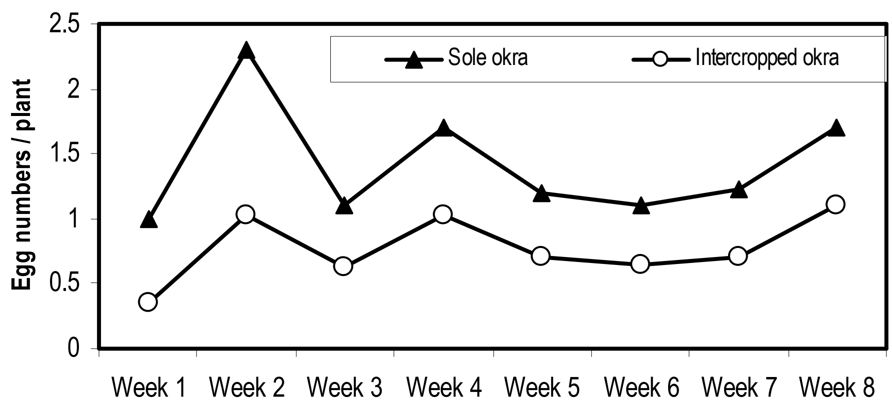

Fig 5: Eggs laid on sole-cabbage and cabbage planted with repulsive companion crops, Juja, Kenya, 2003

THE WAY FORWARD:

It is visualized that a 'push-pull' strategy could be evolved, with a dynamic model for adding / deleting the companion crops according to local / changing needs, so to empower smallholder farmers with access to beneficial crops that can help reduce losses caused by the common caterpillar pests in Eastern Africa.

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EVALUATION OF TWO NEEM PRODUCTS FOR CONTROL OF SOME INSECT PESTS ON CUCUMBER, *CUCUMIS SATIVUS* L. IN KENYA

[1]C. M. Matoka, [1]S. Sithanantham and [2]C. K. P. Ogol
[1]International Center of Insect Physiology and Ecology (ICIPE), P. O. Box 30772, Nairobi, Kenya
[2]Kenyatta University (KU), P. O. Box 43844 Nairobi, Kenya

ABSTRACT

In Kenya, cucurbits are important group of export vegetables. Recent studies on cucumbers (*Cucumis sativus* L.) have shown that several insect pests attack the crop in vegetative and reproductive growth stages, resulting in substantial losses of marketable yield. The present study, undertaken during 1998 – 2000, at Kibwezi (Eastern Province) and Kasarani (Nairobi Province), evaluated two products derived from neem, *Azadirachta indica*, namely neem seed cake powder (Neemros®, aza – 0.5%) and neem oil (Neemroc®, aza – 0.03%), in comparison with the synthetic pyrethroid, lambdacyhalothrin (Karate®). Observations in two field trials indicated that Neemroc® provided a significant reduction in whitefly (*Bemisia tabaci*) infestation, while Neemroc®, Neemros® and Karate caused in significant reduction of leaf beetles (mainly Chrysomelids). Also Neemros® sprays significantly reduced the proportion of fruit fly damaged fruits. Further studies are recommended towards optimising the dose rate and number of applications required for economical pest control, especially during the reproductive stage, so as to maximize the marketable yield. Organoleptic tests and storage effects of the neem treatments should also be undertaken to ensure that market driven quality attributes are taken into consideration as noble pest management options are sought.

Introduction

Cucurbits are emerging as important income generating crops in Kenya for both urban and export markets. The crop production constraints include pest and disease infestation and the lack of safer control options than pesticide use, which can pose human health risks. Chemical control, although outside the realm of peasant agriculture, continues to be a common recommendation for insect pest control (Mensah, 1988). Besides high costs (Nangju *et al*., 1979; Olowe *et al*., 1987), increased adoption of insecticide - dependent pest control technology may harm agriculture and natural ecosystems in the long run (Olowe *et al*., 1987). Further, the possibility of target pests developing resistance to insecticides cannot be excluded together with the issue of residual effects in marketable products like cucumber fruits eaten raw or as salad (Beevi *et al*., 1992).

Due to the concerns and limitations associated with pesticide use, interest has grown for use of safer alternative pest reduction means like cultural methods such as intercrops (Dissemond and Hindorf, 1990; Ampong *et al*., 1994) and pest control agents derived from plants (Schmutterer, 1990) in combination with biological agents so as to minimise frequency of insecticide applications (Mensah, 1988). Botanical pest control is a traditional method with not so much of innovation and it is a return to an old approach with a new ecological understanding of environmentally friendly pest control measures for sustainable long-term food sufficiency (Saxena, 1988). The present study sought to evaluate the efficacy of two neem products so as to provide safer pest control alternatives to the farmers, since neem products are locally available, cheap and easy to prepare.

Materials and methods

Sites description

The investigations were conducted at International Centre of Insect Physiology and Ecology (ICIPE) on its experimental field station at Kenya Institute of Special Education (KISE), and at the University of Nairobi's Institute of Dryland Research Development and Utilization (IDRDU) Kibwezi Farm.

Field trial layout

The study consisted of four treatments listed below and replicated five times in a completely randomised block design (CRBD).

T_1 – No spray (Control)
T_2 - Karate® /Dimethoate® alternate spray (2ml/l)
T_3 - Neem oil spray (20ml/l)
T_4 - Neem powder spray (50g/l)

The two neem products (powder and oil) tested are manufactured by Saroc Company Limited. The neem seed cake powder (NSCP) known as (Neemros®) which contains 0.5% azadirachtin while neem oil (Neemroc®) extracted from the neem seed cake has azadirachtin content of 0.03%. The neem oil (Neemroc®) suspension of 0.03% azadirachtin was prepared by mixing 30ml of oil to a litre of water whereas (Neemros®) was prepared at a dosage of 50g/L.

Data collection

Data collection for insect infestation was limited to leaf miners, whiteflies, thrips, beetles and fruit flies. All marketable sized fruits were harvested weekly from each plot by plucking them from vines. They were graded as "pest - damage free" (marketable) and "pest damaged" fruits, then counted and weighed using a scale balance. This was carried out in all the plots at different harvests. Fruits damaged by fruit flies alone were also counted and weighed separately and ten randomly selected fruits were later taken to the laboratory for dissection to record the number of larvae (maggots) and pupae. The yield loss during the vegetative and reproductive stages was estimated as the reduction in yield over the yield in plots that were protected at both stages and yield records were conducted similarly to that of yield loss experiment.

Statistical analysis
Analysis of variance (ANOVA) was performed on the data and the Student Newman Keul's (SNK) test was adopted as a post ANOVA test to rank the means of those that were statistically different (Sokal and Rohlf, 1981). The analysis was accomplished through SAS system version 3.12 of 1997.

Results
The overall insect infestation in the plots sprayed with the two neem products (oil and powder) is summarised in **Table 1**. Leaf miner incidence in cotyledonary leaves as well as true leaves was not significantly different (P>0.05) among treatments in the first season. In the second season, leaf miner incidence was significantly less (P<0.05) under neem oil, which had an equal level of control as the plots sprayed with karate. Neem oil recorded significantly less (P<0.05) score for whiteflies than the non - sprayed plots, while neem powder recorded a similar significant (P<0.05) reduction level in one season only. In both seasons, such reduction in neem plots was still not on par with the scores in the karate® protected plots. Leaf beetles were significantly less (P<0.05) in the plots receiving neem oil, neem powder or karate® than in non – sprayed plots in both seasons. However, the neem powder spray plots had an equal level of protection as the plots sprayed with karate® in both the seasons, while neem oil spray plots were on par only in the second season.

Interestingly, neem powder resulted in thrip levels equal to that of the plots sprayed with karate in the second season; neem oil recorded significantly less (P<0.05) thrips numbers than non -sprayed plots, but still significantly greater than in the other two treatments. In terms of damage by fruit fly, the intensity per infested fruit in the plots sprayed with neem oil or powder was significantly less (P<0.05) than in non sprayed plots. However, the intensity per infested fruit in the neem treatments was significantly greater (P>0.05) than in karate sprayed plots.

The leaf miners were relatively more abundant on neem powder treated than neem oil protected plots both at the cotyledonary (**Fig. 1**) and true leaf stage (**Fig. 2**), with the unsprayed plots recording the most and the insecticide treated plots the least infestation. The situation was similar for white flies, which were also observed throughout the plant growth stage (**Fig. 3**). Leaf beetles only appeared from the fourth week onwards, with the populations building steadily to the tenth week and later tapered off from the eleventh (**Fig. 4**).

Yields attained under protection by the neem products compared favourably with the chemical insecticide (lambdacyhalothrin/dimethoate) protected plot yields. Neem powder and oil protected plots gave 8.8 and 7.6kg/plot in season one and 9.8 and 6.2kg/plot of damage-free (marketable) fruits in seasons one and two respectively. These were significantly different from Karate®/dimethoate® and non-protected (unsprayed/control) plot yields of 10.8, 12.8kg and 3.8, 4.0kg respectively for seasons one and two (**Table 2**) at (P=0.0001) and (P=0.001).

The yield gain due to protection from pests recorded in the neem products efficacy test (**Fig. 5**) revealed that when no protection was offered, more than 65% and 69% of produced cucumber fruit yields in both season one and two respectively were lost. Protection offered by the neem product oil 30ml/l (aza. 0.03%) had a variable effect. In season one, yield loss resulting after protection was only about 30% where as in season two it was 52%. The neem seed cake powder recorded yield loss of 19% and 23.4% in the two trials, which were lower than the losses incurred in other treatments. This gave an indication that the neem products apparently conferred a substantial level of protection especially against fruit flies.

Discussion
The trials had shown the extent of pest control and yield benefits that could be derived from using the two neem products. In general the neem products tested were moderately effective, although less effective than the chemical pesticide check (Karate®) against the common pests observed. This is understandable since the modes of action of neem are many but more subtle, compared to the quick mortality caused by the contact toxicants. In neem literature, such trend of intermediate efficacy of neem products compared with chemical pesticides is very common. Neem products have been shown to be active against 198 different species of insect pests (beetles inclusive), while they apparently did not harm most of the beneficial insects such as pollinators, predators and parasitoids (Saxena, 1989; Saxena, *et al*., 1989; Schmutterer, 1988; 1990; 1995). The present results are in agreement with the trend of results of testing neem products on *Helicoverpa armigera* (Hübner) defoliating bean leaves (Parmar and Srivastava, 1987),

wherein they were moderately effective, but less effective than the cypermethrins, malathion and endosulfan. Since neem products are likely to be less expensive than synthetic chemicals in areas where neem seeds are readily available and the preparation of the extract is cheap and hence may be preferred for use as pest control products, farmers in such regions may find using it quite affordable. Neem products and *Cedrela ordata* (Spanish cedar) extracts have been recorded to deter striped cucumber beetle (*Acalyma vittatum*) from feeding on sprayed cucumber leaves (Jacobson, 1989).

Between the two neem products – neem powder and neem oil – there were differences observed in their relative efficacy on cucumber pests. Neem oil showed promise against leaf miners and whiteflies while neem powder was more effective on thrips; both were, however, equal in controlling the infestation by the fruit flies. Srivastava *et al*. (1986) reported that application of neem seed oil at 0.5%: water emulsion inhibit cucumber mosaic virus (CMV) through topical application. Both field and laboratory trials with formulated neem seed oil (NSO) and neem seed kernel extract (NSKE) have been found to show strong aphicidal effects on *M. persicae*. NSO has been reported to reduce aphid numbers in a dose - dependent manner with an estimated EC_{50} ranging from 0.2 to 1.4%. The effectiveness of the neem products in some trials appeared to be influenced by host plant, aphid species and weather conditions (Lowery *et al.,* 1997). Mishra *et al*. (1989) found that feeding 0.05% NSO to Epilachna beetle, *Henosepilachna* [*Epilachna*] *sparsa* (Hbst.) increased the duration of life stages in subsequent generations and reduced weights. Females of the beetle, when fed on 0.05% NSO treated leaves, showed longer pre-oviposition and shorter oviposition periods with long term effects on fecundity (Mishra *et al*., 1989). Jeyarajan and Babu (1990) reported anti-feedant activity of NSKE at 1000 ppm to the 4^{th} instar larvae and adult of the Epilachna beetle (*Epilachna sparsa* Hbst.). *E. dodecastigma* (weid.) larvae and adults exposed to leaf discs treated with NSO of concentrations ranging from 0.25 to 2.0% showed decreased feeding activity with increasing oil concentrations (Haque *et al*., 1996).

The present studies on field evaluation of neem products should be complemented by evaluation of their concurrent effects on the natural enemies, so that a more holistic assessment of the ecosystem benefits of the use of the neem products could be made. It would be also useful to undertake trials to optimise the dose rates of the promising neem products in order to derive the best economic impact possible.

Table 1: Pest scores/counts on cucumber crop in neem efficacy trials (2 seasons)

Pest infestation	**Season**	**Non sprayed (Mean ± SE)**	**Neem oil (Mean±SE)**	**Neem powder (Mean±SE)**	**Karate (Mean±SE)**	**C.V. (%)**
Cotyledonary leaf miners	S_1	4.8± 0.2a	3.2 ± 0.5a	4.8± 0.2a	1.6± 0.4a	37.2
	S_2	4.6± 0.20a	3.0 ± 0.2b	4.4 ± 0.2a	2.0± 0.4c	19.8
Leaf mine scores on true leaves	S_1	3.6 ± 0.50a	2.2 ± 0.2a	3.1 ± 0.5a	2.0± 0.3a	21.7
	S_2	4.4 ± 0.40a	2.4 ± 0.2b	4.0 ± 0.4a	2.6± 0.2b	19.2
Whitefly scores	S_1	4.6± 0.20a	3.0 ± 0.0b	4.4 ± 0.2a	2.0± 0.4c	19.2
	S_2	4.8 ± 0.20a	3.0± 0.3b	2.8 ± 0.4b	1.4± 0.2c	21.1
Thrips counts per 10 flowers	S_1	82.6±16.50a	51.4± 10.1a	26.4± 8.3a	28.2± 9.3a	56.4
	S_2	129.8±14.5a	82.2± 14.9b	46.0± 6.7c	39.4± 5.1c	17.8
Beetles counts per 5 plants	S_1	108.2±18.8a	61.2± 8.1b	21.6± 5.1c	17.6± 1.6c	31.8
	S_2	105.8± 22.0a	55.0± 4.7b	25.8± 3.4b	16.0±2.7b	42.9
Fruit flies per 10 damaged fruits	S_1	32.4±2.8a	21.4± 1.03b	18.6± 1.03b	14.6±1.08c	10.7
	S_2	29.4±2.3a	21.4± 1.03b	19.2± 1.40b	12.6±0.75c	10.0
Percent number of fruits infested	S_1	71.8±3.93 c	43.2± 3.57 b	34.0±3.86 b	29.6±3.00a	15.1
	S_2	72.0±9.28 b	59.6± 6.04 b	19.2±4.28 a	16.6±4.28a	21.6

Means followed by same letter within rows are not significantly different from each other (P=0.05), SNK test.

Table 2: Percent yield and weight of damage – free (marketable) fruit under the different neem products efficacy test, Nairobi, 1998 - 1999.

Treatments	Yield of damage – free (marketable) fruits (Mean ± SE) (Kg/plot)	
	Season one	Season two
Non sprayed (control)	3.8 ± 0.58 c	4.0 ±1.3 c
Neem Seed Oil (30ml/l, 0.03% aza.) spray	7.6 ± 0.51 b	6.2 ± 0.58 c
Neem Seed Cake Powder (NSCP) 50g/l, 0.5% aza. spray	8.8 ± 0.58 b	9.8 ± 0.57 b
Chemical spray	10.8 ± 0.73 a	12.8 ± 1.02 a
Coefficient of variation (%)	18.4	20.7

Means followed by same letter within columns are not significantly different from each other (P=0.05), SNK test

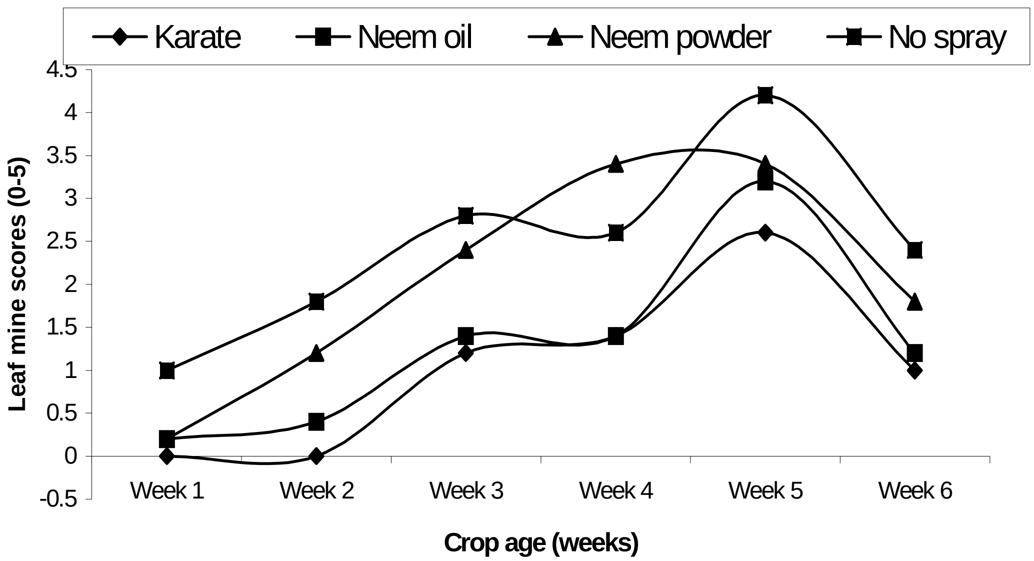

Fig 1: Relative abundance of cotyledonary leaf miners on cucumber in the neem products efficacy trial

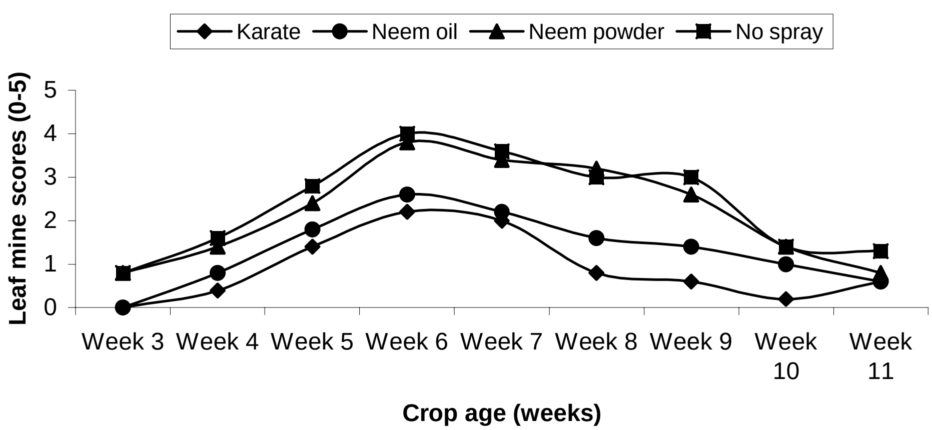

Fig 2: Relative abundance of true leaf miners on cucumber in the neem products efficacy trial

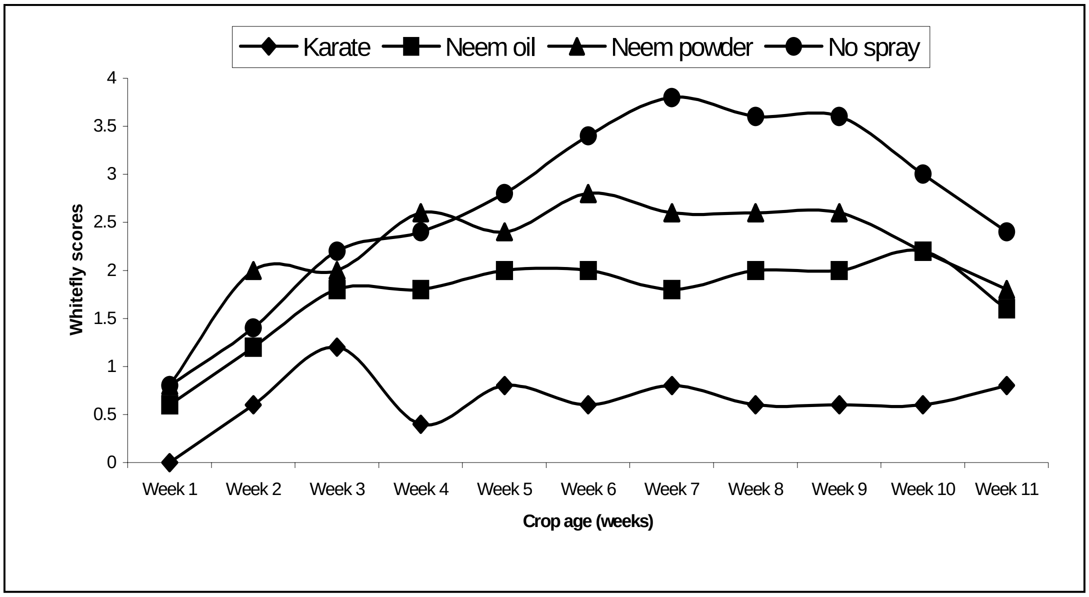

Fig 3: Relative abundance of white flies on cucumber in the neem products efficacy trial

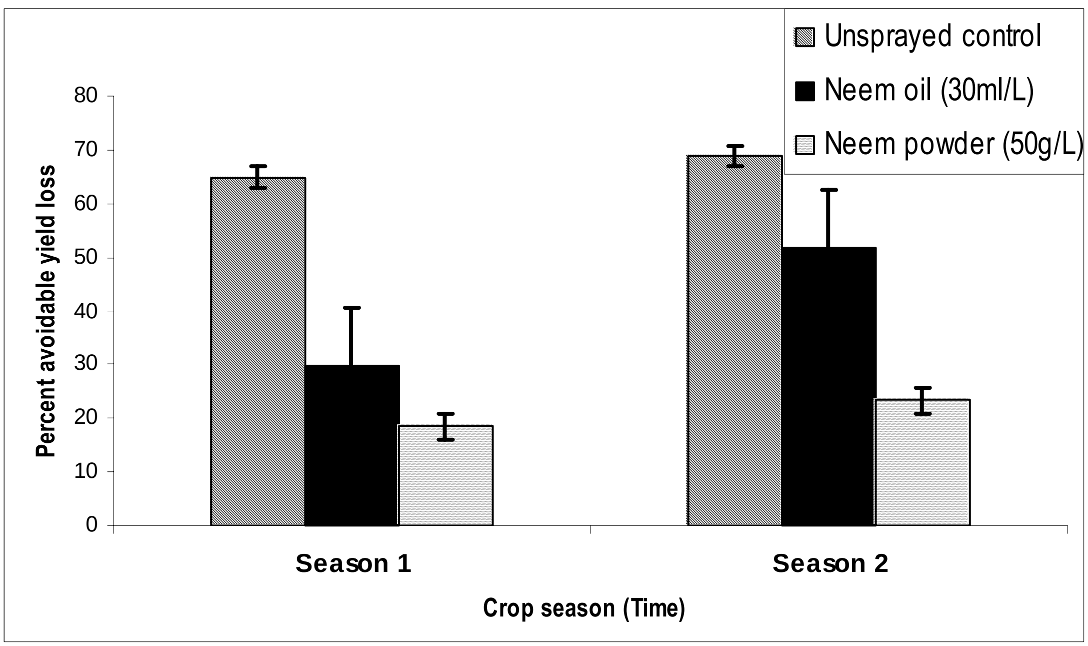

Fig. 4: Cucumber yield loss reduction with the various neem products treatments

Conclusions

It was evident that both the neem products (oil and powder) offer scope as safer alternative control measure to some of the pests infesting cucumber crop at different growth stages. Promising results with neem products comparable to those of Karate® [lamdacyhalothrin] treated plots were obtained in the control of the early infesting pests such as leaf miners attacking from cotyledonary leaf stage. There is scope to further explore possible use as seed treatment, besides working out the optimum dosages of the neem products as well as the appropriate timing of their applications.

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ANALYSIS OF STAKEHOLDER ORGANIZATIONS INVOLVED IN ON-FARM CONSERVATION OF INDIGENOUS LEAFY VEGETABLES IN WESTERN KENYA.

John Mburu and Patrick Maundu
IPGRI

ABSTRACT

This paper analyses the various stakeholders involved in promoting the utilization of indigenous vegetables in Western Kenya and classifies them into stakeholder organizations depending on how they related with the farmers. It aims at determining the kinds of stakeholders organizations involved in in-situ conservation of indigenous vegetables, the different kinds of strategies employed to enhance conservation and the driving factor leading to the emergence of these different strategies. The paper concludes by outlining several policy implications for promoting on-farm conservation of indigenous vegetables in the case study areas.

Key words**:** On-farm conservation, Indigenous vegetables, In-situ conservation strategies.

INTRODUCTION

In-situ conservation or on-farm conservation through utilization[3] has been recognized as an indispensable approach that not only complements ex-situ conservation in gene banks and botanical gardens but also preserves the indigenous knowledge of the farmers. In this approach, In-situ conservation is defined as the continued cultivation and management of a diverse set of crop populations by farmers in the agro ecosystems where the crop has evolved or in secondary centres of diversity. Farmers play an overwhelming important role in that it is them that make decisions on the choice of crop and varieties to plant, produce seeds and select them for storage and planting. Confronted with a diversity of interests and the absence of a single variety that they can fully depend on for food sufficiency, these farmers manage a range of varieties using a diversity of selection criteria. Moreover, the seeds produced are usually exchanged with other farmers from within and outside their communities and thereby new varieties are obtained, and lost or degenerated ones are replaced. By producing food and seeds, these farmers practice a form of crop development and maintain crop genetic diversity through in-situ conservation. Thus, past studies on agro-biodiversity conservation in most developing countries acknowledge that farmers are as major stakeholder group involved in maintaining traditional varieties (Thies, 2000; Virchow, 1990).

The in-situ conservation of indigenous vegetables in Kenya is of great importance to the society due to high nutritive and medicinal values which could be passed to other horticultural crops through breeding, and their contribution towards maintenance of eco-system functions (Chweya and Eyzaguirre, 199). Besides, conservation of the vegetables diversity would help to maintain genetic resources for human population from generation to generation. However conservation of these vegetables is confronted with major challenges since farmers can only continue growing the varieties that suit their own needs. Concisely, if the farmers have to maintain certain varieties of indigenous vegetables in their farms, they must draw marginal utility through their utilization and have desirable economic or cultural incentives that favour their production.

The diversity of indigenous vegetables in Western Kenya has largely developed through thousands of years of farming practices by the local farmers. However, the level of diversity produced by farmers is less than what the Kenyan society would like to have mainly because each farmer makes independent decisions based on observable characteristics of the varieities. For this reason, there could be landraces of no interest to any farmer 9resulting in possible extinction) and there could be landraces of interest to thousands of farmers (resulting inredundancy) (Wale et. al., 2003). Although farmers have a role to play in the conservation of indigenous vegetables through managing diversity and maintaining it by utilization in their production systems, governments and other stakeholders such as non-governmental organizations (NGOs) and private companies also make important contributions (Mburu and Wale, 2003). Success of conservation initiatives of these vegetables would therefore depend on the promotional strategies and capability of individual stakeholders, the type of stakeholder organizations formed after different stakeholders come together and the prevailing driving factors of change. We argue that farmers, in their efforts to enhance production of indigenous or traditional varieties, relate indiffferent ways with other stakeholders in the local areas leading to the formation of different stakeholder organizations. The farmers may be individuals or organized in groups e.g. women groups, self-help groups, work groups etc. Against this background, this paper attempts to tackle the following three questions:

- What kinds of stakeholder organizations are involved in in-situ conservation of indigenous vegetables?
- What strategies do each of the stakeholder organizations employ to enhance conservation?
- What are the driving factors behind the emergence of these different strategies?

Further, the paper, which is explorative in nature, highlights the strengths and weaknesses of each of the strategies in relation to the outcome of on-farm conservation.

Gathering of Data

The empirical data on which this paper is based was gathered in Western Kenya in August 2003, where individual farmers, groups (mainly women groups), local NGOs, local research and extension departments, and academic institutions were visited and key persons involved in production and research activities of indigenous vegetables interviewed. Methods used for data collection included informal interviews guided by a checklist, joint field visits with the members of the organizations or groups and participant observation. Market surveys were conducted in the local markets and market agents, who are mainly middlemen selling vegetables in cities and big towns, were also interviewed. Indigenous vegetables grown in this region include Amaranthus *(Amaranthus dubius, A. hybridus, A. cruentus, and A. graecizans*), Ethiopian Kale (*Brassica carinata)*, cowpeas (*Vigna unguiculata*), spiderplant (*Cleome gynandra*), Jute Mallow (*Cucurbita maxima/moschata*), and African nightshade (*Solanum americanum*, *S.scarbrum, S. villosum, and S. eldorettii*). These vegtables are produced mainly in four zones: 1) Molo/Elburgon/Kabarak (mainly serving Nakuru towun), 2) Ainamoi (main serving Kericho town), 3) Kilgoris/Magena/Nyangusu (mainly serving Nairobi and Kisii towns) and 4) Vihiga, Butere and Luanda (mainly serving Kakamega and Kisumu towns).

Stakeholder Organizations and strategies applied to promote utilization of indigenous vegetables

The stakeholder organizations involved in promoting utilization of indigenous vegetables can be classified into two broad categories depending on the objectives of their activities. The first category comprises of organizations which enhance in-situ conservation through direct promotion of utilization of the vegetables. These include the farmers groups who try diverse varieties, non-governmental organizations which have contracts for seed production and seed exchange projects with local farmers and traders who have established agreements on production of certain vegetables with farmers. The second category is made up of stakeholders whose primary objective or motive is not in-situ conservation through enchanced utilization of crop diversity, but promotion of farmers' involvement in participatory crop improvement breeding approaches, e.g. participatory varietal selection. This later group includes organizations formed in areas where the Kenya Agricultural Research Institute (KARI) is working with farmers to identify locally important varieties of indigenous vegetables and their morphological characteristics.

Farmers-researchers organizations

The Kenya Agricultural Research Institute (KARI) is the key government institution responsible for conserving indigenous vegetables in-situ. However, the KARI is also mandated by the government to promote production of the exotic varieties, e.g. the cabbage. The current policy guiding activities of KARI emphasizes on enhanced production of exotic varieties of vegetables and other crops in order to alleviate food shortage and poverty. Thus, the organization lacks incentives to promote utilization of indigenous vegetables. This is evidenced through its budgetary constraints and a lack of research scientists dealing specifically with the indigenous vegetables. The organization has therefore managed to organize only a few farmers groups (mainly women) to experiment indigenous vegetables in their farms. These groups are normally contracted by the organization to conduct on-farm and exchange information on the evolving and unidentified varieties, e.g. the Solanum spp.

Farmers-traders organizations

In Trans-mara District, farmers are organized in farmers' groups or working groups which relate with certain traders' groups or middlemen. No other stakeholders have been allowed to join these organizations. The farmers are organized in small groups of 10-15 persons. In an Administrative Location with a population of 300-500 farming households, for example, there can be as many as five such local organizations. Likewise, the traders belonging to each of these groups are organized in a group of 3-5 persons. Members of both the farmers' and traders' groups are women though men, whose wives are members, also participate in the cultivation of vegetables. There are no men in the traders' groups.

The key driving force for the establishment of these farmers-traders' groups is the opening up of market in Nairobi for the indigenous vegetables and particularly the African nightshades, cowpeas and amaranthus. The traders mobilize the farmers to organize themselves into groups in order to grow and sell vegetables to them in bulk. These vegetables are then taken to Nairobi, which is about 400 Km away. By organizing the farmers, the traders are able to get agreed upon times of harvesting the vegetables. Their interest is to get enough produce to transport to Nairobi in order to reduce their costs. Normally the traders set the farm gate prices but the farmers groups have the option to negotiate and reach an agreeable price. However the traders have a stronger bargaining position since they can threaten farmers of abandoning their produce and fetching other growers. Farmers who do not belong to any of the farmers-traders' groups are forced to sell their vegetables at lower prices since there are no prior marketing arrangements. The traders' groups have the role to keep the marketing groups informed of the prevailing consumer prices in Nairobi, consumer preferences and any other information necessary for the maintenance of the contractual arrangements.

Farmers' organizations

In these kinds of stakeholder organizations, farmers who were already organized into groups come to realize the gains of cultivating indigenous vegetable all by themselves. Thus, the key driving force for the emergence of such organizations has not been profits from vegetables but other socio-economic problems that they had been established to handle. However, involvement of the organizations in vegetable production activities was cultivated by the demand for leaves in Nairobi and other nearby big towns, and for seed by the local farmers. The members of such organizations are close neighboring families who are homogeneous (in terms of culture) and characterized by high level of social capital. The organizations have the capacity to invite the research and extension agencies to train or advise them on any technology they desire. These institutions are however not allowed to participate in the decision making process. The groups do not have any contractual arrangements with marketing agents or traders since they sell their farm produce in big cities (including Nairobi) to whoever is offering better prices. Such organizations are not many and one is likely to find only a single one in an administrative District. One such organization is the Technology Adoption Through Research Organization (TATRO) women group in Siaya District, which is involved in the cultivation of Sunnhemp and Spider plant leaves and seeds.

NGOs-farmers organizations

This kind of stakeholder organization has two key members: the NGOs and the farmers. The latter are normally organized as women and self-help groups. The farmers' groups are mobilized by the NGOs whose key interest is the promotion of vegetables' cultivation. The Key driving force for the emergence of such organizations is the donor funds from bilateral donors and international research organizations. However, maintenance of the farmers' groups is also enhanced by the accessibility to ready markets for their farms produce particularly the seed which is bought by the NGOs and re-supplied to the farmers. As such the NGO also relate to the farmers as the marketing agents for the seed (NGO sells and buys the seed). The research and extension agencies do not have any relational contracts with the farmers' groups since the NGO has the capacity to train farmers and share any technical information with them. Normally it is the NGO that sets the buying and selling prices of the seeds without negotiating with the farmers. However, the NGO's prices are in most cases below the prevailing market prices. Examples of such NGOs include the Rural Outreach Programme (ROP) in Butere-Mumias District and Sustainable Agriculture Centre for Research Extension and Development in Africa (SACRED Africa) in Bungoma District.

Following the discussion in this section, we summarize in Table 1 the various stakeholder organizations promoting utilization of indigenous vegetables in Western Kenya. In addition, the table shows the various driving factors leading to the emergence of such organizations. It can be observed from this table that the emergence of these stakeholders organizations has mostly being propelled by market access. This is mainly within the last decade consumers living in towns and cities have come to realize the nutritional value of the indigenous vegetables, which is comparatively higher that in exotic vegetables (Chweya and Eyzguirre, 1999). For the KARI and NGOs, availability of donor funds may also be important driving factor which enhances their capacity to work with farmers.

We emphasize that in rating these factors in terms of importance one has to take care of the local conditions. It would be expected that a certain factor could be very important for a certain area and less important for another. Nevertheless, generalization could also be allowed as we find that these factors very similar to conditions that have been documented as key factors favoring emergence of local organizations involved in the management and conservation of other natural resources such as forests, wildlife

Table 1: Types of stakeholder organizations and driving factors leading to their emergence

Stakeholders involve	Key driving forces Stakeholder	Organizations formed
Kenya Agricultural Research Institute (KARI) and farmers Donor funds groups	Research objectives	Farmers - Researchers
Farmers and vegetable traders groups	Market access	Farmers – traders
Farmers	Market access	Farmers groups
NGOs and farmers	Donor funds Market access	Farmers - NGOs organizations

Own table, 2003

water and fisheries (Meinzen-Dick and Knox, 2001).

Strengths and weakness of different strategies employed to promote utilization of Indigenous vegetables through different stakeholder organizations

Farmers -researchers organizations

The strength of the KARI-farmers organization lies on the know-how of the KARI's technical staff to mobilize and organize farmers to grow indigenous vegetables for on-farm experimental purpose. These organizations have also been able to integrate indigenous knowledge of the farmers in the understanding of the evolution of the leafy vegetables. However, it is important to note that this strategy achieves a comparatively low level of in-situ conservation as farmers do not have the freedom to grow varieties of their choice. In addition KARI also suffers drawbacks from the current policy on the conservation of crop genetic resources. Our investigations revealed that the organization does not feed the extension service with messages on on-farm conservation of indigenous vegetables as this contradicts with the packages provided to the farmers for production of high yielding exotic varieties. In addition, both KARI and the extension service lack the capacity to mobilize farmers and to establish strong local organizations with farmers due to budget limitations. They have to rely on donor funds from external organizations. This serves to explain why there are no stakeholder organizations involving the extension service in the research area.

Farmers-traders organizations

The farmers-traders organizations have the capacity to promote on-farm conservation of vegetables as farmers have the market incentive. This incentive is the single most important factor contributing towards organization of farmers and traders. However, the in-situ conservation benefits derived from such organizations are relatively low due to concentration on few varieties according to consumers' preferences and demand. There are also no objectives for long-term conservation as the organizational aspects are dependent on market forces. In addition, farmers involved in the organizations are not fully integrated in the marketing process and flow of market information to them is minimal. There is therefore the likelihood of traders exploiting the farmers since the latter are not represented in the marketing process.

Farmers' organizations

The farmers are organized in small homogenous groups which are able to manage, all by themselves, both production and marketing processes of vegetables. These self-organized farmers' groups are most likely to be relatively more successful than other organizations in terms of level of on-farm conservation. In addition, fairness to individual farmers and resilience of the organization are greatly enhanced since the level of social capital is relatively higher. For instance, the TATRO group quoted in this paper has been cultivating several types of indigenous vegetables for more than six years and all along has retained its small and constant membership: twenty five households. However, activities of such local organizations are often successful due to management capacity of a few local elites and sometimes farmers' ex post transaction costs may be considerably high. Nevertheless, both financial and social benefits reaped in these local organizations would be expectedly higher than the costs.

NGOs-farmers organizations

Just like the self-organized farmers' groups, the NGOs-farmers organizations are likely to yield good results of of-farm conservation since farmers' groups are integrated in the decision making process. However, since these organizations rely on availability of donor funds, their long-term sustainability would be difficult. In addition, majority of the farmers' groups are young and weak; and lack financial, human and self-mobilization resources. They have therefore a continuos demand for technical and organizational inputs from the NGOs.

Concluding Remarks

The empirical cases analyzed in this paper presents many different types of driving factors that can lead to emergence of stakeholder organizations for on-farm conservation. These include efforts to attain conservation and research goals, markets access and availability of donor funds for farmers' mobilization. Market access has emerged as the single most important driving factor and particularly in cases where the net demanders of crop diversity (research organizations, NGOs, etc) are not involved. As the results of this paper have shown, availability of markets would not only have a positive effect on the mobilization of the farmers but also on the overall success of the organizations formed. This has an important policy implication: on-farm conservation of indigenous vegetables could easily be enhanced and successful through provision of markets for the farmers. Thus the government have to invest in infrastructural developments such as roads and consumer awareness programs, and remove adverse subsidies that are disincentives to marketing of these vegetables.

Our analysis also has shown that, for stakeholder organizations involved in on-farm conservation of indigenous vegetables to be effective and successful in terms of achieving relatively high levels of conservation, farmers have to be in small groups and be capable to organize themselves. Moreover, participation of government agencies in on-farm conservation strategies could be enhanced through harmonization of policies on conservation, food production and poverty alleviation as this would allow for easier and cheaper mobilization of farmers. This would also eliminate the difficulties faced by extension agents trying to pass mixed messages to the farmers and hence their participation in conservation initiatives, which is evidently lacking in the case study area.

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OFFICIAL CLOSING SPEECH

PROF. WILLIAM R. OCHIENG,
Director, Institute of Research and Post Graduate Studies, Maseno University
Third workshop on Sustainable Horticultural Production in the tropics from 26th -29th November 2003.

It gives me great pleasure to be with you this evening to perform the official closing of the Third Workshop on Sustainable Horticultural Production in the Tropics. It is impressive to note that, for the last two days you have been following illuminating poster and oral presentations from a large number of researchers, drawn from Kenya, Tanzania, Uganda, Ethiopia and Federal Republic of Germany.

The discussions, Iam informed, have revolved around a topic that has been neglected for a long time: African indigenous vegetables, in addition to Export Horticultural Crops. The themes under African Indigenous Vegetables included: Germplasm Collection, Characterization and bulking; Crop Management, Economic Importance, Marketing and Technology Transfer; and Nutritive Quality and Acceptability. The workshop also intensely examined at great length the other horticultural and Export Crops. I am also glad to note that participants will in the next two days have an excursion to examine the situation on the ground, by visiting farmers in this region. I wish you all the best. Remember, workshops and conferences in Africa are today looked at with suspicion, as idle talking exercises which do not translate into intended actions. I hope your findings in this workshop will translate into practical activities that will benefit mankind

Ladies and Gentlemen, the importance of the horticultural sector in the country cannot be overemphasized. It is currently the second largest foreign exchange earner in Kenya, after tourism. The sector has grown steadily, currently accounting for 15 billion in foreign exchange earnings. Besides, the small scale farmers who account for 80% of the sector, dominate horticultural activities. It is therefore a key income source for our people. Over 50 percent of Kenyans live below the poverty line, and millions have been forced to depend on food aid. Sustainable horticultural production that includes indigenous plants like African indigenous vegetables would contribute significantly to the government's effort to alleviate poverty and empower the rual farmers.

These vegetables have numerous advantages, like having high nutritional value, medicinal properties and agronomic advantages over the exotic ones like cabbage and lettuce. Research on these vegetables, and other horticultural crops, would translate into improved health, income generation and reduced poverty to our people. We believe that a forum such as this one is crucial, because it imparts useful knowledge to participants. Such sessions act as a good beginning for meaningful collaboration between Universities, National and International Research Institutions, and the Private Sector and the farmers. Iam informed that you have had presentations from farmers, this is a very good step towards reaching end-users with our new technologies.

As researchers, you must endeavour to provide solutions that would enable full exploitation of useful but neglected crops, like indigenous vegetables in the country and the continent at large. We should be able to translate quickly our research findings into appropriate and applied technologies that would be available to the farmers. Africa, is plagued with endless calamities, ranging from hifg poverty levels, HIV and AIDS, to raging famine and low agricultural earnings, is a great scandal to the academia of Africa. The Africans are urgently waiting for solutions that would reduce theie misery. Finally our gratitude goes to the German Academic Exchange Service (DAAD) for providing financial support that culminated in the successful staging of this workshop. The joint effort between, Horticultural Association of Kenya, Jomo Kenyatta University of Agriculture and Technology, Maseno University and University of Hannover in Germany represented in this workshop by several professors, is impressive and commendable.

It is now my pleasure todeclare the third workshop on sustainable horticulture production in the tropics OFFICIALLY closed

Thank You

PROGRAMME

DAY 1, WEDNESDAY, NOVEMBER 26TH 2003

08.00 – 09.30 a.m. : **REGISTRATION AND POSTER PLACEMENT**

09.30 – 10.15 a.m. : **OFFICIAL OPENING**
(Chairman: Prof. M.O. Abukutsa Onyango)
(Rapporteur: A.N. Murithi)

<u>**Remarks**</u>

- **Organizers** : **Prof. S.G. Agong, JKUAT**
  : Prof. Dr. H. Stuetzel, University of Hannover, Germany

- **Vice-Chancellors:** **local organizing Universities**
  : Prof. N. Wanjohi, JKUAT
- **Sponsors** : **Dr. Cay Etzold, Director, DAAD Regional Office for Africa**

Keynote Address : **Dr. Mel Olouch, AVRDC, World Vegetable Centre – Regional Centre for Africa**

Official Opening : **Vice-Chancellor, Maseno University**

10.15 – 10.45 a.m. : **TEA BREAK – VIEWING OF POSTERS**

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10.45 – 12.45 p.m. : **SESSION I : CROP MANAGEMENT OF AFRICAN INDIGENOUS VEGETABLES(3)**
(Chairman : Prof. H. Stuetzel)
(Rappoteur : F. Ombwara)

1. Effect of water stress on dry matter production and nutritive quality of spiderplant. Masinde P.W. et al.
2. Studies on horticultural practices of six African indigenous vegetables at Maseno University. Abukutsa Onyango M.O.
3. Management of major vegetable crop diseases in Ethiopia. Review. Yesuf M.
4. African indigenous vegetable production. Farmers experience in Nyamira. Onduso J.M.
5. Etiology of septoria leaf spot of cowpea (Vigna unguiculata) in Kenya. Kiprop E.K. et al.
6. Effect of seed osmotic priming on germination of spiderplant seeds. Kabue S.T.
7. On farm seed production in Kisii district: An overview of the present situation . Okoko W.
8. Integrated crop protection Research for sustainable production of indigenous vegetables in Eastern Africa. Sithanantham S.

12.45 – 01.30 p.m. : **Lunch Break**

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01.30 – 03.15 p.m. : **SESSION II : GERMPLASM COLLECTION, CHARACTERIZATION AND BULKING OF AFRICAN INDIGENOUS VEGETABLES (1)**
(Chairman : (Prof. S.G. Agong)
(Rapporteur : (Dr.G.W.Netondo)

1. Seed production and handling of indigenous vegetables. Review. K'opondo, F.B.O.

2. The ecobiodiversity of domesticated and wild traditional leafy vegetables of Nyang'owa, Western Kenya. Orech F.O. et al.
3. Community seed production of African indigenous vegetables. Okong'o P.
4. Seed production and supply system of African leafy vegetables in Kakamega district. Ndinya C.A. et al.
5. Effects of packaging and storage conditions on seed quality of Cleome gynandra. Kamotho G.N.
6. Farmers knowledge and practices in African indigenous vegetable seed production. Simiyu,J.N.
7. Towards utilizing pest tolerance among landraces in indigenous vegetables in Kenya. Sithanantham S.
8. Taxonomic Characterization and Identification of African Nightshades. Mwai, G.

03.15 – 03.45 p.m. : **TEA BREAK – VIEWING OF POSTERS**

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03.45 – 05.00 p.m. : **SESSION III : ECONOMIC IMPORTANCE OF AFRICAN INDIGENOUS VEGETABLES, MARKETING AND TECHNOLOGY TRANSFER (4)**

(Chairman : Prof. J.A. Omolo)
(Rapporteur : V. Anjichi

1. African eggplants, promising vegetables for home and sale in Tanzania. Macha E.S.
2. The status of African leafy vegetables in Central Kenya. Indigenous knowledge constraints and opportunities. Gitonga L.
3. Promoting community action for sustainable conservation and utilization of indigenous vegetables among small holder farmers. Ogutu W.O.
4. Distribution and consumption of indigenous vegetables among Mijikenda community of coastal Kenya. Lewa K.U.
5. Production and consumption of traditional leafy vegetables in Arusha region, Tanzania. Bujulu E.
6. The diversity of African indigenous vegetables. Maundu P.

05.00 – 05.30 p.m. : **TEA BREAK – VIEWING OF POSTERS**

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05.30 – 06.45 p.m. : **SESSION IV : NUTRITIVE QUALITY AND ACCEPTABLILITY OF AIVs (2)**

(Chairman : Dr.F.M.O.Ndong'a)
(Rapporteur : Dr. D. Isutsa)

1. African indigenous vegetables recipe documentation and their role in food security. Musotsi A.A.
2. Use of indigenous Kenyan vegetables as functional foods. Makokha A.
3. Variations in nutritional quality of African nightshade accessions. Muchiri S.
4. Nutritional value and utilization of indigenous vegetables in Uasin Gishu district. Mwamburi L.
5. Dietary efficacy of African indigenous vegetables in the control of micro-nutrient deficiencies for poverty alleviation and nutrient security.
   Walingo M.K.
6. Effect of nutrient solution, silicon and manganese concentration on cowpea leaf water loss. Owino-Gerroh, C.

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06.45 – 8.00 p.m : **WORKSHOP COCKTAIL**

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DAY 2, THURSDAY, NOVEMBER 27TH 2003

08.30 – 10.45 a.m. : **SESSION V : HORTICULTURAL CROPS RESEARCH(7)**

(Chairman : Prof. B. Hau)
(Rapporteur : J.N. Simiyu)

1. Potential of vegetable crop production for the small scale farmers in the Mt. Kenya highlands. Kaburu M.

2. Implementing an IPM system in a large scale horticultural farm set up in Kenya. Kasina J.M. et al.
3. Response of tomato to different ratios of sand, loam and manure. Kyele S.K.
4. Pathogenecity and fungicide efficacy of fusarium wilt disease of papaya seedlings. Palapala,V.A., Koech,J. and Gudu,S.
5. Mycorrhizal effects on growth and suppression of root pathogens in some horticultural crops. Too E.J.
6. Evaluation of rooting methods for commercial nursery propagation of vanilla in Uganda. Namirembe-Ssonkko,R.
7. Integrated nutrient management in tomatoes in the Taita hills. Muniu, F.K. et al.
8. Fruit crop production in the drylands of Kenya. Muhammad, L.
9. Developing a baculovirus for management of Diamond Backmoth in Brassicas in Kenya. Ogutu W.O.

10.45 – 11.15 a.m. : **TEA BREAK – VIEWING OF POSTERS**

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11.15 – 12.30 a.m. : **SESSION VI : EXPORT CROPS (5)**

(Chairman : Dr. B. Owuor)
(Rapporteur : Dr. K. Ngamau)

1. Linking smallholder horticultural production to the local and international markets. Ouko, R.
2. Marketing and Technological Transfer Challenges facing Kenyan Exotic Vegetable Growers and Exporters. Anjichi V.
3. Field performance of passion fruit varieties as influenced by propagation methods. Isutsa D.K. and Mumera, F.B.
4. Possible interventions in the production of cut flower in North Rift region.Muriithi, A.N.
5. Impact Assessment of training French beans small holder on IPM and Hygieul standards harvest information in selected districts of Kenya. Macharia I.

12.30 – 01.00 p.m. : **WORKING GROUP BRIEFING** (Organizers)

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01.00 – 02.00 p.m. : **LUNCH BREAK – POSTER VIEWING**

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02.00 – 03.00 p.m. : **WORKING GROUPS** (Group leaders)
03.00 – 04.00 p.m. : **WORKING GROUPS PRESENTATION**

(Group leaders)
(Chairman : Dr. A. Fricke)
(Rapporteur : Dr. P.W. Masinde)

04.30 – 04.45 p.m. : **TEA BREAK**

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04.45 – 05.45 p.m. : **HAK - meeting**
05.45 – 06.00 p.m. : **CLOSING CEREMONY**

(Chairman: Prof. S.G.Agong)
(Rapporteur: A.N. Murithi)

Brief Remarks

- **Participants** : Representative
- **Organizers** : Representative
- **Hosts** : Horticulture Department Maseno University, Chairman
- **HAK** : Chairman to invite the guest of honour
- **Official closing** : **Prof W.R. Ochieng', Director, IRPS, Maseno University**
- **Vote of thanks** :To be chosen among the participants

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DAY 3 & 4 28TH AND 29TH NOVEMBER 2003 - EXCURSION PROGRAMME

28th November Maseno, Yala, Nyamira
29th November Nyamira, Kisii

LIST OF PARTICIPANTS

1. ABUKUTSA O. MARY
Department of Horticulture,
Maseno University,
P.O. Private Bag,
Maseno, **KENYA**
Tel: 254-35-51620/2,
Fax: 254-35-51221/51153
E-mail: mabukutsa@yahoo.com

2. AGAK JOHN
Maseno University
KENYA

3. AGONG STEPHEN GAYA
Department of Horticulture, JKUAT,
P .O. Box 62000
Nairobi, **KENYA**
Email:
sgagong@jkuat.ac.ke

4. ANJICHI, VICTORIA A.
Department of Horticulture,
Moi University - Chepkoilel Campus,
P.O. Box 1125,
Eldoret, **KENYA**.
E-mail:
vashiali@yahoo.com

5. ARWA S.PHANUEL
Maseno University
KENYA

6. BUJULU E.
TPRI Box 3024 Arusha
TANZANIA,

7. CAY ETZOLD
Director DAAD
Regional Office for Africa, Nairobi,
KENYA

8. FRICKE , ANDREAS
Institute of Vegetable and Fruit Science
Herrenhaeuser Str. 2
University of Hannover,
D-30419 Hannover,
GERMANY
Email:
fricke@gem.uni.hannover.de

9. FWAYA ONYANGO
Maseno University
KENYA

10. HAU, BENARD
Institute of Plant Diseases and Plant Protection
Herrenhaeuser Str. 2
D-30419, Hannover,
GERMANY.

11. ISUTSA, D.K.
Dept of Horticulture
Egerton University
Box 536 Njoro.
KENYA
dki1@africaonline.co.ke

12. KABUE S.T.
Moi University **KENYA**
stevethuo@yahoo.com

13. K'OPONDO, F.B.O.
Department of Crop Production and Seed Technology,
Moi University,
P.O.Box 1125, Eldoret,
KENYA.
E-mail
fbokopondo@yahoo.com

14. KIPROP, E. KIPTOO.
Dept. of Botany
Moi University
P.O. Box 1125,
Eldoret, **KENYA**.
E-mail:
ekiprop2001@yahoo.com

15. KAMOTHO, G.N.
DeptCrop Science,
Moi University.
seedtech@africaonline.co.ke

16. KENDUIWA, J.K.A.
HCDA-**KENYA**

17. KILUNDO V.K.
Maseno University
kilundov@yahoo.com

18. KYELE, S.K.
Maseno University
KENYA
stevenkyele@yahoo.com

19. KOECH, JOEL
Moi University,
P.O.Box 1125 Eldoret,
KENYA
Email:
Joel_koech@yahoo.com

20. LUTTA M
KARI-Katumani
KENYA.
luttamuhammad@hotmail.com

21. MACHA, ELINA
Tropical Pesticides Research Institute (TPRI)
P.O. Box 3024,
Arusha, **TANZANIA**
Email:
tpri@habari.co.tz

22. MACHARIA IBRAHIM,
ICIPE , P.O Box 30772, Nairobi,
KENYA

23. MAKOKHA, A. 0UMA
Department of Food Science and Post-harvest Technology,
JKUAT,
P.O. Box 62000,
Nairobi, **KENYA**

E-mail:
vam@kenyaweb.com

24. MASINDE, P. WAFULA
Department of Horticulture,
JKUAT
P.O. Box 62000
Nairobi. **KENYA**
Email: Masindepeter@hotmail.com

25. MUCHIRI S. JKUAT
muchiriv77@yahoo.com

26. MULEI J.M.
Moi University **KENYA**
simsim@africaonline.co.ke

27. MURIITHI, A. NAKHUMICHA
Department of Applied Biology
Kenya Methodist University
P.O Box 267, Meru, **KENYA**

28. MUSOTSI , A. ASWANI
Maseno University
P.O. Box 333,
Maseno, **KENYA**
Email:annemuske@yahoo.com

29. MUSYOKI, R.K.
KARI, Katumani
P.O Box 340,
Machakos, **KENYA**
Email:
eckngugi@africaonline.co.ke

30. MAUNDU PATRICK
IPGRI. **KENYA**
p.maundu@cgiar.org

31. MWAI GIDEON N.
Maseno University
KENYA
mwaign@yahoo.com

32. MWAMBURI, A. LIZZY
Department of Botany
Moi University
P.O. Box 1125,
Eldoret, **KENYA**

33. NDEDE AMADI
JKUAT KENYA

34. NDINYA, C.A.
KARIKakamega
KENYA

35. NGAMAU KAMAU
Department of Horticulture
JKUAT,
P.O Box 62000
Nairobi, **KENYA**

36. NGAROGA NDUNG'U
Moi University **KENYA**

37. NGONYO H..M.
JKUAT. **KENYA**

38. NGUGI S.M.
NHRC Thika P.O.Box 220 Thika, KENYA.
sm_ngugi@yahoo.com

39. NJUGUNA ELIZABETH
IPGRI
e.njuguna@cgiar.org

40. NYANAPAH J.O.
Maseno University.
KENYA

41. M'RIBU K
KEMU P.O.Box 267,
Meru, **KENYA**

42. NETONDO G.W.
Maseno University.
KENYA.
netondo@hotmail.com

43. NJOROGE, J. BOSCO
JKUAT
P.O. Box 62000,
Nairobi, **KENYA**
njbosco@hotmail.com

44. NYAMWAGA F.O.
Maseno University
KENYA

45. OCHIENG' W.R.
Director, IRPS Maseno University **KENYA**

46. OGUTU, W. OKELLO
CAB International
Regional Centre,
P.O. Box 633 Nairobi,
KENYA
Email:
W.ogutu@cabi.org

47. OKEYO DAVID
Maseno University
KENYA

48. OKONG'O PAUL
Tatro farmers Yala.
KENYA

49. OKOKO NASAMBU
KARI-KISII, **KENYA**

50. OLUOCH MEL
AVRDC-Africa regional center **TANZANIA**

51. OMBWARA, F. KWEYU.,
JKUAT,
P.O. Box 62000,
Nairobi, **KENYA**
E-mail:
vam@kenyaweb.com

52. OMOLO AKEYO JOSEPH
Maeno University
KENYA

53. OMUNYIN, M. ELEAZAR
Department of Horticulture,
Moi University - Chepkoilel Campus,
P.O. Box 1125,
Eldoret, **KENYA**.
E-mail:
meomunyin@yahoo.com

54. ONYANGO F.N
Vice Chancellor
Maseno University
vc@maseno.co.ke

55. ONYANGO, J.C.
Department of Botany
Maseno University
P.O. Box 333,
Maseno, **KENYA**
email:
jconyango@yahoo.com

56. ORECH, F.O.
BotanyJKUAT
forech@yahoo.com

57. OSEKO, JACQUELINE.
Maseno University
P.O. Box 333,
Maseno, **KENYA**
E-mail:
loseko2003@yahoo.com

58. OTIATO DARIUS A.
Maseno University
KENYA

59. OUKO J.O
HCDA
hcdameb@wananchi.com

60. OUMA GEORGE
P. 0. Box 333,
Maseno, **KENYA**
Email:
gouma@swiftkisumu.compss.george

61. OWINO-GERROH, C.
Department of Horticulture
Maseno University
P.O.Box 333, Maseno,
KENYA

62. OWUOR BARACK
Maseno University
KENYA

63. PALAPALA, VALERIE.
Western University Collge
Kakamega, **KENYA**

64. SEREM D.K.
Maseno University
KENYA

65. SHITANDA, D.
Department of Biomechanical and Environmental Engineering
JKUAT
P.O. Box 62000
Nairobi, **KENYA**
E-mail:
dshitanda@aejkuat.ac.ke

66. SIMIYU, J.N.
MoiUniversity Box 1125, Eldoret,
KENYA.

67. SITHANANTHAM, S..
ICIPE , P.O Box 30772
Nairobi, **KENYA**

68. SSONKO R.N.
Dept of crop science
Makerere university
UGANDA
ebusinge@agric.mak.ac.ug

69. STUETZEL, HARTMUT
Institute of Vegetables and Fruit Science
Herrenhaeuser Str. 2
University of Hannover,
D-30419 Hannover,
GERMANY
Email:
stuetzel@gem.uni.hannover.de

70. TOO E.J.
Dept of Botany
Moi University
Emiltoo@yahoo.com

71. WAFULA, V.W.
JKUAT **KENYA**
ewekesah@yahoo.com

72. WALINGO, M.K.
SOFCONSTEC
Maseno University,
KENYA

73. WANJIHIA V.W
KEMRI Box 23334
NRB **KENYA**

74. WANJOHI N.
Vice Chancellor
75JKUAT, **KENYA**

75 WESONGA, J.M..
JKUAT
P.O. Box 62000, Nairobi,
KENYA
E-mail:
jwesonga@yahoo.com
or jWesonga@jkuat.ac.ke

76 YESUF, M.
EthiopianAgric. Centre Organization
myesuf@freemail.et