Assessment of Constraints in Technology Transfer System and Policies which Limit the Realisation of High Green Leaf Production in the Smallholder Tea Sector of the Kenya Tea Industry: An Empirical Analysis of Economic Efficiency and Supply of Tea
Part II

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ABSTRACT

Technological recommendations for maximizing green leaf production have been made available to smallholder farmers by the Tea Research Foundation of Kenya (TRFK) through various publications. Indeed TRFK has released clones, which are yielding in excess of 4000 kg mt/ha. Consequently, the smallholder tea areas are planted with these clone compared to the estate sub sector with large areas of land planted with old seedling tea cultivars, yielding lower than 2500 kg mt/ha per year. Nevertheless, tea productivity in the smallholder sub sector has been relatively lower than in the estates sub sector over the years and the yields are still well below potential. The Kenya Government projects to produce 350 thousand metric tones by the year 2008, through putting emphasis on efficient use of strategic inputs such as fertilisers and adoption of intensive technologies of tea production to enhance yields. This study investigated the efficiency of adoption of tea production technologies and some policy factors contributing to low tea productivity in the smallholder tea sub sector. Specific objectives were:

1. to identify the major resources being used by farmers in tea production, estimate the tea production function and identify which of the identified resources significantly influenced tea production in the smallholder tea sub sector;
2. to determine whether the farmers were utilising the identified resources efficiently;
3. to determine the economic rationality of small scale tea farmers;
4. to determine compare the relative efficiency between east and west of the Rift Valley regions;
5. to identify the factors influencing the supply of green leaf, estimate the green leaf supply function and determine which of the identified factors significantly affect the supply of green leaf in the smallholder tea sub sector and
6. to identify the major factors limiting tea production, green leaf supply, farm profits and seek solutions to the problems.

The results of this study have policy implications at both the micro- and the macro-economic levels. If the factors that constrain tea production at the farm level are identified, suitable measures can be drawn to address the problems within the current policy framework in the short run. For example, if farmers are inefficient in the use of strategic inputs such as fertilizer, they may profitably reduce the amount spent on that input or increase supervision especially where labour for tea plucking is adequate. If the monthly producer price has a significant effect on green leaf supply, it can be adjusted upwards in the short run to give farmers incentives to supply more tea leaf etc.

Both primary data and secondary data were used in the study. Primary data were collected using a questionnaire instrument from a randomly selected sample of 259 smallholder farmers in Kirinyaga, Nyambene, Nandi and Nyamira Districts. Secondary data were obtained from Kenya Tea Development Agency Limited (KTDA) and Tea Board of Kenya. The analytical procedures used were: Cobb-Douglas production function, supply function and correlation and profit function analyses.

The Cobb-Douglas production function was used to determine the economic efficiency of the sample of farmers in the four districts. The data for each district was further categorized and analysed according to tea growing agro-ecological zones (AEZs) i.e. Lower High Zone and Upper Midland Zone I. The objective was to ascertain resource use efficiency not only for the districts but also for each agro-ecological zone. It was hypothesised that efficient use of inputs, particularly fertilizer, in each district surveyed and the respective agro-ecological zones would improve productivity. The predictors of tea output/year were: fertilizer bags used per year, number of tea bushes and the total labour used i.e. hired labour and family labour in man-hours per year. The results showed that fertilizer input significantly influenced tea output in the UM1 agro-ecological zone in every one of the four districts, and all the districts surveyed except Nyamira District. The test of price efficiency indicated that the fertilizer input was efficiently used in UM1 zone of all the districts, Nyambene and Nandi Districts. However, fertilizer use was inefficient in all the LH zones. The lack of response to the input in the zone could be due to the high altitude leading to slow growth rates. The results suggest a need to develop fertilizer use recommendations based on agroecological zones rather than the present single blanket for the whole country. Factors leading to inefficient use of fertiliser in Lower Highland Zone should be further investigated so as to remove the impediments and improve tea yields. For the whole of the sample, fertilizer significantly influenced green leaf output. However, an analysis of pricing efficiency showed that fertilizer input was inefficiently used in the smallholder sub sector. Labour input influenced green leaf output significantly at 10 % level in Nyamira District and 5% level in Nyamira LH zone. The analysis of price efficiency showed that labour was efficiently allocated in Nyamira District and in particularly Nyamira LH zone. The labour input was inefficiently used in all other Districts and AEZs.

One of the major concerns for smallholders is product quality. The recommended plucking standard in KTDA is two leaves and a bud, resulting in high quality tea, while some estates harvest more than two leaves and a bud, reflecting more but lower quality of made tea per plucking round. As a result, the smallholder teas fetch high prices in the auction markets than the estates teas. It is therefore expected that farmers would be guided by the price factor in the output markets to make quality decisions in the allocation of strategic inputs, within the context of their variable factor price regimes and quantities of fixed factors. Hence, they would be price-efficient in their operations. The extent of price-efficiency, which is a component of economic efficiency, among the small-scale tea farmers needed to be determined. It was hypothesized that the extent of rationality in allocation of resources in the tea enterprise is relatively low. Hence, the smallholder tea productivity has remained relatively lower than in the estate sub sector, high yielding clones and useful agronomic recommendations extended in the smallholder sub sector notwithstanding. "A Test of Economic Rationality Model" was used whereby, the index of economic rationality, **r** is the product moment coefficient of correlation between log (total variable costs-excluding labour costs) and log (labour-in man-days) for each tea district and region.

The results showed that the product moment coefficient of correlation, **r** was: - 0.647 in Kirinyaga District, 0.651 in Nyambene District, 0.793 in Nandi District, 0.743 in Nyamira District, 0.595 in the east of the Rift Valley region, 0.752 in west of the Rift Valley region and 0.674 for all farms surveyed. It was noted that the lowest value of **r** was 0.595 in east of the Rift Valley Region. It means that at least 59% of the variance in the logs of both inputs is due to the variation in the systematic profit-maximizing component of these inputs. The balance of 41% is the maximum that could be occasioned not only by poor technology and/or knowledge gaps but also by errors in the model and noise in the universe. The null hypothesis was rejected

in favour of the alternative hypothesis. The conclusion is that smallholder tea farmers in Kenya are quite price efficient in tea production.

The profit function was used to determine the efficiency of resource use in the districts surveyed and their respective tea agro-ecological zones. This method assumes that farms are relatively homogeneous in the way they use technology in the process of production. However, it is not a suitable method to use when farm groups are relatively heterogeneous. For example, tea in Kenya is grown in the east and the west of the Rift Valley regions. Tea farmers in these two regions face different regimes of prices of variable factors such as fertilizer and labour for plucking tea. They also have different quantities of fixed factors particularly land. Hence, it is imperative to determine relative efficiency between the two tea blocks. It is assumed that these farms in the two regions behave according to a certain decision rule termed as profit maximization. An estimation of the profit function for the tea farms in the two regions and comparison of the relative economic efficiency between them was done. "A test for relative economic efficiency" was performed to bring forth an overall comparison of economic efficiency for the two sets of farms. A profit function model was fitted on 212 smallholder farms. The dependent variable was gross margin per farm per year. The independent variables were: number of tea bushes per farm per year, cost of fertilizer (KShs.) per hectare per year, labour wage rate (KShs.) per man-day per year in each farm and a dummy variable where D=1 for the east and D=0 for the west of Rift Valley, respectively. The results depicted that the coefficients of the number of bushes, fertilizer cost/ha/year and labour wage rate/man-day were all positive and significant ($P \leq 0.01$). It had been hypothesized that there is no efficiency difference between east and west of the Rift Valley in tea production. Hence the coefficient of the region dummy would be zero. The results rejected the hypothesis of equal efficiency between the two regions ($P \leq 0.10$). Further more, the positive sign of the dummy variable indicates that east of the Rift Valley tea farms are more profitable, that is more economic efficient, at all observed prices of the variable inputs given the distribution of the fixed factors of production. It is concluded that east of the Rift Valley smallholder tea farmers are more successful in responding to the set of prices (Price efficiency) and/or have higher quantities of fixed factors of production, including entrepreneurship (technical efficiency). Factors responsible for low efficiency in the west of the Rift Valley should be studied and alleviated to increase tea production.

The secondary data collected from KTDA was used to determine some of the factors contributing to the low tea productivity in the whole of the smallholder tea sub sector. Part of the data was used to fit a production function of the smallholder tea sub sector. It was hypothesised that efficient use of inputs would improve productivity. To measure efficiency, Cobb-Douglas production function was used. The predictors of tea yield/hectare were: fertilizer used/hectare, number of bushes/hectare, number of growers/hectare and the number of extension staff/hectare per district. The results showed that fertilizer input significantly ($P \leq 0.05$) influenced tea yield in 1994/95, 1995/96, 1996/97 and 1997/98. The test of pricing efficiency indicated that the fertilizer input was inefficiently used at 1% level in the four consecutive years. The other inputs were not significant ($P \leq 0.05$). The results suggest that fertilizer use efficiency can be increased to improve tea production. Farmers need to be educated about the benefits arising from the application of the fertilizer input according to agronomic recommendations in order to enhance efficiency and ultimately increase tea productivity.

The other part of the secondary data was used to estimate the supply function of the green leaf in the smallholder tea sub sector. The major factors considered to be influencing supply of green leaf were: - the number of tea growers, price of fertilizer, monthly price of green leaf, and end of year price of green leaf

over the years. The General Linear Model fitted the data best. The results revealed that, monthly mean price lagged once (Pmt-1) and end year price ("bonus") lagged five times (Pet-5) significantly ($P \leq 0.05$) influenced the supply of green leaf. Elasticity of supply of green leaf was 32.88 for monthly average price (Pmt-1) and 6.69 for the end year price lagged five times (Pet-5). Hence green leaf supply was relatively responsive to tea price changes. Policy intervention should therefore be focused on improving producer prices particularly the monthly payment in order to increase the quantity of green leaf in the short run and end of year payment in the long run.

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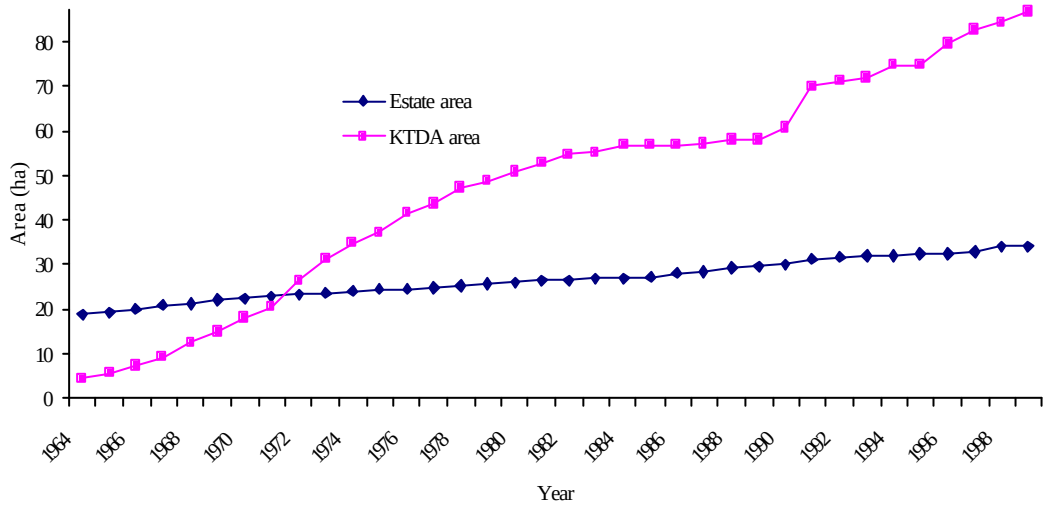
1 INTRODUCTION

1.1. Background Information

Tea was first introduced in Kenya on experimental basis in 1903, but commercial tea planting started in 1924 (Owuor 1999). The Africans or indigenous people were not allowed to grow tea at inception. In the mid 50's, however, experimental tea growing was introduced for Africans and after attaining political independence in 1963, the legislation to bar Africans to grow tea was repealed. The indigenous citizens took immediate and maximum initiatives and commenced massive tea planting programmes and development, leading to a fast growth of the Kenya tea industry (Figure 1.1). Tea production rose from 18.1 thousand metric tones in 1963 to 294 thousand metric tones made tea in 1998, largely due to expansion in the smallholder sub sector, improved productivity per unit area in the estate sub sector of the Kenya tea industry and adoption of technical packages developed by the Tea Research Foundation of Kenya (TRFK), and its predecessor, the Tea Research Institute of East Africa (TRIEA) (Othieno 1981, 1988; Rutto 1995). Kenya is now the leading world exporter of black tea (Anon 1964-2000).

Figure 1.1. Area under tea in different sectors of Kenya



Agricultural industries form the main foundation of Kenyan economy creating the largest employment opportunities and providing the largest foreign exchange earnings. Tea is a main player in this sector and is currently the leading foreign exchange earner (Anon 1997). During 1998, Kenya

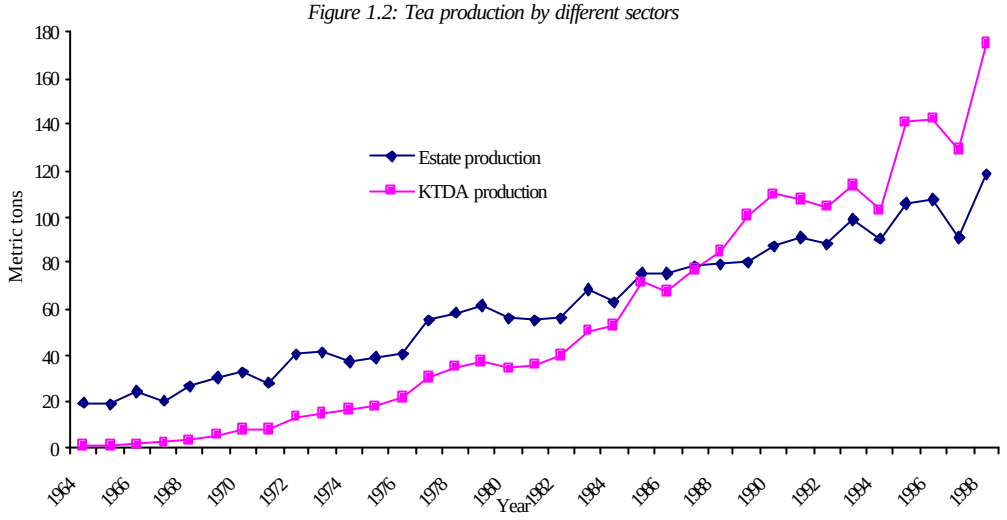
produced 294.2 thousand metric tones of tea earning US$ 545.418 m from the 263.4 thousand metric tones exported, while the balance of 30.8 thousand metric tones was consumed locally and generated extra incomes to the growers (Anon 1964-2000). This accounted for 15% of total world tea export and made Kenya the 3rd largest tea producer after India and China. However, due to unfavourable tea growing conditions the production reduced to 248.8 metric thousand tons (Anon 1964-2000).

The Kenya tea industry is composed of the estate sub sector and the smallholder sub sector. The estate sub sector comprises the multinationals and local farmers whose holdings are generally over 50 ha. The farmers under the estate sub sector operate under the umbrella of the Kenya Tea Growers Association. Generally, the estate sub sector is composed of large-scale plantations operating as companies, which depend on hired labour and management. Estates own both tea farms and factories, and also market their own black tea. It was estimated that in 1995 the estates sub sector of the Kenya tea industry employed 71,000 workers (Sang 1995) supporting an average of 8 people each. The smallholder sub sector is composed of indigenous farmers whose average area under tea is 0.27 ha (Anon 1964-2000). The smallholder tea farmers used to grow tea under license given to the Kenya Tea Development Authority (KTDA) upto 2000, but now operate as free entities with Kenya Tea Development Agency Limited (KTDA) as their commercial managing agent. The farm units are owned as family units in which the individual farmer is the risk-taking manager, with his/her family, he/she provides most of the labour and management and delivers his tea to KTDA factories which process and market the made tea on his behalf at a fee. The smallholder tea sub sector was composed of 289,270 family units supporting about 3 million Kenyans and KTDA had staff strength of 16,000 employees as at 1995 (Cheruiyot 1995). By 2000, the number of the smallholder tea farmers had increased to over 315,000. The tea production sector together with other sectors (marketing, warehousing, brooking, packaging, etc) of the tea industry is estimated to maintain directly or indirectly about 4 million Kenyans.

The Kenya smallholder tea sub sector is considered the largest and one of the most successful smallholder schemes in the world (Lamb and Muller 1982), with over 315,800 growers operating 45 factories and producing 124.1 thousand metric tones of made tea in 1999 (Anon 2000). KTDA is acknowledged as a successful institution in two fields; smallholder rural development and public sector enterprise both of which the Africa experience is often fraught with difficulties and disappointing performance (Lamb & Muller 1982). Although the area under tea in smallholder sub sector has been higher than that in the estates sub sector over the years (Figure 1.1), and total tea production by the sub sector surpassed that of the estates in 1988 (Figure 1.2), productivity in the estates sub sector has always been higher than in the smallholder sub sector (Figure 1.3). For example in 1998, the smallholders had 84,266 hectares of land under tea while the estates had 33,762, but the smallholder sub sector produced 175.6 metric tons of tea while the estates produced 118.5 metric tons in the 1998 (Anon 1999). This translates to an output level of 2,075 and 3,954 kg made tea per hectare for the smallholders and estates, respectively.

Although it had been predicted that the tea production rate would slow down with time (Schluter 1984), the growth rate has been sustained. From diverse tea cultivars, including the low yielding tea planted before 1940's, the estates produced a national average of 3,954 mt/ha in 1998. It is reckoned in the sub sector that teas yielding lower than 2500 kg mt/ha per year (which are mostly old seedling

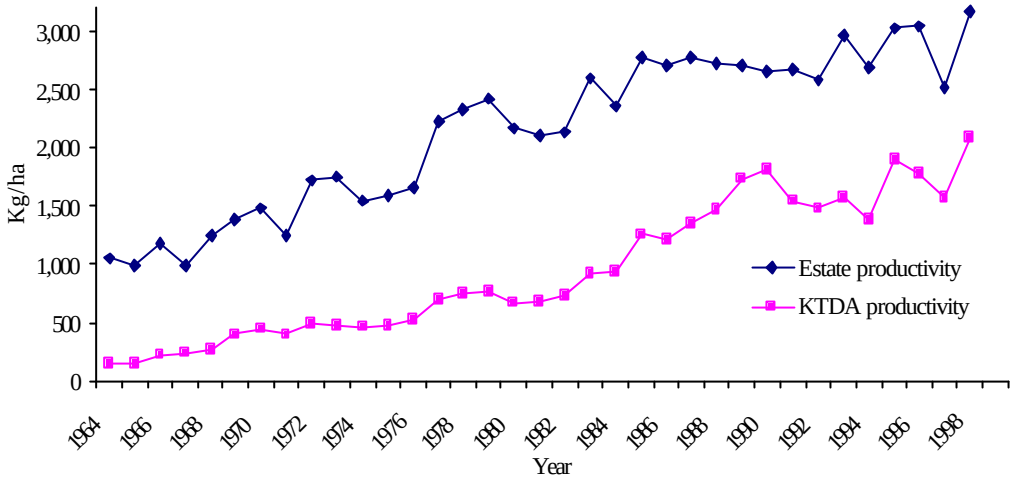
Figure 1.2: Tea production by different sectors



tea) are uneconomical to keep. The smallholders mostly have high yielding relatively young clonal teas capable of yielding much higher. Many experimental research trials tailored to improved productivity of tea producers have been undertaken and recommendations extended to farmers. Various fertilizer application trials have been carried out and results disseminated accordingly. Indeed, the TRFK has released clones to the tea industry, which are yielding in excess of 4000 kilogrammes made tea per hectare per year (kg mt/ha/year) (Othieno 1992; 1994). However, the national average yield in the sub sector is relatively low (Figure 1.3). If the Kenya Government objective of producing 350 thousand metric tones by the year 2008 (Anon 2001) is to be attained, the major increase is expected from the smallholder sub sector in the short run. The disparity in tea production has persisted over the years (Figure 1.3) and the large gap between the smallholder productivity and estates is a major source of concern, which needs to be addressed (Rutto 1996).

Smallholder sub sector presents peculiar difficulties for building and sustaining effective development. Each smallholder is a complex unit within which it is difficult to divorce the production (business) from consumption (way of life) dimensions. The behaviour of the smallholder unit is subject to a wide range of internal and external factors that can be social, cultural, political, technological as well as economic. It involves a large number of farmers pursuing multiple objectives and operating in a risky and uncertain environment such that management approaches and organizational framework in use in the estate sub sector may not be applicable. Nevertheless, the smallholder tea sub sector has gone through several phases of successful development. In the first phase it had outstanding record in the initial establishment of itself and of the smallholder tea industry. This was followed by a phase of rapid expansion and diversification into processing and marketing (Etherington 1973). Phase three hopes to consolidate the earlier gains, assuring continued efficiency and high returns when expansion is much slower and external environment uncertain (Schluter 1984). The uncertain prices and continued low prices of tea (Anon 1964-2000) (Figure 1.4) implies that although the future may rely on tea quality, it is more promising to get more profits by improving productivity per unit area as in the case of the commercial estates.

Figure 1.3: Tea production per hactare in different sectors

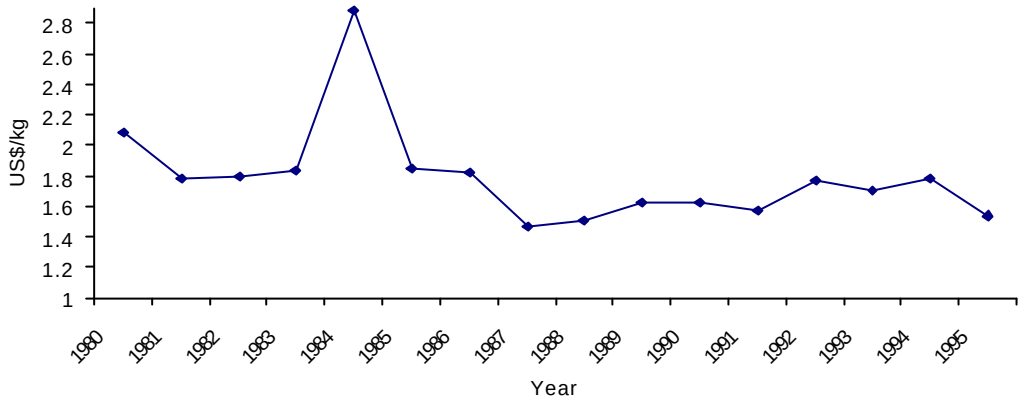


A problem which has received little attention but faces most researchers and development agencies is how to improve the speed of adoption of developed technological packages even when the technologies have immediate obvious and proven advantages. Expectations are that adoption of improved technology would lead to increased farm productivity. However, experience shows that immediate and uniform adoptions of innovations in agriculture are quite rare (Feder 1981). Some innovations have been well received while other improvements have been adopted by only a very small group of farms. Improved productivity in the agricultural sector is more difficult when one is dealing with traditional oriented smallholders (Leonard 1977). However, farmers recognizing that their traditional farming techniques and present level of knowledge impose a limitation on farm enterprise seem to be on the road to success (Anthony *et al* 1979). In the long run, farmers can improve productivity through adopting and using more efficient husbandry technologies which are made available through development of sufficient technological and organizational innovativeness (Leonard 1977).

Increased agricultural productivity will only come about through revolution in the pattern and methods of production on the individual farm units. These changes may result from adoption of new technologies or due to reallocation of the inputs already available at existing prices (Upton 1978) and must occur by gradual diffusion of ideas or a radical and rapid transformation. The changes may be the result of the decisions of the many individuals, indigenous producers or direct government intervention. Over the past three decades the Kenyan farming community has in general understood the benefits of adopting new and/or innovative technologies and farming practices provided that the cost/return relationships are perceived as favourable (Anon 1989). However, a closer look at the transfer and/or adoption of technological advancement and improved farming practices show that it is the Kenyan large-scale tea farmers/estates who have benefited from the use of these technologies (Othieno 1981; 1991b, 1992, 1994). The small-scale farmers who account for the bulk of agricultural production have lagged behind in adoption of improved practices (Rutto 1996). Pandey and Anderson

(1990) remark that a new technology is generally useful only if farmers adopt it. Hence an assessment of effects at the farm level is at the heart of any evaluation process. The impact at the farm level and the probability of adoption depend on how well the requirements of the technology fit into the particular niche in which a farmer operates.

Figure 1.4: Mean tea price (US$/kg) over time



The tea industry in Kenya is facing a mysterious predicament in transfer and adoption of new technologies and improved practices by the small-scale tea farmers. At the moment many growers may know as much about tea as extension workers. However the yields of smallholder tea farmers are still well below potential probably because their techniques of production are inferior to the estates' (Othieno 1992, 1994). Smallholder growers tea therefore need high level technical sophistication particularly research linked questions like the response of different planting varieties to drought, optimal fertilizer use, etc. It has been observed that achievement of these need better qualified staff, improved farmer extension worker ratio, use of computerized green leaf collection data for identifying unproductive farmers etc. But smallholder tea productivity remains low probably due to low adoptability of developed technological packages and under plucking in the sub sector as a result of labour shortage (Venkata Ram 1981). Although hired labour is necessary in smallholder tea production, cost of hired labour remains high (Etherington 1973) and this may be a contributory factor to low productivity. Payment trends should therefore take into account inflation, and payment periods need to be shortened as delays reduce marginal returns and quantity produced. It has been argued that opportunity cost of labour in picking tea is determined by returns from major expanding enterprises. However, no study has been done so far to establish if labour drops occur during months of peak labour demand for food crops.

Gender relations also affect smallholder tea production negatively and lead to low productivity and neglected tea fields (Sorensen and von Bulow 1990). Tensions arise as a result of conflicts over the control of proceeds of tea sales, as the smallholder controls the labour of the household members only to the extent that they also benefit from production. As women make up large part of the labour force in smallholder tea schemes, it is vital to consider gender in relation to extension service, transfer of skills, choice of technology, effects of subsistence crops (Lamb and Muller 1982; Sorensen and

von Bulow 1990). It is not established whether women are effectively integrated in education and training, especially extension service (Anon 1989).

The success of policies for raising agricultural productivity in low income countries depends upon the quality of decision making by farmers as the efficiency of farmer decision making influences the design of development strategy in a country (Pachico 1980). If farmers are inefficient in the management of resources, then simply improving the allocation of resources, without having to develop new technologies, which usually are relatively expensive can raise agricultural production. On the other hand, if productive technologies are developed, inefficient decision-making reduces the gains from these technologies, both to the farmers and society as a whole. The factors that contribute to stagnating tea productivity need to be identified and understood to facilitate appropriate decision making at all levels.

1.2. Research Problem Statement

1.2.1 The need for improving productivity

Tea is planted in the prime lands with very good soils and climate (Othieno 1991a). Thus there is a pertinent need to maximize its productivity. Although the objective of the Kenya Government is that the country should produce 350 thousand metric tones made tea per annum by the year 2008 (Anon 2001), suitable land for tea expansion is limited and hence this target can only be attained by improving technical efficiency of production within the existing tea plantations. If the productivity of the smallholder tea can only increase to about 2500 kg/ha/year, this projection can be realized without allocating more land to tea enterprise, which when done, substitutes food crop enterprises. Factors responsible for the low productivity in the sub sector therefore need to be determined and corrective measures undertaken to ameliorate the situation.

Unlike most research undertakings, tea research in Kenya is highly integrated into the industry. Both the former TRIEA and TRFK have enjoyed backward linkages with the tea farmers and forward linkages with tea producers (farmers and factories). The tea industry funds and strengthens its research activities through cess payments by farmers, which is administered by the Tea Board of Kenya. Thus tea research scientists do not operate abstractly and in isolation in generating production technologies but rather concentrate on solving real problems arising from any felt need areas within the tea industry. The industry therefore consumes most of the technologies developed through research. As a result of this interaction, the estate sub sector of the Kenya tea industry has undergone improvement in productivity unparalleled by any other tea producing countries (Othieno 1994). However, the adoption of the technological packages is not very successful in the smallholder tea sub sector, probably due to use of inappropriate policies to transfer the packages to the sub sector. For both the smallholder and estate sub sectors of the tea industry, technological packages for improved productivity are developed by the TRFK (Othieno 1981) or adopted from other tea research institutes. The information is disseminated to the growers through seminars, symposia, courses, annual reports, journal publications, demonstrations and advisory (extension) visits. Despite these efforts, information may not be reaching most of the smallholder tea growers, probably leading to low average productivity. This study examined: -

(i) The level of adoption of the technological packages available to the Kenya tea industry in the smallholder tea sub sector;

(ii) If the level of adoption of the available technology contributes to low productivity;
(iii) If the policies used to transmit the technologies are appropriate to the smallholders.

Adoption success of the developed technologies have been assumed to be easier in the smallholder sub sector since technical packages KTDA administers in the field and factories are presumed to be simpler and already tested and proven in the estate sub sector of tea production. The objective of this study was to investigate and explain why technological packages while widely adopted in the estate sub sector resulting in high productivity, are not being widely adopted in smallholder sub sector. The findings will help in providing data to create policies to improve smallholder technology adoption. Whereas, socio-economic factors could be partly responsible, technological package transfer problems from the researchers could also play a major role. It was therefore important to examine the level of technology adoption in tea production by the smallholder and identify the factors that circumvent and/or circumscribe technological transfer and/or adoption.

1.2.2 Available technologies probably not reaching the smallholder tea farmers

Several technological packages have been developed and made available to the Kenya tea industry through various TRFK publications like the *Tea Growers' Handbook* (Anon 1986), *Annual Reports, Tea Magazine, Quarterly Bulletin*, various international and national journals, symposia, seminars, courses, demonstrations and advisory visits (Rutto 1995). Summaries of these recommendations have been given in the Tea growers' Handbook (Anon 1986) and various recent reviews (Othieno 1988; Owuor 1995, Rutto 1995). The available technological packages for maximizing green leaf production for the Kenya tea growers include selection of suitable tea growing areas, proper land preparation and soil conservation methods, procedures for planting vegetatively propagated materials, general crop husbandry methods and recommendations on necessary farm inputs. Development and selection of planting materials has been done and high yielding clonal plants released to the industry. Indeed yields of up to 11,995 kg made tea per hectare have been achieved from clonal tea under estate management practice (Oyamo 1992). Suitability of planting materials to an area has been assessed and correct planting density for maximum leaf production suggested for use. Better ways of bringing into bearing, fertilizers for young tea, and weed control methods in young tea have been developed to ensure proper establishment of planted tea. Correct fertilizers including rates and time of application have been recommended and chemical methods of diagnosis for nutrients availability or deficiencies on mature plants through leaf and soil chemical analysis developed to advise the growers on the correct plant nutritional status and effective types and rates of fertilizers to use to correct possible deficiencies. Plucking methods inclusive of plucking standards, plucking equipment, and plucking frequencies have been recommended to the growers to ensure high yields per bush and production of high quality black tea. Pruning technologies have been developed for the industry to ensure proper timing during the year, heights and types suitable for various geographical regions. And after pruning, the optimal tipping height has been provided to the growers. The Kenya tea growers have also been provided with cost effective ways of pests and diseases control based on biological control methods.

Although an impressive range of technological packages for the improvement of green leaf production have developed and disseminated in Kenya to tea growers, there has been no study to

assess the levels of adoption of the technologies. This is more critical in the smallholder sub sector which relies wholly on the technical advise from the TRFK unlike the estates sub sector with a whole range of forward interlinked technical departments and a host of advisers or consultants to follow up and further examine whether the packages availed to the sub sector are correctly implemented.

1.2.3 Possible factors responsible for smallholder low production

Many factors could contribute to the low green leaf production in the smallholder sub sector of the Kenya tea industry. Some of the factors could be due to lack of adoption of the above technologies for various reasons and/or socio-economic or cultural factors. Labour constraints or availability was one of the reasons impeding tea production in the smallholder sub sector of the Kenya tea industry (Etherington 1973). Possibly, this problem has persisted. It is suspected that some smallholder tea farms are in the marginal drought susceptible regions while others are in very high altitudes where low temperatures limit tea growth. While neither of these regions maybe suitable for tea growth, the existence of tea in them could reduce the national average of smallholder tea production and growing tea in such areas could be uneconomical. It is not known if such areas are extensive or not and farmers in such areas are probably better off engaging in alternative farm enterprises. Also, the prices of Kenya tea have stagnated or have been declining in the last decade (Figure 1.4) and this could be making farmers to direct attention to alternative competing farm enterprises.

Although the above technical packages have been produced and made available to the growers, it is not known if they reach the targeted users. People in smallholder farms include the smallholders, smallholders' wife/family, and hired worker. It is important to know who in the smallholder tea sub sector receives the technical information or training and how often each smallholder actually receives technical advice and uses of it.

1.2.4 Objectives of the study

The general objective of the project was to "assess the level of adoption in the smallholder tea sub sector of technological packages available to the Kenya tea industry and examine policy factors responsible for their low adoption leading to the low productivity per unit area". The specific objectives were: -

1. to investigate the extent of awareness and /or knowledge of the various recommended tea production technologies within the smallholder tea sub sector of Kenya and to identify the technological packages in use by small scale tea farmers;
2. to investigate the extent of adoption within the smallholder tea sub sector of Kenya of the recommended technological packages available for tea production;
3. to study the effectiveness of the present methods of technology transfer to the smallholder tea farmers and assess if there is need to change/modify methods of transferring the available technology to the smallholders;
4. to find out whether there are any differences in tea yields across agro-ecological zones where technical methods of production are relatively homogeneous,
6. to establish the profitability of the tea enterprise within Kenya's smallholder tea sub sector;
7. to determine the break-even price for the tea enterprise in the smallholder tea sub sector of the Kenya tea industry.

1.2.5. Hypotheses

There are three broad areas on which hypotheses testing was based. These are: -

a) Effectiveness of extension

It may be possible that only a few smallholder tea farmers have awareness and/or knowledge of the technologies identified and available for high tea productivity, hence the packages are not reaching the smallholders effectively. Alternatively, many smallholders are using hired labour or members of the family who do not receive the technological packages as training or extension services maybe directed to the farm owners who do not pass the information on to the personnel doing the actual farm work. As a result, tea yields remain low because technology transfer is not effective. The following hypotheses were tested:

i) that less than half of the smallholder tea farmers have knowledge of the tea technologies identified;
ii) that in more than half of tea farms, training in tea and extension services are directed to the farm owners and not to the personnel doing the real tea work;
iii) that in less than half of tea farms, the farm owners do not have adequate time to train their workers after attending tea production training and/or receiving advice from tea extension staff;
iv) that more than half of the farmers have no access to credit to purchase the recommended inputs or where the inputs are available on credit, they do not reach the smallholder on time;

b) *Socio-economic and/or cultural factors.*

Probably many smallholders with awareness and/or knowledge of the identified technologies have not adopted them. The packages may be reaching the farmers but are not being implemented due to socio-economic and/or cultural factors. The following hypotheses were tested: -

i) that there are some recommended technologies which are not culturally acceptable for use in some regions;
ii) that more than half of the smallholder tea farmers have not adopted the recommended levels for each identified technology;
iii) that there is a significant difference between the recommended level and the application level on the farm for each identified technology;
iv) that tea production is a profitable farm activity;
v) that there is no difference between the computed break-even price and the monthly producer price paid by KTDA

c) *Suitability of land for tea growing*

It is possible that some smallholder teas are planted in agro-ecological zones not suitable for tea production. This leads to situations where there are differences in yields of tea across different agro-ecological zones or regions where technical methods of production are relatively homogeneous. As a result, the average tea yields in the smallholder tea sub sector would be lower than estate sub sector tea yields. The most suitable zone for tea in Kenya is Lower Highland Zone I (LH 1). The following hypotheses were tested: -

that there is a significant difference in tea yield between Lower Highland Zone (LH) and Upper Midland Zone I (UM 1).

1.2.6 Justification of the study

The problem this project investigated was the general failure of available technological developments and packages to reach the rural farmers for enhanced farm productivity. This scenario translates a high yielding prime land with good soils and excellent climate to a low yielding uneconomical production thus enhancing poverty in rural Kenya despite the high potential. The lack of effective technology transfer policy and methods is therefore slowing down agro-industrial and economic development. This makes it very necessary that factors responsible for low adoption of the existing technologies are identified and proper policies put in place to ameliorate the situation.

The tea industry in Kenya has had an enviable economic performance and growth during the last decade when compared with other similar industries. Although the smallholder sub sector has accomplished high level of expansion, productivity has remained low. Comparison of the adoption level of the technological packages between the sub sector and the estate sub sector offers excellent opportunity for policy makers to understand the constraints smallholders face in adapting existing technologies. In all East and Central Africa tea growing countries, the smallholder tea sub sectors are producing very low yields compared to the estates (Owuor 1999). Results from this project therefore have wider audience including governments and Tea Boards of the countries who could use the findings to improve efficiency of their smallholder tea industry and/or production through the use of appropriate policy of technological transfer.

The projected future development in Kenya is set to be in rural areas where the smallholders are major stakeholders (Anon 1997). Kenya's population is expanding at a fast rate resulting in rampant poverty and unemployment. Increase in tea production in the smallholder sub sector would therefore create job opportunities in the rural areas, promote more rural agro-industrialization, improve the socio-economic development and ultimately reduce poverty.

Tea is the leading foreign exchange earner for Kenya (Anon 1997). Improvement of the smallholder sub sector will play a major role in sustaining the high in flow of hard currency that the country needs for industrial development and to sustain servicing of high foreign debts. This project investigated ways of improving the productivity of smallholder tea in Kenya leading to more inflow of foreign currency earnings. The study would help in developing appropriate methods to alleviate the possible technological transfer problems to the smallholder tea sub sector which would in turn increase the productivity of the smallholder tea production thus enhancing the profitability to the growers. This would help change the policy of technological transfer to the smallholder enterprises and help both the KTDA and TRFK to identify weak points in the presently used technological transfer mechanisms. The research is also meant to make it possible to introduce a better technological transfer mechanism and adoption methodology to smallholder farmers in general. Many lessons could be drawn for other smallholder enterprises in Africa and this would hopefully have positive effects on both the policy makers and researchers in Africa.

1.2.7 Organisation of the Report

The subsequent chapters in this report are organised as follows. Chapter two, methodology, describes the relevant conceptual framework and the analytical procedures adopted. Results and discussions are presented in chapter three in two parts. Part one presents the frequency statistics results for the socio-economic characteristics of the extension staff in the study areas, while part two presents the descriptive statistics results for smallholder tea growers in the study area. It summarises the socio-economic characteristics of the farm survey respondents i.e. information on the farm operator, adoption of tea technologies, use of labour in tea enterprise. It also presents the tea enterprise analysis. Chapter four summarises the conclusions and policy implications of this study.

2

METHODOLOGY

2.1 Data Sources and Collection

The areas the smallholder tea cover are in regions east and west of the Rift Valley on the foothills of Abadares and Kenya mountains in the east of the Rift Valley (in Nyeri, Murang'a, Kiambu, Kirinyaga Districts (in Central Province), Embu, Meru, Nyambene, Tharaka/Nithi Districts (in Eastern Province)) and Mau, Nandi, Kisii and Kakamega Hills in the West of the Rift Valley (covering Kericho, Bomet, Bureti, Nandi, Trans Nzoia, Keiyo, Marakwet, Trans Nzoia, Nakuru, and Narok Districts (in Rift Valley Province), Nyamira, Kisii, Gucha, Trans Mara and Rachuonyo Districts (in Nyanza Province), Kakamega, Vihiga, Butere/Mumias and Bungoma Districts (in Western Province). For ease of administration, KTDA has subdivided the districts into East covering Central and Eastern Provinces and West of the Rift Valley covering Rift Valley, Nyanza and Western Provinces. Some of the districts have been further sub divided to give the above districts, however, during the study period, the administrative boundaries for KTDA was as outlined in table 2.1. The rainfall pattern in the East of Rift Valley is unimodal with main rains in September to December, but in the West of the Rift Valley, rainfall is bimodal with rains in long rains in April to June and short rains in September to December. The framers in the tea growing areas practised mixed farming of maize, beans, and dairy.

Mainly the Kikuyu, Embu and Meru inhabit the areas of tea under KTDA in the East of the Rift Valley and Kalenjin, Kisii and Luhya in the West of the Rift Valley. This study covered four districts. Two districts from the East namely Kirinyaga and Nyambene to represent district with high and low mean productivity per unit area respectively. These districts also covered different cultures i.e. Kikuyu and Meru cultures respectively. Nyamira and Nandi districts covered in the West of the Rift Valley to represent high and low productivity respectively among Kisii and Kalenjin cultures respectively.

This study adopted an exploratory form of research design and data collection was done in July, August, September, and November 1999 for Kirinyaga, Nyambene, Nandi and Nyamira, respectively. Cross–sectional data was obtained from a sample of smallholder tea producers in four districts representing high tea producers and low tea producers in Kenya. These districts were Kirinyaga and Nyamira representing high yielding districts and Nyambene and Nandi representing low yielding districts. A questionnaire instrument targeted to the farmers was developed, pre-tested, adjusted and then administered to the farmers. The questionnaire sought to obtain information concerning adoption and application levels of the various recommended tea technologies i.e. site selection, land preparation, nursery establishment, field management, use of chemical inputs, labour use and extension services.

The altitude of each farm visited was recorded using Thommen Classic altimeter plus barometer while rainfall data was received from the records of the nearest factories.

Table 2.1: Administrative districts of the KTDA, area under each district, number of growers per district and mean production per hectare* during the 1997/98 financial year**

East of Rift District	Area under tea (Ha)	No. of Extension staff mt/ha)	No. of growers	Mean production kg
Kiambu	6,809	48	18,769	2,517
Murang'a II	5,836	37	19,673	3,163
Murang'a III	5,326	35	21,318	2,899
Nyeri	6,314	46	24,271	2,366
Kirinyaga	5,480	27	17,112	3,217
Embu	3,447	24	12,657	2,317
Tharaka/Nithi	1,380	13	5,491	2,694
Meru	4,378	28	14,968	1,335
Nyambene	3,300	12	13,070	1,861
West of Rift				
Kericho	8,145	25	19,558	1,534
Bomet	6,747	43	21,102	1,775
Nyamira	9,500	41	47,500	2,045
Kisii	7,297	48	46,154	1,517
Nandi	2,490	20	6,820	1,028
Kitale	736	7	1,012	810
Vihiga	1,698	16	9,449	1,284
Kakamega	511	8	2,408	1,018
Olenguruone	1,013	1	1,346	404
Total	80,407	479	302,698	2,101

**Based on total green leaf production and using a factor of 0.225 (Anon 1986) to convert green leaf into made tea. **Source KTDA Statistical data; +Tea officers plus assistant tea officers and technical assistants. ++This figure excludes Nyayo Tea Zones Development Corporation areas.*

2.2 Research Design and Survey Methods

In order to better understand the mode of technological package transfer within the smallholder tea sub sector, proper classification of all institutions involved was made. Grouping the institutions in terms of the roles they play in technology transfer gave an impetus for desired analysis. Also, the classification of the technologies for tea production assisted in the quantitative technical and economic description and interpretation of the levels of adoption and the existing technological constraints. In terms of design, the study had both quantitative and qualitative components. The empirical data generated in various tea farms was quantitatively analysed and compared with each other between low, and high yielding districts for the purpose of pin-pointing significant differences and/or similarities that existed and this was used as a basis for recommending improvements to adoption of various technologies to smallholders.

Diagnostic activities included a set of questionnaire. A formal survey established actual baseline data for economic relationships. The questionnaire was directed to a representative sample of smallholders. It was structured with both coded and open-ended expected responses. Verbal interviews were conducted for the individual farmer, by the investigating scientists with the help of the KTDA personnel. The information sought was related to the knowledge of existing technological packages for green leaf production, methods and effectiveness of the methods being used to disseminate the information to growers, possible factors causing poor yields in the smallholder sub sector and suggested ways of overcoming them. Training programmes by KTDA for the farmers were

also assessed in relation to the targeted users, i.e. whether the person involved in day to day operation were being trained or if the smallholders were trained to train their hired workers or members of the family.

2.3 Research Design and Sampling

The smallholder tea growing districts had a total of 84,502 tea growers (Table 2.1). If 50 percent figure is considered to give the highest sample acceptable and assuming 50% of the growers were not receiving adequate technological information for high tea production, the desired sample size (Yamane 1973) was computed as follows:

$$n = z2pqN/(z2pq + Ne2) \quad \text{(Eq. 1)}$$

Where z = the standard deviate

p = the proportion of the population with the desired characteristic

q = 1 - p

N = Number of growers in the districts of study

e = desired degree of accuracy.

In this study, p was estimated at 50%, z = 1.96 for 95% confidence level and a degree of accuracy of 0.05.

Therefore, substituting in the above equation

$$n = 1{,}962x0.5x0.5x84502/(1.962x0.5x0.5 + 84502x0.052) = 382 \quad \text{(Eq. 2)}$$

A slightly high figure of 450 was proposed to be taken to allow for loss of cases. Thus, it was envisaged that such a sample size adequately represented the study population and reliable inferences could be drawn from it. However, at the start of the study, a budget constraint was occasioned by reduction of the expected research funds by a half. As a result, the expected sample size was reduced accordingly. When the survey work commenced, KTDA and TRFK decided to lend a hand in terms of transportation and personnel. Consequently, the sample size was rationalised and adjusted upwards towards achieving the targeted size. The achieved sample size represented the population adequately because it was within the large sample size range i.e. above 30 (Lapin 1987), which is approximated by the normal distribution.

Proportionate sampling was done per district as follows:

n = nKirinyaga + nNyambene + nNyamira + nNandi

N = NKirinyaga + NNyambene + NNyamira + NNandi

For every district the sample size was

$$ni = Nixn/N \quad \text{..... (Eq. 3)}$$

i.e. ni = Ni x 450/84502 as presented in Table 2.2 below.

Where ni was the district sample size and Ni was the total number of farmers in the district.

Table 2.2: Sample size per district.

	Kirinyaga	Nyambene	Nandi	Nyamira	Total
Target size	90	72	42	246	450
Expected size after budget reduction by half	45	36	33	90	204
Achieved size After KTDA/TRFK chipped in	70	44	39	106	259
Reference population	17,112	13,070	6,820	47,500	84,502

In all tea growing districts, tea factories keep growers records. Each factory is served by a number of buying centres where farmers deliver tea leaf. The factories keep systematic records for every buying centre within its jurisdiction. The sampling frame therefore consisted of the factories, buying centres and the individual farmers. The number of buying centres in each factory was first ascertained. Then the total number of the buying centres was obtained by summing them in each district. A number of buying centres were randomly selected proportionately in each factory with reference to the sample size in each district. From every selected buying centre, one grower was randomly selected to represent it. Thus, multi-stage random sampling was used to appropriate farmers into the sample size in every district. However, in Nandi District, there was only one tea factory (Chebut) with an expansive tea leaf delivery catchment. As a result, the selection was based on divisions, buying centres and individual growers and had the same consistency as the rest of the districts. Although the sampling was random, growers were covered from all the tea growing agro ecological zones in the various districts.

The interviews of the farmers were focused on the knowledge, adoption and use of the available technologies in their farms, problems encountered in the adoption of the technologies, factors not related to tea production but causing reduction in tea productivity and possible suggestions of improving productivity in their farms. Other factors assessed included provision of extension services, adequacy of farm in-puts from the KTDA, supply of farm in-puts on time and application level by the farmers.

2.4 Analytical Procedures

Three procedures were used to assess the awareness and/or the knowledge of the recommended technologies, the level of adoption by the smallholders and the factors leading to low adoption, differences in tea yields across agro-ecological zones, profitability of the tea enterprise and the break-even price. These procedures were: frequency and descriptive statistics, comparison of means and gross margin analysis

2.4.1. Frequency and Descriptive Statistics

This method involves the use of frequency distributions, calculating means, percentages and tabulations of responses for qualitative and quantitative cross sectional data obtained from tea farmers. The frequency distributions and the percentages obtained were used for testing most of the general hypotheses related to qualitative data.

Descriptive statistics involved computing frequency distributions, calculating means and tabulations of responses for quantitative cross sectional data obtained from tea farmers. It was used to analyse the level of technology adoption for each identified agronomic recommendation. It analysed socio-economic and cultural factors such as: awareness and/or knowledge of the recommended technologies, the level of technology adoption, methods used in the extension mechanism to transfer information to tea farmers, factors inhibiting the flow of technological information, whether transfer of information through “local barazas” reaches the farm workers, availability of credit to farmers, etc. The mean of each recommendation use level was computed and compared with the research recommendation level. The test statistic used for comparison was specified as: -

$$t = (m - \mu)/[s/(n - 1)1/2] \qquad \text{(Eq.4)}$$

where: μ =Research recommendation level;
m = Farm application level;
s = Standard Deviation for the samples;
n = Farmers sample size.

The computed t statistic was then compared with critical t to find out whether there was a significant difference between the farm application level and the agronomic recommendation level. The results were then used to test the hypothesis that there is a significant difference between the research recommended level and the farm application level for each identified recommendation. The testing was done for quantifiable recommendations only. These were as follows: - Soil pH, land preparation, nursery establishment, fertilizer rates, etc. The testing was done on district-by-district basis. The null hypothesis tested was that there was no difference between the research recommendation level and the farm application level i.e.

Ho :m = μ. (Eq 5a)

This was tested against the alternative hypothesis that there was a difference between the research recommendation level and the farm application level. i.e.

HA : m ¹ μ... (Eq 5b)

The testing for significance was done for each quantifiable recommendation and the computed t - value was compared with the critical t value at 5 per cent level of two-tailed test of t-distribution. The null hypothesis was accepted if t < tc or t > tc where t was negative. This would imply that m- μ.= 0 i.e. m.= μ. This would then mean that the farmers' application level and the recommendation level are not different. The null hypothesis could be rejected in favour of the alternative hypothesis if t > tc or t < tc where t was negative. This would imply that m - μ ¹ 0, that is, m ¹ μ. This would mean that the farm application level of the recommendation and the research recommendation level are significantly different. Hence the extension knowledge reaching the farmer would be deemed to be inaccurate. Analysis of socio-economic characteristics of technology adoption helped in diagnosing farm business weaknesses and strengths. On the strength of these results, recommendations were based on facts and figures.

2.4.2. Mean Comparison

This method involves the calculation of means for quantitative data in descriptive statistics. The means were subjected to various statistical methods in order to determine: differences in population characteristics, variation or even the effect of one variable on another. This method was used to analyse the differences between research recommendation levels and the farm application level of the technologies, yield differentials across agro-ecological zones and to establish whether the use of the available technologies had an impact on tea production among smallholders. Two statistical methods were used. The first one tested the deviation of the application level of the farmers for each technology from the research recommendation level. The test statistic was specified below as: -

t = (m - l)/[s/(n - 1)1/2] (Eq. 6)

Where:

m = sample mean knowledge or application level of the recommended technology;

I= Research recommendation level;
s = standard deviation of knowledge level or application level of the technology;
n = sample size for tea farmers.

The second method tested whether there were any differences between tea yields in different agro-ecological zones. The t - statistic was used to test statistical difference in mean yields using equation 7 below.

t = (X- - Xj-)/ [S21/n1 + S2j/nj]1/2 ..... (Eq. 7)

Where:

X- = mean tea yield per hectare in Lower Highland (LH) zone;
Xj- = mean tea yield in Upper Highland (UH) or Upper Midland (UM) zone;
S21 = variance of tea yield in LH;
S2j = variance of tea yield in UH or UM zone;
n1 = sub-sample size of tea farmers in LH zone;
nj = sub-sample size of tea farmers in UH or UM zone;

The means of yields computed for the agro-ecological zones were compared to find out whether there were any differences. Thus, the equation was used to compare mean output in kg/ha between Lower Highland zone and Upper Mid-land zone and between west and east of the Rift Valley. The hypothesis tested aimed at finding out whether the Upper Midland zone contributed to low tea productivity. The hypothesis was tested for statistical significance for every UM1 in the districts using LH as control zone for tea production. The null hypothesis was that there is no difference in tea yields per hectare between UM1 and LH zones. i.e.

Ho: ml = mj (Eq.8a)

This was tested against the alternative hypothesis that there is a difference between tea yields per hectare in the UM1 and LH zones i.e.

HA: ml ¹ mj (Eq. 8b)

The computed t value was then compared with the critical t-value. The null hypothesis was accepted or rejected depending on whether the computed "t" value was less or greater than the critical "t" value. If Ho was accepted, that meant that there is no difference in tea yields between UM1 and LH on the other hand. Its rejection indicated that there is a difference between tea yields in UM1 and LH. The same hypothesis was used to find out whether there is any difference in tea yields between east and west of the Rift Valley.

2.4.3. Gross Margin Analysis

Gross margin (GM) analysis was used to analyse the viability of the tea enterprise and to determine its profitability. Break-even price analysis was also undertaken using data on gross margin analysis. Gross margins are widely used in farm planning. They can be used to prepare partial budgets for marginal changes in the farm programs, or whole farm budgets for major changes in farm programs (Sturrock, 1971). Gross margin involves computing total variable costs (TVC) and total output value (TOV) associated with an enterprise. The difference between total output value and total variable costs is the gross margin for that enterprise. This in essence, is the return to fixed costs, management

and risk. A number of efficiency measures can be computed from the enterprise analysis and compared with the standards to diagnose areas of potential improvement. Possible efficiency measures include: - a) gross margin per unit of enterprise, b) gross margin per unit of a scarce resource and c) gross margin per unit of investment. In this study, gross margin was done for purposes (a) and (b). The results of this analysis were used to determine whether tea is a profitable farm activity.

The break-even point is that scale of activity where income equals total costs. A break-even price is the price necessary to cover the cost of production at a certain yield level (Ronald, 1986). Break-even price for green leaf was calculated on the basis of total direct costs of production. These are the short run costs, which were directly applicable and accrued specifically to tea enterprise. There has been a general complaint by the smallholder tea farmers that the monthly payment of green leaf is too low to intensify and ultimately increase tea production. In this sub-section, analysis to gauge the profitability of the tea enterprise and the break-even price of the green leaf in the smallholder tea sector were reported. Gross margin involves computing total variable costs (TVC) and total output value (TOV) associated with an enterprise. The difference between total output value and total variable costs is the gross margin for that enterprise. The break-even point is that scale of activity where income equals total costs. A break-even price is the price necessary to cover the cost of production at a certain yield level (Ronald 1986). Break-even price for green leaf was calculated on the basis of total direct costs of production. These were the short run costs, which were directly applicable and accrued specifically to tea enterprise. The results of the analysis were therefore used to test the hypothesis that the computed break-even price was not different from the monthly payment of KShs. 6.00 per kg in 1998/99 (during the study). The alternative hypothesis was that the computed monthly break-even price was different from the monthly payment. The null hypothesis could be accepted if the computed t was less than the critical t ($t < tc$). The alternative hypothesis could be accepted if $t > tc$. The equation used to compute t was: - $t = [P-P0]/[s/(n-1)1/2]$ where P is the sample mean price; P0 is the current monthly payment; s is the sample standard deviation and n is the sample size. Table 4.7 gives a summary of the results of gross margin analysis based on the 1999/ 2000 production systems in the smallholder sub-sector. The prices used to compute revenue and costs were those that prevailed in the tea industry during the 1998/99 financial year. The calculations of tea output values, variable costs, interest and total variable costs (TVC) are means of individual variables, and were not derived from the means of the related variables. For, example, tea output value was not a product of mean of tea output and mean of producer price, but was a mean of tea output value variable. The interest was not simply 20% of the mean of variable costs but a mean of 20% of variable costs variable, etc.

3 RESULTS AND DISCUSSION

3.1 Socio-economic Frequency Statistics on the Factors Inhibiting Flow of Tea Production Technologies to Smallholders

3.1.1. Introduction

All Kenya tea growers pay service cess to the Tea Board of Kenya, partly for the development of tea industry through research. The TRFK does the research on behalf of the Tea Board. Tea production technologies produced by the TRFK are therefore intended for and are the properties of the Kenya tea growers. The produced technologies should reach the tea growers to help them increase tea productivity and/or production and reduce costs of production. At present, the smallholder tea sub sector produces over 60% of Kenya tea (Anon 2000). This implies that over 60% of cess money, generating tea production technologies is contributed by the smallholders. However, productivity of tea in the smallholder sub sector has remained low compared to what is achieved in the estate sub sector (See Figure 1.3). This low productivity is possibly due to lack of adequate tea production technologies reaching the individual farmers or that though available, the technologies are not being adopted by the farmers in the sub sector. The results of the farmers' responses to inquiry of their knowledge, access to and factors impeding access to tea production technologies are reported.

3.1.2 Information on the farm operators.

The number of the farmers in the district surveyed, those interviewed and information on those interviewed are presented in Table 3.1. Most of the farmers interviewed were the owners of the farms. It was hoped when the smallholder tea sub sector was being established that the family units would manage their farms (M'Imwere 1997, 1999). This was indeed the case as when the owner was not managing the farm, a son or daughter or relative did the management. Most of the decisions on the farms were made by the key members of the family unit (husband and wife). Unlike what used to be on tea previously, when females (wives) never made important decisions on tea production (Sorensen and von Bulow 1990), the situation has changed. Indeed in many farms, husbands and wives made most of the decisions jointly. Where this was not done, about equal percentage of females as males were individually managing the enterprises (Table 3.1).

The mean age of the smallholder farmers interviewed was about 45 years in all the districts. Although this suggested that most of the farms are managed by mature personnel, there was a general complaint from the children of the farmers that the parents are unwilling to subdivide to them pieces of the tea holdings, despite their doing most of the work on the farms. This may be a problem in tea production as it creates less incentive for the youngsters to work on tea farms since their work is paid in kind not by cash. As unemployment increases in Kenya, rural industrialisation is being

projected as possible way of overcoming the problem (Anon 1997), smallholder tea production is likely to be a key player in the rural industrialisation process and there is need to develop a proper rewarding system for the family labour. Most farmers interviewed indicated their unwillingness to subdivide the farms in fear of the possibilities of the youngsters selling off their portions if they get alternatives ways of making a living. A proper study should be done to come out with clear policy on how to deal with this problem.

The majority of the smallholders had either not gone to school or had only reached primary level of education. Indeed the mean period spent in school ranged from 5 years in Nyambene district to 8 years in Nandi district. The low formal education level of most farmers (Table 3.1) implied that passing technical information through bulletins is unlikely to help technology diffusion in the smallholders tea sub sector. Consequently, it is necessary that the technologies are disseminated to the smallholder farmers through on farm courses based on practical demonstrations in which the farmers have contact with the trainers. However, this situation is likely to change with time as the old farmers are gradually being replaced by younger and better-educated farmers. Both bulletins and demonstrations should therefore be used for groups, which need them.

Table 3.1: Information on the farm operators interviewed

		Kirinyaga	Nyambene	Nandi	Nyamira
Registered farmers		17,112	13,070	6,820	47,500
Number interviewed		70	44	40	106
Are you the owner of the farm	Yes	89	61	69	77
	No	10	34	31	23
	Missing	1	5	0	0
If no, who are you on the farm?	Employed Mgr	3	0	0	1
	'' relative	1	0	0	2
	Son	4	18	15	8
	Daughter	3	2	5	1
	Others	4	18	10	10
Who make decision on the farm?	Husband	20	23	28	13
	Wife	23	18	18	25
	husband & wife	43	46	46	50
	Employed Mgr	1	2	0	1
	Others	13	9	8	11
	Missing	0	2	0	0
Mean age of farmers	Age (years)	47.97	44.53	46	48.02
What is your education level?	unschooled	24	36	15	25
	Primary level	53	48	49	40
	Secondary ''	19	16	28	33
	College	4	0	8	2
How many years did you spend in school?	6	4.9	8	6.89	

The mean number of people living in each household ranged from 6 to 9 (Table 3.2). Most of these people were members of the core family (parents and children). Large percentage of the family members lived permanently on the farms and thus derived their livelihood from the tea enterprise. Except in Nandi district, most smallholders did not have any occupation apart from farming. As had been intended (M'Imwere 1997, 1999), the smallholder tea enterprises help the immediate family members make a living. This demonstrates the need to put in place policies that ensure the smallholder tea production is sustainable. A collapse of the sub sector can lead to high unemployment and loss of

livelihood to many Kenyans. Indeed, as at 1995 (Cheruiyot 1995), the smallholder tea sub sector, was composed of 289,270 family units supporting about 3 million Kenyans at farm level, over 16,000 KTDA employees plus their families and other sectors (marketing, warehousing, brooking, packaging, etc) of the tea industry. It was estimated to maintain directly or indirectly about 4 million Kenyans. This number has gone up and by 1999 there were over 315,000 smallholder tea farmers (KTDA Statistics). It is hoped the other tea sub sectors also increased with tea production since additional new factories have been built and old ones expanded to cope with additional production.

A reasonable number of the smallholder tea farmers had other jobs in addition to tea growing. If the sub sector does not do well, a large number of the farmers will continue to seek other methods of making a living and may grow tea as a part time occupation or may abandon it altogether. Since the smallholder labour is based on family labour, this will further reduce production and productivity in the sub sector. Clear Government and KTDA policies are crucial to keep the farmers well remunerated to reduce incentives for moving on to other enterprises. There was no clear relationship between smallholders having other jobs and tea productivity in all districts.

Table 3.2: Details on households

		Kirinyaga	Nyambene	Nandi	Nyamira
Mean number in house hold		6	8	9	7.91
How many are	Children	4	5	5	5
	Parents	2	2	2	2
	Others	0	1	2	1
Do all of them (%) live on the farm consistently?	Yes	72	84	77	77
	No	27	16	23	23
If no, how many have lived consistently on the farm during last year?	On the farm	5	5	7	6
	Outside farm	1	5	2	3
Do you (%) have any other occupation a part from farming?	Yes	33	32	44	26
	No	66	68	56	74

The average tea growing experience of the smallholders was high and ranged from 18 to 23 years (Table 3.3). There was no major difference in age between smallholders in the east and west of the Rift Valley or between the districts with low or high productivity per unit area. Again most of the smallholders grew tea as a means of living and their main objective was to maximise profits or both profits and production (yields) (Table 3.3). This implies that it is in the interest of the smallholder tea farmers to increase production and/or productivity while reducing costs of production to enhance the profitability of the enterprise. Farmers would therefore benefit from technologies for achieving these targets.

The sizes of the total areas of land owned by the smallholders varied considerably. Generally the smallholders in the east of the Rift Valley owned less land than those in the west of the Rift Valley (Table 3.3). Again in each side of the valley, there was higher productivity per bush where farmers had smaller pieces of total land areas. This probably was due to absence of competing farm enterprises, as the available land was too small to support other farm activities. The land pressure is forcing the smallholders in these areas to concentrate on tea production. This difference was also noted between east and west of the Rift Valley. Tea production patterns followed the land pressure pattern such that the lower land holdings in the east dictated higher production per unit area compared

to west of the Rift Valley where mean land holdings were higher. Again since the number of people living in individual households were about the same in west and east of the Rift Valley (Table 3.2), it can also be argued that there may be adequate labour to maintain tea in the east of the Rift Valley while the farms in the west were too large for the family units. They are therefore unable to remove the entire crop or to manage the farms effectively. However, this needs confirmation in a separate study.

In Kirinyaga and Nyamira districts, high percentage of the smallholder tea growers did not have any other farms except where the tea was planted (Table 3.3). These were also the districts with highest productivity per bush in the east and west of the Rift Valley, respectively. On the other hand almost half of the smallholders in Nandi and Nyambene districts had other farms apart from the tea gardens. These districts had the lowest tea productivity per bush west and the east of the Rift Valley respectively. Possibly the smallholder tea farmers in these two districts were spending part of their time on other non-tea enterprises in these other farms, consequently lowering tea productivity due to divided loyalties. Indeed, it was noted that most of the smallholder tea growers spent a lot of time on "miraa' (Kat) than tea in Nyambene, while in Nandi most growers spent a lot of time on maize production and dairy farming. It is likely that these competing farm activities contributed largely to the low tea productivities in these districts. Detailed socio-economic study is necessary to evaluate the economic advantages of these individual crops so that farmers are encouraged to concentrate on crops or farm undertakings giving best returns.

In the east of the Rift Valley, despite the farmers in Nyambene district owning more land than farmers in Kirinyaga district, less land per farmer was dedicated to tea growing (Table 3.3). This might have been due to the farmers in Nyambene district having an alternative crop, (Khat) which they perceive to give better returns than tea. A proper study is necessary to establish if this perception is valid. In the west of the Rift Valley, on the average the farmers dedicated almost the same percentage of their land units to tea growing. However, because of the large land units per farmer in Nandi district compared to Nyamira district the smallholder growers had more land under tea.

Table 3.3: Objectives, experience in tea growing of tea growing and land holdings details

		Kirinyaga	Nyambene	Nandi	Nyamira
Mean length (years) of tea growing		23	23.2	18	21.79
Why do you grow tea (%)	As business	87	77	87	91
	No employment	3	9	3	3
	As way of life	3	5	3	2
	As inheritance	7	9	8	5
Main objective of growing tea (%)	Maximise yield	3	7	8	4
	Maximise profit	36	37	41	28
	Max. yield & profit	50	52	49	66
	Others	11	2	0	1
	Missing	0	2	2	0
Size of whole farm (Ha)	1.2	1.7477	4.970	2.03	
Own other farm (%)	Yes	23	56	46	29
	No	77	43	51	75
	Missing	0	1	3	1
If yes how many (ha)	1.5	1.066	3.9	1.15	
Total land owned (ha)	1.5	2.3	7.0	2.27	
Area under tea (ha)	0.51	0.30	0.73	.33	
Land area (%) under tea	40.7	23.95	20	19.95	

3.1.3. Awareness and application of recommended tea production technologies

3.1.3.1. Soil characteristics

Tea requires specific soil characteristics to grow and produce economic yields (Othieno 1991a). These include soil depth, slope, pH, texture and free drainage. The majority of the smallholders interviewed did not know these requirements. The lack of knowledge was higher in the west (94 and 97% in Nandi and Nyamira districts, respectively) than in the east (73 and 84% in Kirinyaga and Nyambene districts, respectively) of the Rift Valley. When individual soil characteristics were examined, majority of the farmers did not know the slopes of their tea farms, and recommended soil depths for planting tea. All the smallholders interviewed did not know the soil texture or pH of their tea farms. This was possibly because most smallholder tea growers plant tea after the districts have been surveyed and declared tea-growing zones. Farmers therefore grow tea because their lands happen to be within the gazetted areas. There is little incentive for the individual farmers to know these requirements. However, these requirements were not even known to the extension staff (Owuor *et al* 2001). The knowledge might not have therefore been available to the individual tea farmers.

Although an area may be gazetted as tea growing zone, there shall always be pockets within the zones not suitable for growing tea. Such areas may be unsuitable due to poor soil texture, high pH, water logging, very steep slopes, etc. It is important that knowledge on how to avoid bad areas during tea planting is made available to the tea growers. Since smallholder areas under tea are relatively small, averaging just about 0.27 hectare per farmer (M'Imwere 1997, 1999), poor choice of a site can lead to total crop failure or very slow and expensive tea establishment. Both are waste of resources to the smallholders and should be avoided.

Most smallholder tea growers were keen to know how they could learn about the soil requirements of the tea plant, but did not know how this can be done. This demonstrates the lack of effective extension system in the sub sector. It is important the smallholders are educated on the sources of technical information available to them as this can enhance their tea production. Both the TRFK and KTDA extension services need to address these problems.

The areas where smallholder teas are growing were assessed and established to have been receiving adequate rainfall in most years. The altitude range in which tea was growing was within the limits. All farmers interviewed had farms in Upper Midland zone I and Lower Highland zone (Table 3.4). These areas had been surveyed and are recommended tea-growing areas. On the average Nyambene district received more rainfall than the other districts. Kirinyaga and Nandi districts received about the same amount of rainfall, but the farms surveyed in Nandi district had higher altitude than farms surveyed in Kirinyaga district. The rainfall in Nyamira district was higher than that of Kirinyaga district and Nandi districts, but lower than that of Nyambene, while the mean altitudes of the farms visited in Nyamira and Nandi districts were similar. It is noted that the rainfall received, altitude or zone of the tea growing could not explain the tea productivity patterns. These results are surprising because tea yields decrease with rise in altitude. Indeed, Squire *et al* (1993) and Obaga *et al* (1988) had reported yield decrease of 200-300 kg made tea per ha with a rise in altitude of 100 m. Total rainfall *per se* is not as useful in tea production as its distribution. For very good tea production, there should be a minimum of 120 to 150 mm rainfall per month (Othieno 1991, 1994). However, rainfall distribution data was not obtained in this study.

Table 3.4: Mean rainfall, farm visited altitudes and zone of growing tea

		Kirinyaga	Nyambene	Nandi	Nyamira
Average rainfall in the area (mm)		1654.29	2514	1630.77	1804.2453
Mean altitude (m.a.m.s.l.)		1750	1652	1915.63	1923.63
Location of farm	Upper Highland zone (UH)	0	2	0	0
	Lower Highland zone (LH)	44	30	51	68
	Upper Midland zone (UM)	56	68	49	32

3.1.3.2. Land preparation

In most smallholder areas, land preparation was done by the most commonly available and used implements. A Bulldozer was never used probably because of the high costs involved or small sizes of the holdings. The majority of the farmers in the east of the Rift Valley used combination of pangas, jembes and rakes (Table 3.5). These seemed to be what are commonly used in the areas due to both sizes of the land holdings and the land terrains. Although these implements were also used by reasonable percentage of smallholders in Nyamira and Nandi districts, it was noted that a sizeable percentage prepared their lands using tractors, especially in Nandi where the land holdings are large (Table 3.5). It is necessary that mechanical machinery suitable for use in smallholder land holdings that are small and most of the times with very steep slopes be introduced in Kenya agricultural systems. These will alleviate the present difficulty of using pangas, jembes and rakes to cultivate lands.

In all areas, ripping was done to a depth of about 0.2 m and most farmers removed all roots from the prepared lands. The ripping depth was slightly deeper in Nandi district because many farmers used tractors to prepare their lands. This is important since roots left in the soil are the source of inoculum for Armillaria root rot infection. Despite the ripping, however, in most farms young plants dried up, possibly due to poor plant methods and/or planting into bad weather. Most farmers did not know the causes of death for the young tea plants.

In most farms the lands were cleared then ploughed during preparation before planting. However in some areas this was not done. Indeed this might not have been necessary as in many smallholder tea farms, tea growing was started in areas that were previously used to grow food crops (Othieno 1994). For those who ploughed, the lands were ploughed more times in the west than in the east of the Rift Valley (Table 3.5). Most of the farmers then harrowed their fields. Since the harrowing machines are not suitable for very small farms, most farmers did subsequent ploughing after the first as a way of harrowing. Harrowing was done more times in the east than west of the Rift Valley. When harrowing and ploughing were considered as part of one operation, there was no difference in the number the operations were done east and west of the Rift Valley.

In many farms after ploughing and harrowing, the lands were surveyed, and contour terraced to conserve the soil and water. In some farms, however, this was not done. Most farmers planted tea after this operation. One aspect noted under land preparation was that there were many questions the farmers did not respond to. This might have been due to the farmers not knowing the history of their farms There are many farmers who had inherited or bought the tea farms and were not involved in the original planting exercise. These groups of farmers are unlikely to know how their lands were prepared since smallholders are poor at keeping records. Also there were farmers who might have forgotten since they planted the tea on the average almost 18 years ago (see Table 3.3).

The mean number of plants the smallholders had varied with districts (Table 3.6). Generally this was dependent on the size of the tea enterprises. Farmers with larger areas under tea enterprises had more plants, but this did not exactly translate to the equivalent of 8611 plants per hectare originally recommended for the smallholders. If this recommendation was strictly followed, the mean number of plants per farm should have been 4392, 2583, 6286 and 2842 plants, for Kirinyaga, Nyambene, Nandi and Nyamira districts, respectively. In Nyambene district, the mean number of tea plants recorded from the farmers' records was higher than what it should have been. This may be due to farmers using closer plant spacing than the 5 x 2.5 ft (1,52 x 0.91 m) recommended by KTDA. Closer planting leads to higher tea production per unit area (Bore *et al* 1998; Wanyoko and Owuor 1995). However, a closer look at the farms did not indicate such planting was being used in Nyambene district. It is likely most of the smallholders in Nyambene district either did not know the number of plants in their farms or the exact area under tea. In the other districts, the mean number of tea plants the farmers indicated they had was less than what was expected This was attributed to lack of infilling for a long time. The fields had many vacancies in all the districts. It is important that infilling is carried out urgently as vacancies in the field translate to under use of land resource. Areas where tea plants had died/dried in the middle of the plantations cannot be used for another useful farm enterprise and are wasted, and lead to low productivity of tea.

Table 3.5: Methods of land preparation by farmers (%)

		Kirinyaga	Nyambene	Nandi	Nyamira
Tool for clearing/ripping land for tea growing (%)	Pangas/Jembes/Rakes	90	96	33	79
	Tractor	0	0	33	11
	Others	3	0	26	10
	Do not know	7	4	8	0
Length of ripping tool (m)	0.21	.20	0.28	0.20	
Were all roots from previous trees removed prior to tea planting (%)	Yes	79	77	67	60
	No	9	14	18	27
	Do not know	12	9	15	13
Did some of your tea die in the 1st and/or 2nd year after planting (%)	Yes	64	89	80	81
	No	19	5	10	11
	Do not know	17	6	10	8
Was land ploughed after clearing? (%)	Yes	64	27	72	67
	No	20	68	15	31
	Do not know	16	5	13	2
If yes, how many times (mean number)		1.67	1.67	2.43	2.50
Did you harrow it? (%)	Yes	21	23	33	31
	No	56	71	56	60
	Do not know	23	6	11	9
If yes how many times (mean number)		1.72	1.82	1.37	1.67
Was field prepared, surveyed & contour terraced for soil & water conser.?(%)	Yes	79	68	69	64
	No	6	23	18	33
	Do not know	15	9	13	3
After contour terracing what did you do to protect the bare soil?	Planted tea immediately	51	71	49	72
	Planted oats	0	0	0	2
	Planted food - maize/beans	1	2	31	13
	Mulched the soil	11	5	0	0
	Left it bare	11	5	3	1
	Others	10	2	8	7
	Do not know	14	14	9	5

Table 3.6: Mean number of plant per farmer and recommended planting density

		Kirinyaga	Nyambene	Nandi	Nyamira
How many tea plants do you have on the tea enterprise?		3222	2835	4867	2534
Are you aware of the recommended plant density for tea in this region?	Yes	57	50	68	47
	No	43	50	32	53
If Yes, what is it per ha.? (number)	8952	8755	9564	7799	
If Yes how did you come to know about it?(%)	Own expe-	9	5	3	9
	Agricultural	47	43	56	29
	Tea neigh	1	5	3	6
	TRF	0	0	3	0
	Other (Specify)	0	5	3	2
Do you apply this recommendation on your farm when planting tea?(%)	Yes	49	48	62	41
	No	9	25	26	28

Most of the smallholders did not know the correct plant spacing. This implied that if they were to increase the areas under tea, they would use incorrect spacing. There is urgent need to educate the tea farmers on the most economical planting densities for increased tea productivity and production. For those who had the knowledge, it mostly came from the KTDA extension staff. Most of those who knew the recommendation applied it while some knew it but did not apply the information. They probably used other planting densities giving higher yields (Bore *et al* 1998; Wanyoko and Owuor 1995) or learnt it after planting their tea.

3.1.3.3 Nursery techniques

The fast expansion of the smallholder tea sub sector could not have been possible without availability of planting materials. Farmers who planted tea initially used seedling materials from either the KTDA nurseries or estates. However, developing plants from seeds took too long, upto three years from seed planting to planting in the field (Othieno 1981). Also transporting the seedling plants from the nurseries was cumbersome and expensive. Indeed it involved transportation of a lot of soil with the plants making them heavy. When the plants were transported over long distance on poor roads, the survival rate in the field was low. Again the plants from seeds were not pre-selected for any advantage like high quality or yield. It therefore became necessary that easier methods of availing superior plants to the farmers be sought. This culminated in the development of vegetative propagation method (Othieno 1981). The method was simplified such that even smallholder farmers can use it. Indeed, the fast expansion of smallholder tea sub sector in Kenya was only made possible by the easy availability of the vegetative plants. Unlike seedling plants, vegetatively propagated plants took only between 9 and 18 months in the nursery. With vegetative propagation, it became possible to only develop plants with desirable characteristics like high yields and quality. On annual basis, today smallholder tea in Kenya has the highest quality and this is attributed to use of high quality clones, especially 6/8 (Othieno 1981). Most importantly, vegetative propagation removed the burden of the smallholder transporting heavy plants over long distance. Farmers chose their own plants to propagate. The extension system of the KTDA and TRFK (or the TRIEA) trained the farmers to propagate their own planting materials on site. An assessment was done on present farmers' knowledge on the nursery techniques.

A large percentage of the farmers established their own nurseries, or received plants from the KTDA nurseries, a few purchased plants from their neighbours, and a reasonable percentage got

their plants from multiple sources (Table 3.7). Since not all the farmers interviewed were the original owners who planted the tea, some farmers did not know the source of their tea plants. Very few farmers received their planting materials from the estates, while none bought plants from the TRFK nursery.

Table 3.7: Sources and types of planting materials (%)

		Kirinyaga	Nyambene	Nandi	Nyamira
How did you get your young tea plants for transplanting?	Established own nursery	39	39	36	36
	Buy from neighbours	9	9	13	8
	Buy from KTDA Farms	29	21	23	28
	Buy from TRFK	0	0	0	0
	Buy from Estates	0	2	8	2
	Multiple sources	14	23	15	24
Did you choose the plants to buy?	Yes	27	30	51	34
	No	73	70	49	66
Basis of choosing the plants	Popular clones	0	2	10	0
	High yielding clones	12	9	36	24
	High quality clones	2	0	0	0
	Drought resistant clones	0	2	0	1
	Highly adaptable clones	1	5	0	0
	Any other (Specify)	13	11	5	13
	Whatever was available	72	71	49	62

Most of the smallholder tea farmers did not choose the plants to grow. However, about 50% of farmers in Nandi district selected plants to grow. For those who received their plants from KTDA nurseries, pre-selection had been done and further selection was not necessary. Indeed, as a policy KTDA only gave farmers mixed clones with proven yields and quality traits. Most of the farmers who prepared their own nurseries obtained cuttings from the KTDA nurseries, and these were also from pre-selected clones. The farmers did not therefore have selection criteria. However, those who made selections from either earlier planted tea on their farms or their neighbours' teas, made selection using high yields, popularity and adaptability as main criteria (Table 3.7).

The success of establishing the plants in the nursery depends on the vigour of the planted cuttings and how the plants are tendered while in the nursery. It is therefore necessary that the mother bushes be well taken care of so that by the time of obtaining the cuttings, the shoots are in active growing phase. Most farmers, except in Nyambene district indicated they knew how to treat mother bushes in readiness for obtaining cuttings (Table 3.8). Their detailed knowledge was not however assessed. But it was noted that a large number of the farmers did not know how to treat mother bushes in readiness for obtaining cuttings.

Most of the smallholders indicated the mean age of the cuttings to be obtained for propagation ranged from 3 to 5 months (Table 3.8). Ideally this should be about 6 months. Again most smallholders did not know the recommended age of shots from which to prepare cuttings. A few who knew indicated this should be less than 6 months.

After deciding the plants to make mother bushes, the normal practice is to prepare them so that they can grow vigorously. This is usually done by pruning the plants, keeping the bushes weed free and after they recover from prune, applying fertilizer. Most farmers who indicated they knew how this is done actually knew (Table 3.8). They learnt this mainly from the KTDA extension staff, although many of them seem to have experimented and developed their own experience.

Table 3.8: Assessment of how smallholders prepare mother bushes and/or obtain cuttings.

		Kirinyaga	Nyambene	Nandi	Nyamira
Do you know how to prepare cuttings from the mother bushes? (%)	Yes	69	48	59	55
	No	31	52	41	31
If Yes, what is the age of the shoots from which you prepare cuttings? (Mean age in months)		4.69	5	3.36	5.35
Are you aware of the recommended age of tea shoots from which to preparre cuttings?(%)	Yes	31	25	28	31
	No	69	75	72	69
If yes, what is it? (Mean months) (<6)	4.23	5	2.6	4.56	
Are you also aware of how to treat the mother bushes before taking cuttings? (%)	Yes	39	21	28	32
	No	61	79	72	68
If Yes, how do you treat them?	Prune & water	3	0	0	0
	Prune & spray	0	0	3	0
	Prune & fertilise	23	15	33	28
	Peg & fertilise	0	0	0	0
	Other (Specify)	10	5	8	6
If Yes how did you come to know about these methods? (%)	Own experience	10	9	8	11
	Agric extension staff	20	9	21	19
	Tea neighbours	5	2	5	4
	TRF	0	0	0	0
	Other (Specify)	1	2	8	1

In the preparation of the cuttings for planting, most farmers knew that the shoots are immersed in water after being removed from the mother bushes. Generally the farmers knew the recommended stem length of the cuttings and the duration they are supposed to be immersed in water (Table 3.9). However, about 30% of the farmers in all districts did not have this knowledge. After the cuttings are planted and the nursery beds are made, it is important that they are continuously monitored and adjustments made to ensure the plants are growing properly. Most farmers regularly checked the nursery beds (Table 3.9). When the plants have formed roots they are prepared by way of making them acclimatise to the conditions they will be subjected to in the field before transplanting. The polythene sheet is removed gradually as abrupt removal leads to the plants drying since they were not used to such environment. However, the shade remains and is also only removed slowly (gradually). Plants do not remain under shade until the time of transplanting. Generally the smallholder farmers noted that it took at least 6 months before the shade was completely removed and then left to harden for at least 3 months (Table 3.9).

Most of the farmers knew that it is mandatory to water the plants in the nursery (Table 3.10), and indicated this is done either once or twice a week. In practice, this should be done as dictated by prevailing weather conditions, but it must be ensured the plants have adequate moisture to grow freely. Over watering must be avoided as it leads to water logging and plants death and encourages development of some diseases. Again, most farmers applied fertilizer to nursery plants mostly as NPKS 25:5:5:5. The application was done as a spray in water as is recommended, but few farmers broadcast the fertilizer. Broadcasting the fertilizer is not recommended, as the amount put is usually very small doses at a time. If it is broadcast, it is very difficult to apply it uniformly. A lot of fertilizer put in a single dose causes plasmolysis leading to plants death. Most smallholder tea farmers were applying fertilizer to the nursery plants once a month.

The period the plants take in the nurseries vary from 9 to 18 months depending on the altitude at which propagation is done. At very high altitude where growth rate is slow, it takes longer than at low altitudes where growth is faster. Most farmers knew the recommended period the tea plants should take in the nursery (Table3.10). Indeed the mean age they gave was correct and this knowledge was mainly acquired from the extension staff of KTDA.

Table 3.9: Assessment of how smallholder tea growers prepare cuttings for nursery planting.

		Kirinyaga	Nyambene	Nandi	Nyamira
What do you do with	Leave in sunlight	0	2	3	8
the cuttings after remo-	Put in water	67	59	56	63
ving them from the	Plant directly in sleeves	1	2	0	2
mother bushes? (%)	Other (specify)	7	5	3	4
	Do not know (Missing)	25	32	28	23
Are you aware of the	Yes	64	61	56	64
recommended stem	No	36	39	44	36
length and the duration they are supposed to be immersed in clean water? (%)					
If Yes, what are they? (lenght, Cm)	Mean	3.43	4	4.34	4.884
If Yes, what are they? (duration, Minutes)	Minutes	40	47	110	62.62
If Yes how did you come	Own experience	10	14	8	15
to know about them? (%)	Agricultural extension staff	47	39	36	35
	Tea neighbours	1	5	10	11
	Tea Research Foundation	0	0	0	0
	Other(Specify)	3	29	8	5
	Do not know (Missing)	39	40	38	34
Do you apply these	Yes	59	59	59	70
	Do not know (Missing)	51	41	41	30
Do you check the beds	Yes	76	59	59	76
	No	6	14	3	5
	Do not know (Missing)	18	27	38	19
If Yes, how many times	2	3	4	3	
Do you prepare your rooted	Yes	71	39	41	41
cuttings for transplanting? (%)	No	1	23	18	39
	Missing	28	38	41	20
When the roots of the roots of	Nothing	0	0	0	0
the cuttings have reached	Remove sheeting abruptly	3	7	5	5
the bottom of the sleeves,	Remove sheeting gradually	69	59	59	67
what do you do? (%)	Transplant the cuttings	0	0	0	0
	Other (specify)				
	Do not know (Missing)	28	34	46	28

Under nursery techniques, the knowledge of the farmers was about the same in all districts. About 30% of the farmers did not know the techniques across the board. The percentages given in Tables 3.7 to 3.10, therefore do not add up to 100%. The differences were those farmers who were unaware of the techniques. This percentage is very high and it is necessary that awareness be created. Even those farmers who indicated knowledge of nursery techniques did not know all of them. The diffusion of nursery techniques to the farmers is therefore not complete. There are farmers who need awareness of all techniques and those who only need refresher courses. Effort should be made to accomplish this.

Table 3.10: Assessment of nursery management techniques.

		Kirinyaga	Nyambene	Nandi	Nyamira
Do you shade the cuttings	Yes	31	39	41	42
	No	46	30	28	34
	Do not know (Missing)	23	31	31	24
If No, at what age of the cuttings do you remove the shade? (Months)		6.56	8	7.14	7
How long do the cuttings remain in the nursery after the shade is removed? (Months)		4.11	3	2.41	3.4
What is the purpose of removing the shade sometime before transplanting the cuttings? (Hardening%)		61	55	56	50
Do you water your nursery	Yes	76	64	64	76
	No	1	7	0	3
	Do not know (Missing)	23	29	36	21
If yes, how often do you water	Daily	1	0	10	4
nursery plants? (%)	Once a week	33	18	15	17
	Two times a week	17	18	21	36
	Monthly	4	2	8	2
	Any other (specify)	20	25	13	18
	Do not know (Missing)	25	37	33	23
What fertilizer do you apply	NPKS	51	43	56	24
to your nursery plants?	DAP	9	2	3	16
(%)	NPKS + DAP	0	18	15	1
	SSP	1	0	0	0
	TSP	0	0	0	0
	Urea	0	0	0	0
	CAN	4	2	0	0
	Any other (Specify	3	0	0	30
	Do not know (Missing)	33	35	26	39
How do you apply fertilizer	Broadcast (Bc)	4	16	0	11
to nursery plants? (%)	As spray in water	57	39	56	27
	Bc and spray in water	1	0	0	0
	Any other (Specify)	6	9	21	23
	Do not know (Missing)	32	36	23	39
How often do you apply	Daily	0	0	5	0
fertilizer to your nursery	Once a week	13	7	0	6
plants? (%)	Monthly	16	30	26	14
	Once in six months	7	5	5	6
	Once in a year	9	2	8	3
	Any other (Specify)	24	30	33	30
	Do not know (Missing)	31	26	23	41

The demand for planting materials in the smallholder tea sub sector out strips supply. Most farmers who want to either make new planting, or do infilling or expand their tea holdings must therefore increasingly propagate their own planting materials. This can only be achieved if the farmers have the technologies to propagate the plants. Indeed, for farmers with tea, it was observed (see sub section 3.1; 3.5) that there were vacancies, which reduce the productivity of most tea farms and render high potential agricultural lands to no use, as other crops cannot grow effectively in these patches. Beneficial use of these sections can only be from tea. Farmers therefore urgently need the sources of planting materials. The continued expansion of the smallholder tea sub sector requires all farmers to be taught all nursery techniques. Indeed with knowledge of preparing mother bushes, individual tea growers stand a better chance of making their own selections for expansion and/or infilling their farms.

3.1.3.4 Field planting and bringing into bearing

For successful plant establishment, tea planting should be done after the field is well prepared and during the correct season. Planting must be done during rainy season to ensure high rate of survival and fast establishment. Planting during drought leads to high plant mortality and should be avoided. Most smallholder tea farmers (Table 3.11) were aware that transplanting into the field is done during rainy season, but 14, 7, and 1% of the farmers in Kirinyaga, Nyambene and Nyamira districts, respectively, thought planting should be done in dry season.

The recommended holes for planting should be 15 to 20 cm deeper than the length of the sleeves and double the sleeve diameter. For a standard sleeve 25 cm long and 6.25 cm diameter, commonly used in the smallholder sub sector, the holes should be 40 cm deep and 25 cm in diameter. The average depths and diameters given by the farmers are presented in Table 3.11. There were no large differences in the hole sizes in various districts and they were on the average smaller than recommended.

Table 3.11: Assessment of field planting methods and in puts by smallholder tea growers.

		Kirinyaga	Nyambene	Nandi	Nyamira
At what season do you transplant the cuttings? (%)	Dry season	14	7	0	1
	Rain season	79	93	95	93
	Do not know	7	0	5	6
How wide and deep are your holes for planting tea cuttings? (%)	Width (cm)	21.2	23	23	17.1
	Depth (cm)	32.5	39	29	30.62
Do you apply fertilizer in the cuttings? (%)	Yes	39	31	64	39
	No	50	61	33	55
	Do not know	7	8	3	6
If Yes, what type of fertilizer do you apply in the holes? (%)	DAP	20	21	59	22
	CAN	0	2	0	1
	SSP	7	2	3	2
	Other (Specify)	11	5	8	17
	No and do not know	62	70	30	58
If Yes, how much fertilizer do you apply per hole? (gm/hole)		14.05	10	10	18.21

During planting, it is recommended that fertilizer rich in phosphorous is used. Usually 30 gm of single super phosphate is mixed with the soil removed from the hole before planting. However, DAP can also be used at the same rate. In the east of the Rift Valley and Nyamira district, most farmers did not plant tea with fertilizers, while in Nandi district, most farmers used fertilizers in the planting hole. Those who knew fertilizer should be used in the planting hole were applying very low rates. Either way, a large percentage of the farmers were not using fertilizer for planting tea. Possibly this was due to the fact that the majority of the smallholders planting tea for the first time had not registered with KTDA and did not have fertilizer credit facility. Some farmers, however, did not have the information that it is necessary to use fertilizer in the planting holes. Efforts should be made to ensure that use of fertilizer in the planting hole is made known to all farmers, and especially prospective new farmers. Planting with phosphatic fertilizer ensures that the young tea plants develop good rooting system and start growing vigorously. This helps the plants to establish faster and withstand drought. The majority of the farmers who used fertilizer in the planting holes used DAP, while others used SSP and a small number

used CAN (Table 3.11). But despite the use, in all districts the mean amount of fertilizer used per planting hole was too low. However, the relationship between fertilizer used in the planting hole and yields were not apparent in the study. This is because use of fertilizer only helped the plants to establish faster and better in the early years of planting and had no relationship with yields of mature tea.

In the establishment phase of tea, there is a period when financial returns may depend on the speed and efficiency with which the young tea plants are brought into bearing. The method of bringing tea into bearing should therefore result in economic production of an even stand of healthy bushes attaining their optimum yield potential as soon as possible and maintaining this optimum yield. The lower part of the branch of the bush will form a permanent frame that will remain largely unaltered throughout the life of the bush or until the bush is down pruned to rejuvenate it. The frame must therefore be low, strong and have good spread. A system of bringing tea into bearing which enables plucking to start very early may first seem satisfactory but prove poor in the long run if the system restricts root development or encourages more shoot and less root growth as that makes the plants susceptible to drought or results in narrow framed bushes which cover the ground slowly and give low yields when pruned next. Operations designed to help the plant form permanent branch system from the time the plants are in the nursery to the time they are tipped-in to form a plucking table are collectively called “bringing into bearing”.

When a shoot of tea is removed, axillary buds are stimulated to develop about 10 to 12 cm below the cut. Young tea can be brought into bearing by pruning or by pegging. When bringing into bearing by pruning, the shoots are first pruned at 15 cm. Most farmers gave an average first pruning height ranging from 18 to 25 cm (Table 3.12), which is a little high. This should be done when the plants are 30 cm tall, but most farmers thought it should be done when the heights of the plants ranged from 34 to 50 cm. These answers indicated that farmers started bringing their tea into bearing late. This delayed the period the farmers could start harvesting their tea plants economically. However, the delayed pruning ensures plants develop deeper rooting system to withstand drought better.

Table 3.12: Bringing young tea into bearing by smallholder tea growers

		Kirinyaga	Nyambene	Nandi	Nyamira
At what height do you prune the young tea for the first time (decentring)? (cm)		18.16	21.7	24.9	18.88
What is the approximate length of the central stems at the point of first pruning? (cm)		34.15	50	45	48.08
After decentring, indicate the	1st pruning	35.61	39	27.3	19.87
the heights at which you	2 nd pruning	48.25	49	34.7	27.22
prune your young tea	3 rd pruning	57.oo	51	41.3	40.25
sequentially. (Pruning Height (cm))					
At what length of the lateral shoots do you start pegging them? (cm)		49.83	59.6	37.2	39.28
At what height of the central stems	Height (cm)	48.71	48	41.1	48.17
and length of the lateral shoots do	Length (cm)	59.10	59	52.6	48.20
you establish plucking table for your tea plants?					

Subsequent prunings are done at 28, 40, and 50 cm respectively. Farmers in the east of the Rift Valley gave high average height at which they did the subsequent prunings, while farmers in the west

of the Rift Valley gave lower heights (Table 3.12). Either may, the means given indicated lack of knowledge of the recommendation.

However, if plants are brought into bearing by pegging, after the plants are decentred at 15 cm when they are 30 cm high, the first pegging is done when the lateral shoots are not less than 50 cm and not more than 65 cm high. While most farmers in the east of the Rift Valley knew the correct height, the farmers in the west of the Rift Valley were pegging when the plants were too short (Table 3.12). The first plucking table is normally established at 50 cm height. Farmers from the east of the Rift Valley indicated a higher height while farmers from the west of the Rift Valley were establishing their plucking tables at the correct height (Table 3.12).

3.1.3.5 Field management

Plucking and leaf collection

The economic part of the tea bush is the young tender shoots which are harvested to process various tea beverages. Efficiency of harvesting the shoots can dictate whether tea enterprise is profitable or not. If plucking is done at very long intervals, yields (Odhiambo 1988, Owuor *et al* 1997) and quality (Owuor 1997, Owuor *et al* 1997, 2000) decline. Plucking rounds in Kenya vary from 7 to 10 days during favourable growing seasons and 12 to 15 days during dry or very cold seasons. On the average, the farmers interviewed were plucking on 10 or 11 days plucking rounds (Table 3.13). However, examination of individual farms and/or factory deliveries records showed that many farmers still pluck after very long rounds, while there are farmers who are over plucking at very short intervals. The plucking rounds indicated did not vary much with the districts.

For plucking to be efficiently done, it is necessary that the plucking table is kept flat and uniform. When the table is not uniform, plucking rates become slow and plucking is made more difficult. Farmers find it more difficult to keep set plucking standard and a lot of leaf that is ready for harvesting is left on the bush. Again it leads to farmers harvesting immature leaf. It is recommended that when plucking, pluckers should use plucking wands (long sticks) to ensure the table is maintained. Although most farmers knew the recommendation, in all districts, the farmers did not use the wands (Table 3.13). Consequently in most farms, the plucking tables were uneven which makes plucking very inefficient. Most farmers believed that use of plucking wand slowed down their plucking speeds and hence plucker productivity. It is important to educate the farmers on the benefits of using plucking wands.

Most of the smallholder tea farmers started plucking between 7 and 8 am, although a few, especially in the west of the Rift Valley started plucking at 6 am (Table 3.14). In Nyambene, Nandi and Nyamira districts, plucking in most farms ended between 12 noon and 1 pm. This duration is too short for all leaf to be removed from the fields. In Kirinyaga district, however, farmers plucked for longer durations upto 4 pm. Indeed, where plucking stopped early, farmers indicated that they did not have enough time to remove all crop. In the west of the Rift Valley more farmers plucked for longer duration in Nyamira district than in Nandi district. Again in the east of the Rift Valley, productivity per bush was higher in Kirinyaga district where plucking duration was longer than in Nyambene district. Indeed, in the overall Kirinyaga district where farmers were plucking for longest period per day had the highest productivity per bush. For farmers to have adequate time to harvest all the available leaf, it is necessary that plucking is started early in the morning. These results demonstrated that it is important to work

out for farmers plucking schedules, which enable them to spend more time plucking. Ways should be found to increase plucking time to between 3 and 5 pm in all districts.

Most farmers did not have adequate plucking time because the leaf collection lorry came too early (Table 3.13). Through discussion with the farmers, it was noted that in the west of the Rift valley, the leaf collection lorry collected leaf only once in a day from most buying centres. This was unlike Kirinyaga district where the leaf collection lorry collected leaf at least two times a day. This arrangement must have been made between the farmers' representatives, tea officers, leaf collection managers and factory managers. Other districts should copy this system that is working well in Kirinyaga district.

The earliest time most farmers delivered their leaf to buying centres was between 10 am and 12 noon in the east of the Rift valley and 10 am and 11am in the west of the Rift Valley (Table 3.14). However, it was noted that a large percentage of farmers in Nyamira and Nandi districts indicated that they delivered their leaf at any time, i.e. there was no timing. This is because the lorry came only once a day, at times that were not regular, and farmers rushed to the buying centres whenever it arrived. Although early delivery of leaf to buying centres especially where it is collected at least two times a day is beneficial as it helps factory personnel to handle and process leaf more efficiently, most farmers could not deliver their leaf early to give them enough time to pluck. However, a reasonable percentage of farmers could not do early delivery because the leaf clerks did not come to buying centre early enough. In many centres this is because one leaf clerk is in charge of more than one buying centre, but in some cases, this was attributed to lack of discipline and/or supervision.

Table 3.13: Plucking arrangements in the smallholder tea farms

		Kirinyaga	Nyambene	Nandi	Nyamira
What is your plucking round for tea? (Days)		11	11	10	10.5
How do you maintain a plucking table for your tea? (%)	Experience	91	77	82	88
	Long straight stick	6	23	8	11
	Other (specify)	3	0	10	0
When does plucking start in your farm? (%)	6 am	16	9	31	37
	7 am	34	50	56	47
	8 am	39	36	12	14
	9 am	6	5	0	0
	Other (specify)	5	0	0	0
	Missing (not timed)	0	0	1	2
When does plucking stop in your farm? (%)	10 am	1	2	18	14
	11 am	1	9	39	14
	12 noon	10	11	28	43
	1 pm	14	32	15	20
	2 pm	13	46	0	7
	3 pm	22	0	0	0
	4 pm	39	0	0	1
	Missing (not timed)	0	0	0	1
Do you feel you normally have enough time to pluck your tea? (%)	Yes	69	55	20	36
	No	31	45	80	64
If No, why is the time inadequate? (%)	Buying centre too far	1	2	3	2
	Lorry comes too early	14	25	62	52
	Pluckers not willing to pluck for long hours	3	5	0	1
	Busy with other entrps.	9	14	0	0
	Any other (Specify)	0	0	8	3

Whereas most farmers in the east of the Rift Valley had 4 pm as the latest time to deliver leaf to buying centres, in the west of the Rift Valley, this was a bit early and was mostly determined by the time the leaf lorry arrived. Farmers were unable to deliver leaf later due to the last delivery time being set by the buying centre committee and/or because the leaf buying clerk left the centre too early (Table 3.14). The arrangement of leaf buying centre committee setting the last leaf delivery time brings order in the operation and should be encouraged. However, the data presented here showed that leaf collection arrangement in the west and east of the Rift valley were not the same. Farmers in the west of the Rift Valley have shorter plucking duration (Table 3.13) and earlier time for leaf delivery to buying centres (Table 3.14) than farmers in the east of the Rift Valley. This may be one factor reducing leaf productivity and production in the west of the Rift Valley compared to the east of the Rift Valley. Efforts should be made so that more plucking and leaf delivery durations are created, especially in the west of the Rift Valley. Farmers need to be educated to start plucking early to create extra harvesting duration, while policies should also be made to ensure leaf is collected at least two times a day and that leaf clerks spend longer durations at the buying centres. In every district, it is necessary that farmers and KTDA staff (extension, leaf collection and factory staff), work out a system that ensures farmers harvest all the available leaf and that whatever is harvested is collected on time for processing. Kirinyaga district seemed to have been in the forefront in such arrangements.

Table 3.14: Timing leaf delivery to buying centres by smallholder tea farmers (%)

		Kirinyaga	Nyambene	Nandi	Nyamira
What is the approximate earliest time in a day you can deliver leaf to buying centre?	9 am	0	5	3	22
	10 am	14	30	37	26
	11 am	44	27	40	20
	12 noon	24	39	0	0
	1 pm	4	0	0	7
	2 pm	6	0	0	1
	3 pm	2	0	0	18
	4 pm	3	0	0	32
	Not timed	4	0	22	25
Why can you not deliver leaf earlier?	Clerks come late	30	21	18	21
	Time to pluck more leaf	43	55	64	59
	No labour to deliver leaf	1	5	15	1
	Any other (Specify)	19	18	0	11
	Missing	7	1	3	8
What is the approximate time in a day you can deliver leaf to buying centre	1 pm	3	9	13	20
	2 pm	4	11	10	18
	3 pm	17	23	10	11
	4 pm	66	41	5	12
	5 pm	0	0	0	0
	6 pm	0	0	0	29
	Not timed	10	16	62	10
Why can you not deliver leaf later?	Clerks come early	4	5	5	4
	Leaf clerk leaves early	23	16	59	27
	No labour to deliver leaf	1	0	3	2
	Official time	56	61	33	51
	Any other (Specify)	13	14	0	9
	Missing	3	9	9	7

As noted earlier, the arrival of the leaf collection lorry is crucial to leaf delivery and collection. In the east of the Rift Valley, the first lorry arrived between 10 am and 12 noon which was about the same as 10 am and 1 pm the first lorry arrived in the west of the Rift Valley. However, whereas in the east of the Rift Valley there would be another delivery, in the west of the Rift Valley to many farmers the first lorry was also the last lorry. Again its timing was more irregular in the west of the Rift Valley with most farmers indicating they could not time it (Table 3.15). This is because the lorry most of the time collected the leaf only once in a day and most of the time the first lorry did not arrive until late in the afternoon or even in the night. Generally, the arrival time in the west of the Rift Valley tended to be more irregular than that in the east of the Rift Valley. Efforts should be made especially in the west of the Rift Valley to improve leaf collection by making the lorries collect the leaf more times a day and also to make the collecting time more regular.

In Kirinyaga, most of the time the last lorry arrived by 11 pm. This is unlike the other districts where the arrival of the late lorry was not regularly timed. This is because in some districts the last lorry was also the first lorry. But generally when there was too much leaf that could not be all carried by the scheduled one trip in the districts where collection was done once the leaf could stay in the buying centres until the next day or longer.

Most farmers were usually spending at most only one hour at the buying centres (Table 3.15). However, the longest time farmers had spent in the buying centres was long, being more than 12 hours in most districts except in Nandi district. The reason for the long stay is that the leaf clerk avoids buying too much leaf he/she cannot keep it good condition. The farmers are therefore left with their leaf to look after until the time the leaf collection lorry arrives. Again if there is too much leaf, the leaf clerk and the lorry driver alone cannot load it into the lorry. Farmers wait at the buying centres to help load the leaf. A mechanism should be found so that farmers avoid spending too much time in the buying centres as this denies them a chance to do other farm and personal duties. In some districts farmers have now hired leaf loaders to take care of the leaf after it has been purchased but before it is collected by the leaf collection lorries and to load the leaf into the lorries. This coupled with the leaf clerk arriving at the buying centre on time will help reduce the durations farmers spend at the buying centres.

The reason given in most cases for poor leaf collection programme is the poor state of the roads. Farmers now pay cess to improve and maintain the roads. Tea roads are therefore being maintained by funds contributed by the farmers. Most farmers, especially in the west of the Rift Valley and Nyambene district observed that the tea roads were in very poor states (Table 3.15). Indeed, this was impacting negatively on tea production. Again in the districts where the state of the roads was noted to be poor, leaf collection programme was also poor. It is therefore not possible to correct the poor leaf collection problem without improving the state of the roads. These two problems must be solved concurrently. Due to the fact that the tea farmers are now paying substantial amount of money to ensure the roads are in a fair state, accountability should be enhanced so that the money collected is used for the intended purposes only.

Pruning and in-filling

For tea in production, the table rises at a rate of about 20 cm per year (Mwakha 1997). After three to four years, the table reaches a height of about 120 to 150 cm, which is too high for efficient management,

particularly plucking, which becomes very difficult or unmanageable. It becomes necessary to prune the plants to a lower height. This is normally done from 45 cm, rising to 70 cm each time the pruning height is increased by 5 cm above the previous pruning height. After reaching the 70 cm pruning height, it is again brought down to 45 cm. The common type of pruning in the smallholder tea sub sector is the cut across method, and pruning is done using pruning knives. It is recommended that the prunings (the cut leaves and branches) are left *in situ* in the field to return nutrients, reduce soil erosion and conserve moisture as the prunings also act as mulch.

Table 3.15: Assesment of problems of leaf collection and state of roads (%)

		Kirinyaga	Nyambene	Nandi	Nyamira
When does the first leaf lorry arrive to collect leaf from your buying centre?	10 am	20	32	15	30
	11 am	43	23	23	21
	12 noon	19	25	10	9
	1 pm	7	9	13	7
	2 pm	0	0	5	3
	3 pm	1	2	0	2
	Not timed	10	9	34	28
When does the last leaf lorry arrive to collect leaf from your buying centre?	6 pm	3	0	3	7
	7 pm	0	2	3	0
	8 pm	6	0	0	0
	9 pm	1	11	0	2
	10 pm	17	11	0	4
	11 PM	70	0	0	5
	Not timed	0	76	94	82
How long do you normally stay at the buying centre?	Less than one Hour	71	71	85	78
	1 Hour	13	14	15	9
	2 Hours	6	9	0	3
	3 Hours	1	2	0	1
	4 hours	0	0	0	1
	Not timed	9	4	0	7
What is the longest time you have spent at the buying centre?	3 hours	20	9	41	20
	4 Hours	6	4	0	6
	5 Hours	3	0	3	1
	6 Hours	14	0	15	6
	8 hour	4	2	0	0
	10 hours	0	0	0	1
	11 hours	0	0	0	0
	12 hours	4	2	0	12
	> 12 hours	47	80	36	56
	Not timed	2	4	5	8
How do you rate the state of tea roads in your area?	Very good	0	5	0	0
	Good	14	5	3	5
	Fair	37	27	18	9
	Poor	49	64	73	86
	Not decided	0	4	6	0
Does the state of tea roads affect your green leaf production?	Yes	71	86	92	96
	No	29	14	8	4

Most of the smallholders were pruning after three years as recommended (Table 3.16). Some, especially in the west of the Rift Valley were pruning after four years. Since plucking has been intensified and many farmers now pluck on 10 to 11 days plucking rounds (Table 3.13), it is justifiable for farmers

to increase pruning cycles lengths to four years. Indeed farmers should not prune as a routine but as a means of keeping the plucking table at manageable heights. There were farmers who were pruning when the plucking tables had not even reached 50 cm, but just because it is three years since they last pruned. This needs to be avoided. The average pruning heights as given by the farmers are shown in Table 3.16. However, examination of the farmers' fields indicated that pruning heights were not measured in the smallholder tea sub sector. Indeed, most farmers never pruned themselves, but used hired pruners. The hired pruners were not supervised as they pretended to be specialists who know more about pruning than the farmers. The farmers treat them as experts. These pruners generally pruned the tea plants at very low heights, sometimes even below the formative pruning height level at which the plucking table was established. They do so that during pruning they have only few branches to cut, thus facilitating fast completion of the task since pruners are paid on task basis.

Table 3.16: Information on pruning technology and vacancies in the field.

		Kirinyaga	Nyambene	Nandi	Nyamira
After how long do you prune	One year	0	2	0	0
you tea? (%)	Two years	1	9	10	3
	Three years	93	61	51	56
	Four years	3	5	26	23
	Five years	2	5	0	9
	Six years	0	0	0	1
	Seven years	1	16	10	8
	Do not know (Missing)	0	2	3	0
The mean pruning heights	First cycle	43	47	48.14	47.8
in five successive pruning	Second cycle	47	54	54.09	53.4
cycles (cm)	Third cycle	52	59	55.23	58.3
	Fourth cycle	52	61	56.06	62.8
	Fifth cycle	48	50	58.08	53.1
	Sixth	-	-	61	47
After how long do you do down or height reduction pruning? (mean years)		11	9.2	13.29	9.5
What type of pruning do	Cut across	97	98	100	96
you do on your tea farm?	Rim lung	3	0	0	4
(%)	Any other (specify)	0	2	0	0
What pruning implements	Pangas (a)	56	48	10	0
do you use in your farm?	Saws	0	0	0	2
(%)	Pruning knives (b)	41	50	90	94
	Other knives	0	0	0	2
	Combination of a & b	3	0	0	0
	Others (specify)	0	2	0	2
Do you remove your	Yes	26	25	15	21
prunings from the pruned	No	74	75	85	79
field? (%)					
Mean vacancies in farms. (%)	5.2	13	14.33	9.1	
Mean in filling periods. (Every years)	2	1	1.17	2	

The low pruning has several disadvantages. When it is done below the initial formative pruning, farmers need to bring tea into bearing again. The tea plants therefore take a long time to recover from prune, which delays the time the plants come back into production. Apart from long recovery time, low

pruning reduces yields (Kaptich 1985, Njuguna and Magambo 1990) as it reduces the plucking table size. The low pruned fields take long to cover the ground and this raises the costs of production since the fields must be weeded more times. Also low pruning causes large wounds on the tea bushes at very low heights. The height and size of the wounds make it easier for *Hypoxylon Serpens* inoculum to infect the tea bushes (Otieno 1997). Many farms visited had heavy Hypoxylon wood rot infections making the future of tea on the farms more uncertain. Again the low pruning height means that pluckers must bend most of the time to harvest the tea. This makes them tired faster, thus reducing their productivity. In the long run, this constant bending while plucking causes backache to the pluckers. Low pruning therefore hurts both the tea plant and the farmers and must be avoided. Although the pruning height should be increased by 5 cm most farmers did not know how it should be done (Table 3.16). But since it did not appear as though the farmers were actually monitoring the pruning height, this knowledge, although poor, was not being put to use.

Most smallholder tea farmers especially in the west of the Rift Valley used pruning knives to prune their tea plants as recommended. However, large percentage of the smallholder tea farmers in the east of the Rift Valley were using pangas to prune tea (Table 3.16). They argued, using pangas made pruning faster. However, this creates a problem, as the pangas usually caused cracks on the tea bushes making the cutting wounds even larger/bigger and the plant more predisposed to Hypoxylon wood rot infection. Indeed in several tea farms, many plants are already dying because of hypoxylon wood rot. Again maintaining uniform pruning height is more difficult to achieve with the use of a panga for pruning. Farmers should be educated to prune correctly and to use appropriate implements. In all the districts, most farmers leave the prunings in the field (Table 3.16), but in many areas farmers are still removing the prunings for use as firewood. This needs to be discouraged.

As a result of disease, pests and other natural calamities, some plants are lost causing large vacancies in the farmers' fields. There were vacancies in the fields visited with means ranging from 5 to 14% (Table 3.16). Tea production or productivity per bush in various districts did not follow the pattern of vacancies means. For the dead tea plants it is only possible to infill during the year of prune. However, farmers gave infilling frequencies of 1 or 2 years (Table 3.16). If this was done, it is unlikely the plants survived. However, most farmers were not infilling their farms. Since no other crop can grow viably in these vacancies, the lack of infilling programme implied that large areas of prime lands are being under utilised as no crop is grown on them. There should be a continuous infilling programme to increase tea production in the farms.

3.1.3.6. Adoption and use of chemical inputs on tea

Fertilizers and manures

Tea in regular production has to get nutrients supplemented in form of fertilizers and/or manures to continue to give high yields. In the smallholder sub sector of the Kenya tea industry, the recommended fertilizers for tea (Othieno 1988) and supplied by KTDA on credit is the NPKS 25:5:5:5. Most farmers (Table 3.17) used fertilizers on tea and knew they were receiving NPKS 25:5:5:5 or simply called it "fertilizer for tea". However, there were farmers in Nyambene, Nandi and Nyamira districts who were not applying fertilizers. These farmers were either not applying to get fertilizers from KTDA on credit or sold whatever they received to their neighbours or used the fertilizers they received on other farm enterprises.

The fertilizer use per unit area varied largely from district to district. This followed the same pattern as productivity such that areas, which applied more fertilizers, realised higher production per bush (Table 3.17). Kirinyaga district that had applied the highest rate of fertilizer had the highest productivity per bush, followed by Nyamira district. The rates of fertilizer applied and productivity per bush achieved in Nyambene and Nandi districts were the same and low. Fertilizer application is therefore one technology whose use ensures farmers get higher green leaf production.

Table 3.17: Assessment of fertilizers and manures use on tea.

		Kirinyaga	Nyambene	Nandi	Nyamira
Do you apply fertilizers on your tea? (%)	Yes	100	98	95	97
	No	0	2	5	2
	Missing	0	0	0	1
If Yes, what type(s)? (%)	DAP	3	0	0	1
	NPKS 25:5:5:5	90	96	95	91
	Urea	0	0	0	1
	Other (specify	7	0	0	5
	Do not apply	0	4	5	2
If Yes, what rates do you apply on mature tea?	Bags/hectare/year	23.16	12.43	12.68	16.95
	Kg/hectare/year	1157.81	631.5	634	847.5
	KgN/ hectare/year	290	155	159	212
Indicate the fertilizer rates you apply/applied yearly on your immature tea. (Bags/ha/year)	1st year from planting	1.4	.9	1.7	6.86
	2nd year from planting	2.6	1.3	2.7	8.3
	3rd year from planting	3.1	1.4	3.2	9.73
	4th year from planting	5.1	1.8	4.0	11.01
Month fertilizer received for your tea last year? (%)	May	0	0	3	0
	June	0	0	3	0
	July	0	2	0	2
	Aug	30	4	8	4
	Sep	53	46	33	43
	Oct	7	16	18	16
	Nov	1	2	10	2
	Dec	0	1	25	1
	Did not receive	9	32	0	32
How many bags did you get? (bags)		8.9	5.5	10.03	4
How many bags did you buy directly from the market or your neighbour? (bags)		7	0.7	2.1	1
How many bags did you apply to your tea? (bags)		9	5.6	9.1	5
Do you apply organic on your tea? (%)	Yes	34	41	5	14
	No	64	59	92	85
	Missing	2	0	3	1
If Yes, what type? (number)	Cow dung	0	21	3	4
	Goat manure	0	2	0	1
	Pig manure	0	2	0	1
	Maize stalks	1	5	3	4
	Others (specify)	0	11	0	1

For young tea, farmers used increasing and progressive rates of fertilizers with time (Table 3.17). Although the bags per hectare are given in Table 3.17, the data is suspect because most farmers did not plant all their tea in the same year. They had increased areas under tea gradually, but the calculation was based on the areas under tea for each farmer. The only important observation is that farmers knew when the tea is still young it receives less fertilizer, which is increased in progression upto when the tea is mature at which point it starts receiving a full dose.

It is deduced from Table 3.17 that a very high percentage of the farmers have access to fertilizer credit. However, there seems to be a problem of timely distribution of the input to the farmers. Generally farmers should receive fertilizers in July, August and latest in September for application when the rains come in October. In 1998, in Kirinyaga district, most farmers received fertilizer in August and September, while in Nyambene and Nyamira districts, most farmers received fertilizer in September, and October, but in Nandi district most farmers received fertilizers in September, October, November and December (Table 3.17). Thus except in Kirinyaga district where the fertilizer supply was timely, in other districts supply was generally late. This resulted in late application of the fertilizer and it is unlikely the applied fertilizer benefited tea production during the season as it was applied after the rains had ended. This led to low yields in these districts during the period. Inputs supply needs to be made on time in all areas for farmers to be able to use them to increase production.

The mean amount of fertilizer obtained by the farmers on credit (Table 3.17) was proportional to the mean areas under tea (Table 3.3). However, most farmers believed that the amount of fertilizers they were obtaining on credit was inadequate, and therefore purchased additional fertilizer for tea from the market or their neighbours (Table 3.17). In Kirinyaga district the extra amount of fertilizer bought was large leading to mean higher application than that envisaged by KTDA. This was followed by Nandi, Nyamira, and Nyambene districts, in that order. Use of higher rates of nitrogen than recommended raises the tea costs of production without reasonable economic benefits (Owuor and Othieno 1996, Owuor and Wanyoko 1996), reduces black tea quality (Owuor *et al* 1997, 2000) and causes other soil management problems (Owuor 1997). However, in this study the mean rate was not more than recommended rates, except in Kirinyaga district. But it is likely there are individual farmers who may be using over 300 kgN/ha/year. These need to be identified and advised. Similarly in the other areas, there were producers not using fertilizers or using very low rates. These farmers need to be identified and urged to use fertilizers to boost their production.

In the west of the Rift Valley, farmers did not use organic manures on tea, while in the east of the Rift Valley considerable number of farmers use organic manures (Table 3.17). The common type of organic manure used was cow dung, goat manure, pig manure and maize stalks. There is nothing wrong in the use of the organic manures provided it supplies the necessary nutrients and it is used at the correct rates.

Weeds, pests and diseases control

Weeds in tea production cause yield reduction/losses as applied fertilizers mostly go to feed the weeds. It is therefore necessary that tea plantations are kept weed free. Generally this is done manually using “jembes” or hoes, or chemically using herbicides. However, manual weeding destroys feeder roots system of the plants thus impeding the ability of the plants to absorb nutrients from the soil (Othieno 1981). Herbicide weeding is therefore recommended in tea production. However, 93%, 93%, 85% and 96% of the farmers in Kirinyaga, Nyambene, Nandi and Nyamira districts, respectively used manual weeding. Indeed, most of the farmers did not know the herbicides for controlling weeds in tea and those who knew did not know appropriate rates to use. Education of the farmers on herbicides weeding is necessary in all tea growing districts.

There are several pests, which attack tea in Kenya (Owuor *et al* 2001). The pests which could be identified by most farmers was mole rats which occurred in 41%, 21%, 28% and 26% of the farms

belonging to farmers in Kirinyaga, Nyambene, Nandi and Nyamira districts, respectively (Table 3.18). Few farmers also noted the occurrence of mites, scales and aphids in their farms. But it is noted that 35%, 56%, 40% and 42% of farmers in Kirinyaga, Nyambene, Nandi and Nyamira districts, respectively (Table 3.18) could not identify any pests. Thus they did not know even if there were pests in their tea fields.

If pests existed in their farms they left it to laws of nature to control them (Table 3.18) However, few farmers believed that they could control the pests using field management practices, while fewer farmers in the East of the Rift Valley use pesticides. Most farmers did not know the pesticides to use and when they knew, they did not know the recommended/correct rates and safe use of the pesticides. The problem of mole rats was most prevalent in many farms (Table 3.18) and they were controlled by manual trapping.

Table 3.18: Tea pests and diseases and their control by smallholder (%) tea growers.

		Kirinyaga	Nyambene	Nandi	Nyamira
Name tea pests, which occur in your tea farm.	Mites	0	7	3	3
	Aphids	3	5	8	2
	Mole rats	41	21	28	26
	Scales	0	11	0	1
	Others (specify	21	14	21	26
	Do not know	35	56	40	42
How do you control pests and diseases in tea?	Chemicals	9	2	0	0
	Field management	16	9	5	24
	Laws of nature	75	89	87	75
	Other (specify)	0	0	8	1
Do you experience problem with mole rats?	Yes	71	57	62	60
	No	29	43	38	40
If Yes, how do you control them?	Manual trapping	40	55	49	57
	Poison bating	9	2	5	2
	Fumigation with smoke from Kirinyaga mole machine	9	0	8	0
	Other (specify)	6	5	3	2
Name tea diseases you know.	Armillaria root rot	37	39	8	2
	Hypoxylon wood rot	1	2	3	1
	Phomopsis canker	0	0	0	0
	Leaf spots	0	0	0	0
	Others (specify)	1	0	3	3
	None	61	59	86	94
Which ones can you identify?	Armillaria root rot	31	36	5	4
	Hypoxylon wood rot	1	0	3	0
	Others (specify)	1	0	3	2
	None	66	64	87	94
Name tea diseases in your farm.	Armillaria root rot	36	32	3	6
	Hypoxylon wood rot	1	0	0	0
	Do not know	63	68	97	94

Several diseases attack Kenyan tea (Owuor *et al* 2001). Reasonable percentage of the smallholder growers in the east of the Rift Valley and only few in the west of the Rift Valley could identify Armillaria root rot while very few farmers could identify Hypoxylon wood rot of tea (Table 3.18). The majority of the farmers could not identify any disease of tea. Again a reasonable number of farmers from the east of the Rift Valley and very few farmers from the west of the Rift Valley reckoned the presence of Armillaria root rot in their farms. Most farmers did not know if they had any diseases in their farms.

Without knowledge of pests and teadisease, it is unlikely farmers can control them. Farmers' education on identification and control of pests and disease is urgently required.

3.1.4. Labour use in tea

The main use of labour in tea production is in plucking (harvesting). Although at the inception of smallholder tea sub sector in Kenya, it was hoped that the smallholder tea would only be tendered by the family (husband, wife and children) (M'Imwere 1997, 1999), the production has grown to an extent that in most farms the family alone cannot cope. Again most children go to school and are not available for plucking. Child labour is also discouraged by Kenya laws.

Most smallholder tea producers used hired labour in their farms (Table 3.19). The percentage of hired labour use in Nyamira district was lower than other districts, which were using about the same percentage. Most smallholder tea farmers used male and female workers, however, there was a large percentage of farms in Kirinyaga, Nyambene and Nyamira districts only hiring females. They reckoned female workers were easier to control than male counterparts. This observation underscores the vital role females play in tea production in Kenya. But in Nandi district, there was no farm employing only females, although 18% of the farms hired only males. This was due to presence of many immigrant workers from other districts and in most instances the immigrant workers were either only males or were couples. However, the data from all districts put together demonstrate that the dominant hired labour in smallholder tea sub sector are females.

Table 3.19: Smallholder tea growers labour use(%) and tea output

		Kirinyaga	Nyambene	Nandi	Nyamira
Do you hire people to work	Yes	77	73	71	55
on your tea enterprise?	No	23	27	39	45
If Yes, what sexes are they?	Male	2	0	18	0
	Female	23	14	0	14
	Both	53	64	44	43
Do you hire children to work	Yes	29	30	8	6
on tea enterprise also?	No	71	70	92	94
Are there some family	Yes	91	91	72	93
members who work on the tea enterprise?	No	9	9	28	7
If Yes, what sexes are they?	Male	10	5	8	7
	Female	30	21	13	28
	Both	60	74	79	65
Do some of your children	Yes	49	39	38	51
work on the tea enterprise also?	No	51	61	62	49
Who are the dominant tea	Males	1	2	56	9
workers in this region?	Females	90	91	13	70
	Both	9	7	31	21
How much tea leaf did you	Mean output (kg green	4410.96	1979.80	2678.33	1706.82
produce from your farm last	Mean producer price	25.10	23.28	21.33	21.33
year?	Plucking cost/kg gl	2.77	2.77	2.82	2.48

High percentage of the smallholder farms used family labour either exclusively or in addition to the hired labour (Table 3.19). Like hired labour, females were the dominant source of family labour. The data put together show that most smallholder tea is produced by females. The use of children to pluck tea was more dominant in Nandi district where 50% of the farmers used their children to pluck

tea (Table 3.19). In other districts fewer farmers used children. Indeed some farmers noted they were not using children because they spoiled tea plant and lowered plucking standards.

The tea output varied with districts (Table 3.19) in a similar pattern to the areas under tea. The mean producer prices also varied in the different districts. This mainly depended on prices realised at international markets. Generally areas east of the Rift Valley received high producer prices than areas west of the Rift Valley. Areas that received better producer prices produced better quality black teas (Owuor and Othieno 1991, Owuor *et al* 1987, 1988, 1993). Quality is therefore an important determinant of producer prices. Although quality is affected by many factors including geographical conditions (Owuor 1995), it is important that efforts are made to improve agronomic and processing techniques to ensure production of high quality teas.

Plucking costs were highest in Nandi district, followed by Kirinyaga and Nyambene districts and lowest in Nyamira district (Table 3.19). It seems where most farmers used hired pluckers, the cost of plucking was higher. The plucking cost was therefore demand driven.

3.1.5. Extension services and training

The success in farmers knowing, adopting and adapting recommended tea production technologies is largely dependent on the extension system reaching the farmers and educating them on ways of improving tea production and productivity. An assessment of the KTDA extension system was done to understand its weaknesses which maybe impeding effectiveness in technology diffusion. Many farmers noted most of the extension staff visited their farms (Table 3.20). However, in Nandi district more than half of the farms were not visited by extension staff and in Nyambene and Nyamira districts about 37% of the farms were not visited, while in Kirinyaga district 23% of the farms had not been visited. Even in Kirinyaga district where most farms had been visited, the percentage of farmers not visited during the year was substantial. Indeed there were farmers who had never, ever been visited by any extension staff before. There were more farmers visited in Kirinyaga district followed by Nyamira district. The visits to farms in Nandi and Nyambene districts were about equal (Table 3.20). It is noted that where the visits were more, tea productivity was also higher. This lack of adequate technology transfer through extension staff visits is an aspect impeding tea production in the smallholder tea sub sector. During the visits in Kirinyaga, Nyambene and Nyamira districts, the extension staff advised the growers on best methods of growing tea, especially the current technologies applied (Table 3.20). Most of the visits to the farmers were for undisclosed reasons. It is necessary that extension visits are planned and made such that they are beneficial to both the farmers and extension staff, and are intended for technology transfer purposes.

Apart from attending tea 'barazas'(public meetings), most farmers had never attended any formal course on tea production (Table 3.21). The percentage of those who had not attended any course varied slightly between the districts. Whenever there was a baraza to educate farmers on tea production technologies, it is mostly the owners of the farms, interpreted to mean the "man of the home" who attended the meetings. But in several cases both spouses attended. In Nyambene and Nandi districts, in most cases the person who attended the meetings never passed information learnt to the farm worker. These new knowledge were therefore a waste as the wrong persons were trained and the information never reached the farm operators. The training techniques should be changed so that the correct personnel are trained to ensure technologies are reaching the intended group who can effect change in production patterns.

Table 3.20: Assessment of extension services and training

		Kirinyaga	Nyambene	Nandi	Nyamira
Do agricultural extension officers visit your farm? (%)	Yes	77	64	49	62
	No	23	36	51	38
If Yes, how many times do they visit you per (Number)	Month	2	1	1	2
	Year	12	4	5	7
Number of visits last year. (number)	9	3	5	7	
Do they advise you on the best methods of growing tea? (%)	Yes	77	57	41	55
	No	23	43	59	45
Do they advise you on the current technologies e.g. fertilizer application, plucking methods etc for this area? (%)	Yes	77	57	41	54
	No	23	43	59	46

Whenever the extension staff visited the tea farms, they usually met the owner of the farm "read husband" or both husband and wife. However, in many farms, they were met by the wives, except in Nandi district (Table 3.21). It is likely that the people meeting the extension staff at the farm level were not the farm operators and were not imparting any technologies leant through the visits to the farm operators. Most of the technologies therefore do not reach those who can profitably use them to improve tea productivity and production. It is important that a policy is developed and put into practice that facilitates the farm operators to easily receive information on tea production technologies. This should be done fast as most farmers do not want their workers to have more knowledge than them. However, although the farmers would like to monopolise knowledge, their knowledge does not transform to tea production.

Table 3.21: Assessment of smallholder tea growers training (%) on tea production technologies

		Kirinyaga	Nyambene	Nandi	Nyamira
Have you ever been trained on tea production?	Yes	26	9	18	5
	No	74	91	82	95
If there is a baraza to educate farmers on better technologies concerning tea production who attends it?	Owner of the farm	51	64	64	13
	Spouse (wife)	14	9	8	21
	Employed manager	2	2	0	2
	One of the workers	0	0	0	1
	One of the children	6	0	8	7
	Both husband & wife	20	14	8	23
	No one	7	11	12	33
Is the person who attends tea educational barazas or training the same one who manages the farm?	Yes	83	68	67	81
	No	10	23	26	15
	No one	7	9	7	4
Does the person who attends the training pass on new ideas learnt at training to the rest of tea workers?	Yes	84	50	58	62
	No	16	50	42	38
When the agricultural extension officers come around on the farm to give advice on tea production matters, whom do they advise?	Owner of the farm	31	27	33	25
	Spouse (wife)	22	16	8	21
	Employed manager	1	0	0	1
	One of the children	2	5	5	4
	Both husband & wife	27	27	21	31
	Not visited	17	25	33	18
Does the person pass on the information to the rest of the tea workers?	Yes	74	61	49	63
	No	1	14	18	13

Some farmers voiced concern that when the farm operators became more aware of the tea production technologies, they became more marketable and difficult to maintain. Thus the individual farmers looked at training farm workers as an undertaking that benefits their neighbours/competitors rather than themselves.

Few farmers noted that there were different tea production technologies not favoured by the workers (Table 3.22). However, most tea farmers felt that all tea recommended production technologies were useful. The basket for carrying plucked green leaf is one implement that many farmers, especially in Nandi district felt the male farm operators did not like carrying on their heads or back. This arises from cultural beliefs that a man should not carry such things on their heads. It is advisable to develop some farm operator/user friendly carrying equipment for the use.

Table 3.22: An assessment of acceptability (%) of production technologies

		Kirinyaga	Nyambene	Nandi	Nyamira	
Are there some tea	Yes	34	23	46	16	
recommendations not	No	46	77	54	84	
favoured by tea farmers and the workers in general?						
If Yes, which tea	Fertilizer recommendationss	2	0	0	0	
recommendations don't	Weed control recommendation	0	0	0	1	
augur well with the	Plucking methods	6	0	0	8	
community here?	Plucking equipment e.g. baskets		20	27	46	1
	Other specify	14	0	5	9	
Do male workers here have	Yes	33	41	64	23	
a problem of carrying tea	No	67	59	36	77	
baskets on their heads or back?						

3.1.6. Tea production and extension policies

The success of tea production in the smallholder tea sub sector is heavily dependent on appropriate production technologies reaching the farmers, especially the farm operators. This can only happen if correct production and technology transfer policies are put in place. Farmers were assessed on their perception of the tea production and extension policies of the KTDA. The extension staff visited most farms using their own schedules and rarely on invitation (Table 3.23). This probably is because the farmers' knowledge on technology and even how to acquire the technology is so low that most of them do not know when they have problems in their farms. Alternatively the extension staff are too few so they do not honour invitations. As an alternative since the extension staff were not directly under KTDA management they adopted negative attitudes and the farmers could not do anything to change the situation. Consequently the farmers described the system as long, slow, with too few staff, inadequate and needing overhaul (Table 3.23). Policy makers need to take note of this and make necessary adjustment.

Most farmers in Nyambene and Nyamira districts felt that getting technical information from TRFK directly could be useful (Table 3.24). While this is necessary to be done to complement what KTDA extension service is doing, as it will ensure farmers get their problems solved faster, it is also necessary that TRFK strengthens its advisory system to meet farmers expectations. Indeed it was observed under sources of technologies the farmers use that no farmer indicated he/she ever learnt any of the techniques from TRFK.

The results on the response to TRFK reveals other problems. First it shows that the farmers are not feeling the effectiveness of the TRFK extension services. It is necessary that the TRFK changes its present approach to the farmers. At present farmers are visited on recommendation of the KTDA extension staff. In this study however, farmers were randomly selected. It is likely that when extension staff select farmers to be visited, visits are made only to farmers who are either doing very well as a show of the extension staff effectiveness or farmers are selected who are close to the main road. Both these techniques do not allow visits to farmers who are in real need of tea production technologies. It is necessary that apart from visiting farmers with problems as identified by the extension service of KTDA, TRFK extension service needs to make its own regular visits in which the farmers are selected randomly. Again, the staffing of the TRFK extension services has been lean over the years. Most of the visits are therefore made by scientists who go out to solve specific problems, at the invitation of KTDA extension services staff. The TRFK extension staff service needs to be strengthened so that its effectiveness is felt.

Table 3.23: Views of smallholders (%) on the KTDA extension system.

		Kirinyaga	Nyambene	Nandi	Nyamira
How do you get field exten	By inviting them	6	5	8	1
sion staff to visit your farm?	Using own schedule	94	77	64	81
	No response	0	18	28	18
How would you describe the existing extension structure in tea industry?					
i) It is:	Long	59	86	74	74
	Short	41	14	26	26
ii) It is:	Quick	39	18	18	23
	Slow	61	82	82	77
Iii) Has:	Too many officers	9	11	15	10
	Too few officers	91	89	85	90
Current extension system: -	Adequate for farmers	16	11	3	3
	Inadequate for farmers	84	89	97	97
Current extension system: -	Needs to be continued	33	21	10	15
	Needs to be overhauled	61	79	90	85

The TRFK sources its finances from the farmers through cess paid to Tea Board of Kenya. But is noted that very few farmers actually knew they were contributing money to do research (Table 3.24). This implies they either thought the research technologies being developed for the Kenya tea industry was being financed by the government or by some donors. The lack of information that they owned the technologies might have made most farmers feel that it was a privilege getting the technologies from TRFK. It is necessary to change this view, as it shall make the farmers search for available technologies as nobody wants to spend money for nothing.

Most farmers recognised the need to have technologies that could help them improve their tea production and productivity. This they realise can be done through either courses or seminars. The majority of farmers need courses/seminars on tea production at least once in a year (Table 3.24). For effectiveness and ease of reaching the farmers they recommended group-training approach. Again for effectiveness, the farmers suggested a need to transfer the extension staff to be under the factories. This has since been done and it is hoped the extension services will be more effective as the staff will now be answerable to the farmers. Thus the new system has increased accountability of the extension staff to the farmers.

Table 3.24: Views smallholders (%) on additional sources of technology and methods of transfer.

		Kirinyaga	Nyambene	Nandi	Nyamira
Should you get direct advice from TRFK without passing through KTDA?	Yes	50	64	46	67
	No	50	36	54	33
Are you aware you are contributing money to TRFK to give you advice?	Yes	36	45	21	27
	No	64	55	79	73
How often should tea production training be done for farmers?	Once a month	17	17	8	8
	Two time a year	26	30	39	27
	Thrice a year	10	5	5	22
	Once a year	37	30	31	20
	Once in two years	7	9	8	13
	Once in three years	0	0	5	0
	Once in four years	2	7	3	0
	Other (specify)	1	2	1	10
Which method of extension is most effective for you?	Single farmer approach	26	21	26	12
	Group approach	64	61	59	69
	Baraza approach	9	18	15	17
	Other (specify)	1	0		2
Do you think there is need to establish tea extension office and staff in each factory?	Yes	84	96	51	75
	No	16	4	49	25

Adequate and timely payment to the farmers is the key to any commercial agricultural production. Most farmers felt that the payment during the study of Kshs 6 per kg green leaf as minimum guaranteed payment on monthly basis followed by a second payment ("bonus") after the tea has been sold to give a full value at the end of financial year was not adequate. The first (monthly) payment was too low to run their tea business. They suggested monthly payment of KShs 11 to 12 per kg green leaf (Table 3.25). This payment mode has since been adjusted to KShs 7.50 and it is likely the amount may still be inadequate to run the tea farms. It is necessary that the rate of payment to farmers be objectively worked out to enable the farmers to produce tea more effectively.

Generally, farmers in the west of the Rift Valley and in Nyambene recommended that second payment should be done once at the end of the financial year, while only 26% of farmers in Kirinyaga district preferred this mode of payment. The farmers liking this system observed that it helped them to save money (Table 3.25). Most of the farmers who did not like this mode of payment because the first payment was too low and therefore they wanted more regular payment of part of the bonus to meet the recurrent costs of running the tea farms. Consequently most farmers wanted a payment mode with higher first (monthly) payment followed by second (bonus) payment at six months intervals (Table 3.25). KTDA has been making this mode of payment lately.

Table 3.25: Views of smallholders on green leaf payment policy.

		Kirinyaga	Nyambene	Nandi	Nyamira
Is the current first green leaf payment adequate to run your tea farm? (%)	Yes	10	16	10	3
	No	90	84	90	97
If No, how much first green leaf payment do you think will be adequate?	KSh /kg green leaf.	11.84	12.2	11.09	11.16
Should KTDA wait until end of the financial year to make second payment to tea farmers? (%)	Yes	26	71	62	72
	No	74	29	38	28
If Yes, why? (%)	Help farmers save	3	66	56	68
	Help farmers earn interest	0	2	0	0
	Any other (specify)	21	0	3	1
If No, why? (%)	First payment is too low	61	32	28	15
	Farmers to save their money themselves	3	0	8	3
	Farmers have little confidence in KTDA	3	0	5	2
	Any other (specify)	0	0	0	7
Give suggestion for your preferred mode of green	Monthly payment of total proceeds	10	0	3	1
	1st payment then one 2nd payment	86	32	49	47
	1st payment then two 2nd payments at six months intervals	0	64	46	41
	1st payment then 2nd payment as soon as net sales are realised	1	2	2	10
	Others (specify)	1	0	0	0
	Missing (Undecided)	2	2	0	0

3.1.7 Causes of low tea production.

Factors which the farmers believed contributed to low green leaf production in the small holder tea sub sector (Table 3.26) were mainly poor crop husbandry, late supply of farm inputs (fertilizers), inadequate plucking funds, poor leaf collection programmes, drought, excessive rainfall, cold weather, hail storms, and inadequate factory capacity. Except drought, cold weather, hail storms and too much rain, most of the other factors were man made and could be minimised by correct policy intervention.

Indeed, the farmers suggested that tea production could be enhanced through extension services if the number of extension staff was increased (Table 3.26). Also green leaf production in the smallholder sub sector could be improved by improving first payment, intensifying extension, training the tea farmers, creating incentives for farmers doing well and improving tea roads (Table 3.26).

Table 3.26: Assessment of factors contributing and method to overcome low green leaf production and productivity (%)

		Kirinyaga	Nyambene	Nandi	Nyamira
What do you think contributes to low leaf production in smallholder tea production?	Hail storms	4	0	18	57
	Cold weather	20	7	8	8
	Poor leaf collection programme	6	32	49	62
	Poor crop husbandry	37	66	77	53
	Inadequate extension services	9	34	56	47
	Late inputs supply (fertilizers)	46	39	51	42
	Inadequate funds for plucking	41	27	26	36
	Drought	14	25	10	42
	Too much rain	11	5	3	2
	Inadequate factory capacity	3	2	3	2
	Others (specify)	4	21	0	2
Suggest possible ways of improving tea extension to enhance leaf production among smallholders	More extension staff	53	46	26	53
	Intensify supervision of extension staff	20	5	35	10
	Transfer extension officers to KTDA	23	11	10	16
	Others (specify)	0	36	28	18
	Missing (No suggestions)	4	2	0	0
Suggest possible ways of enhancing leaf production in smallholder tea sub-sector	Improve first payment	73	77	72	71
	Intensify extension services	26	64	69	64
	Hold more regular seminars	33	46	62	63
	Avail farm inputs readily	54	41	46	52
	Avail farm inputs to farmers based on tea area	24	16	10	7
	Create incentives for farmers doing well	20	30	33	25
	Expand tea factories	1	7	3	5
	Improve tea roads	33	43	74	76
	Others (specify)	3	9	10	8

3.1.8. Frequency statistics on technical knowledge of farmers. Testing of hypotheses

The results of frequency statistics for the smallholder tea farmers were used to test the hypotheses that: -

(i) less than half of the smallholder tea farmers have knowledge of tea production technologies identified.

(ii) in more than half of the smallholder tea farms, training on tea husbandry and extension services are directed to the farm owners and not to the personnel doing actual tea work.

(iii) in less than half of the smallholder tea farms, the farm owners do not have adequate time to train their workers after attending tea production trainings.

(iv) that there are some recommended technologies which are not culturally acceptable for use in some regions;

v) that more than half of the smallholder tea farmers have no access to credit to purchase the recommended inputs or where the inputs are available on credit, they do not reach the smallholder on time;

Table 3.27 shows the quantifiable technologies considered in each district, the respective responses and percent responses. Figure 3.1 shows the summary of the percentage of research recommendations below/above 50% responses. The results show that amongst the technologies identified, 46, 58, 52 and 65% in Kirinyaga, Nyambene, Nandi and Nyamira Districts respectively, had responses, which were less than half of the farmers interviewed. Therefore, the hypothesis that less than half of the farmers have adequate knowledge of tea production technologies identified was accepted except for Kirinyaga District, which had 46%. Nevertheless, it was very close to half of the identified tea production technologies where the farmers responded. The general observation was that the percentage of the technologies in which less than half the farmers responded was over 50% in three of the four districts hence the hypothesis was accepted. Thus, a high percentage of farmers do not have adequate knowledge of tea production technologies.

The second hypothesis tested was that in more than half of the tea farms, training on tea technologies and extension services are directed to the farm owners and not to the personnel doing the actual tea work. The results (Table 3.21) show that 83, 68, 67 and 81% of farms in Kirinyaga, Nyambene, Nandi and Nyamira districts respectively, the person who attends "barazas" and tea training is the same person who manages the farm. Table 3.1 shows that more than 50% of the farms are owned and managed by the owners. The inference drawn from the results is that in more than half of the farms, training on tea production technologies and extension services are directed to the farm owners and not to the farm workers. Hence the hypothesis was accepted.

The results in Table 3.21 show that 84, 50, 58 and 62% of farms in Kirinyaga, Nyambene, Nandi and Nyamira districts, respectively, the person who attends the training passes on the new ideas learnt at the training or extension services sessions to the rest of the tea workers. The hypothesis that most of the owners of the tea farms do not have enough time to educate their workers after attending tea production training was rejected.

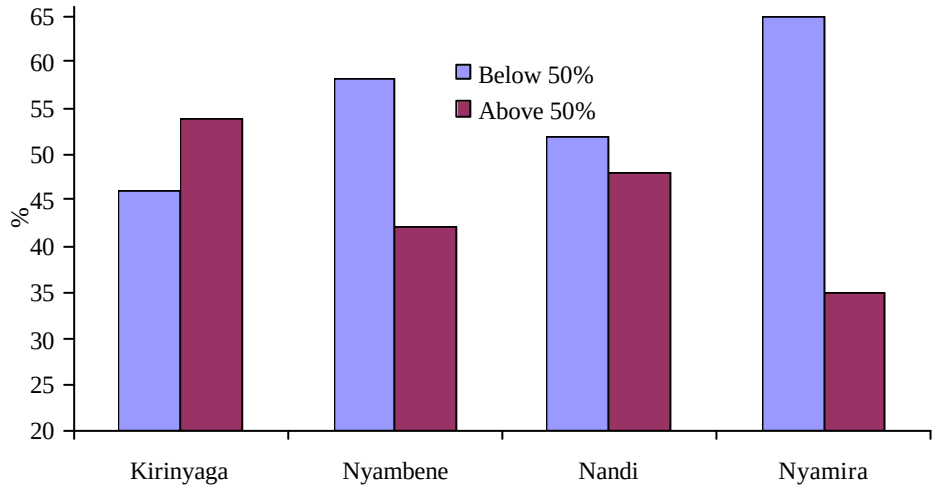
The results of the frequency analysis were also used to test the hypothesis that there are some recommended technologies, which are not culturally acceptable in some tea growing regions. From the results, (Table 3.22) it was inferred that there is no technological recommendation, which is significantly unacceptable. However, 64% of male workers in Nyamira District have a problem of carrying tea baskets on their heads or backs. It is necessary to develop more user-friendly tea carrying equipment for these workers.

The frequency statistics results were also used to test the hypothesis that more than half of the farmers have no access to credit to purchase the recommended inputs or where the inputs are available on credit, they do not reach the smallholder on time. It was deduced from Table 3.17 that a very high percentage of the farmers have access to fertilizer credit. The results further showed that except in Kirinyaga district where the fertilizer supply was timely, in other districts supply was generally late. This resulted in late application of the fertilizer and it is unlikely the applied fertilizer benefited tea production during the season as it was applied after the rains had ended. Hence contributing to low yields in these districts.

Table 3.27: Percentage responses for the various recommendations in Kirinyaga, Nyambene, Nandi and Nyamira Districts.

	Kirinyaga		Nyambene		Nandi		Nyamira	
	N=70 N	% responses	N=45 N	% responses	N=35 N	% responses	N=106 N	% responses
Knowledge of soil depth (m)	8	11			5	13	8	8
Length of ripping tool (m)	58	83	41	91	33	85	77	73
Plant density per ha.	38	54	21	51	26	67	49	46
Age of shoots for cuttings (months)	41	59	16	36	18	46	49	46
Period of stay in nursery (months)	48	69	23	51	25	64	74	70
Stem length of cuttings? (cm)	44	63	28	62	24	62	76	72
Period cuttings should remain in water (minutes)	30	43	20	44	16	41	58	55
Width of planting holes (cm)	58	83	38	84	35	90	98	92
Depth of planting holes (cm)	58	83	38	84	35	90	97	92
Fertilizer amount put in holes (gm)	21	30	10	22	22	56	33	31
Height of pruning young tea first time (cm)	49	70	29	64	30	77	78	74
Length of central stems at first pruning (cm)	23	33	10	22	23	59	52	49
Height at 1st pruning (cm)	14	20	6	13	15	38	15	14
Height at 2nd pruning (cm)	10	14	2	4	13	33	9	8
Height at 3rd pruning (cm)	9	13	2	4	11	28	8	8
Length of lateral shoots when pegging (cm)	47	67	26	58	14	36	38	36
Height of central stems when establishing plucking table (cm)	41	59	22	49	17	44	40	38
Length of lateral shoots when establishing plucking table (cm)	36	51	17	38	15	38	37	35
Plucking rounds (Days)	70	100	44	98	39	100	103	97
1st pruning height (cm)	37	53	9	20	20	51	34	32
2nd pruning height (cm)	34	49	6	13	17	44	31	29
3rd pruning height (cm)	30	43	6	13	13	33	27	25
4th pruning height (cm)	27	39	4	9	9	23	10	9
5th pruning height (cm)	26	37	2	4	5	13	5	5
6th pruning height (cm)	6	9					2	2
Fertilizer rates for mature tea (bags/ha)	70	100	43	96	35	90	104	98

Figure 3.1: Percentage of research recommedations below/above 50% response by farmers



3.2 Descriptive Statistics on the Level of Farmers' Application of Agronomic Recommendations

The results of descriptive statistics are summarized in Tables 3.28 to3.32. The technological recommendations considered for the various districts were: - 26 in Kirinyaga, 24 in Nyambene, 25 in Nandi and 26 in Nyamira district. The overall comparative results were shown in Figure 3.2. The results showed that in the east of the Rift Valley region represented by Kirinyaga and Nyamira Districts, 42 percent and 29 percent of the technological recommendations had an application level which was significantly different from the research recommendation level. In the west of the Rift Valley region represented by Nandi District and Nyamira District, 54 percent and 62 percent of the technological recommendations had an application level which was significantly different from the research recommendation level. Thus, in the east of the Rift Valley 58 percent and 71 percent of the technological recommendations in Kirinyaga and Nyambene District respectively, were not significantly different from the agronomic recommendations. These results imply that in the east of the Rift Valley, farmers have fairly accurate agronomic information about tea husbandry.

Table 3.28: Testing recommendation level aganist farmers practice level in Kirinyaga District

	N=70 n	m	s	u	Cal T	Critical tc	Test	Decision
Knowledge of soil depth (m)	8	1.206	0.845	2.0	-1.766	-2.306	t>-tc	Not Diff.
Length of ripping tool (m)	58	0.214	0.110	0.6	-26.39	-2.010	t<-tc	Different
Plant density per ha.	38	8952.24	1727.240	11000	-7.212	-2.023	t<tc	Different
Age of shoots for cuttings (months)	41	.690	2.120	6.0	-3.908	2.021	t<tc	Different
Period of stay in nursery (months)	48	10.980	2.250	10.5	1.463	2.012	t<tc	Not Diff.
Stem length of cuttings? (cm)	44	3.428	2.846	3.25	0.409	2.019	t<tc	Not Diff.
Period cuttings should remain in water (minutes)	30	40.120	61.980	30.0	0.879	2.042	t<tc	Not Diff.
Width of planting holes (cm)	58	21.197	6.620	25.0	-4.371	-2.004	t<-tc	Different
Depth of planting holes (cm)	58	32.353	14.641	45.0	-6.519	2.004	t<-tc	Different
Fertilizer amount put in holes (gm)	21	14.050	13.150	15.0	-0.323	2.080	t<-tc	Not Diff.
Height of pruning young tea first time (cm)	49	18.163	7.320	15.0	2.994	2.011	t<tc	Different
Length of central stems at first pruning (cm)	23	34.152	16.537	30.0	1.178	2.069	t<tc	Not Diff.
Height at 1st pruning (cm)	14	35.607	15.569	28.0	1.762	2.145	t<tc	Not Diff.
Height at 2nd pruning (cm)	10	48.250	17.323	40.0	1.429	2.228	t<tc	Not Diff.
Height at 3rd pruning (cm)	9	57.000	24.668	50.0	0.803	2.262	t<tc	Not Diff.
Length of lateral shoots when pegging (cm)	47	49.830	16.714	57.5	-3.112	2.014	t<-tc	Different
Height of central stems when establishing plucking table (cm)	41	48.707	19.913	50.0	0.411	2.021	t<tc	Not Diff.
Length of lateral shoots when establishing plucking table (cm)	36	59.097	17.508	57.5	0.540	2.029	t<tc	Not Diff.
Plucking rounds (Days)	70	10.940	1.910	8.0	12.786	1.997	t<tc	Different
1st pruning height (cm)	37	43.324	12.684	45.0	-0.793	2.031	t<-tc	Not Diff.
2nd pruning height (cm)	34	47.272	13.600	50.0	-1.152	2.038	t<-tc	Not Diff.
3rd pruning height (cm)	30	49.242	15.245	55.0	-2.034	2.042	t<-tc	Not Diff.
4th pruning height (cm)	27	52.185	17.370	60.0	-2.294	2.052	t<-tc	Different
5th pruning height (cm)	26	51.962	18.441	65.0	-3.535	2.056	t<-tc	Different
6th pruning height (cm)	6	47.917	20.274	70.0	-2.436	2.447	t<-tc	Not Diff.
Fertilizer rates for mature tea (bags/ha)	70	23.155	16.393	14.0	-4.639	1.997	t<-tc	Different

In the west of the Rift Valley however, 54 percent and 62 percent of the technological recommendations in Nandi and Nyamira respectively had an application level, which was significantly different from the agronomic research recommendation level. Thus, only 46 percent and 38 percent of the technological recommendations in Nandi and Nyamira Districts respectively were not significantly different from the agronomic recommendations. These results imply that the level of accurate technology adoption among smallholder farmers in west of the Rift Valley region is relatively low.

For the whole sample, 62 percent of the technological recommendations had application levels, which were significantly different from the research recommendation levels in the four districts. As a result, low productivity of the green leaf in the smallholder sector is inevitable if only 38 percent of the agronomic research recommendations are fairly applied accurately on the farm. These results were used to test the hypothesis that more than half of the smallholder tea farmers have not adopted the recommended levels for each identified technology. The results revealed that 62 percent of the technologies were applied inaccurately. Therefore, the hypothesis was accepted.

Table 3.29: Testing recommendation level against farmers' practice level in Nyambene District

	N=45 n	M	S	μ	Cal T	Critical tc	Test	Decision
Length of ripping tool (m)	41	0.201	0.122	0.6	-20.619	2.019	t<-tc	Different
Plant density per ha.	21	8755.19	1606.310	11000	-6.2500	2.080	t<-tc	Different
Age of shoots for cuttings (months)	16	5.25	1.440	6.0	-2.017	2.120	t>-tc	Not Diff.
Period of stay in nursery (months)	23	14.650	5.560	10.5	3.501	2.069	t>-tc	Different
Stem length of cuttings? (cm)	28	4.2563	1.986	3.25	2.633	2.048	t>tc	Different
Period cuttings should remain in water (minutes)	20	47.150	47.290	30.0	1.581	2.086	t<tc	Not Diff.
Width of planting holes (cm)	38	23.342	10.733	25.0	-0.940	2.023	t>-tc	Not Diff.
Depth of planting holes (cm)	38	39.342	19.250	45.0	-1.788	2.023	t>-tc	Not Diff.
Fertilizer amount put in holes (gm)	10	9.200	9.390	15.0	-1.853	2.228	t>-tc	Not Diff.
Height of pruning young tea first time (cm)	29	21.693	9.332	15.0	3.795	2.045	t>tc	Different
Length of central stems at first pruning (cm)	10	50.000	19.978	30.0	3.003	2.228	t>tc	Different
Height at 1st pruning (cm)	6	37.833	14.247	28.0	1.543	2.447	t<tc	Not Diff.
Height at 2nd pruning (cm)	2	48.500	4.950	40.0	1.717	4.303	t<tc	Not Diff.
Height at 3rd pruning (cm)	2	51.000	8.485	50.0	0.118	4.303	t<tc	Not Diff.
Length of lateral shoots when pegging (cm)	26	59.596	21.129	57.5	0.496	2.056	t<tc	Not Diff.
Height of central stems when establishing plucking table (cm)	22	47.955	15.320	50.0	-0.612	2.074	t>-tc	Not Diff.
Length of lateral shoots when establishing plucking table (cm)	17	59.353	12.262	57.5	0.604	2.110	t<tc	Not Diff.
Plucking rounds (Days)	44	10.980	3.020	8.0	6.471	2.017	t>tc	Different
1st pruning height (cm)	9	46.944	8.582	45.0	0.476	2.262	t<tc	Not Diff.
2nd pruning height (cm)	6	53.667	7.394	50.0	1.109	2.447	t<tc	Not Diff.
3rd pruning height (cm)	6	58.750	7.374	55.0	1.137	2.447	t<tc	Not Diff.
4th pruning height (cm)	4	61.250	13.769	60.0	0.157	2.776	t<tc	Not Diff.
5th pruning height (cm)	2	50.000	14.142	65.0	0.131	4.303	t<tc	Not Diff.
Fertilizer rates for mature tea (bags/ha)	43	16.573	11.830	14.0	1.410	2.018	t<tc	Not Diff.

Table 3.30: Testing recommendation level against farmers' practice level in Nandi District

	N=39 n	m	s	μ	Cal T	Critical tc	Test	Decision
Knowledge of soil depth (m)	5	18.450	26.458	2.0	16.45	2.776	t>tc	Different
Length of ripping tool (m)	33	0.279	0.126	0.6	-14.478	2.017	t<-tc	Different
Plant density per ha.	26	9564.08	1630.53	11000	-4.403	2.060	t<-tc	Different
Age of shoots for cuttings (months)	18	3.360	1.490	6.0	-7.305	2.110	t<-tc	Different
Period of stay in nursery (months)	25	10.880	3.440	10.5	0.541	2.064	t<tc	Not Diff.
Stem length of cuttings? (cm)	24	4.335	1.401	3.25	3.714	2.069	t>tc	Different
Period cuttings should remain in water (minutes)	16	110.00	174.36	30	1.777	2.131	t<tc	Not Diff.
Width of planting holes (cm)	35	23.00	9.850	25	-1.184	2.034	t>-tc	Not Diff.
Depth of planting holes (cm)	35	28.970	13.00	45	-7.190	2.034	t<-tc	Different
Fertilizer amount put in holes (gm)	22	10.140	9.640	15	-2.310	2.080	t<-tc	Different
Height of pruning young tea first time (cm)	30	24.864	17.785	15	29.867	2.045	t>tc	Different
Length of central stems at first pruning (cm)	23	45.127	15.528	30	4.569	2.074	t>tc	Different
Height at 1st pruning (cm)	15	27.280	7.440	28	-0.362	2.145	t>-tc	Not Diff.
Height at 2nd pruning (cm)	13	34.650	6.450	40	-2.873	2.179	t<-tc	Different
Height at 3rd pruning (cm)	11	41.280	7.890	50	-3.495	2.228	t<-tc	Different
Length of lateral shoots when pegging (cm)	14	37.200	12.930	57.5	-5.661	2.160	t<-tc	Different
Height of central stems when establishing plucking table (cm)	17	41.140	11.900	50.0	-2.978	2.120	t<-tc	Different
Length of lateral shoots when establishing plucking table (cm)	15	52.580	16.800	57.5	-1.096	2.145	t>-tc	Not Diff.
Plucking rounds (Days)	39	10.030	2.440	8	5.129	2.025	t>tc	Different
1st pruning height (cm)	20	48.140	11.860	45	1.154	2.093	t<tc	Not Diff.
2nd pruning height (cm)	17	54.090	11.630	50	1.407	2.120	t<tc	Not Diff.
3rd pruning height (cm)	13	55.230	7.010	55	0.114	2.179	t<tc	Not Diff.
4th pruning height (cm)	9	56.060	8.870	60	-1.256	2.306	t>-tc	Not Diff.
5th pruning height (cm)	5	58.080	7.840	65	-1.765	2.776	t>tc	Not Diff.
Fertilizer rates for mature tea (bags/ha)	35	12.686	5.439	14	-1.409	2.034	t>-tc	Not Diff.

Figure 3.2: Percent numberof technological recommendations different/not different from farm application level

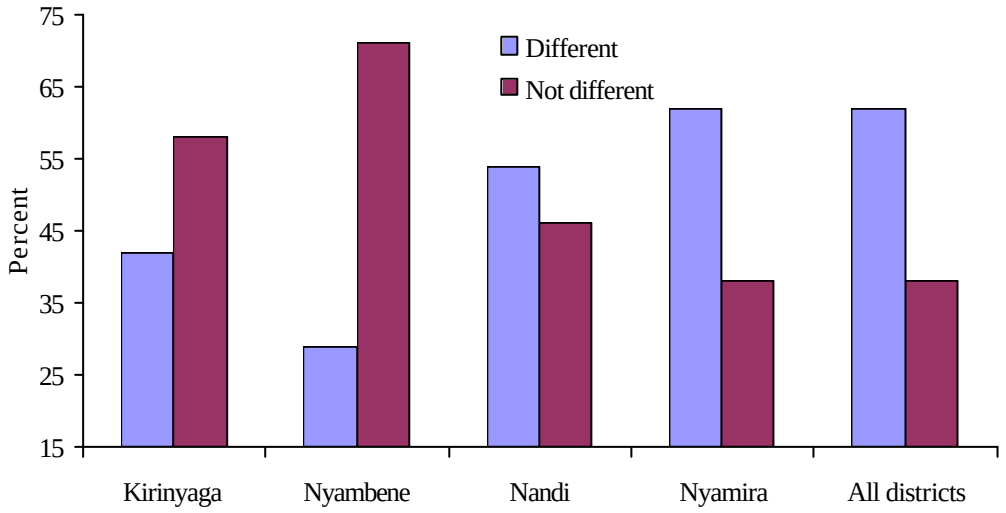


Table 3.31: Testing recommendation level against farmers' practice level in Nyamira District

	N=106 n	m	s	μ	Cal T	Critical tc	Test	Decision
Knowledge of soil depth (m)	8	1.950	0.923	2	-0.143	2.306	t>tc	Not Diff.
Length of ripping tool (m)	77	0.202	0.053	0.6	-65.113	1.994	t<-tc	Different
Plant density per ha.	49	7798.86	3230.81	11000	-6.860	2.016	t<-tc	Different
Age of shoots for cuttings (months)	49	5.350	2.710	6	-1.662	2.016	t>tc	Not Diff.
Period of stay in nursery (months)	74	11.320	2.910	10.5	2.408	1.995	t>tc	Different
Stem length of cuttings? (cm)	76	4.884	4.997	3.25	2.832	1.995	t>tc	Different
Period cuttings should remain in water (minutes)	58	62.620	101.89	30	2.417	1.981	t>tc	Different
Width of planting holes (cm)	98	17.101	7.018	25	-11.086	1.987	t<-tc	Different
Depth of planting holes (cm)	97	30.616	11.356	45	-12.411	1.988	t<-tc	Different
Fertilizer amount put in holes (gm)	33	18.21	18.250	15	0.995	2.036	t<tc	Not Diff.
Height of pruning young tea first time (cm)	78	18.883	11.375	15	2.995	1.994	t>tc	Different
Length of central stems at first pruning (cm)	52	48.077	19.419	30	6.648	1.987	t>tc	Different
Height at 1st pruning (cm)	15	19.870	6.650	28	-4.574	2.145	t<-tc	Different
Height at 2nd pruning (cm)	9	27.220	8.900	40	-4.061	2.306	t<-tc	Different
Height at 3rd pruning (cm)	8	40.250	14.750	50	-1.749	2.365	t>-tc	Not Diff.
Length of lateral shoots when pegging (cm)	38	39.276	16.563	57.5	-6.693	2.027	t<-tc	Different
Height of central stems when establishing plucking table (cm)	40	48.175	17.499	50	-0.651	2.021	t>-tc	Not Diff.
Length of lateral shoots when establishing plucking table (cm)	37	48.203	17.625	57.5	-3.165	2.027	t<-tc	Different
Plucking rounds (Days)	103	10.520	2.870	8	8.868	1.986	t>tc	Different
1st pruning height (cm)	34	47.809	18.539	45	0.870	2.034	t<tc	Not Diff.
2nd pruning height (cm)	31	53.371	15.264	50	1.210	2.042	t<tc	Not Diff.
3rd pruning height (cm)	27	58.315	16.110	55	1.049	2.052	t<tc	Not Diff.
4th pruning height (cm)	10	62.750	16.420	60	2.750	2.062	t>tc	Different
5th pruning height (cm)	5	53.100	9.489	65	-2.508	2.776	t>-tc	Not Diff.
6th pruning height (cm)	2	47.000	4.240	70	-5.424	12.706	t>-tc	Not Diff.
Fertilizer rates for mature tea (bags/ha)	104	16.949	8.263	14	3.623	1.986	t>tc	Different

The policy implication is that tea technology transfer and adoption among farmers be intensified through farmers' training, demonstrations and field visits in order to give farmers accurate agronomic research recommendations to be applied on the farm. In general, TRFK and KTDA should create and/or strengthen "Tea Economics and Extension Departments" to co-ordinate and deal with the problems of technology transfer and adoption in the smallholder sub-sector. The two departments should conduct tea research in the areas of socio-economics, extension, technology transfer and adoption, production economics, market and prices, inputs and socio-cultural aspects of tea. They should also develop modern extension materials to reach farmers more effectively e.g. small extension pamphlets, send to farmers through green leaf delivery centres, video programs, television and radio programs to enhance current train and visit, demonstrations and field days methods of extension.

Table 3.32: Recommendation level aganist farmers' practice level for the four districts

	N=259 n	m	s	μ	Cal T	Critical tc	Test	Decision
Knowledge of soil depth (m)	19	1045	0.919	2.0	2.538	2.093	t>tc	Different
Length of ripping tool (m)	198	0.1976	0.045	0.6	-124.40	1.967	t<-tc	Different
Plant density per ha.	134	8618.31	0.102	11000	-11.263	1.978	t<-tc	Different
Age of shoots for cuttings (months)	124	4.83	2437.60	6.0	-5.617	1.979	t<-tc	Different
Period of stay in nursery (months)	170	11.61	2.310	10.5	4.123	1.972	t>tc	Different
Stem length of cuttings? (cm)	172	4.333	3.500	3.25	3.753	1.971	t>tc	Different
Period cuttings should remain in water (minutes)	124	60.79	3.771	30.0	3.378	1.979	t>tc	Different
Width of planting holes (cm)	229	20.076	101.100	25.0	-8.745	1.962	t<-tc	Different
Depth of planting holes (cm)	228	32.259	8.502	45.0	-15.067	1.962	t<-tc	Different
Fertilizer amount put in holes (gm)	86	14.080	14.328	15.0	-0.583	1.991	t>-tc	Not Diff.
Height of pruning young tea first time (cm)	186	20.096	14.550	15.0	5.939	1.969	t>tc	Different
Length of central stems at first pruning (cm)	108	44.661	11.671	30.0	6.648	1.984	t>tc	Different
Height at 1st pruning (cm)	50	28.655	18.741	28.0	-4.574	2.016	t<tc	Not Diff.
Height at 2nd pruning (cm)	34	37.500	12.722	40.0	-4.061	2.039	t>-tc	Not Diff.
Height at 3rd pruning (cm)	30	46.369	13.830	50.0	-1.749	2.042	t>-tc	Not Diff.
Length of lateral shoots when pegging (cm)	125	47.238	17.352	57.5	-6.693	1.979	t<-tc	Different
Height of central stems when establishing plucking table (cm)	120	47.320	18.932	50.0	-0.651	1.980	t>-tc	Not Diff.
Length of lateral shoots when establishing plucking table (cm)	105	54.368	17.336	57.5	-3.165	1.985	t>-tc	Not Diff.
Plucking rounds (Days)	256	10.64	2.610	8.0	8.868	1.961	t>tc	Different
1st pruning height (cm)	100	46.138	14.519	45.0	0.870	1.987	t<tc	Not Diff.
2nd pruning height (cm)	88	51.173	13.721	50.0	1.210	1.991	t<tc	Not Diff.
3rd pruning height (cm)	76	54.240	14.460	55.0	1.049	1.995	t<tc	Not Diff.
4th pruning height (cm)	50	55.721	15.923	60.0	2.750	2.016	t>-tc	Not Diff.
5th pruning height (cm)	38	52.814	16.008	65.0	-2.508	2.036	t>-tc	Different
6th pruning height (cm)	9	49.167	16.703	70.0	-5.424	2.262	t>-tc	Different
Fertilizer rates for mature tea (bags/ha)	241	16.285	7.257	14.0	3.623	1.961	t>tc	Different

3.2.1. Mean comparison for the Agro-Ecological zones and regions

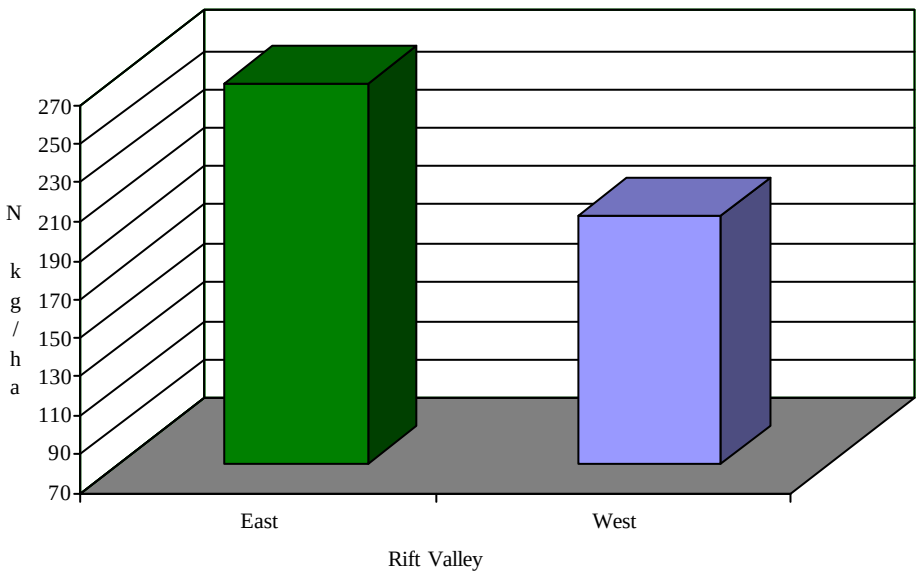
The results of mean comparison for the Agro-Ecological zones and regions are presented in Table 3.33, revealed that in east of the Rift Valley tea yields were greater in UM1 zones than in LH zones. However, the results were not significant at 5 per cent level. In west of Rift Valley, tea yields are greater in LH zones than in UM1 zones, but the results were also not significant at 5 per cent level. Therefore, the hypothesis that some smallholder tea is planted in agro-ecological zones not suitable for tea production resulting in low average yield in the sector was not accepted. This was because no farmers were found producing tea neither in Upper Highland zone nor below UM1 zone. All farmers were producing tea either in LH or in UM1 zones and there was no significant difference in tea yields.

Table 3.33: Comparison of LH and UM1 tea yields/ha and west and East Rift regions

District	Mean	Std	N	t	tc	Test	Decision	Results
Kirinyaga:								
LH	3898.194	3720.348	31	-0.844	1.671	t<tc	Non rejection	Not different
UM1	4818.536	5383.783	39					
Nyambene:								
LH	6031.536	5443.280	14	-0.061	1.684	t<tc	Non rejection	Not different
UM1	6144.407	6382.189	30					
Nandi:								
LH	3604.818	3503.396	20	0.579	1.697	t<tc	Non rejection	Not different
UM1	2995.213	3063.687	19					
Nyamira:								
LH	7030.096	5819.088	72	0.706	1.657	t<tc	Non rejection	Not different
UM1	5682.812	10389.76	34					
West Rift	5713.00	6832.702	145	3.784	1.654	t>tc	Rejection	Different
East Rift	8986.00	6969.071	114					

The comparison between east and west of Rift Valley showed that there was a significant difference in tea yields in kilograms/ha. This meant that East of Rift Valley produces more tea yield per hectare than west of Rift Valley. The differences could be accounted for by differences in soils, climate, cultural attitudes and different levels of input utilization. These inputs were: - fertilizer, hired labour, family labour, and the number of bushes/hectare on the farm. The comparisons in input use intensities between east and west of the Rift Valley were shown in Figures 3.3 to 3.6 below. Figure 3.3, shows average fertilizer use intensity in terms of N kg/ha between the two regions

Figure 3.3 Comparison of nitrogen fertilzer use between east and west of the Rift Valley



Different ecological zones and cultural practices require different fertilizer rates. For high yielding tea, growers are advised to test yield/fertilizer rates under their ecological and cultural practices. Generally in Kenya, the recommended fertilizer rates range between 100 to 250 kg nitrogen per hectare per year depending on yield performance of a field (Othieno 1988). For smallholder tea, KTDA/TRFK fertilizer demonstration plots at divisional level in all tea growing areas have shown that NPKS 25:5:5:5 or NPK 20:10:10 fertilizer rates of up to 150 kg nitrogen per hectare per year are profitable (Othieno et al 1981, 1983, 1984, Owuor et al 1984). The results revealed that 260.75 N kg/ ha were used in the east of the Rift Valley while 199.13 N kg /ha were used in the west of the Rift Valley. Fertilizer use in east of the Rift Valley was outside the recommended range while that of the west of the Rift Valley was within the recommended range but still above the recommended average.

Tea is a labour intensive crop. The tea crop needs both hired labour and family labour. Hired labour is necessary in smallholder tea production since it is easier to control and to manage than the family labour. Figure 3.4 shows the intensity of labour use between the east and the west of the Rift Valley. The results showed that almost double amount of hired labour (3770.75 Mhrs/ha) was used in east of Rift Valley as compared to the west of the Rift Valley (1913.93 Mhrs/ha). Also east of the Rift Valley smallholders used less family labour (3592.64 Mhrs/ha) than west of Rift Valley (4222.82 Mhrs/ha) smallholders. In total, the east of the Rift Valley tea growers used more labour (7363.47 Mhrs/ha) than west of the Rift Valley (6136.75 Mhrs/ha) growers. Thus production intensity is higher in the east than in the west of the Rift Valley

The number of tea bushes per hectare was relatively lower in east than in the west of the Rift Valley (Figure 3.4). The average number of tea bushes/ha in the east of the Rift Valley was approximately 8010 while that in the west of the Rift Valley was 8460. These physical efficiency measures indicate that east of the Rift Valley is better than west of the Rift Valley in terms of technical efficiency of resource use. Ultimately, east of the Rift Valley realised greater output of green leaf per hectare as shown in Figure 3.6. Thus with greater use of fertilizer and hired labour which is easier to supervise than family labour, east of the Rift Valley had higher output/ha of tea than west of the Rift Valley. It is therefore recommended that farmers in the west of the Rift Valley should improve on their resource use intensities in order to enhance efficiency and increase green leaf productivity. Most of the husbandry activities should be geared towards increasing green leaf output per hectare or per bush.

Figure 3.4: Labour use (man hours/ha/year) in the East and West of the Rift Valley.

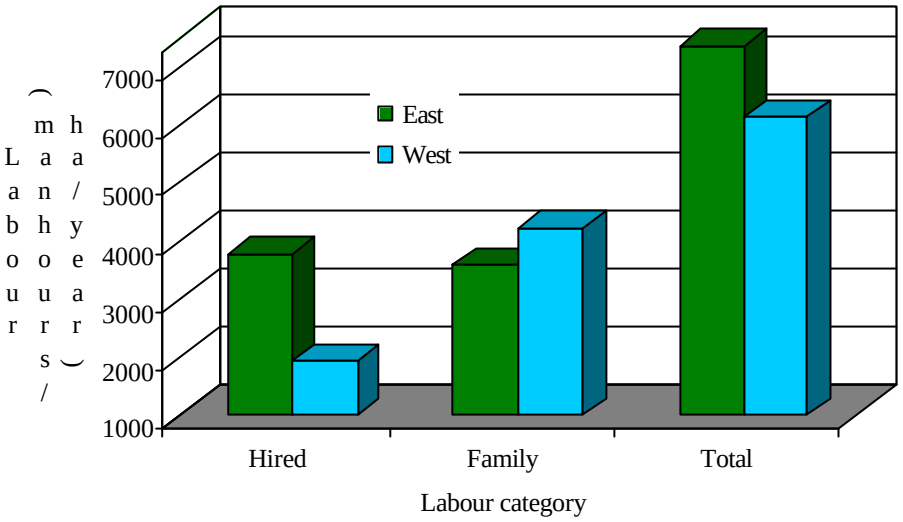


Figure 3.5: Average number of bushes per hectare in the east and west of the Rift Valley

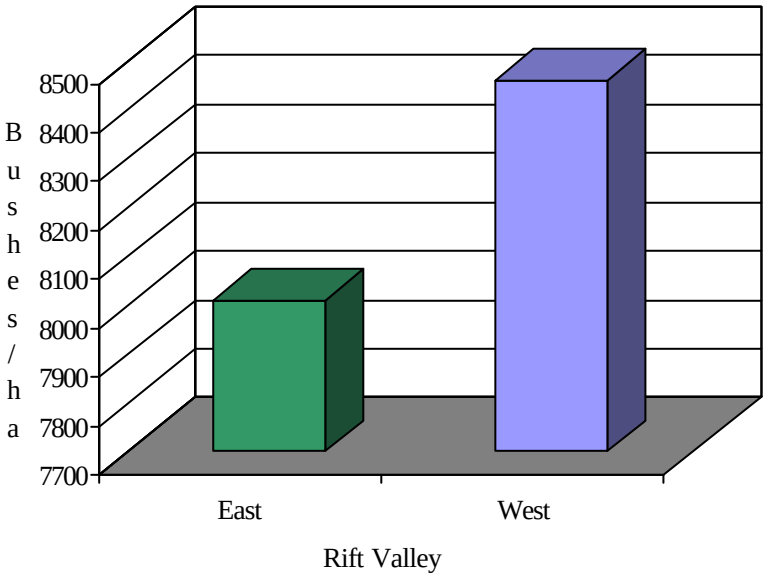
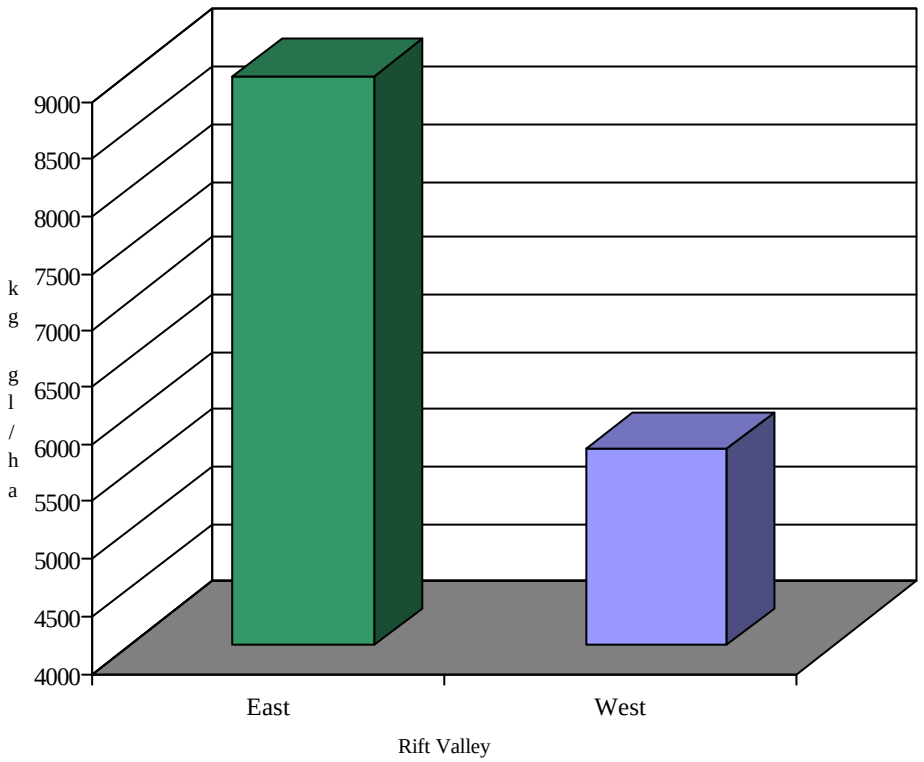


Figure 3.6: Average green leaf output (kg gl/ha/year) in the East and West of the Rift Valley



3.2.2. Gross margin and break-even price analyses of the tea enterprise

The results of gross margins (Table 3.34) and break-even price analyses of the tea enterprise showed that in the short run, smallholder tea production under the current production system is economically viable.

The tea enterprise is able to cover all the variable costs and has a positive return to depreciation, management and risk. The gross margin per hectare, per man-day and per bush can be assessed in the presence of other figures for comparison e.g. from other countries or for competing enterprises. For example, small-scale dairy keeping is one of the main competing enterprises in the tea growing zones in the east of the Rift valley region. The gross margin per man-day of the average dairy farm in Kiambu District in east of the Rift valley region was found to be KShs. 68.20 (Kilungo 1998). The average tea enterprise gross margin per man-day for the east of the Rift valley region was found to be KShs. 210.11. Hence the tea enterprise earns more return per man-day than in the dairy enterprise. On the basis of this comparison, a decision can be made on how much labour to allocate to the tea enterprise and the dairy enterprise so as to maximize profits.

The results further revealed that there was a noticeable difference between east and west of the Rift Valley regions. For the four measures of efficiency considered, east of the Rift Valley region was better than the west of the Rift Valley region. This could be explained by the differential resource use intensities between the two regions as shown in Table 3.35.

Table 3.34: Gross margins for smallholder tea sub-sector in Kenya.

	Districts/regions						
Items	**Kirinyaga**	**Nyambene**	**Nandi**	**Nyamira**	**East Rift**	**West Rift**	**All Farms**
Area under tea(ha)	0.51	0.40	0.73	0.33	0.47	0.44	0.45
Labour-man-days/yr	253.03	366.81	381.95	265.31	298.13	295.92	296.89
Average tea bushes/farm	3222	2835	4867	2534	3063	3156	3115
Tea income							
Tea output (Kg)	4410.96	1979.80	2678.36	1706.93	3472.61	1968.21	2630.38
Producer Price (KShs)	25.10	23.30	21.33	21.33	24.40	21.33	22.70
Tea output value (KShs)	110709.29	46091.61	57121.36	36414.02	84721.36	41983.97	59659.70
Variable costs (KShs)							
Fertilizer	10024.70	6368.80	10357.55	5377.61	8613.64	6631.55	7524.67
Weed control	38.14	13.64	92.42	9.62	28.68	29.56	29.16
Pest control	113.40	32.73	2.86	94.71	82.24	71.58	76.38
Disease control	11.43	1.59	0.00	0.02	7.63	0.01	3.43
Plucking cost	12160.30	5483.73	7631.99	4190.70	9583.36	5116.27	7082.48
Variable Costs (VC)	23193.60	11900.51	19591.21	9710.30	18834.85	12090.36	15153.60
Interest (20% VC)	4638.72	2380.10	3918.24	1942.06	3766.97	2418.07	3030.72
Total Variable Costs (TVC)	27286.60	14280.61	22003.10	11614.68	22082.52	14267.05	17746.84
Gross margin/year (KShs)							
(GM=TOV-TVC)	83422.70	31810.99	35118.30	24799.34	62638.84	27716.92	41912.86
Gross margin per hectare/yr	164574.30	79726.80	48173.25	74696.80	134707.20	62136.50	92933.16
Gross margin per man day/yr	329.70	86.73	91.94	93.50	210.11	93.66	141.17
Gross margin per bush/year	25.90	11.22	7.22	9.80	20.45	8.78	13.46

Table 3.35: Resource use intensities between East Rift Valley and West Rift Valley.

	Input use per hectare				
Region	Fertilizer (Bags/ha)	Hired Labour (Man-days/ha)	Family Labour (Man-days/ha)	Total Labour (Man-days/ha)	Tea Bushes/farm (No. of Bushes/ha)
East Rift Valley	20.86	471.35	449.08	920.43	8010
West Rift Valley	15.93	239.24	527.85	767.09	8460

The results showed that smallholder tea farmers in the East of the Rift Valley use resources more intensively than those in the Western of the Rift Valley. The farmers from the East of the Rift Valley used more fertilizer bags per hectare than farmers from the West of the Rift Valley. They also used more of hired labour; which is easier to control than family labour, thus enhancing labour use efficiency. The numbers of tea bushes were fewer in Eastern region than in the Western region. As a result of greater resource use intensity and efficiency in the Eastern region, total production and productivity was higher than in the Western region. It is therefore recommended that West of the Rift Valley smallholder tea farmers should improve on resource use efficiency in order to increase tea productivity. The response by the farmers in the East of the Rift Valley can be improved by increasing the number of bushes per hectare through intensive in filling programme.

Table 3.36 shows the results of break-even analysis. The break-even price was calculated for every individual farm by dividing total variable costs by the total tea output delivered per year. A mean price for all the farms was then computed. A histogram with normal curve was plotted for the break-even price variable for each district and region. The outliers were knocked out of the sample before computing the mean break-even price. This reduced the sample sizes. The results indicated that, the break-even price of tea for all farms in 1998/99 is approximately KShs. 7.50.

The results of the break-even analysis were used to find out if there was any significant difference between the computed break-even price and the current monthly payment of green leaf. The test results showed that the computed **t** was greater than the critical **t** in all the districts and regions. There was a significant difference between the computed break-even price and the monthly payment of green leaf in the smallholder sector. This means that the 1998/99 monthly payment of Kshs 6.00 per kg green leaf did not adequately meet the recurrent costs of tea production and could be contributing to low green leaf output. Although this price has been adjusted to Kshs 7.50 per kg green leaf for the 1999/2000 crop, the adjustment has been accompanied by rise in production costs. Thus this level of payment may still be lower than break-even point. Frequent farm surveys should therefore be done to determine tea production costs and returns. The break-even price computed from the surveys and the subsequent tea enterprise analysis shall enable policy makers in the industry to make price decisions based on facts taking into account the various dynamic changes in the industry. Indeed, adequate payment of the farmers will improve green leaf output.

Table 3.36: Break-even analysis results

	District/Region						
Items	**Kirinyaga**	**Nyambene**	**Nandi**	**Nyamira**	**East Rift**	**West Rift**	**All Farm**
Monthly Price	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Break-even price	7.11	7.61	8.22	7.41	7.20	7.88	7.47
N	66	39	24	89	105	113	218
T	2.830	3.141	4.000	4.854	4.062	6.480	7.475
tc	1.998	2.025	2.064	1.991	1.985	1.981	1.977
Test	t > tc	t > tc	t > tc	t > tc	t > tc	t > tc	t > tc
Decision	Reject	Reject	Reject	Reject	Reject	Reject	Reject
Result	Different	Different	Different	Different	Different	Different	Different

4 CONCLUSIONS & RECOMMENDATIONS

This chapter gives a summary of the objectives, methodology, results the conclusions and the policy inference from this study. The policy interventions proposed could if implemented enhance tea production, productivity and incomes in the study areas and other tea producing districts with similar conditions and potentialities.

4.1. Conclusions and Recommendations

Several conclusions and recommendations on the assessment of technological adoption and policy factors impeding the production of green leaf in the smallholder tea farms in the Kenya tea industry were arrived at. These were as given below: -

4.1.1. Assessment of Technological Adoption and Application Levels by the Smallholder *Tea Farmers*

1. Most of the smallholder tea farms are managed owners or members of the family, as was hoped when the smallholder tea sub sector was being established. Generally the key members of the family unit (husband and wife) made the decisions on the farms. Unlike what used to be on tea previously, when females (wives) never made important decisions on tea production, the situation has changed. Gender sensitivity is therefore high in smallholder tea unit and this should be encouraged.
2. Large percentage of the family members lived permanently on the farms and thus derived their livelihood from the tea enterprise. The government must put in place policies that ensure the smallholder tea production is sustainable as the collapse of the sub sector can lead to high unemployment and loss of livelihood to many Kenyans.
3. Most smallholders were relatively old and were unwilling to subdivide the tea holdings to their children, despite the children doing most of the work on the farms. This creates less incentive for the youngsters to work on tea farms since their work is paid in kind not by cash and may lower tea production. A proper study should be done to come out with clear policy on how to deal with this problem.
4. The majority of the smallholders had no or low level of education. Passing technical information through bulletins is unlikely to help technology diffusion in the smallholders tea sub sector. It is recommended the technologies be disseminated to the smallholder farmers through on farm courses based on practical demonstrations in which the farmers have contact with the trainers. This situation is likely to change with time as younger and better-educated farmers are gradually replacing the old farmers.

5. In each side of the valley, there was higher productivity per bush where farmers had smaller pieces of total land areas possibly due to absence of competing farm enterprises, as the available land was too small to support other farm activities and the land forcing the smallholders in these areas to concentrate on tea production. Where the tea holdings were too large, labour to maintain tea seemed inadequate and farmers possibly were unable to remove the entire crop or to manage the farms effectively. It is recommended that this be confirmed in a separate study.
6. Productivity was low in districts where farmers had other farm competing enterprises e.g. "miraa' (Kat) in Nyambene, or maize production and dairy farming in Nandi. Detailed socio-economic study is necessary to evaluate the economic advantages of these individual crops so that farmers are encouraged to concentrate on crops or farm undertakings giving best returns.
7. The application levels of the technological recommendations were significantly different from the research recommendation levels, particularly in the West of the Rift Valley. This implies that East of the Rift Valley, farmers have fairly accurate agronomic information about tea husbandry. This should lead to higher production per unit area. Indeed, Kirinyaga district leads in tea production per unit area in all smallholder tea districts. The relatively low productivity in Nyambene district is surprising considering the high level of awareness of the technical recommendations for producing tea. Tea extension services must therefore be intensified in the West of the Rift Valley. Factors causing low productivity in Nyambene District also should be ascertained.
8. Tea production/productivity was higher in districts where farmers had longer plucking duration per day as transport schedules are optimised. Leaf collection schedules needs to be drawn in a manner that ensures farmers are plucking for longer durations. KTDA management not the lorry/ tractors drivers should decide these schedules. It was noted that in some districts the leaf collection lorry collected leaf only once in a day from most buying centres, and in some buying centres this was done by 11 am.
9. The poor leaf collection programme is mainly due the poor state of the roads. Due to the fact that the tea farmers are now paying substantial amount of money to ensure the roads are in a fair state, accountability should be enhanced so that the money collected is used for the intended purposes only. Again as tea is a major contributor to the Kenya economy, the government needs to inject further money to maintain tea roads. Tea roads must be in fair conditions to improve smallholder tea production/productivity.
10. In some districts extension staff had not not visited more than half of the farms. There is therefore inadequate technology transfer through extension staff visits. This is an aspect impeding tea production in the smallholder tea sub sector. It is necessary that an extension service is developed that ensures that farmers are visited regularly.
11. Apart from attending tea "barazas"(public meetings), most farmers had never attended any formal course on tea production. Again, whenever there was a baraza to educate farmers on tea production technologies, it is mostly the owners of the farms who attended the meetings. In most cases the person who attended the meetings never passed information learnt to the farm worker. These new knowledge were therefore a waste as the wrong persons were trained and the information never reached the farm operators. The training techniques should be changed so that the correct personnel are trained to ensure technologies are reaching the intended group who can effect change in production patterns.

12. Whenever the extension staff visited the tea farms, they usually met the owners of the farm who were not necessarily the farm operators. It is likely that the people meeting the extension staff at the farm level were not the farm operators and were not imparting any technologies learnt through the visits to the farm operators. Most of the technologies therefore do not reach those who can profitably use them to improve tea productivity and production. It is important that a policy is developed and put into practice that facilitates the farm operators to easily receive information on tea production technologies.
13. The mean comparison for the Agro-Ecological zones revealed that in east of the Rift Valley tea yields were slightly higher in UM1 zones than in LH zones. In west of Rift Valley, tea yields are slightly higher in LH zones than in UM1 zones. All smallholder tea is planted in agro-ecological zones suitable for tea production. The differences in productivity cannot be attributed to agro ecological zones.
14. The mean comparison between east and west of Rift Valley showed that East of Rift Valley produces more tea yield per hectare than west of Rift Valley. The differences could be accounted for by differences in soils, climate, cultural attitudes and different levels of input utilization like fertilizer, labour use and the number of bushes/hectare on the farm. Indeed both fertilizer and labour use were more intense in the East than West of the Rift Valley. It is therefore recommended that farmers in the west of the Rift Valley should improve on their resource use intensities in order to enhance efficiency and increase green leaf productivity. There should be concerted efforts to intensify labour and fertilizer use in the West of the Rift Valley.

4.1.2. Gross Margin and Break-Even Price Analyses

1. The average tea enterprise gross margin per man-day for the east of the Rift valley region higher than that of dairy enterprise. Farmers can therefore maximise their earnings through tea production rather than dairy farming. It is necessary that similar gross margins be established for other enterprises competing with tea in different regions and agro ecological zones.
2. The break-even analysis showed that there was a significant difference between the computed break-even price and the monthly payment of green leaf in the smallholder sector. This means that the 1998/99 monthly payment of Kshs 6.00 per kg green leaf did not adequately meet the recurrent costs of tea production and could be contributing to low green leaf output. Although this price has been adjusted to Kshs 7.50 per kg green leaf for the 1999/2000 crop, the adjustment has been accompanied by rise in production costs. Thus this level of payment may still be lower than break-even point. Frequent farm surveys must be done to determine tea production costs and returns. The break-even price computed from the surveys and the subsequent tea enterprise analysis shall enable policy makers in the industry to make price decisions based on facts taking into account the various dynamic changes in the industry. Indeed, adequate payment of the farmers will improve green leaf output.

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