AN ECONOMIC ANALYSIS OF DIVERGENCIES FROM AGRO-CHEMICAL USE RECOMMENDATIONS ON COFFEE SMALL-HOLDINGS IN MACHAKOS DISTRICT, KENYA

BY

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Thesis submitted in part fulfilment for the Degree of Master of Science in the University of Nairobi

1980

I hereby declare that this Thesis is my original work and has not been presented for a degree in any other University

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I DEDICATE THIS THESIS TO MY PARENTS

A C K N O W L E D G E M E N T S

I wish to express my sincere gratitude first, to the German Academic Exchange Service, (DAAD), for providing me with the Scholarship to undertake this study and second, to Professor M.J. Dorling for his tireless help, direction and advice without which the Thesis would not have been completed.

I am also indebted to Dr. K.L. Sharma for his invaluable assistance in some sections of the Thesis; the two Coffee Co-operative Societies' Secretaries: Mr. N. Ndeto of Muisuni Co-operative Society and Mr. Waema of Kilalani Co-operative Society for their courtesy and help during the collection of data from members of their Co-operative Societies.

Finally I would like to thank Miss. Lucy Wangugi who accepted to type the Thesis.

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The study records the levels of agro-chemical use on mature coffee, viz : nitrogen, copper and captafol fungicides; and their frequencies of application, exhibited by a sample of small-holders in the Northern division of Machakos district in the 1977/78 crop year. Measures of deviations in the levels of agro-chemical use and frequencies of application from official recommendations are also provided. Several hypotheses are tested to determine whether on average, farmers deviate from official recommendations in the application of agro-chemical inputs on the mature coffee enterprise.
To complete the study,simple correlation and multi-linear regression models are used to identify socio-economic variables which are associated with the levels of use of agro-chemical inputs and frequencies of application.

Both primary and secondary data are employed in the study. The former were collected from a random sample of 35 farmers, members of two contiguous co-operative societies in the Northern division of Machakos district. Secondary data were obtained from the Coffee Research Foundation technical circulars, and the Machakos district coffee annual reports.

The three general hypotheses tested are:-

(1) That farmers on average do not deviate from recommended levels of agro-chemical use and frequencies of application on mature coffee;

(2) That farmer expenditures on agro-chemical inputs for mature coffee enterprises bear no definable simple linear relationships with enterprise total variable costs and total costs in the year of study; and

(3) That levels of agro-chemical use and related frequencies of application on mature coffee enterprises are not correlated with selected socio-economic variables.

The research findings are divided into two categories, the descriptive data analysis presented in Chapter 7 and the results of tests of general hypotheses discussed in Chapter 8. Included in the former are figures summarising costs and returns for sample mature coffee enterprises. These data are arrived at using a strictly defined residual accounting model. In the 1977/78 crop year these data show that the average mature coffee enterprise adequately covered all incurred costs. Furthermore income from coffee accounted on average for 69 per cent of total farm income. Thereby easily making it the most important cash earning crop in the Northern division of Machakos district where the study was centered.

The descriptive data analysis also indicates that on average small-holders deviated significantly from the officially recommended levels of agro-chemical use and frequencies of application on mature coffee enterprises in the crop year 1977/78. Compared with recommendations, nitrogen was on average over-used on a physical basis by approximately 63 per cent, while fungicides, viz: copper, and captafol, were under-used on average on a physical basis by approximately 74 and 82 per cent respectively. Using 't' tests on regression coefficients for the 2nd general hypothesis stated above null hypotheses were rejected at the .05 level of significance, leading to sample based inference that for the population of mature coffee enterprises in the period studied, total enterprise expenditure on each of the agro-chemical inputs investigated - nitrogen, copper and captafol fungicides (the latter two are considered together) bore fixed proportional relationships to total variable costs and total costs for the same enterprises. While this result must be interpreted cautiously it nonetheless suggests strongly that small-holder coffee producers probably see their expenditures on agro-chemicals in terms of proportional relationships with cost totals rather than according to strict interpretation of area recommendations.

Therefore this finding offers a definite reason why coffee growers were not found to be following official recommendations closely. More research is needed to compare the results for other crop years in the area studied.

If in fact there is correspondence in the picture disclosed for other periods, then inquiry needs to establish why expenditure should be related to cost totals and not more strictly to recommendations.

Finally the third general hypothesis was neither totally rejected nor totally accepted. This is because a number of important selected socio-economic variables were found to be significantly correlated with levels of agro-chemicals use and frequencies of application, while others showed no acceptable strengths of relationship.

CHAPTER 1

INTRODUCTION AND STATEMENT OF THE PROBLEM

Agriculture is the most important sector of Kenya's economy providing for the livelihood of about 85 per cent of the country's population. Between 1963 and 1973 (24) for example, agriculture contributed 40 per cent of the Gross Domestic Product (GDP)[1]. However due to the development of other sectors, this figure has recently gone down slightly. Between 1974 and 1977 the contribution to GDP by agriculture was only 33.4 per cent (9).

Agricultural products dominate Kenya's foreign trade. In 1965 agricultural exports accounted for 82 per cent of all domestic exports. In 1977 agriculture was still contributing as much as 71 per cent of domestic exports (appendix Tables 1 & 2 deal with GDP and domestic exports).

Kenya's Agriculture consists of the subsistence and cash crop sectors. The former does not make as big a contribution to the GDP as the latter. Indeed the government, through the Ministry of Agriculture, has as one of its major policies the encouragement of subsistence farmers to grow more cash crops, such as coffee, tea, pyrethrum and cotton, depending on the climatic suitability of the location. The objective has been and still is to change the bulk of the population from subsistence farming to a cash economy basis and hence improve earning capacities and standards of living.

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1. The procedure of first stating the full title and abbreviation and then only stating the latter in any further mention will be followed throughout the thesis.

Prior to Kenya's independence in 1963 most of the major cash crops such as coffee and tea were mainly grown on Estates. Although African small-holder farmers were allowed to grow cash crops like coffee, this was only under very strict conditions. After independence, however, these restrictions were relaxed and consequently the hectarage under cash crops has expanded enormously-in some crops, for example coffee, surpassing that of the Estates.

A high proportion of the cash crop economy is therefore increasingly shifting from large-scale farms[1] to small-holder farmers. Whereas the first type of farms are well endowed with resources, namely : land, capital, technology, labour and management, these factors are often seriously deficient in the second type. This situation calls for detailed studies of small-holder farmers to identify the constraints which account for the low productivity, and when overcome would allow considerable improvement.

In its effort to assist farmers in the most economic farming methods, the government has set up research stations which draw up recommendations for growing the most important crops. The recommendations concern the planting of seeds and seedlings, weeding, application of fertilizers and manures, control of diseases and insects-including timing and rates of application, pruning, mulching, picking and harvesting of crops. Although these recommendations are available to farmers and they know the advantages to be gained by their use, it is still not clear why small-holder farmers often do not use them strictly.

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1. See Appendix Table 8 for estimated yields per hectare by the Estates in all coffee growing districts in Kenya.

The present study deals with coffee, the most important cash crop in Kenya's agricultural economy. Coffee is grown by more small-holder farmers than is the case for any other cash-crop.[1] The study was conducted for the 1977/78 crop year under liason with The Coffee Research Foundation (CRF), Ruiru.

In the initial discussions with CRF staff, it was stated that the productivity per hectare of small-holder coffee farmers is comparatively low. It was suggested that one of the main reasons for this could be the failure to follow CRF recommendations for the use of agro-chemicals. It was therefore decided to undertake a thesis study to determine how closely small-holder coffee growers followed official recommendations for the use of selected agro-chemical inputs. In so doing it was hoped that the measurements of certain socio-economic variables would help to explain any serious divergencies from recommendations.

The recommendations considered in the study are those which pertain to the use of nitrogen and fungicides. Insecticides, important as they are have no strict recommendation pattern particularly with respect to frequencies of application. They were therefore left out of the study, since it would be difficult to attempt any generalization from sample data in these particular cases.

On the basis of rainfall received, small-holder coffee growing areas fall into two categories: the high potential receiving high rainfall and the low potential with little rainfall. In the study attention was focussed on Machakos district falling within the second category.

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1. In 1978 coffee was grown by 300,000 small-holder farmers who were members of 176 coffee Co-operative Societies in Kenya.

Although Machakos district is a low potential coffee growing area from the standpoint of rainfall its productivity per hectare is surprisingly much higher than that of the high potential areas. In 1978 its productivity per hectare was nearly twice (1511 Kg.) that of the national average (844 Kg.) of small-holder coffee farmers (appendix 3). Consequently choice of Machakos district for the study held the strong possibility that some important connections between use of agro-chemicals and performance would be observed. If that was infact the case it would prove a valuable comparison with similar studies under lower productivity conditions.

1:1 COFFEE IN MACHAKOS DISTRICT

Coffee is the most important cash earning crop in Machakos district, providing about 70 per cent of all income from cash crops (appendix 4). Although coffee in Kenya was first introduced as early as 1893 at the Church of Scotland Mission, Kibwezi, it was not grown by small-holder farmers in Machakos district until 1954, when the Swynnerton Plan came into effect. The main concentration of coffee hectarage is found in the Northern division of Machakos district where the study is centred.

The main coffee varieties grown are SL 34 and SL 28 at medium altitudes; the Leaf Rust resistant varieties SL 6 and K7 below 1646 metres; and Ke 20 above 1829 metres. Generally coffee in Machakos district is grown in those areas between 1372 and 1890 metres above sea level, which receive an average annual rainfall between 863.3 and 1219.2 mm. Soils in most coffee growing areas range from deep red loams on the hill slopes to light brown clay or greyish sandy clay in the lower regions (6).

Small-holder farmers are organised into co-operative societies which market the crop and provide short-term credit to their members, mainly for inputs. By using this credit, farmers can obtain readily all the required agro-chemical inputs and even money for the purchase of needed implements.
In fact co-operative societies run their own stores where inputs, particularly agro-chemicals, are sold to farmers.

In the Northern division of Machakos district the first co-operative society was formed in 1957 and at present there are six co-operative societies in this division.
The total number of co-operative societies for Machakos district as a whole is thirteen, all of which are afilliated to Machakos Co-operative Union Ltd., which was formed in 1964.

1:2 ORGANISATION OF THE STUDY

The study consists of nine chapters, details of which are as follows:-

The first chapter introduces the coffee industry in Kenya and states generally the research problem. The second chapter reviews the economic importance of coffee in Kenya's economy. It also deals with historical aspects over time from production standpoints.Chapter three deals with the basic technical aspects of coffee husbandry and the official agro-chemical recommendations. The fourth chapter presents a literature review of research findings thought to be of particular relevance to the study. This review is concerned with the results from socio-economic studies on coffee production in Kenya. The fifth chapter states objectives and hypotheses used in the study.

Chapter six presents the methodology which includes sources and type of data collected, sampling procedure and analytical techniques applied. Chapter seven describes the sample data for costs of production, revenue and physical application measures for agro-chemicals. The remaining results for tests of hypothesis concerning means and correlations and regression coefficients, are given in chapter 8. Finally chapter 9 gives a summary of the main research findings and recommendations.

CHAPTER II
COFFEE INDUSTRY IN KENYA

2:1. HISTORICAL DEVELOPMENT

Coffee is the single most important cash crop in the Kenya Economy. In 1969 it provided 18.3 per cent of total value of domestic exports. In 1977 during the coffee boom this figure went up to 42.5 per cent. Between 1969 and 1977 coffee accounted for 22.9 per cent of domestic exports. Tea the second most important cash crop after coffee in value terms, provided 12.7 and 14.9 per cent in 1969 and 1977 to domestic exports respectively. Between the two periods, tea accounted for 11.73 per cent of domestic exports, which is only half the contribution by coffee. During the period 1974-77 coffee has provided an average of 50 per cent of total annual income from all agricultural commodities as shown by appendix Table 2.

Coffee was the first cash crop to be introduced in the Kenyan Economy and its significance has never subsided. Writing about coffee in Kenya, in 1956, Hill observed that coffee was the first crop that enabled the pioneer settlers to start the building of Kenya's economy. He observed that:

> "Coffee has always been a very important factor in the colony's economy and a major part of the domestic export which only 60 years ago consisted of a few tusks of ivory and a few bags of beans" (16, preface).

The first coffee plantation in Kenya was established by the Scottish Missionaries at Kibwezi in 1893. The plantation was abandoned when the mission moved to Kikuyu. Later in 1901, St. Austin's Mission initiated a plantation near Nairobi and

it is from this plantation that many of the plantations in Kenya originated (16). Until 1937 when Africans were allowed to grow coffee, the latter was reserved for the white settlers only. Although Africans were allowed to grow coffee after this date, in practice this was not done on any significant scale until 1954, when the Swynnerton Plan (34) lessened the restrictions and allowed African small-holders to grow coffee widely. The coffee industry, therefore, developed as an Estate sector owned and managed by the Europeans up to the mid 1950's, after which African small-holder farmers began taking over.

African growers started as small-holders in 1937 and their coffee husbandry was strictly controlled by the Ministry of Agriculture. The white-settler coffee growers strongly objected to the introduction of the crop to the then "native reserves" areas on the grounds that the Africans did not possess the technical know-how necessary to maintain high quality coffee production. Due to this objection, the planting of coffee by Africans was a very slow process, with more individual hectarage allowed only when an African farmer satisfied the Ministry of Agriculture that he was capable of handling the crop.

Although white settlers began growing coffee in the 1890's, it was not until the Crown Lands Ordinance of 1902 was passed that coffee was planted on a large scale. By the end of 1907, Kenya had between 202.4 hectares under coffee, most of which was not bearing. In 1909 production was 8.5 metric tonnes and it rose steadily after this year, so that in 1914 Kenya was producing 275 tonnes valued at £18,502 (16). By mid 1930's the land under coffee was 42,105.30 hectares and in 1935/36 production was 22,400 tonnes of pulped coffee (33). This production was the highest obtained so far and because of the decline which followed during the Second World

War, it was regarded as the initial peak for the industry. This peak was surpassed only in the 1950's when world coffee prices improved.

The decline of the industry in the late 1930's was brought about by several factors. The most important of these was the very low coffee prices obtained, which meant that farmers could not completely cover costs of production. This adverse situation was later reinforced by the difficulties incurred by the Second World War, such as the risk taken in shipping coffee to Europe.

Another reason for the decline of the coffee industry in the late 1930's was that the earlier planting spree brought unsuitable land into coffee production. Soon, farmers realised that it was uneconomic to operate the marginal lands due to low yields and rising costs. This led to the reduction of coffee hectarage in Estates both during and after the war.

The coffee industry was at its lowest point in 1942, when Estate-farmers left coffee unattended and the total hectarage fell by nearly half to 24,291 hectares. Coffee production was also very low at this time. In the bad weather of 1949-50 total production was less than 6,618.2 tonnes. After the war, however, coffee enterprise rehabilitation was commenced encouraged by the rising prices of the 1950's, and in the crop year 1951-52 production reached 16,290.8 tonnes. Rowe states that:

> "This high price period was extremely profitable to most Estates and capital was freely invested, almost regardless of its cost, in bringing the Estates up to a high standard of productivity, using the best scientific techniques now available after many years of research work, to subdue pests and diseases" (33, P. 107).

Consequently, in the crop year 1955-56 coffee production in Kenya reached a record of 23,418.2 tonnes surpassing the 1935-36 production for the first time. After this year production did not drop to anything below 20,000 tonnes. Stability in coffee production took over from fluctuations of the previous years. Rowe indicates that by 1960 most of the suitable land which the Estate Sector could expand into had come under coffee. He says that the Estate coffee sector had by 1960 almost reached its zenith.

2:1 HECTARAGE UNDER COFFEE BETWEEN 1946 - 1978

Hectarage under coffee increased from 31000 ha. to 86400 ha. between 1946 - 1978 as shown by Table 2:1 below.

2.1. SMALL-HOLDER AND ESTATES SECTOR COFFEE HECTARAGE 1946 - 1978

YEAR	COFFEE ON ESTATES '000 HA.	COFFEE ON SMALL-HOLDINGS '000 HA	TOTAL COFFEE HECTARAGE '000 HA.
1946	30.9	0.13	31
1948	25.2	0.3	25.5
1950	24.2	0.6	24.8
1955	24.2	3	27.2
1956	24.4	4.9	29.3
1957	25.4	7.2	32.6
1958	26.1	8.2	34.3
1959	27.5	10.6	38.1
1960	28.8	13.4	42.2
1961	30.1	17.9	48
1962	30.5	28.3	58.8
1963	30.7	46.7	77.4
1964	30.9	51	81.9
1965	29.6	52.7	82.3
1976	28.6	56.6	85.2
1977	27.8	56.6	84.4
1978	30.8	56.6	86.4

SOURCE : Adapted from coffee in the Kenya Economy (24, p. 84).

Although small-holder coffee growers started producing coffee in the 1930's initial expansion was extremely low. Table 2:1 shows that in 1946 only approximately 130 hectares were under coffee against 30900 ha. in the Estates. Also in 1950 small-holders hectarage was still quite low at 600 ha. approximately. Nevertheless, whereas land under coffee on Estates was being reduced in the 1930's and the 1940's that in the small-holder sector was at least growing slowly. The dramatic change in this sector, however, occurred after the Swynnerton Plan in 1954 whose objective was:

> ".....to bring traditional farmers into greater contact with the market and hence raise their standard of living by encouraging the growing of cash crops, particularly coffee" (26, p. 43).

Therefore hectarage under coffee on small-holdings had expanded from approximately 600 in 1950 to 3000 ha. in 1955. By 1960 the figure was nearly half of that of the Estates standing at 28,800 ha. In 1962 the two sectors were virtually the same in terms of hectarage. In 1963 Kenya became politically independent. As a result, political power was transferred from the white-settlers to the Africans. The latter were therefore able to expand coffee growing without the previous restrictions. Consequently in 1963 the small-holder sector had a commanding lead in coffee growing on an area covering 46,700 ha. compared with 30,700 ha. for the Estates. Hectarage under small-holder coffee increased up to 56,600 ha. in 1978 and presently seems to be stabilising at that figure. The Estate sector,on the other hand declined to 27,800 ha. in 1977 and then rose to 30,800 ha.in 1978. The small-holder coffee sector is therefore almost twice as large as the Estate sector in terms of area. It is important to remember this central fact in any study that compares small-holder and Estate coffee production.

Small-holder coffee growing areas are situated mainly in areas East of the Rift Valley and in Nyanza Province. The latter region is, however, not as suitable as that East of the Rift Valley. Coffee growing areas for both Estates and the small-holder sector, in Kenya are shown in Map 2.1.

2: 3 COFFEE PRODUCTION BETWEEN 1946 - 1978

Coffee produced by both small-holders and the Estates between 1946 and 1978 is shown in Table 2.2 below.

TABLE 2.2. SMALL-HOLDER AND ESTATES COFFEE PRODUCTION, 1946 - 1978.

YEAR	COFFEE FROM ESTATES (TONNES)	COFFEE FROM SMALL-HOLDINGS (TONNES)	TOTAL FROM ESTATES AND SMALL-HOLDINGS (TONNES)
1945/46	7,868.3	46.7	7,915
1947/48	9,173.9	92.5	9,266.4
1949/50	10,295.7	118.9	10,414.6
1954/55	18,560.3	1,151.2	19,711.5
1955/56	24,246.1	2,856.1	27,102.2
1956/57	18,761.4	3,849.8	22,611.2
1957/58	22,261.7	3,337.6	25,599.3
1958/59	19,769.4	6,491.6	26,261.-
1959/60	21,657.2	6,579.9	28,237.1
1960/61	23,923.9	9,760.2	33,684.1
1961/62	19,140.4	10,646.2	29,786.6
1962/63	23,774.6	13,589.6	37,354.2
1963/64	25,119.9	17,186.5	42,306.4
1964/65	23,775.7	15,647.2	39,422.9
1965/66	28,400.-	28,500.-	56,900.-
1966/67	19,200.-	28,800.-	48,000.-
1967/68	18,800.-	20,800.-	39,600.-
1973/74	31,914.-	40,872.-	72,786.-
1974/75	29,985.-	35,465.-	65,450.-
1975/76	37,675.-	36,135.-	73,810.-
1976/77	49,685.-	47,660.-	97,345.-
1977/78	33,685.-	47,744.-	81,429.-

SOURCE: Adapted from Coffee in the Kenyan Economy (24, p. 86).

MAP 2:1 — COFFEE GROWING AREAS IN KENYA

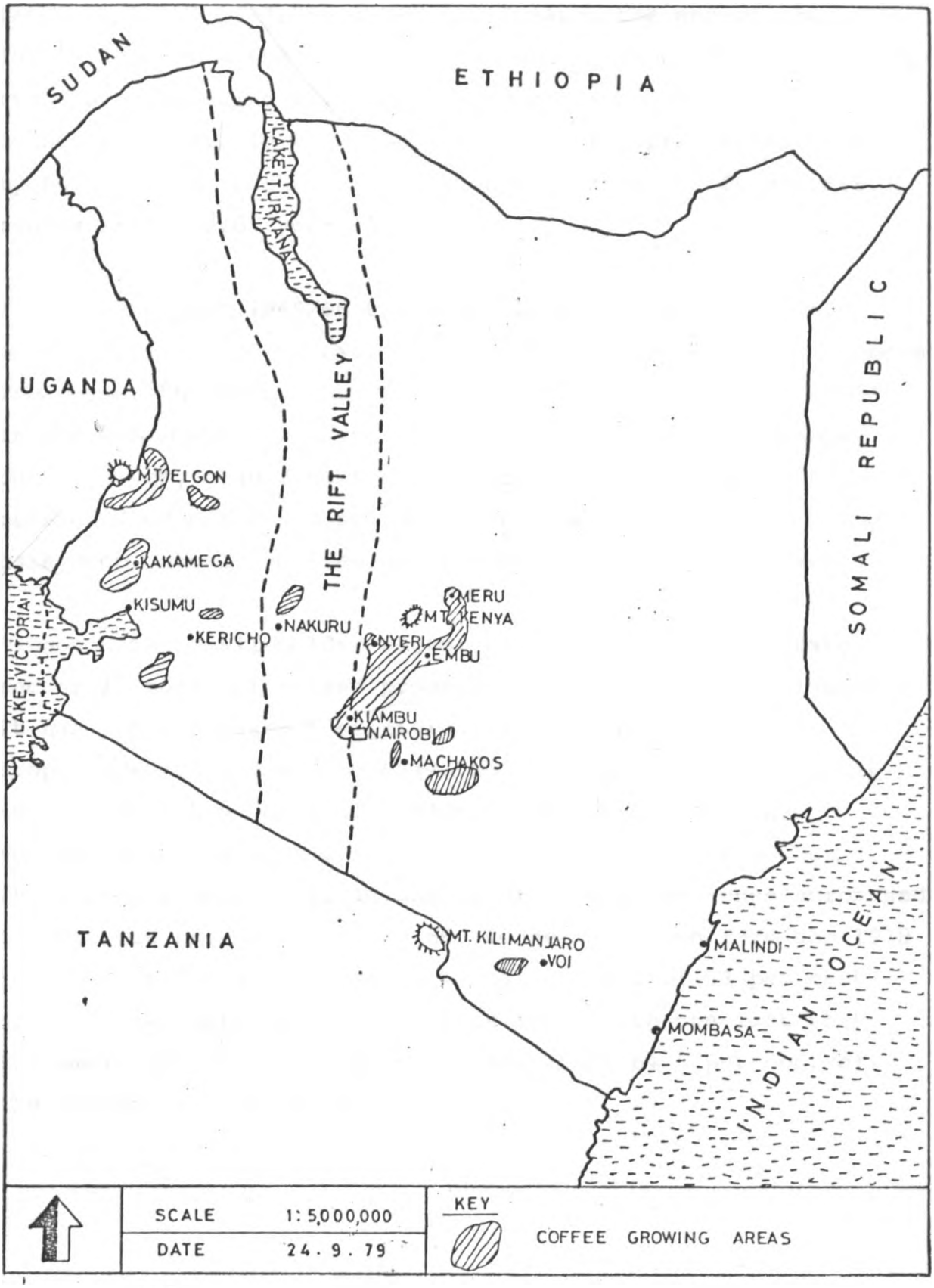

Table 2.2 shows that in the 1940's and the 1950's the small-holder sector was producing much less coffee than the Estates. In the crop year 1945/46, for example, the small-holder coffee sector produced 46.7 tonnes of coffee compared with the Estate's total of 7,868.3 tonnes. Towards the end of the 1950's, however, the small-holder sector showed an unprecedented trend by increasing its coffee production by thousands of tonnes annually. In the crop year 1960/61 coffee production by this sector reached 9,760.2 tonnes increasing from 2,856.1 tonnes in the crop year 1955/56.

In the crop year 1965/66 the small-holder sector produced more coffee (28500 tonnes) than the Estate sector (28400 tonnes). The former therefore took over the lead in coffee production in the succeeding crop years. This was not only remarkable but also very significant because it means that the main producers of Kenya's most important foreign exchange earning cash crop, namely coffee, are now the small-holder farmers.

Although the small-holder sector caught up with the Estate sector in terms of coffee production in the crop year 1965/66, it has not yet taken a significantly noticeable lead. In the crop years 1975/76 and 1976/77 the Estates produced slightly more coffee than the small-holders. This situation was however reversed in the following crop year, 1977/78 when the latter produced 47,744 tonnes of coffee and hence surpassed the Estates production of 33,685 tonnes. Between 1974 and 1978 the small-holders produced an annual average of 53 per cent of the total marketed coffee. This is despite the fact that the small-holder sector accounts for about 64.6 per cent of the hectarage under coffee.

Productivity per hectare in the small-holder sector is therefore very low. In 1978, the small-holder sector produced 737.7 Kg. per hectare which is only slightly higher than 50 per cent of the Estates yield of 1319.5 Kg. per hectare. Given the fact that most small-holders are situated in high potential areas with adequate rainfall, low productivity can only be explained by factors other than climate and soils. It is potentially possible for small-holder farmers to double or even treble their present coffee production. Machakos district, for instance, though a low potential coffee growing area produced 1511 Kg. per hectare in 1978, which was nearly double the national average (844 Kg. per hectare) of the small-holder coffee growers. The low productivity of small-holder coffee farmers, therefore, calls for research to identify factors which hold it back.

2.4 COFFEE QUALITY 1974/75 - 1977/78

Despite the fact that small-holders' coffee productivity per hectare is extremely low, the quality of the coffee they produce is surprisingly high. Table 2.3 below shows coffee quality over a period of four years broken into ten classes for both Estates and the small-holder sectors.

2.3. SMALL-HOLDER AND ESTATES COFFEE QUALITY, 1974/75 - 1977/78

COFFEE QUALITY CLASS	YEAR	S E C T O R		
		SMALL-HOLDERS %	ESTATES %	NATIONAL %
1 - 3	1977/78	24.1	3.4	15.4
	1976/77	18.1	1.1	9.3
	1975/76	20.8	1.7	10.6
	1974/75	21.14	2.9	13.2
4 - 6	1977/78	64.4	83.7	72.4
	1976/77	67.8	87.6	77.9
	1975/76	71.76	88.5	80.6
	1974/75	58.8	88.6	72.5
7-10	1977/78	3.4	8.1	5.6
	1976/77	7.4	9.0	8.3
	1975/76	7.5	9.8	8.8
	1974/75	8.1	6.8	7.7
MBUNI *	1977/78	8.1	4.8	6.7
	1976/77	6.7	2.3	4.5
	1975/76	10.3	3.6	6.8

SOURCE : Coffee Board of Kenya, Annual Report, (8, p. 4).

* Local name for sun-dried cherry.

Table 2.3 indicates that the small-holder sector produces coffee of a higher quality than the estates. In 1974/75 crop year, for example, 21.4 per cent of the coffee produced by the small-holders was in the first three classes. In comparison, only 2.9 per cent of coffee produced by the Estates belonged to the same classes. The small-holder sector did even better in 1977/78 when 24.1 per cent of its coffee was placed in the same classes. The Estates managed to improve slightly, but only 3.4 percent of their coffee fell in the first three classes in 1977/78 crop year.

The Estates, however, lead in the second category of classes, namely 4 - 6 where for a period of four years, 1974/75 to 1977/78, an annual average[1] of 87 per cent of their coffee was classified. The comparable per centage for the small-holders was 65.6. The Estates also dominate the last three classes (7-10), where over the same 4 year period an annual average of 8.4 per cent of their coffee occurs. In comparison the small-holders had an annual average of 6.6 per cent only in these classes. The picture is different though for Mbuni[2] coffee. In the period 1974/75 - 1977/78 for example, an annual average of 8.3 per cent of coffee produced by the small-holders was classified as Mbuni, compared with 3.5 per cent for the Estates.

Before small-holder coffee is marketed[3], it is first processed at the Co-operative Societies to remove the flesh of the cherry from the coffee bean. The beans (parchment coffee) are held for a short while, in large farmentation tanks to allow easy removal of the surrounding mucilage during subsequent washing

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1. Here 'Annual Average' refers to a straight average of the percentages shown in Table 2.3 over the period stated.

2. Mbuni - Local name for sun-dried cherry.

3. Marketing of coffee whether produced by the Estates or the small-holder sector is handled by the Coffee Board of Kenya.

and grading with running water. The beans are then sun-dried in their protective parchment skin. At this stage the coffee is ready for delivery to the Kenya Planters Co-operative Union (KPCU) situated in Nairobi. At the KPCU parchment coffee is cleaned and the outer cover removed. Coffee is then graded into seven standards according to size and shape of the beans for the purpose of marketing. Marketing of Kenya coffee for both Estates and the small-holders is carried out by The Coffee Board of Kenya. At the Coffee Board samples of the coffee beans are roasted and ground.Coffee made from these beans is then tested and classified into ten classes according to the quality of the flavour. Such classification enables buyers of Kenya coffee to make their choice easily.

As Table 2.4 indicates, most of Kenya's coffee is imported by European countries. In 1978 for example, the Federal Republic of West Germany bought more coffee than any other country and accounted for 30 per cent in value of Kenya's income from coffee. The Netherlands was second, although the value of the coffee which she purchased was about half of that ascribed to the Federal Republic of West Germany. About 50 per cent of the remaining income from coffee was shared by 36 countries.

Most of Kenya's coffee is produced for export with about 95 per cent of the crop marketed in this way. The remaining 5 per cent is sold locally under heavy subsidy by the Coffee Board of Kenya.

TABLE 2.4. MAJOR IMPORTERS OF KENYA COFFEE IN 1978

COUNTRY	QUANTITY TONNES	VALUE K£	% VALUE
1. FEDERAL REPUBLIC OF GERMANY	29,146	46,614,630	30
2. NETHERLANDS	12,809	20,167,873	16
3. SWEDEN	5,114	7,850,287	6
4. U.S.A.	5,876	7,720,819	6
5. U.K.	4,619	7,224,054	6
6. FINLAND	3,883	6,205,512	5
7. ITALY	3,976	5,883,653	5
8. YUGOSLAVIA	3,200	4,900,087	4
9 FRANCE	2,412	3,259,680	3
	72,776	113,528,612	90
OTHER COUNTRIES	10,687	16,070,397	10
	83,687	129,599,009	100

SOURCE : Coffee Board of Kenya, Annual Report (8, p. 5).

The major problem with coffee marketing is the price fluctuations brought about by periodic excessive supply of coffee in the world market. To avoid these fluctuations in prices both coffee producers and consumers signed the First International Coffee Agreement (23) in 1962, whose objective was to limit coffee supplies to the world market by a system of quotas. It was argued that the agreement would achieve a reasonable balance between supply and demand and hence alleviate the serious hardship to producers by burdensome surplusses.

Kenya became a signitory of this Coffee Agreement in 1962. The quota allocated to her, however, was based on 1961 coffee exports and did not take into account the large hectarage of non-bearing coffee planted between 1959 and 1962. In 1962 most of the Latin American coffee producers had reached their full capacity for production but Kenya at this time still had a lot of suitable coffee land remaining, and therefore could increase her coffee supplies cheaply. The agreement was consequently disadvantageous to Kenya.

Another international coffee agreement was signed in 1968, but due to inherent contradictions, it broke down in the early 1970's. Kenya has taken the opportunity, brought about by this breakdown, to bring more of the suitable land into coffee production in anticipation of another agreement, which would then find her in a more advantageous 'full capacity' situation.

CHAPTER III

COFFEE HUSBANDRY

This chapter deals with cultural practices in coffee husbandry. Specifically it briefly describes coffee climate and soil requirements, diseases and pests and methods of control, fertilizer use, pruning and desuckering, irrigation, mulching and weeding. The purpose of the chapter is to provide technical background information on coffee husbandry, especially the use of agro-chemical inputs. Once these details are understood, it is possible to proceed with the study methodology and analysis. In other words the technical matters dealt with provide the background understanding which is necessary for the rest of the study.

3.1. CLIMATE AND SOILS

The variety of coffee grown in Kenya is known as Coffea-Arabica, which thrives well in a sub-tropical climate. Coffea-Arabica requires annual average rainfall ranging between 1750 to 2000 mm. and temperatures of 10^{o}c to 30^{o}c. In Kenya, however, it is grown in areas which receive between 1000 and 1800 mm. of annual rainfall and which fall within the 1500 - 2000 metres altitude range above sea level (18). Besides the total amount of rainfall required, coffee is also favoured by a well distributed pattern of rainfall, which allows for a dry season in which the flowering cycle can begin.

In order to make the coffee industry economically profitable, therefore, it is important that the above climatic conditions exist before coffee is grown. Coffee planted in areas which are too warm is more susceptable to diseases, especially the leaf rust. If grown in areas with low rainfall or too long a dry season, it will need irrigation which is

normally expensive, especially to small-holders.

Coffee trees require deep, fertile soils. Preferably, soils which are heavy to work and not too loose and sandy so that they lose moisture rapidly (14). They should be well drained and slightly acidic with a P.H. of 6 to 6.5 (11). A soil depth of two to three metres is considered necessary to provide sufficient water storage between wet and dry seasons (17).

Soils in most coffee growing areas of Kenya meet most of the above requirements. They are mainly of volcanic origin, deficient in nitrogen and phosphorous but rich in potassium and minor elements (17).

3.2. FUNGAL DISEASES AND THEIR CONTROL

The most serious coffee disease in Kenya is the Coffee Berry Disease (CBD), which appeared for the first time in 1922. CBD attacks the green tissue of coffee berries at any stage of their development, often penetrating into the inner rim and destroying the beans (14). This disease spread quickly and in 1961 it had reached all coffee growing districts in Kenya. Losses attributed to CBD increased rapidly each season up to the major nation-wide outbreak of 1967, in which 30 per cent of coffee was destroyed (17).

In order to curb the threat posed by CBD, the Government set up in 1955 a special research team - "The Coffee Berry Disease Unit" to deal specifically with the disease through experimental research. As a result, effective fungicides have been developed and this disease is now under control.

The other major coffee disease is known as Leaf rust. It attacks coffee grown in low altitude warm areas. The fungus attacks coffee leaves in the wet season making them fall off the tree. This reduces the trees nutrient formation process and results in disappointingly low coffee yields.

Leaf rust was particularly serious in the 1950's. Consequently Leaf-rust resistant coffee strains were developed and at the same time effective fungicides were discovered. The disease has therefore been largely brought under control.

Table 3.1 shows six fungicidal spray programmes recommended by the Coffee Research Foundation (CRF) to control CBD and Leaf rust in Kenya coffee growing areas. Each programme is based on experimental research findings and is tailored to either one or both of these main diseases.

TABLE 3.1.RECOMMENDED FUNGICIDE SPRAYING PROGRAMMES[1.] FOR COFFEE IN KENYA - 1977.

PROGRAMME	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.
I		&	&	&	&	&	&			&	&	
II		=	+	=	+	=	+			=	+	
III		=	=	=	=	+	+			+	+	
IV		O	OO	O	OO	O	O			OO	O	
V		X	X	X	X	X	X			X	X	

		OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY.	JUN.	JUL.	AUG.	SEP
VI	a	O	O	+	O	O	=	=	=				
	b	X	X	+	X	X	=	=	=				

SOURCE : Technical Circular No. 33, Coffee Research Foundation (39, p. 3).

& - Tank mixes of captafol 2.2. Kg/ha.,or Delan 1.5 Kg/ha, or Daconil 2.2. Kg/ha; with Derosal 1.5 L/ha, or Bavistin 0.5 Kg/ha., or Benlate 0.5 Kg/ha.

= - Captafol 4.4 Kg/ha, or Delan 3.3 Kg/ha, or Daconil 4.4 Kg/ha.

+ - Bavistin 1.0 Kg/ha, or Derosal 3.0 L/ha, or Benlate 1.0 Kg/ha.

O - Copper formulation 11.0 Kg/ha.

X - Captafol 2.2 Kg/ha, or Derosal 1.5 L/ha, or Daconil 2.2 Kg/ha; plus 50 per cent copper formulations 5.5 Kg/ha.

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1. Each spraying programme is a complete schedule in itself.

The spraying programmes in Table 3.1 are based on diseases found in the coffee growing areas. Programmes 1 to 3, for example, which involve use of any of the fungicides, namely : Captafol or Delan, or Daconil, mixed with Derosal, or Bavistin, or Benlate, are designed for CBD control in areas where this disease is severe and where Leaf rust is not a significant problem. Programme 4 uses copper fungicides and is exclusively designed for coffee growing areas whose major disease is Leaf rust. Coffee regions which are attacked by both CBD and Leaf rust, use spray programme 5 which mixes fungicides to control both main diseases. Programme 6 is intended to be used in areas where there is predominantly an early crop.

Coffee is sprayed with fungicides eight times in a crop year. In programmes 1 to 5 the spraying months are January, February, March, April, May, June, July and then October and November. Coffee areas with an early crop begin spraying in October through May without a break. Spraying of fungicides begins just before the rains start and is intensified during the rain season; ending when the crop is ripening.

3.3. PESTS AND THEIR CONTROL

Coffee is also attacked by numerous types of pests.
The most serious pest of coffee trees in Kenya is mealybug, which in the 1930's threatened the very existence of the whole coffee industry (30). Initially, mealybug was controlled by a technique known as "cresto-banding".
Later more effective banding greases were discovered and now mealybug is under control. Thrips is another pest which posed a serious threat to coffee in the 1940's. A few years later, however, this pest could be controlled easily by

insecticides which were then available. Antestia bug and Leaf-miner have also been a menace to the coffee industry. Fortunately these pests do not worry coffee farmers now as much as they did in the 1940's, because very effective insecticides have been discovered to control them.
Due to sporadic pest attacks on coffee, recommendations for insecticide use are not very precise, especially for the frequencies of insecticide application in a crop year. Farmers are simply advised to spray an insecticide whenever they detect pests on their coffee. The quantity they use and the number of applications within a crop year, however, depends on what they consider to be the economic level of insecticide use.

In order to effectively control coffee diseases and pests, and hence maintain high coffee quality, the Kenya government formed The Kenya Coffee Board in 1933 as a statutory board, charged with the responsibility of supervising coffee production activities in the country, including licencing growers, coffee millers, nurseries and marketing. To enhance the activities of the Coffee Board a research station run by the (C.R.F.) was founded, near Nairobi in 1963. The station employs technical and scientific personnel to study through experimentation, the best methods of coffee husbandry with special emphasis on control of pests and diseases. Recommendations based on the research findings are then passed on to coffee farmers through extension officers.

3.4. FERTILIZER USE

Most soils in coffee growing areas in Kenya are deficient in nitrogen (17). Acland (3) observes that nitrogen is by far the most important element in coffee nutrition, and good yields are never maintained without regular applications of it.

Fertilizers are therefore added to the soil to improve its nutrient status and its ability to support plant growth. The response to fertilizer application is reflected in coffee yield per tree. In fact it is claimed that an average use of fertilizers according to CRF recommendations, increases yield of coffee by 85 - 100 Kg. of clean coffee per one acre[1] (equivalent of 1½ Kg. of cherry per tree), provided weeds, pests and diseases are properly controlled (11).

Before fertilizer is applied, however, it is important to establish the nutrient requirements of both the coffee tree and the soil, so that deficient nutrients are not ignored, and the uptake of unwanted nutrients does not prove toxic to the plant (29). The right quantity of fertilizer application depends also upon the amount of crop on the trees. Trees carrying large crops require larger quantities of nitrogen than trees with little crop. In the same way coffee areas receiving heavy rainfall or irrigation, need more fertilizer than areas which experience low amounts of rainfall or irrigation, or where irrigation is not used. This is because heavy rainfall or irrigation increases leaching of nitrogen from the soil.

Table 3.2 shows the recommended rates of nitrogen application based on expected yields per hectare.

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1. Equivalent to 0.45 hectare.

TABLE 3.2. RECOMMENDED RATES OF NITROGEN APPLICATION PER HECTARE FOR COFFEE IN KENYA - 1977.

AMOUNT OF CROP EXPECTED IN THE CURRENT SEASON	KG. NITROGEN PER HA. PER YEAR	KG. FERTILIZER PER HA. PER YEAR			GRAMS. FERTILIZER PER TREE PER YEAR		
		A 21% 1.	B 23% 1.	C 26% 1.	A 21% 1.	B 23% 1.	C 26% 1.
LESS THAN 1000 KG. CLEAN COFFEE PER HA. (5 KG. CLEAN CHERRY PER TREE).	80	390	350	310	330	300	260
1000-1500 KG. CLEAN COFFEE PER HA. (5-7 (5-7 KG. OF CLEAN CHERRY PER TREE).	140	680	610	540	570	520	460
1500-2000 KG. CLEAN COFFEE PER HA. (7-10 KG. OF CHERRY PER TREE).	140-200 to	680 to 975	610 to 875	540 to 775	570 to 850	520 to 700	460 to 620
OVER 2,000 KG. CLEAN COFFEE PER HA. (OVER 10 KG. OF CHERRY PER TREE).	UP TO 300	UP TO 1460	1310	1160	UP TO 1200	1000	901

SOURCE : COFFEE RESEARCH FOUNDATION (38, p. 2)

1. = PURE NITROGEN.

Table 3.2 indicates that a farmer expecting to harvest 1000 Kilograms of clean coffee from each hectare needs to apply 80 Kilogrames of nitrogen to that hectare. To get 80 Kg. of nitrogen, however, a farmer will have to purchase 390 Kg. of fertilizer marked (A) whose nitrogen content is 21%, or 350 Kg. of fertilizer marked (B) with nitrogen content of 23%, or 310 Kgs. of fertilizer (c). As the Table indicates, the amount of nitrogen required to be applied increases as the expected coffee yield gets larger.

Studies carried out by Jones (29) have shown that an annual application of 50 Kg. of nitrogen per hectare represents the lowest rate at which a consistent yield response is obtained. If this volume of fertilizer is applied at once it could all be leached during the rains, although for optimum growth and cropping coffee trees require an adequate level of nitrogen at all times. It is therefore recommended that the annual requirement of nitrogen fertilizer should be split into three or four equal applications. Table 3.3 shows the recommended timing of nitrogen applications in one crop year.

TABLE 3.3. RECOMMENDED TIMING OF NITROGEN APPLICATIONS FOR COFFEE IN KENYA.

RIFT VALLEY AND COFFEE GROWING AREAS WEST OF RIFT VALLEY	EAST OF THE RIFT VALLEY : TWO WET SEASONS		
	MERU DISTRICT	OTHER DISTRICTS	
		IRRIGATED COFFEE	NON-IRRIGATED COFFEE
MARCH MAY AUGUST NOVEMBER	APRIL MAY NOVEMBER DECEMBER	JANUARY APRIL MAY/JUNE NOVEMBER	APRIL MAY NOVEMBER

SOURCE : Coffee Research Foundation, 1977, (37, p. 3).

Table 3.3 gives recommended periods for the application of fertilizers in coffee growing areas within and West of the Rift Valley, and those East of the Rift Valley. The former should receive fertilizers in the wet months of March, May, August and November. Areas in the East of the Rift Valley are divided into three, based on the amount of rainfall received. Meru which receives rainfall and where leaching of nitrogen is high is recommended to receive fertilizers four times in the crop year. Districts which supplement rainfall with irrigation are also given their own schedule. Coffee growing areas which do not use irrigation, and where rainfall is not too heavy are recommended to apply nitrogen three times (37).[1]

Nitrogen fertilizers should be applied about two weeks after the start of a particular rain season. Where a second application of fertilizer is made to non-irrigated coffee in the same rain season, it should be made about four weeks after the first application (37).

The most common forms of inorganic nitrogen fertilizers are : Calcium Ammonium Nitrate (CAN), Ammonium Sulphate (AS), and Ammonium Sulphate Nitrate (ASN). Studies conducted between 1960 and 1971 showed CAN to be the best form of nitrogen fertilizer, followed by AS and ASN. Use of CAN fertilizer has been found to increase the yield of coffee to as much as 1558 Kg. per hectare (29).

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1. These recommendations do not include the use of Farm-yard manure, which is normally applied once a year. Thus, in places where small-holders use manures, the frequency of fertilizer use should be increased by one application.

Small-holder coffee growers also use Farm-yard manure for adding nitrogen. Mehlich (23) established that every 8 Kg. (1 debe) of manure contains 97 to 121 gm., or 24.2 per cent of nitrogen by weight. Thus manures are very rich in nitrogen. In addition to providing nitrogen, De Geus (II) also notes that manures supply other crucial nutrients often lacking in inorganic nitrogen fertilizers. The CRF recommended intensity of use and frequency of application of manure is 1 to 2 debes per tree per every two years.

Foliar nitrogen fertilizer is also becoming increasingly used. Generally, this form of nitrogen fertilizer could be applied only in the case of emergency need for plant nutrients. This may occur during unexpected dry weather, when coffee trees cannot take up sufficient plant food, or when a critical shortage is detected of a certain nutrient in the soil. Tag (36), however, indicates that foliar nitrogen fertilizers can not be used as a substitute for the main nitrogen fertilizers, because the method of application could be wasteful and result in excessive expenditure.

3.5. OTHER COFFEE HUSBANDRY PRACTICES

Pruning and the removing of suckers from coffee trees ensures high productivity over many years. Coffee trees which have been pruned and have had suckers removed are easier to spray and can be maintained at high yields more easily.

There are different forms of pruning techniques depending on the growing altitude and spacing of coffee trees. The two most common forms of pruning techniques are : the multiple stem and the single stem systems. The multiple stem pruning system involves removal of the lower primaries on coffee trees to leave a bearing head of about one metre high. The single stem system on the other hand allows for one main stem and is mainly recommended for low attitude areas (32).

Coffee which is older than six years should be pruned on the multiple system allowing two or three stems during the second and subsequent cycles (32). Generally, pruning and removal of suckers should be done immediately after the final picking of the main crop.

Irrigation and mulching are particularly important in marginal coffee growing areas. In these regions, the dry season tends to be longer than in high rainfall coffee growing areas. It is therefore important that soil moisture is maintained in the dry season by either mulching or use of irrigation. Unfortunately, small-holder coffee growers in Kenya usually find irrigation and mulching too expensive to practice (17). Indeed, due to the small size of plots irrigation is mostly uneconomic on small-holder farms (32). In the past mulching has been standard practice but as mulching material becomes scarcer the practice also receives less attention (17).

Finally, weeds compete with coffee trees for water and nutrients. The effect of this competition is to reduce coffee yields seriously. It is therefore necessary that farmers remove weeds from coffee farms so as to get bigger yields (32).

This chapter has discussed some important cultural practices in small-holder coffee growing, with special emphasis on C.R.F. technical information on the best use of agro-chemical inputs.

As mentioned at the beginning of the chapter, the information presented provides essential details of Agro-chemical Application in coffee growing, which the thesis goes on to study from further technical, social and economic standpoints. Hence the main purpose of this chapter has been to explain the context of the study. In the case of operations not directly concerned with Agro-chemical Application, these have been mentioned to complete the picture and to throw light on the inter-relationships and inter-dependence involved in Agro-chemical use and operations such as mulching, irrigation, pruning and weeding.

CHAPTER IV

LITERATURE REVIEW

The literature available on coffee growing in Kenya can be divided into two main types, first the technical literature prepared by the Coffee Research Foundation (CRF), on the basis of experimental results, and second , the socio-economic literature which largely describes various constraints faced by small-holder coffee farmers in the use of official CRF recommendations.

The technical literature, already presented in chapter three, describes the most effective agro-chemical inputs farmers should use, the intensities of use, and the frequencies of application within one crop year (32). There is a strong emphasis on the recommended fungicides, insecticides and different forms of fertilizers required by coffee. In addition, recommendation on general coffee husbandry, namely, weeding, pruning, desuckering, mulching, and irrigation are also given. As a result coffee small-holder farmers are technically in a position to produce high yields of coffee per hectare and maintain a very high quality. However, it has been suggested by researchers that their low productivity is strongly associated with the poor use of the above recommendations. Several studies cited below indicate that small-holder farmers use the recommendations poorly because they operate under certain socio-economic constraints.

These socio-economic studies cite the increasing scarcity of labour, perpetual shortage of working capital, insufficient extension and low price incentive as important constraints on the effective use of recommendations, particularly in the case of Agro-chemicals.

Shortage of labour is becoming a crucial problem in small-holder coffee growing. Farm labour can be divided into family and non-family labour. The former is the most dominant in coffee husbandry. Non-family labour whether permanent or casual, becomes a vital input in the peak seasons only, for example, during weeding and picking of coffee. Several studies, especially those conducted by Wallace (40, 44, 45), Waters (41), and Mutuku (20), deal particularly with the problem of labour scarcity in small-holder coffee growing. Wallace observes that the effect of the present inadequate labour supply in peak seasons, such as weeding and picking, is to lower coffee quality and production per hectare. Yet, farm labour is not likely to increase in the future because:-

(1) There is an increasing number of farmers growing coffee in the coffee growing areas, demanding all the labour available.

(2) The number of children attending school is increasing in such areas. This has reduced available labour drastically.

(3) In some areas men take off-farm employment.

(4) In the high potential areas, labour is also being competed for by tea and other farm enterprises.

Waters indicates that within the small-holder sector the quality of labour increases as the size of the production unit increases. The very small production units tend to employ

only the labour of juvenile and aged family members. The able bodied adults in the very small units prefer to look for jobs elsewhere, since their opportunity cost in larger scale coffee production is above the increased net return possible from their employment on smaller units. It is, therefore, only on units of a certain size, where it will pay adults of prime working age to forego alternative employment opportunities. Where this happens to be the case it will undoubtedly increase labour quality and result in higher coffee yields per hectare.

In a study on the economics of coffee production in Nyeri, Mutuku (20) found farm labour to be the most expensive input. As a result farmers are increasingly using herbicides to kill weeds and thus alleviate the labour shortage problem in the high potential areas, where coffee competes with other crops for the same labour. Coffee picking however, has to be done by hand and will continue to demand labour for a long time. Provision of credit to farmers, so that they can offer competitive rates of pay, is considered the most effective means of solving the shortage of labour problem. Such credit should therefore be readily available during the peak seasons such as weeding or picking coffee (31 and 44).

Wallace (44) gives the following measures as necessary to improve the supply and efficiency of labour for picking and other peak season activities:-

1. Co-operative Societies should recruit labour from non-coffee growing areas. By providing transport and constructing labour camps in the coffee belt, 'migrant' workers might be encouraged to move in for the peak months.

2. The price structure for 'cherry' should be devised to provide a picking price incentive. This could take the form of a bonus system for pickers. To facilitate this development, coffee farmers attending courses at Farmers Training Centres should receive lectures on labour management.

He notes that labour could be saved by:

1. The provision of more buying sub-centres, serviced by better roads and transport operated by the Co-operative Societies.

2. The easing of factory bottlenecks by increasing the number of supervisory staff for sorting, weighing and issuing receipts.

Wallace further observes that the day to day running of the coffee enterprise is frequently left to the farmer's wife. In most cases her first concern appears to be the production of food crops for the family. It is therefore unlikely that women are able to provide adequate labour and management. It is also difficult to improve coffee quality and productivity unless men help their wives to manage the coffee enterprise.

The liquidity problem provides another constraint faced by coffee small-holder farmers. A number of studies have identified the inadequate cash reserves of small-holder farmers, for purchasing agro-chemical inputs and hiring labour, as a possible explanation for the low productivity in coffee production. Wallace (44) indicates that normally small-holders are paid for the coffee crop at times when they do not need the money most. Consequently, they spend it on other social demands. Coffee pay-outs should therefore be re-organized to

ensure growers a regular supply of cash, both for the fulfillment of social demands (school fees, and uniforms, taxes etc.), and to enable them to purchase essential inputs. Pay-outs should also be tailored to the seasonal pattern of demand, providing the largest amounts of cash for times of peak labour demand and peak social demands.

Short-term credit in the form of physical inputs, advanced against the coffee crop, have been widely used. Given the low level of liquidity this form of credit will continue to be essential in the future. Mutuku (20) notes that coffee production costs are so high that lack of adequate capital could easily result in poor productivity. In a study on 'The economics of coffee in Nyeri', he found the cost of hired labour to be extremely high, followed by other inputs, namely : fertilizers, manures, insecticides and fungal sprays. Mureithi (28) indicates that prices for such inputs are always increasing. Between 1969 and 1975 for example, fertilizer (CAN) price increased from KShs.43 per 100 Kg.- bag to K.Shs. 192, while the price for the ASN form of fertilizer, increased from Shs. 65 per 50 Kg bag in 1972 to Shs. 192 in 1974.

Oloya (31) indicates that good coffee husbandry requires adequate capital. He observes that private investment is especially limited due to the general poverty of the farmers. He therefore suggests that government should increase assistance to farmers through subsidies and production grants. The subsidies should be used to purchase inputs such as fertilizers, fungicides, insecticides, spraying equipment and general farm machinery.

In order to have small-holder farmers follow recommendations satisfactorily, it is important that the extension service should be adequately supplied. Wallace (40) sees the extension service as including the activities of government advisers and all aspects of farmer education. Wallace observes that extension is largely concerned with the improvement of the management resource (knowledge, understanding, skills), which is itself an essential complement of other productive resources, particularly labour and capital. The supply of the management factor resource, he notes, may limit the willingness of farmers to use recommended inputs well, since their marginal value products will largely depend on the standard of management. Under peasant farm conditions the availability of extension is therefore crucial in the use of factors of production. Extension also provides information on the alternative production possibilities that any farmer should be constantly assessing.

In a study, The Bugisu Coffee Industry, Belshaw and Wallace (45) found that small-holders frequently ignored recommendations because of a failure to grasp the real purpose of sprays, due to inadequate explanation by the extension staff. Consequently sprays were applied after disease had appeared, when it was too late to stop the leaf fall caused by leaf rust attack. The resulting ineffectiveness of sprays disillusioned farmers and led them to lose faith in the whole exercise. Coffee farmers should therefore be well informed about the use of agro-chemical inputs, so as to improve both coffee quality and yield. Arthur Lewis (4) notes that expenditure for bringing new knowledge to peasant farmers is probably the most productive investment which can be made in any of the poor developing countries. The indication is that governments should consider training more extension officers who can educate coffee farmers in improving their coffee husbandry.

Maitha (25, p. 317) gives four possible explanations for the low productivity in the Kenya coffee small-holding sector:-

1. A fairly large proportion of the area under coffee in the small-holding sector is marginal land.

2. Management and labour-use are often very inefficient.

3. There is a greater lag in adopting technological innovations on coffee small-holdings than on the estates.

4. Due to economies of scale the Estates can afford to take advantage of costly innovations, whereas the small-holding sector feels less able to gain from these improvements and is likely to take more time to adopt the same innovations.

The net effect of these factors is that the small-holder sector is not likely to take full advantage of technological innovations until some of the constraining factors become relaxed.

Wallace (40) on the other hand gives three considerations for the improvement of coffee husbandry by small-holders:

(a) Relevant research should be done on each coffee growing region to identify unique problems facing farmers. Recommendation based on such research findings should be followed strictly by farmers.

(b) The extension service should be increased by training farmers occasionally at Farmers Training Centres, and by using the extension staff to perform demonstrations of recommended coffee husbandry practices on coffee farms.

(c) Co-operative societies should help their members in the acquisition of implements by providing credit. Credit for purchasing costly equipment, like oxen-drawn carts and spray-pumps, so that at least each farmer has access to the necessary implements.

Economic studies (19, 25, 31) indicate that Kenya could receive higher coffee revenue by selling more coffee in the world market. The studies point out that as Kenya produces a relatively small part of the supply of world coffee, she is not in a position to influence world prices unilaterally. Besides, her relatively high quality coffee is easily sold in most coffee-consuming countries. Koester (19) argues that given a situation where the Estates cannot economically put more land under coffee, then small-holders should be encouraged to cater for this new production. The latter still have ample land under-utilised which could be used for this purpose. Given the low productivity by small-holders, however, it may not even be necessary to increase hectarage, since use of agro-chemicals and other inputs, such as labour, according to recommendation would achieve the same results.

Some small-holder producers cannot use recommendations to the best advantage because of the uneconomic sizes of their coffee plots. Oloya (31) indicates that farmers can only receive high returns from their coffee enterprise if both

technical and economic efficiency can be attained. However, this is only possible on reasonably sized plots[1] where economies of scale occurs, small plots should if possible be amalgamated to create more economic units. Oloya cites the benefits of land amalgamation in the United Kingdom and Sweden as evidence that increased efficiency in the coffee industry can result from similar rationalization. Amalgamation makes the use of modern technology easier, for example, mechanization; and consequently labour inputs can be substituted for by capital resulting in higher productivity. Under larger scale coffee production, indivisible inputs can be used economically, and incomes are generally high enough to enable farmers to purchase the necessary implements and agro-chemicals.

It has been found that small-holder coffee farmers respond to price incentives positively (25). Coffee small-holders tend to use more agro-chemicals: fertilizers and fungicides, during periods of boom and less when low prices are expected. In this respect the farmers therefore appear to be risk minimizers.

Finally, although the studies cited above have discussed certain constraints faced by small-holder coffee farmers, none of them actually considers how strictly the official recommendations for input use are used. It is also noticeable that the technical literature is fairly well detailed and specific to each input, especially fungicides and fertilizers whereas the socio-economic literature is more general in its findings; being

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1. Oloya does not give the optimum plot sizes but it can be assumed that these are mostly 1 hectare and above.

mainly concerned with the small-holder coffee industry as a whole. The study reported on in the following chapters, represents an attempt at least to understand how closely small coffee producers keep to technical recommendations for Agro-chemicals in a particular coffee growing Area.

CHAPTER V

OBJECTIVES AND HYPOTHESES

5.1. OBJECTIVES

Although small-holder coffee farmers in Kenya control over 50 per cent of the coffee industry, little research work has been done on their coffee farming practices to find out how they use the recommended agro-chemical inputs. Yet, if the small-holder sector is to increase its productivity, which is quite low at the moment, detailed studies are needed to show not only what farmers are doing but indeed what they could do to increase coffee output and hence improve their incomes. The present study is concerned with an economic analysis of divergencies from agro-chemical use recommendations in coffee small-holder production in the Northern division of Machakos district. Specifically it endeavours to do the following:-

I. (a) Collect information on the use of agro-chemical inputs on the mature coffee enterprises in the Northern division of Machakos district.

(b) Give measurements of deviations from official recommendations in the use of agro-chemicals on the mature coffee.

(c) Determine statistically whether farmers on average deviate from recommended levels of agro-chemicals and frequencies of application for the mature coffee enterprises.

(d) Calculate three profitability levels, namely; net family farm income, net farm income, and managerial earnings on mature coffee enterprises.

(e) Test the relationships between total variable costs, and total costs on the mature coffee enterprises and total expenditures on selected agro-chemical inputs in the crop year 1977/78.

II. Identify socio-economic variables related to levels of agro-chemical use and frequencies of application on the mature coffee enterprise.

4.2. HYPOTHESES.

Arising from the above main objectives, the following three general hypotheses are tested in the study:-

FIRST GENERAL HYPOTHESIS

That on average, small-holder coffee farmers do not deviate from the recommended levels of agro-chemical use and frequencies of application.

Specific hypotheses regarding mature coffee enterprises:

That on average small-holder coffee farmers do not deviate from the recommended levels of:-

(a) Nitrogen fertilizer use and frequencies of application.

(b) Copper fungicide use and frequencies of application.

(c) Captafol fungicide use and frequencies of application.

SECOND GENERAL HYPOTHESIS

That expenditures on agro-chemical inputs on mature coffee enterprise do not bear any definable linear relationships with total variable costs, and total costs in the crop year of the study.

Specific hypotheses regarding mature coffee enterprise:

(a) That total expenditures on nitrogen fertilizer are not linearly related with total variable costs, and total costs.

(b) That total expenditures on the fungicides, namely, copper and captafol are not linearly related with total variable costs, and total costs.

The above hypotheses will be tested using, in the first case, ordinary least squares regression (permitting an intercept value), and secondly, least squares regression through the origin.

Both types of regression can show up linear relationships. However, the difference between them is that the former, with an intercept value does not indicate a fixed proportional relationship, whereas the latter does. Thus both relationships indicate the arithmetic increase in the dependent variable per unit increase in the independent variable. But in addition to this the relationship through the origin states that such increases in the dependent and independent variables will define a fixed proportional relationship between corresponding total amounts over the range of values studied.

THIRD GENERAL HYPOTHESIS

That no statistically significant linear relationships exist between levels of agro-chemical inputs' use and frequencies of application on the one hand and selected socio-economic variables on the other.

Specific hypotheses regarding mature coffee enterprises:

That no statistically significant linear relationships exist between :-

(a) Levels of nitrogen fertilizer used, and frequencies of application; and numerous selected socio-economic variables.

(b) Levels of copper fungicide used and frequencies of application; and numerous selected socio-economic variables.

(c) Levels of captafol fungicide used, and frequencies of application; and numerous selected socio-economic variables.[1]

The last set of specific hypotheses in relation to the selected socio-economic variables will be tested firstly on the basis of simple correlation coefficients. Where the latter show significance, they will indicate possible simple and multiple linear regression relationships, and the models and analytical results will be discussed later.

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1. The selected socio-economic variables used in the analysis are : Farmer's wealth (on the basis of farm assets); per centage of income from coffee as a proportion of total farm income in the crop year; Net family farm income, net farm income and managerial earnings (from coffee); Total variable costs and total costs on mature coffee enterprise; coffee yield; value of equipment used on mature coffee enterprise; working family members (man equivalent); farmer's age; farmer's educational level, and farmer extension contact days in the crop year 1977/78.

CHAPTER VI

METHODOLOGY

6.1. LOCATION OF STUDY

Over 60 per cent of the small-holder coffee in Machakos district is grown in the Northern division on map 6.2. The remaining 40 per cent is produced by the other seven separate regions within the district, namely : Mitaboni, Maputi, Kithimani, Kikima, New Iveti, Kithangathini and Mua Hills (27). Due to the problem of distance between these regions it was impossible to study all of them within the allocated time. It was decided therefore, to study one region only, namely, the Northern division. Several factors influenced this decision. These are:-

1. Coffee in Machakos district was first introduced in the Northern division in 1954, and later spread to the other regions. It is therefore a well established crop in the area chosen.

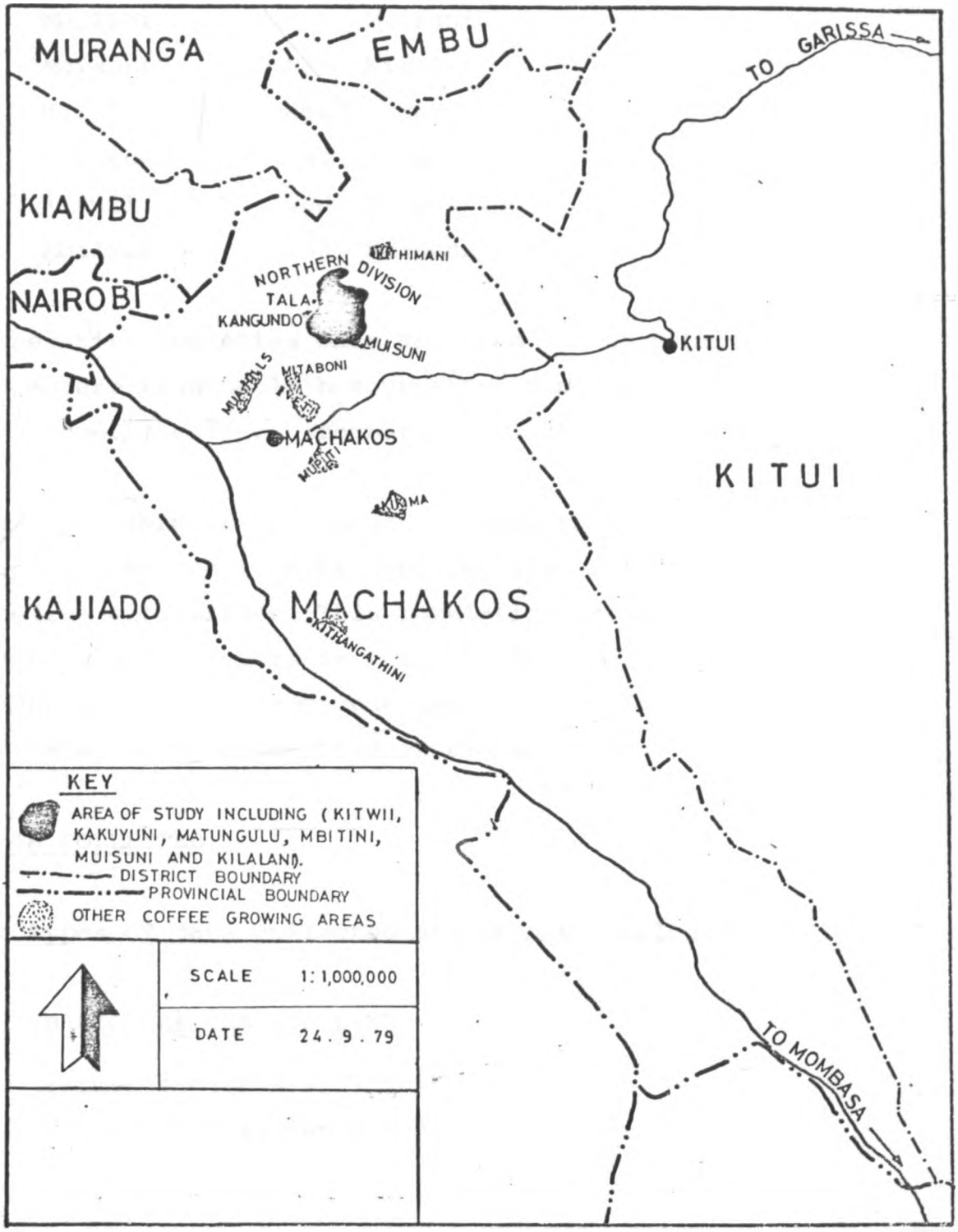
2. Coffee in the Northern division contributes approximately 70 per cent of all total farm income, making it the most dominant cash crop.

3. The Northern division is the only part of the district where coffee is grown by almost all the farmers.

6.2. SAMPLING PROCEDURE

Coffee small-holder farmers in the Northern division are organized into six co-operative societies. In order to make the study manageable, therefore, only two societies were considered. These two, namely Muisuni and

MAP 6.2- COFFEE GROWING AREAS IN MACHAKOS DISTRICT



Kilalani, were randomly selected by first arranging the six co-operative societies[1] into six contiguous pairs shown below:-

1.	Mbilini	and	Muisuni
2.	Muisuni	and	Kilalani
3.	Kilalani	and	Kakuyuni
4.	Kakuyuni	and	Kitwii
5.	Kitwii	and	Matungulu
6.	Mbilini	and	Muisuni

The co-operative societies were arranged in the manner shown so as to ensure reasonable homogeneity in micro-climate, soils and general coffee husbandry for each pair.

A sample of 35 farmers was randomly drawn from the total population of the two selected co-operative societies having mature coffee enterprises. This population amounted to approximately 3000 members in the 1977/78 crop year. An appointment with each respondent was arranged for obtaining required data, using a prepared interview schedule.

6.3. DATA COLLECTED.

The main types of data collected are itemised below:-

1. BASIC DEMOGRAPHIC DATA:

   Farmer's age, sex, level of education, number of children and ages.

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1. See Appendix 5 for coffee hectarage by co-operative in Machakos district in 1977/78 coffee crop year.

2. GENERAL FARM DATA:

(a) Inventory and valuation of fixed and working capital items at the beginning and end of the crop year under study (1977/78) comprising:-

- Land hectarage
- Buildings (including the farmer's house), machinery and equipment.

(b) Labour availability, both family and hired.

(c) Farm crop and livestock enterprise incomes.

(d) Valuation of farm wealth.

3. MATURE COFFEE ENTERPRISE DATA:

(a) Hectarage under mature coffee.
(b) Land improvement values for fencing and furrow irrigation.
(c) Coffee labour profile.
(d) Yield of coffee in the crop year under study.
(e) Types of agro-chemicals used, quantities applied and frequencies of application.
(f) Total fixed costs and total variable costs on the basis of operational inputs; and mature coffee enterprise tasks which include weeding; pruning; desuckering; and picking of coffee.

(g) Credit available to the farmer for the coffee enterprise.

(h) Number of contact days with extension officers concerning coffee in the crop year studied.

The interview schedule was first tested for suitability on five farmers. This pilot study revealed two things: first that some questions were ambiguous and therefore needed to be reframed so that respondents could understand them easily; and, second, that farmers were not always clear as to the nature of the inputs used, particularly the names of Agro-chemicals and the amounts applied. Consequently, the final interview schedule was refined with the purpose of making the collection of data easier.

The co-operative societies were approached to furnish the local names for agro-chemical inputs and to provide information which some of the respondents could not recall, particularly how the farmers used certain inputs in the 1977/78 coffee crop year. Such information was obtained with the full permission of the respondents concerned.

The interview schedule mentioned above was split into two parts, namely that for the general farm husbandry and that for the mature coffee enterprise. The former was intended to show the position of coffee on the farm amongst the various other enterprises. The second part was more detailed and was specifically concerned with the use of inputs in the mature coffee enterprise. The interview schedule was designed in such a way that the most important information provided by respondents could be counter-checked.

Due to the nature of the study, it was found necessary to interview the Machakos district coffee officer; the co-operative societies' secretaries, chairmen and some committee members; and extension officers in the area of study.

Such interviews were dual purpose, first, 'to enrich the researchers' background on coffee husbandry in the area of study, and, second, to clarify or supplement technical information which some respondents were not clear about, such as the conditions under which credit is issued.

The secondary data used were obtained from "Technical Circulars" from the Coffee Research Foundation and the Machakos district coffee annual reports. Technical circulars data were in the form of recommendations for coffee husbandry viz; input intensities and frequencies of application; weeding methods, recommended pruning, desuckering, mulching and irrigation. The district reports on the other hand contained a list of the inputs used by farmers in Machakos district;total coffee production figures in 1977/78; area under coffee; number of co-operatives and membership; and the general revenue position of coffee in relation to all other crops grown in the district.

6.4. DATA ESTIMATING PROCEDURES

Physical measures of inventory items, labour and total coffee yield were collected from each farm and valued simultaneously. Physical quantities were used to establish the levels of use of agro-chemicals and the deviations from official recommendations. Valuation of inputs enabled the costing of mature coffee enterprises. Once this had been done, the residual accounting technique was used to show profitability levels for the enterprises.

Prices for most equipment, agro-chemicals and farm produce, whether coffee or subsistence crops, were easily obtainable at the co-operative societies, or at the main provision stores. However, farmers were first asked to give price and cost

estimates. Valuation of subsistence crops was done by asking the farmer to estimate the number of bags of particular crops that he produced in 1977/78. The correct values were then established by using the market prices for the 1977/78 year.

Most farmers used Farm-yard manure from their livestock on the coffee enterprises. The number of oxen-drawn carts of manure used on coffee was established by asking the farmer to give an estimated figure. One full cart of manure is equal to one tonne. Therefore using the co-operative society's price for one tonne, including transportation cost , the cost of farm manure could be calculated easily as shown in Appendix 7.

Recommended measures for agro-chemical inputs are given per hectare of mature coffee. In most cases though small-holdings have less than a hectare of coffee, it was therefore necessary to calculate recommended levels of agro-chemical input use for each coffee enterprise as a whole. Appendix 8 gives the procedure for calculating the recommended quantities of agro-chemicals for each coffee enterprise in the sample.

For asset valuation purposes a general list of possible inventory items was prepared and the farmer asked to indicate whether he possessed any of the listed items. In order to find the values of indicated items the farmer was asked questions concerning the original price of each item and the number of years it takes to depreciate out under his farm conditions. The actual age of each item was also recorded. By use of the straight line depreciation method shown below the beginning and end of year valuations can easily be obtained.

Straight line annual depreciation $= \frac{Vo - Sv}{t}$

Where : Vo = original value
Sv = salvage value[1]
t = expected years of life

Hence with this information it was possible to estimate the average value of total investment for a mature coffee enterprise. The average involves the beginning and end of year figures for proportions of items used on the coffee enterprise.

Most farmers did not know their enterprise hectarages. Fortunately, due to the standard spacing of coffee trees it was possible to calculate the exact land area under coffee. A farmer with 150 coffee trees for instance, has 0·112 hectares of coffee. This is obtained by dividing 150 trees by 1330, the number of trees in one hectare of coffee. The average value of land under mature coffee was found to be Shs.12,000 per hectare, while one mature coffee tree was generally valued at Shs.20 ·

Areas per farm of grazing land and the land under subsistence crops were obtained from the Department of lands in the Ministry of Lands and Settlement which was finalising adjudication of the Northern division at the time when the study was being conducted. The average values of grazing land and land under subsistence crops were assessed at Shs.4000 and Shs.6000 respectively per hectare.

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1. For the sample farms studied it was assumed that original values were depreciated right out with no salvage values remaining.

Valuation of buildings and farmer's houses took into consideration the material used in construction and the number of years elapsed since they were built. On this basis each farmer was asked to give his estimate of present value. In some cases where it was obvious that over-estimates or under-estimates had been given, figures were adjusted to conform to valuation levels officially accepted for the area.

6.5. PROBLEMS IN DATA COLLECTION

The only major problem encountered in collecting data was a general lack of records, which is common in most small-holding studies in Kenya. Consequently the memory of farmers was heavily relied upon and assumed correct. Fortunately a lot of information collected for coffee enterprises could be easily counter-checked at the co-operative societies, where records are kept for agro-chemicals used by farmers, coffee outputs and incomes.

6.6. SOCIO-ECONOMIC VARIABLES USED IN THE STUDY

The socio-economic variables listed below are used in the regression and correlation analysis discussed later in the chapter.

1. WEALTH : Farmer's wealth excluded his income but included total farm assets such as land, buildings, coffee trees, livestock and equipment. The level of farmer's wealth was postulated as being important in explaining his use of Agro-chemicals on coffee. Wealthy farmers were thought to be less averse to risk than poor ones.

2.	TOTAL VARIABLE COSTS FOR THE MATURE COFFEE ENTERPRISE:	This variable included the cost of labour used in weeding, pruning and picking of coffee, the cost of other variable inputs such as Agro-chemicals, and transportation costs. The latter was used as an explanatory variable for expenditure on Agro-chemicals.
3.	TOTAL COSTS FOR THE MATURE COFFEE ENTERPRISE:	Total cost included total variable cost; annual depreciation of equipment, and opportunity cost of capital at 6 per cent interest rate.[1] Capital consisted of: land, mature coffee trees, and equipment apportioned to the mature coffee enterprise.
4.	LABOUR ON THE MATURE COFFEE ENTERPRISE:	As mentioned earlier, labour used in the coffee enterprise was divided into family and non-family labour. The amount of time devoted to the coffee enterprise by family labour (including the farmer), was established by asking the farmer to estimate the hours spent on seasonal operations such as, weeding, fertilizing, manuring, spraying, picking coffee, and pruning. A wage of Shs.10 per day was used to calculate

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1. This is the interest rate paid to farmers on savings by the Co-operative Bank of Kenya.

opportunity cost of family labour. Child labour was calculated in terms of adult equivalents by multiplying hours by a factor of .05. In most cases, casual labour was paid by "piece rate" rather than per day worked.

If paid per day the average rate of Shs.10.00 per day was used. It was found satisfactory to cost the picking of coffee at a price of Shs.2.50 a 'debe', weighing 13.3 Kg. of cherry.

5. PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME:

From an income proportion standpoint position of the mature coffee enterprise was measured in relation to the total farm income. The reason for doing this was to be able to test whether farms with higher proportional income dependence on coffee were disposed to using more agro-chemicals per hectare on coffee.

6. VALUE OF EQUIPMENT FOR THE MATURE COFFEE ENTERPRISE:

The value of equipment used on the mature coffee enterprise was apportioned. This was done with the purpose of investigating whether there was any linear relationship showing between equipment value and specific levels for the agro-chemical inputs for the coffee per hectare, and the total enterprise.

7. COFFEE YIELDS:

Yield of coffee per tree, hectare and enterprise was recorded for each farm. The per hectare and enterprise yields were subsequently correlated with levels of agro-chemical use.

8. PROFITABILITY MEASURES FOR THE MATURE COFFEE ENTERPRISE:

For each sample member, net family farm income, net farm income and managerial earnings, as defined later are calculated per hectare and per mature coffee enterprise thus permitting for the whole sample averages to be calculated. These give measures of profitability for the mature coffee enterprise, and by use of the correlation model, it is possible to explore whether a significant linear relationship exists between the above measures and levels of application of agro-chemical inputs and frequencies of application.

9. NUMBER OF EXTENSION CONTACT DAYS:

The farmer was asked the number of days he had attended agricultural training courses and demonstrations.
Occasionally coffee small-holder farmers are called for meetings at the co-operative societies' factories where extension officers address them on the recently developed methods of coffee husbandry. Most of the time, however, the extension officers are supposed to visit farmers on their farms, with or without prior appointment and advise them on the particular problems they are experiencing. In summary, the farmer was asked the number of days in the study period on which he made contact with any form of extension activity.

10. EDUCATION: The education level of the farmer was thought to be a factor in explaining the extent to which he decided to use particular Agro-chemicals. Reasonably highly educated farmers can appreciate recommended methods of coffee husbandry better than uneducated ones. Consequently it was found useful to establish the number of years each farmer had received formal education.

11. FARMER'S AGE: The ages of the small-holder farmers in the sample were recorded. This was done so as to find out whether the farmer's age bears any linear relationship with the use of the agro-chemicals.

6.7. MATURE COFFEE ENTERPRISE DATA ANALYSIS

Several models are used to analyse the mature coffee enterprise data. Except for the residual accounting one, all the models use statistical tests of hypothesis with regard to population parameters.

6.7.1. RESIDUAL ACCOUNTING MODEL

In order to obtain income measures on farms for mature coffee per hectare and enterprise, viz : net family farm income; net farm income; and managerial earnings, the residual accounting model was applied. The procedure for calculating the above measures by this model is shown below:-

		Gross revenue from coffee
	-	Operating costs (hired labour, inputs
(minus)		depreciation on equipment).
	=	Net family farm income
	-	Opportunity cost of unpaid labour and
(minus)		manager's labour.
	=	Net farm income
	-	Opportunity cost of average capital
(minus)		investment (interest on value of mature coffee enterprise, and associated equipment, at 6 per cent interest rate[1]).
	=	Managerial earnings.

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1. This is the interest rate paid to farmers on savings by Co-operative Bank of Kenya .

The residual accounting model, therefore, shows the mature coffee enterprise income received by small-holder farmers on per hectare, or total enterprise basis. Such levels of incomes can be used to determine the overall performance of the enterprise.

In most cases the net family farm income should be reasonably high, since small-holder farmers tend to provide most of the labour which is therefore not taken into consideration in this income measure . The net farm income, on the other hand, is more realistic in determining the economic performance of the coffee enterprise because it takes into account all the farm family labour including the farmer's own labour on the mature coffee enterprise. Lastly, managerial income can be considered to be an ultimate profit measure that acrues to the farmer for having undertaken the enterprise. If managerial earnings are negative, it is a clear indication that the farmer's opportunity cost on average investment is not being covered. Consequently nothing is left as a return to management activity and risk bearing.

6.7.2. MATURE COFFEE ENTERPRISE DATA ANALYSIS - STATISTICAL MODELS.

Each of the three general hypotheses, already discussed, is tested by different statistical models as shown in the remaining section of this chapter. The first general hypothesis (and its specific ones) is tested by two models given below[1]. The first one tests for the sample average levels of agro-chemical use against the sample recommended ones; while the second tests for the average small-holder frequencies of agro-chemical application against the official recommendations for the crop year 1977/78. Whereas in the latter, we deal with the sample average X_1 and the recommendations sample constant which can be seen as the population mean, μ, in the first test we are concerned with two sample averages, X_1 and X_2. The first of these indicates the average use of agro-chemicals on mature coffee enterprises and the second indicates the mean recommended levels of agro-chemical use in 1977/78. The two tests involve the calculation of 'Z' values as shown by the respective formulas.

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1. These tests are limited in scope and this must be borne in mind when interpreting results. For example in the extreme it is possible for the null hypothesis in these tests - no difference between population means - not to be rejected, and yet no single recorded value be equal to the recommended value. Therefore in such cases, the test is of interest because total actual usage can equal total recommended use for the population as a whole - Although as already explained even if these are equal it doesn't necessarily mean, and most likely couldn't mean, that individual growers are following recommendations closely. Secondly, however, the tests are an obvious indication of individual grower differences between Actual and recommended Application, when pairs of population means are themselves inferred to show differences. It is in the latter sense that the tests are likely to show intepretation in the study.

Test (a) (large sample : $n \geq 30$):

$$\text{'Z' Statistic} = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where:

$\bar{X}_1$ = Sample mean for actual agro-chemical application levels during crop year.

$\bar{X}_2$ = Sample mean for recommended agro-chemical application levels during crop year.

S_1^2 = Standard deviation for sample 1 observations.

S_2^2 = Standard deviation for sample 2 observations.

n_1 = Size of sample 1.

n_2 = Size of sample 2.

Test (b) (large sample $n \geq 30$):

$$\text{'Z' Statistic} = \frac{\bar{X}_1 - \mu_1}{S_{\bar{X}_1}}$$

Where:

$\bar{X}_1$ = Sample mean of actual agro-chemical application frequency for crop year.

μ = Official recommended application frequency of agro-chemical in crop year.

$S_{\bar{X}_1}$ = Standard error of $\bar{X}_1$ ($S_{\bar{X}_1} = \frac{S_1}{\sqrt{n_1}}$), where

S_1 is standard deviation of sample observations and n_1 is sample size.

In the two formulas , if the calculated 'Z' value is greater than the critical 'Z' value at the .05 level of significance, the null hypothesis will be rejected in favour of the alternative one. The specific null hypotheses and alternative ones formulated will be explained when the results of the tests are discussed later.

Descriptive statistical data, namely: means; standard deviations; and population mean 95 per cent confidence intervals, are used in the study to measure amounts of agro-chemicals used in the mature coffee enterprise, and their frequencies of application. Their calculation is shown below.

(a) SAMPLE MEAN

$$\bar{X}_1 = \frac{\Sigma X_i}{n_1}$$

Where:

$\bar{X}_1$ = Sample mean

ΣX_i = Sample observation value summation.

n_1 = Sample size.

(b) STANDARD DEVIATION

Standard deviation is a measure of variation of sample data.

The formula for calculating standard deviation is:-

$$S_1 = \sqrt{\frac{\Sigma (X_i - \bar{X}_1)^2}{n_1 - 1}}$$

Where: S_1 = Standard deviation

Xi = Sample observation

$\bar{X}1$ = Sample mean

n_1 = Sample size.

(c) CONFIDENCE INTERVAL (INTERVAL ESTIMATE)

Confidence intervals are used to estimate parameters (μ). The formula shown below is used to calculate 95 per cent confidence intervals.

$$\bar{X}_1 - Z_{.05}\frac{S_1}{\sqrt{n_1}} < \mu_1 < \bar{X}_1 + Z_{.05}\frac{S_1}{\sqrt{n_1}}$$

Where: $\bar{X}_1$ = Sample mean

μ_1 = Population mean

Z = Tabular value

S_1 = Standard deviation of sample observations.

The second hypothesis makes it necessary to test for linear relationships between total variable costs and total costs on the one hand and total expenditure on nitrogen, and fungicides on the other, within the crop year 1977/78 for mature coffee enterprises. The tests required, therefore, will indicate whether linear relationships are not acceptable or not.

As indicated in the previous chapter, the related specific hypotheses are tested using ordinary least squares regression and least squares regression through the origin. The two regression models are given below:-

(a) Ordinary least squares regression

$$\hat{Y} = a + bX_i$$

Where : $\hat{Y}$ = Estimated cost of specific agro-chemical input on mature coffee enterprise

a = Estimated intercept coefficient.

b = Estimated regression coefficient.

Xi = Total variable costs or total costs on mature coffee enterprise.

The above model while testing whether $\beta = 0$ is also used in the analysis to test whether α, the population intercept coefficient, is different from zero[1]. This latter test was performed directly from calculated 't' values given in the computer output. If this is found not to be the case at the .05 level of significance, we can then conclude statistically that a fixed proportionate relationship (through the origin) might well exist between Yi and Xi, providing β was thought to be greater than zero. However, to assert that a given increment in X will be accompanied by a given increment in Y so as to maintain a constant proportional relationship, we have to test for the significance of b in the second model below[1]:-

(b) Least squares regression through the origin.

$$\hat{Y}i = bXi$$

Where :

$\hat{Y}i$ = Estimated cost of specific agro-chemical input on mature coffee enterprise.

b = Estimated regression coefficient.

Xi = Independent variable :- total variable costs or total costs on mature coffee enterprise.

The coefficient b is tested at the .05 level of significance (one-sided) by using the formula shown below:

$$\text{Calculated 't' statistic} = \frac{b - \beta}{S_b}$$

---

1. Tests on the significance of a and b coefficients at the .05 level are conducted as appropriate one-sided costs.

Where : b = Estimated regression coefficient
β = Population regression coefficient
S_b = Standard error of the estimated regression coefficient.

Under the null hypothesis formulation, $\beta = 0$ in both ordinary and through the origin least squares regression. The formulae for calculating b and S_b in the two models are given below[1]:-

Least squares regression through the origin

$$b = \frac{\Sigma(X_i Y_i)}{\Sigma(X_i)^2}$$

Where : Xi and Yi are sample observation values
b = estimated regression coefficient.

$$S_b = \sqrt{\frac{\Sigma(Y_i)^2 - \frac{(\Sigma X_i Y_i)^2}{\Sigma(X_i)^2}}{\Sigma(X_i)^2 \quad (n-1)}}$$

Where : Yi and Xi are sample observation values
S_b = Standard error of the regression coefficient.
n = Sample size.

1. See. Snedecor, ref. no. 35 for reference of least squares through the origin.

Ordinary least squares regression

$$b = \frac{\Sigma (x_i y_i)}{\Sigma (x_i)^2}$$

Where: xi and yi are deviation values

$(X_i - \bar{X}) = x_i$ and $(Y_i - \bar{Y}) = y_i$

b = estimated regression coefficient.

$$S_b = \sqrt{\frac{\Sigma (y_i)^2 - \frac{(\Sigma x_i y_i)^2}{\Sigma (x_i)^2}}{\Sigma (x_i)^2 (n-1)}}$$

Where : xi and yi are deviation values

$(X_i - \bar{X}) = x_i$ and $(Y_i - \bar{Y}) = y_i$.

S_b = Standard error of the regression coefficient.

n = sample size.

6.7.3. CORRELATION ANALYSIS

Simple correlation* and multi-linear regression are used for testing the third hypothesis. Simple correlation is used to investigate the strengths of linear relationship existing between levels of agro-chemical use and frequencies of application chosen subsequently as dependent variables in regression; and farmer wealth, coffee yield, family labour, per centage of income from coffee as a proportion of total farm income, value of equipment apportioned to coffee, total variable costs, total costs, net family farm income, net farm income, managerial earnings, number of mature coffee trees, extension contact days, education level, and farmer's age. This analysis is performed on both per hectare and per enterprise mature coffee data.

Having decided to consider levels of agro-chemical use and related frequencies of application as dependent variables in regression, the above correlations allowed selection of independent explanatory variables. Hence the correlations allowed a listing of associated variables with any one dependent variable. These were then thought of as possible independent variables in the corresponding regression model. However final selection of appropriate independent variables depend on their being lack of multi-colinearity in related regression analysis. The rule adopted was that wherever the simple correlation coefficient was 0.65 or above between two potential independent variables, one of them would be dropped in favour of the other.[1] A general listing of dependent and independent variables is given in the next section under the heading of multi-linear regression model. Specific combination of variables in regressions will be made clear when discussing the analytical results.

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1. While somewhat arbitrary as a criterion level it was thought to represent a reasonable safeguard against such occurrences.

* See footnote on page 73.

6.7.4. MULTI-LINEAR REGRESSION MODEL

The multi-linear regression model is employed to show how levels of agro-chemical use and frequencies of application on mature coffee as dependent variables, per hectare and per enterprise, are related to selected independent socio-economic variables[1]. The general multi-linear regression equation can be stated as follows:-

$$\hat{Y}_1 = a + b_1X_1 + b_2X_2 + \cdots b_nX_n$$

Where dependent variables in turn are:-

Y_1 = Level of nitrogen (in Kg.) applied on mature coffee in crop year

Y_2 = Frequency of nitrogen application on mature coffee in the crop year

Y_3 = Level of copper fungicide (in Kg.) used on mature coffee in the crop year

Y_4 = Frequency of copper fungicide used on mature coffee in the crop year

Y_5 = Level of captafol fungicide (in Kg.) mature coffee in the crop year

Y_6 = Frequency of captafol fungicide application on mature coffee in the crop year

and the following are the selected socio-economic variables (without specification for any particular regression):

X_1 = Farmer wealth level (in K. Shillings) on the basis of farm assets)

X_2 = Coffee yield (in Kg.) in the crop year 1977/78

X_3 = Family labour (man-days) on mature coffee enterprise

X_4 = Per centage of income earned by coffee as a proportion of total farm income

X_5 = Value of equipment (in K.Shillings) apportioned to coffee

1. As with the simple regression models the tests of significance (or the b coefficients) at .05 level are conducted as appropriate one-sided tests.

X_6 = Net family farm income (in K. Shillings) derived from the mature coffee enterprise

X_7 = Net farm income (in K. Shillings) derived from coffee

X_8 = Managerial earnings (in K. Shillings) from the coffee enterprise

X_9 = Total variable costs (in K. Shillings) on mature coffee

X_{10} = Total costs (in K. Shillings) on mature coffee enterprise

X_{11} = Farmer age (in years)

X_{12} = Farmer extension contact days

X_{13} = Farmer education level (in years)

See the starred footnote on page 71.

* While this cannot be regarded as a fool proof method simple correlation was used to identify likely explanatory variables in multiple regression in relation to a dependent variable. Since multiple regression analysis in the study was regarded as a supplementary stage any lack of identification of explanatory variables is not thought to be serious. Moreover this procedure does help to condense an otherwise lengthy repetitive analysis.

CHAPTER VII
DESCRIPTIVE DATA ANALYSIS

This chapter provides a descriptive data analysis of the sample average mature coffee enterprise in the Northern division of Machakos district. Specifically summarized data is given for the revenue and cost structure of the coffee enterprise; selected socio-economic variables; agro-chemical inputs and measurements of their deviation from recommended levels of use and frequencies of application; and finally the farmer's evaluation of official recommendations.

7.1. MATURE COFFEE ENTERPRISE AVERAGE REVENUE AND COST STRUCTURE, 1977/78

The average mature coffee enterprise revenue and cost structure is shown in Table 7:1 below.

1.

TABLE 7:1 SAMPLE AVERAGE MATURE COFFEE ENTERPRISE REVENUE AND COST STRUCTURE 1977/78

	MEAN, SHS.	RANGE, SHS.	95% CONFIDENCE LIMITS	STAD. DEV.[4]
TOTAL REVENUE FROM COFFEE	6,394.60	802.00-28,061.65	6,394.60 ± 1,874.60	6,528.43
OPPORTUNITY COST OF FAMILY WEEDING LABOUR	847.02	198.02- 2,241.00	847.02 ± 147.80	513.95
HIRED WEEDING LABOUR	394.71	0.00- 4,482.00	394.71 ± 276.35	962.40
COST OF NITROGEN[2]	550.79	0.00- 1,971.70	550.79 ± 219.05	762.88
COST OF NITROGEN APPLICATION	65.92	0.00- 312.50	65.92 ± 26.25	91.46
COST OF SPRAYS[3]	279.92	0.00- 1,191.15	279.92 ± 147.80	514.78
COST OF SPRAY APPLICATION	27.20	0.00- 504.00	27.20 ± 27.10	94.45
COST OF PRUNING AND DESUCKERING	419.84	56.00- 2,700.00	419.84 ± 175.15	610.00
COST OF PICKING	323.72	45.50- 1,142.25	323.72 ± 91.50	318.70
DEPRECIATION OF EQUIPMENT (ANNUAL)	276.07	30.90 975.90	276.07 ± 72.97	254.13
INTEREST ON AVERAGE INVESTMENT VALUE OF COFFEE ENTERPRISE	1,424.20	289.30- 8,795.40	1,424.20 ± 484.80	1,688.50
NET FAMILY FARM INCOME	4,518.72	*-735.05-16,756.20	4,518.72 ± 1,310.95	4,565.60
NET FARM INCOME	3,339.60	*-2,392.45-14,386.80	3,339.60 ± 1,213.66	4,226.74
MANAGERIAL EARNINGS	1,993.60	*-3,581.28-11,939.60	1,993.60 ± 1,024.82	3,569.07

SOURCE : AUTHOR'S SURVEY
1 : APPENDIX TABLES 9- 30 SUMMARISE SAMPLE FARMER BY FARM.
2 : NITROGEN : INCLUDES NITROGEN FERTILIZERS AND FARM-YARD MANURE .
3 : SPRAYS : INCLUDES COPPER AND CAPTAFOL FUNGICIDES.
4 : STANDARD DEVIATION.
* : MINUS SIGNS.

Table 7:1 shows that the total coffee enterprise revenue received in the 1977/78 coffee crop year, ranged between Shs.802 and 28,062, with a sample average of Shs.6,395. The revenue distribution, however, indicates that the ten farmers with the largest number of coffee trees had an average revenue of Shs.14,840; while another ten with the lowest number of coffee trees received a mean income of Shs.1,686. Despite these large ranges, coffee is nevertheless the dominant crop, contributing 69 per cent on average to total farm revenue.

Coffee production costs incurred by small-holders include those for weeding labour; nitrogen, fertilizer and manure, sprays, and their application; pruning and desuckering; coffee picking; annual depreciation of equipment; and interest on the value of average investment in coffee enterprise.

Cost of weeding labour can be split into two, namely, that for the family and that for hired labour. Family labour contributes on average about 70 per cent of all the labour available for the coffee enterprise. The remaining 30 per cent is provided by hired persons. As a result the average opportunity cost for the family weeding labour is Shs.847 with a range of between Shs.198 and Shs.2,241. The average expenditure on the hired weeding labour is only Shs.395. When family and hired weeding labour costs are combined, weeding of coffee becomes the most expensive activity on the mature coffee enterprise.

Cost of nitrogen and its application is the second most expensive operation on the mature coffee enterprise. On average, each small-holder farmer interviewed spent Shs.551 to buy nitrogen and Shs.66 to apply it on the coffee enterprise. Application costs are rather high because nearly all the plant nutrients used were in the form of Farm-yard manure, which needs more labour to apply than the inorganic fertilizers. Thus, application cost of Shs.66 is equivalent to six and a half days of one man's work, since one day costs Shs.10 for either family or non-family labour.

Average coffee enterprise expenditure on fungicides in the 1977/78 crop year was Shs.280 and Shs.27 for the application. Cost of application was low because most of the farmers depend on the co-operative societies to spray their coffee free of charge. In fact the above spray application cost was incurred by farmers who pointed out that the co-operative society's "spray team" applied fungicides in a wasteful manner and therefore they preferred to hire better people to spray for them.

Sample average enterprise cost for pruning and desuckering operations is Shs.420. Pruning coffee trees is a more expensive activity than removing unwanted suckers, the former therefore costs the farmer Shs.0.50 while the latter costs Shs.0.30, per tree.

Enterprise expenditure on coffee picking ranges between Shs.46 for the farm with the lowest coffee yield and Shs.1,094 for that with the highest total yield. The sample average is Shs.324. Like weeding, picking is one of the

busiest times for the small-holder farmer and almost every one of them has to engage casual labour to help in picking coffee. Farmers without cash to pay for such labour may lose some of their crop which cannot be picked on time. As a matter of fact two of the farmers interviewed pointed out that they lose a substantial quantity of coffee every year because they never have enough money to hire sufficient labour to pick their coffee on time.

Both the annual depreciation of implements and the interest on value of the coffee enterprise are fixed costs. In so far as farmers do not pay these costs directly they can be seen by the farmer as being less onerous in the short run. The first one indicates the average annual cost of wear and tear and obsolescence of equipment used on mature coffee, while the second type of fixed cost shows the opportunity cost of investment in the coffee enterprise. The average depreciation per coffee enterprise was Shs.276, while mean annual interest on average investment was Shs.1,424 in the 1977/78 crop year.

Mean net family farm income, net farm income and managerial earnings are profitability levels which measure the average performance of the mature coffee enterprise in 1977/78. The average net family farm income received from 1977/78 coffee sales was Shs.4518. This is the income which acrues to the family before the opportunity cost of family labour is considered. When the opportunity cost of the family labour is taken into account, however, the residue income becomes the net farm income. The sample average net farm income received in 1977/78 was Shs.3,339 with a range of between Shs. - 2,392 and Shs.14,387. Net farm income may be regarded

as more realistic since it takes into account virtually all costs except interest on average investment value in the coffee enterprise. When the latter is deducted from the net farm income, however, we remain with the managerial earnings. The average managerial earnings in the same year was Shs.1994 ranging between Shs. - 3501 and Shs. 11,940. The sum Shs.1994, therefore, is mature coffee enterprise income which goes to the farm manager and is considered to be a profitability measure. The fact that all the above margins are, on average, positive is some indication that coffee small-holders were, on average, covering essential costs.

7:2. DATA SUMMARY ON SELECTED SOCIO-ECONOMIC VARIABLES

Table 7:2 below presents the average holding coffee data summary of selected socio-economic variables namely:- farmer's wealth, family labour, per centage of income from coffee as a proportion of total farm income, value of equipment used on mature coffee, coffee yield, mature coffee trees, total variable costs and total costs, extension contact days, farmer's education level and farmer's age.

TABLE 7:2 DATA SUMMARY OF SELECTED SOCIO-ECONOMIC VARIABLES FOR SAMPLE COFFEE HOLDINGS - 1977/78

SOCIO-ECONOMIC VARIABLES	MEAN	RANGE	95% CONFIDENCE LIMITS	STANDARD DEVIATION
1. WEALTH	SHS.55,404.60	3,661-243,000	55,404.60 ± 16,419.80	57,183.91
2. FAMILY LABOUR	2.17(PERSONS)	1 - 4	2.17 ± 0.32	1.12
3. PER CENTAGE OF INCOME FROM COFFEE ENTERPRISE AS A PROPORTION OF . TOTAL FARM INCOME	69	7 - 95	69 ± 6.8	24
4. VALUE OF EQUIPMENT APPORTIONED TO MATURE . COFFEE ENTERPRISE	SHS.1090.80	73 - 3,566	1090.80 ± 3331.14	1153.25
5. COFFEE YIELD	304.3 (KG.)	20.50 - 1432	304.3 ± 94.94	330.67
6. MATURE COFFEE TREES	502 (TREES)	70 - 3000	502 ± 192.63	681.36
7. TOTAL VARIABLE COST	SHS.2,777.60	552.55-14,326	2,777.60 ± 865.71	3014.96
8. TOTAL COST	SHS.4,470.61	1137.65 - 23,363.40	4,470 ± 1452.82	5059.64
9. EXTENSION CONTACT DAYS	2.83(DAYS)	0 - 8	2.83 ± 0.5	1.77
10. EDUCATION LEVEL	3.03(YEARS)	0 - 11	3.03 ± 0.97	3.41
11. AGE	46.51(YEARS)	21 - 70	46.51 ± 4.17	14.55

SOURCE : AUTHOR'S SURVEY.

Average farmer's wealth in this study includes the value of land under coffee, subsistence crops, and grazing land, livestock, buildings(including farm houses) and equipment. The wealth level of the poorest farmer in the sample was Shs.21,896 while that of the wealthiest farmer was Shs.243,441. The sample average wealth level, however, was Shs.55,405.

The average number of family members providing the mature coffee enterprise labour is 2. By and large this labour is performed by the wife and her husband, since virtually all children aged 7 and above are in school. In addition to the coffee enterprise the two also provide labour to several other enterprises on the farm which include:- subsistence crops, livestock and in some cases horticultural crops, or even a shop in the local market. The small number of family persons for the numerous farm operations, therefore, points to the severity of labour shortage in the coffee growing areas in Machakos district.

The higher per centage of income received from coffee vis-a-vis total farm enterprises, indicates the danger farmers face when coffee world prices fall, since they have no other significant cash crop to supplement coffee. It is, therefore, suggested that other cash crops, such as horticultural crops, which can do well in Machakos coffee growing areas, be adopted to minimize the risk of receiving low incomes during periods of low coffee world prices.

Average apportioned value of equipment to the mature coffee enterprise was Shs.1091 with a range of values showing Shs.73 and Shs.3,566. Equipment used in the mature coffee enterprise include pruning saw and shears, spraying pump, hoes, fork hoes, pangas, spades, and wheelbarrows, ploughs,

oxen-drawn carts, sacks, buckets, and debes. These equipment items are expensive and unless a farmer has a big coffee enterprise, it is obviously uneconomic purchasing some of them. Consequently, most farmers with few trees tend to have the pruning saw and shears, hoes, fork hoes, pangas, sacks, buckets and debes mainly. They carry coffee to the factories on their backs and use the co-operative spray pumps when need arises. Bigger mature coffee enterprises on the other hand, have most of the equipment, although not always in sufficient quantities. All the farmers interviewed therefore indicated their pressing need to have more equipment especially wheelbarrows and carts for transportation purposes. Thus if agro-chemical inputs are to be used well, it is necessary that farmers have enough equipment.

Average coffee yield per holding in the sample in 1977/78 crop year was approximately 304 kilogrammes of clean coffee[1], which is equivalent to 992 Kg. per hectare. This production level was reasonably high, considering that the estates in Kenya had only 1091 Kg. per hectare in the same year. The national average coffee production for the small-holders was however, much less at 844 Kg. per hectare[2] in the crop year 1977/78. The data analysis also indicates that the ten

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1. Milled Coffee.

2. Average yield for the sample was below the Machakos district official figure of 1511 Kg. per hectare. This raises the question as to whether the official figure itself is not too high. But since both the sample average (992 Kg. per hectare) and the Machakos district official figure (1511 Kg. per hectare) are higher than the national average figure (844 Kg. per hectare), one can feel happy that the sample average figure does not yet contradict the national official yield figure.

best small-holder farmers produced 1697 Kg. per hectare, while the poorest ten had only 410 Kg. per ha. This provides a clear indication of the low productivity of a fairly large number of small-holders, due mainly to poor coffee husbandry methods, especially the use of recommended agro-chemical inputs to control diseases and pests; and fertilizers to increase yield.

The mature coffee trees variable was put in the study to indicate the average coffee holding size. As is seen in Table 7.2, the average enterprise number of mature coffee trees is 502, which requires 0.37 hectares of land. The average number of mature coffee trees per enterprise, however, is between 1224 for the largest 10 farms in the sample, requiring 0.92 ha, and 153 trees for the smallest 10, requiring 0.114 ha. The latter group has, nevertheless, the highest productivity per hectare.

The per hectare production of the 10 smallest coffee farms was 1492 Kg., while that of the largest 10 farms was only 901 Kg. This indicates clearly that the smallest coffee enterprise were more intensively farmed.

Total variable costs per enterprise in Table 7.2. include weeding, purchase and application of nitrogen, cost of fungicides and their application, pruning and desuckering, picking of coffee and transportation costs. As expected, the larger small-coffee farms had more total variable costs per mature coffee enterprise than the very small ones, since they bought larger quantities of inputs than the latter.

Average total costs per enterprise in Table 7.2 are obtained by the addition of annual interest on the average investment value of the mature coffee enterprise, the total variable

costs stated above and the annual depreciation of equipment used on the mature coffee enterprise.

The average number of extension, contact days per farmer, in the crop year 1977/78 was approximately three. Thus, at least each small-holder in the sample was exposed to some form of extension such as a coffee farming demonstration, an agricultural tour, or a talk at the co-operative society's factory by coffee experts. Most of the farmers interviewed, however, indicated that such extension conduct was not educative enough especially on the coffee recommended rates of agro-chemical use and frequencies of application.

Small-holder coffee farmer education levels are extremely low, in fact, 48 per cent of the farmers interviewed were completely illiterate; approximately 6 per cent had completed primary education, while only approximately 9 per cent had finished secondary education. The sample average years of formal education, however, was 3. It is therefore obvious that the majority of the farmers cannot read growing recommendations, often written in Kiswahili or English.

The average age of the coffee farmers in the sample was approximately 47 years, which is fairly low for any farming community. Normally, this figure would be expected to be high, say over 60, depicting the fairly old farmers who own land. In the study however, only 31 per cent of the farmers interviewed were 65 or more years; the majority (40%) were either 40 years or below. There was, therefore an emphasis on younger people in the management of the mature coffee enterprise. The complexity of agro-chemical use, pruning and desuckering practices calls for younger management who can cope more easily. It was in fact observed that some farmers tended to subdivide the coffee enterprise amongst their mature sons, or ask one of the sons to help them in the management of the enterprise.

7:3 MEASUREMENTS OF DEVIATIONS FROM OFFICIAL RECOMMENDATIONS FOR MATURE COFFEE ENTERPRISE

In measuring the deviations from recommendations on an individual sample farm basis for nitrogen, copper fungicide and captafol applications on coffee trees, it is necessary to bear in mind that officially approved recommendations are stated by the C.R.F. with average annual conditions in mind. Therefore to the extent that individual farmers felt that the conditions facing them in the crop year studied called for variations in recommended application levels, frequencies and timing, departures from specifications may in fact be reasonably justified. The simple comparison between actual and recommended practice needs to be used carefully. However, where the deviation between actual and recommended practice is of considerable magnitude and degree, there can be little doubt as to shortcomings in efficiency of agro-chemical use. It is with such consideration that the following measurements of observed agro-chemical use from official recommendations are presented.

Table 7:3 shows average and other enterprise data for agro-chemical inputs applied by the sample of farmers interviewed. In addition,average recommended levels of inputs used by the same farmers are presented; and the magnitude of deviations from the recommendations shown in per centages.

TABLE 7:3 AVERAGE MATURE COFFEE ENTERPRISE LEVELS OF AGRO-CHEMICAL INPUTS COMPARED WITH OFFICIAL RECOMMENDATIONS - 1977/78

ACTUAL LEVEL OF USE					RECOMMENDED LEVEL		
VARIABLE (KG)[1]	MEAN (KG)	95% CONFIDENCE LIMITS	STD. DEV.*	DEV. FROM REC. (COMP.[3] OF SAMPLE MEANS)	MEAN (KG)	95% CONFIDENCE LIMITS	STD. DEV.
NITROGEN	63.30	63.30 ± 22.9	76.78	+ 62.7%	38.9	38.9 ± 12.7	44.5
COPPER	4.52	4.52 ± 2.72	8.91	- 73.7%	17.2	17.2 ± 6.4	22.3
CAPTAFOL[2]	1.2	1.2 ± 1.87	6.53	- 82.2%	6.76	6.76± 2.2	8.8

SOURCE : AUTHOR'S SURVEY

*STD.DEV.- STANDARD DEVIATION

DEV.FROM REC. - DEVIATION FROM RECOMMENDATION

1. - NITROGEN : INCLUDES NITROGEN FERTILIZERS AND FARM YARD MANURE

2. - ALSO KNOWN AS ORTHODIFOLATON.

3. - COMPARISON OF SAMPLE MEANS.

Table 7:3 shows that the mean recommended amount of pure nitrogen per enterprise in the 1977/78 crop year was 38.9 Kg., yet farmers applied an average of 63.3 Kg. which is 62.7 per cent above the recommended level. Nitrogen was over-used because most of it was available plentifully on the farms as farm-yard manure. Copper fungicide and captafol were on average under-used by as much as 73.7 and 82.2 per cent, for the former and the latter respectively. Indeed, farmers applied a mean 4.52 Kg of copper instead of the recommended average of 17.2 Kg.; and 1.2 Kg. of captafol while the recommended amount was 6.76 Kg. per enterprise within the crop year.

The sample average frequencies of application for agro-chemical inputs are shown in Table 7.4.

TABLE 7:4 - AVERAGE MATURE COFFEE ENTERPRISE FREQUENCIES OF AGRO-CHEMICAL APPLICATION COMPARED WITH OFFICIAL RECOMMENDATIONS - 1977/78

ACTUAL FREQUENCIES OF APPLICATION					RECOMMENDED LEVEL		
VARIABLE	MEAN	95% CONFIDENCE LIMITS	STD. DEV.[2]	DEV. FROM REC.[1] (COMP.* OF SAMPLE MEANS	MEAN	95% CONFIDENCE LIMITS	STD. DEV.[2]
NITROGEN[3]	1.97	1.97 ± 0.28	1.00	-51.5%	4	0	0
COPPER	1.94	1.9 ± 0.37	1.29	-75.75%	8	0	0
CAPTAFOL	1.71	1.71 ± 0.41	1.45	-78.6%	8	0	0

SOURCE : AUTHOR'S SURVEY

1. DEV. FROM REC. : DEVIATION FROM RECOMMENDATIONS
2. STD. DEV. : STANDARD DEVIATION
3. NITROGEN : INCLUDES NITROGEN FERTILIZERS AND FARM YARD MANURE.

* : COMPARISON OF SAMPLE MEANS.

Farmers are recommended to apply Farm-yard manure once, just before the short rains, in October, when the coffee crop year begins[1] in Machakos district. Chemical fertilizers are then applied later during the wet season. The recommended number of applications for the latter is 3 times. Observations, however, show that the mean frequency of application of nitrogen was 2. Virtually all the farmers interviewed pointed out that they applied farm-yard manure at least once during the dry months of September or October, and applied chemical fertilizers also once in the rain season. The mean deviation below official recommendation for nitrogen application frequency is therefore approximately 52 per cent. The mean deviations regarding frequencies of copper and captafol applications were even less satisfactory than for nitrogen. The recommended number of applications in the crop year for both fungicides, viz copper and captafol, is 8 times, yet hardly any farmer interviewed sprayed more than four times in the 1977/78 crop year. Therefore on average the farmers interviewed deviated from official recommendations by approximately 76 and approximately 79 per cent, in the number of times copper and captafol were applied respectively.

Graphs 7.1, 7.2 and 7.3 show the distributions of per centage deviations from recommended levels of agro-chemical inputs by the farmers interviewed. Deviation, whether above or below the corresponding recommendations are expressed in per centages on the horizontal axis while the number of farmers associated with such divergencies are given on the vertical axis. In the summary discussion that follows, only the mid-point per centages for divergence classes are quoted unless otherwise stated. The classes themselves are shown on the graphs.

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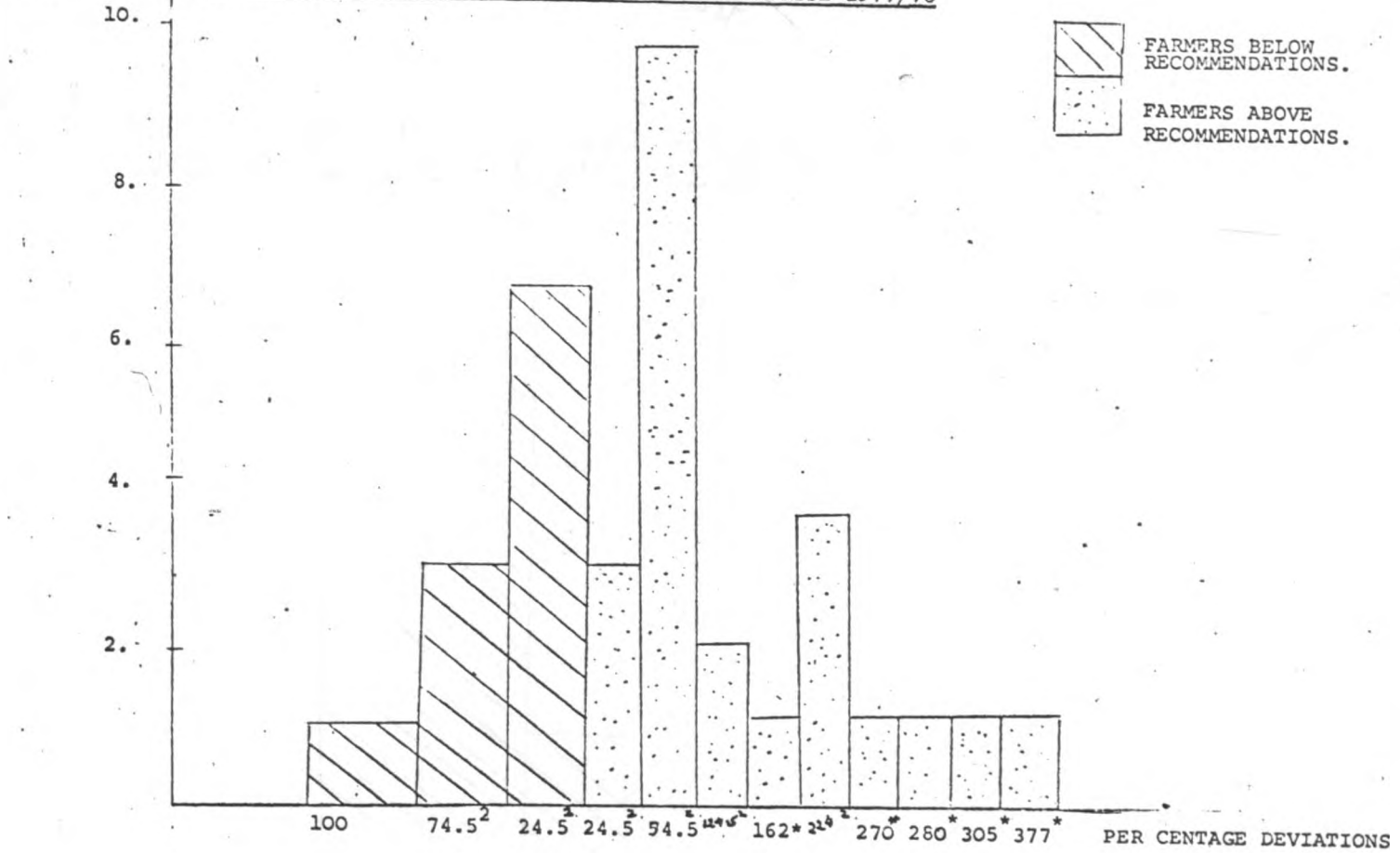
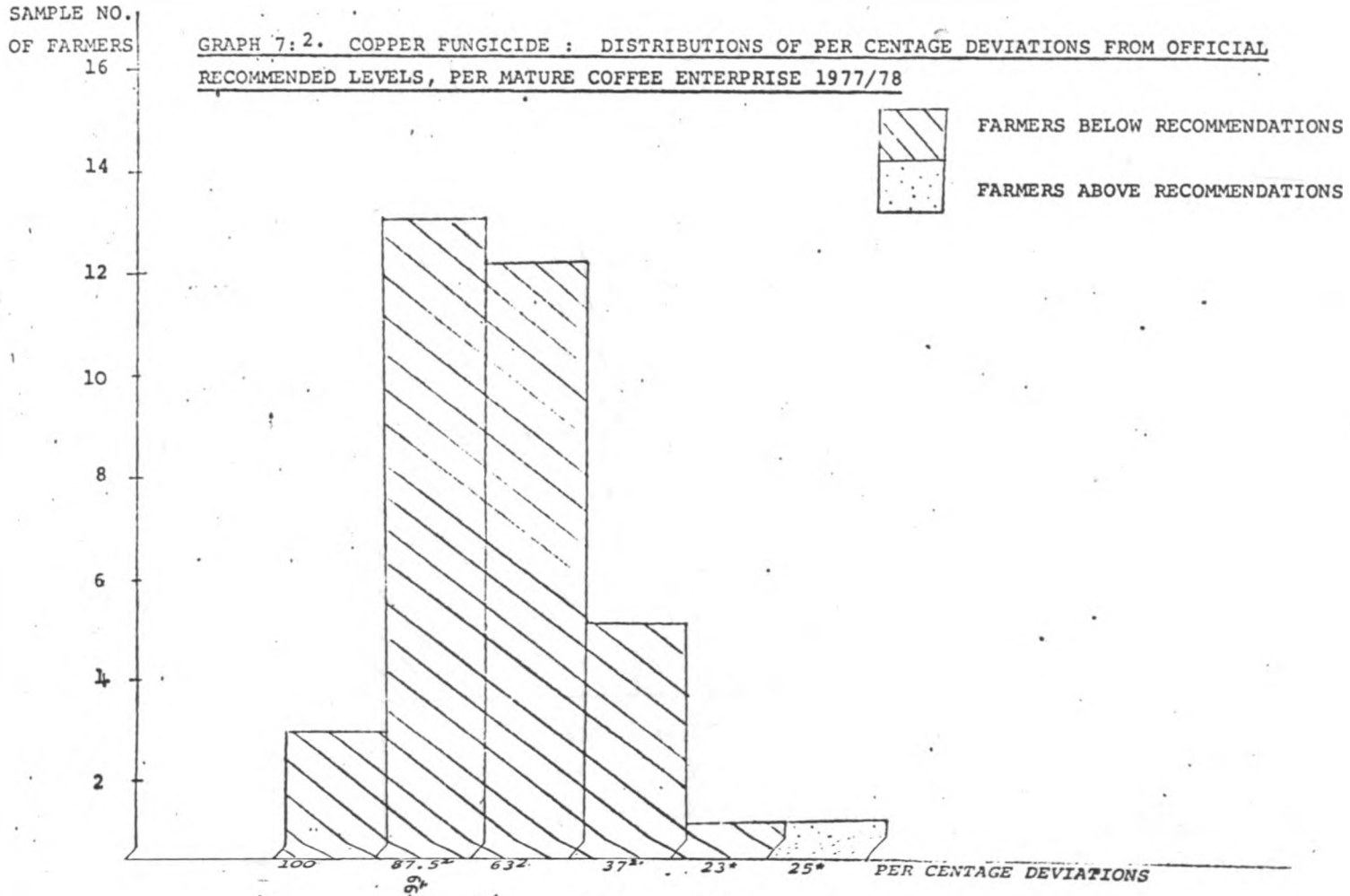
1. The coffee crop year in Machakos coffee growing areas begins in September - October.

GRAPH 7:1 NITROGEN : DISTRIBUTION OF PER CENTAGE DEVIATIONS FROM OFFICIAL RECOMMENDED LEVELS, PER MATURE COFFEE ENTERPRISE 1977/78



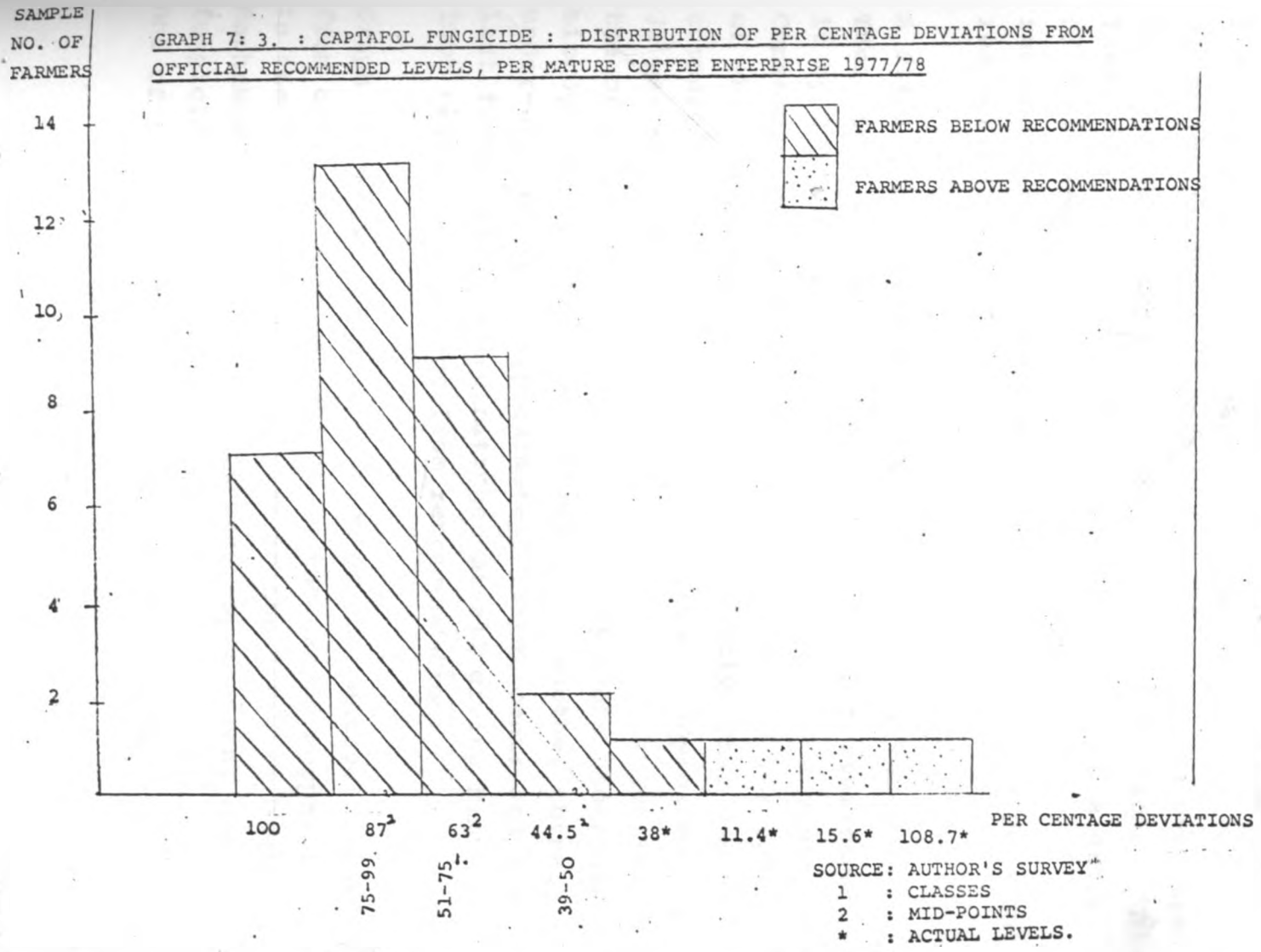
SOURCE : AUTHOR'S SURVEY
1. : CLASSES
2. : MID-POINTS
* : ACTUAL LEVELS.

GRAPH 7:2. COPPER FUNGICIDE : DISTRIBUTIONS OF PER CENTAGE DEVIATIONS FROM OFFICIAL RECOMMENDED LEVELS, PER MATURE COFFEE ENTERPRISE 1977/78



SOURCE : AUTHOR'S SURVEY
1 : CLASSES
2 : MID-POINTS
* : ACTUAL LEVELS.

GRAPH 7: 3. : CAPTAFOL FUNGICIDE : DISTRIBUTION OF PER CENTAGE DEVIATIONS FROM OFFICIAL RECOMMENDED LEVELS, PER MATURE COFFEE ENTERPRISE 1977/78



SOURCE: AUTHOR'S SURVEY

1 : CLASSES
2 : MID-POINTS
* : ACTUAL LEVELS.

Graph 7.1 shows that most of the farmers over-used nitrogen. Three farmers over-applied it above the recommendations by approximately 25 per cent; followed by a group of ten who were approximately 75 per cent above the recommendations; and two farmers who over-used nitrogen by 125 per cent above the recommendations. These were closely followed by one farmer; and a group of four farmers; who used nitrogen beyond the recommended levels by 162 and approximately 225 per cent respectively.

A final group consists of four individual farmers. These used nitrogen rather wastefully. They over-used it by 270,280,305 and 377 per cent (actual per centages). Consequently, 24 farmers or approximately 69 per cent of the sample used nitrogen extravagantly. This can be compared with the remaining 11 farmers or approximately 32 per cent of the sample, who used less nitrogen than the official recommendations. Seven of these under-used nitrogen by approximately 25 per cent; another three under-applied it by approximately 75 per cent; and the last farmer did not use nitrogen at all giving him 100% negative deviation from recommendation.

Graph 7.2 shows the distribution of per centage deviations from official recommendations in the use of copper fungicides in the 1977/78 coffee crop year in the Northern Division of Machakos district. Unlike nitrogen application, copper fungicide was applied below recommendations by all but one of the small-holder farmers in the sample.

This graph shows that one farmer under applied copper fungicides by 23 per cent only while 5 others sprayed below recommendations by 37 per cent. Groups of 12 and 13 farmers did even worse by using less copper than required by as much as 63 and approximately 88 per cent respectively. The last 3 farmers did worst of all by deviating negatively from official recommendations by 100 per cent. In contrast, however, only one farmer had over-sprayed, by 25 per cent.

Graph 7:3 is similar to Graph 2 in the sense that most of the deviations in the use of captafol are below official recommendations. One farmer was below recommendations by 38 per cent, followed by two who deviated negatively by approximately 45 per cent, and nine others who were 63 per cent below recommendations. Another group of 13 farmers were below the recommendations by 87 per cent. The last seven farmers in the sample, however, deviated negatively in the use of this fungicide by 100 per cent.
In all around 86 per cent of the farmers interviewed deviated negatively in the use of captafol fungicide. On the positive side, only three individual farmers over-used captafol by approximately 12, 16 and 109 per cent.

Detailed information about frequencies of application for each agro-chemical input is provided in Tables 7:5, 7:6 and 7:7 below.

TABLE 7:5. - NITROGEN : SAMPLE FREQUENCY OF APPLICATION - 1977/78.

ACTUAL FREQUENCIES OF APPLICATION	NUMBER OF FARMERS	PERCENTAGE
0	1	2.8
1	13	37.2
2	8	22.8
3	12	34.3
4	1	2.8
RECOMMENDED FREQUENCIES IN STUDY AREA 4	SAMPLE NUMBER 35	100

SOURCE : AUTHOR'S SURVEY.

Table 7:5 indicates that approximately 37 per cent of the farmers interviewed applied once, while approximately 34 per cent applied it three times. Only one farmer applied nitrogen four times which is the official recommended frequency. One farmer failed to apply nitrogen at all.

Table 7:6 shows frequencies of copper application in the study period.

TABLE 7:6 COPPER FUNGICIDES : SAMPLE FREQUENCY OF APPLICATION - 1977/78.

ACTUAL FREQUENCIES OF APPLICATION	NUMBER OF FARMERS	PERCENTAGE
0	3	8.6
1	7	20
2	17	48.6
3	5	14.3
4	2	5.7
5	1	2.8
6	0	-
7	0	-
8	0	-
RECOMMENDED FREQUENCY IN THE STUDY AREA 8	SAMPLE NUMBER 35	100 %

SOURCE : AUTHOR'S SURVEY.

Table 7:6 indicates that the highest frequency of copper application achieved by only one farmer in the whole sample was 5. Two farmers sprayed 4 times only. The majority of the farmers, however, fluctuated between 1 and 3 copper applications. Therefore approximately 49 per cent of the farmers sprayed copper fungicides twice, while 20 and 14 per cent applied once and three times respectively. A significant proportion (approximately 9 per cent) did not apply copper at all. The recommmended frequency of 8 applications was therefore never achieved.

Table 7:7 shows the frequencies of captafol application by sample farmers in the 1977/78 coffee crop year.

TABLE 7:7 - CAPTAFOL FUNGICIDE : SAMPLE FREQUENCY OF APPLICATION - 1977/78

ACTUAL FREQUENCIES OF APPLICATION	NUMBER OF FARMERS	PERCENTAGE
0	7	20
1	6	17.5
2	15	42.9
3	5	14
4	1	2.8
5	1	2.8
6	0	-
7	0	-
8	0	-
RECOMMENDED FREQUENCY IN STUDY AREA 8	SAMPLE NUMBER 35	100%

SOURCE : AUTHOR'S SURVEY.

The distribution of the application frequencies for captafol resembles that of copper application. Five was the highest application frequency for captafol application shown by only one farmer. Most farmers, sprayed captafol either once, twice or three times. The majority (approximately 43 per cent) sprayed twice, followed by another group (approximately 18.5 per cent) who sprayed once and 14 per cent who sprayed three times only. A relatively high per centage of the farmers (20 per cent) did not spray at all. Like copper fungicide captafol is recommended to be sprayed 8 times within a crop year. This frequency of application was not shown by any farmer interviewed.

7:4 TIMING OF AGRO-CHEMICAL USE - 1977/78

Tables 7:8, 7:9 and 7:10 indicate the months when each of the agro-chemical inputs studied was applied. The recommended months for the application of the inputs are also indicated.

TABLE 7:8 MONTHS WHEN NITROGEN WAS APPLIED BY SAMPLE FARMERS - 1977/78

MONTHS	NUMBER OF FARMERS	PERCENTAGE
JANUARY	-	
FEBRUARY	-	
MARCH	-	-
APRIL*	14*	40*
MAY*	6	17.4*
JUNE	-	-
JULY	-	-
AUGUST	-	-
SEPTEMBER[1]	17[1]	48.6[1]
OCTOBER[1]	17[1]	48.6[1]
NOVEMBER*	-	-
DECEMBER*	15*	42.9*

SOURCE : AUTHOR'S SURVEY.

* : RECOMMENDED MONTHS OF INORGANIC NITROGEN APPLICATION AND NUMBERS OF FARMERS APPLYING INORGANIC NITROGEN.

1. : RECOMMENDED MONTHS OF FARM-YARD MANURE APPLICATION AND NUMBER OF FARMERS JUST APPLYING FARM-YARD MANURE.

Recommended months for the application of inorganic nitrogen are April, May, November or December. September or October are recommended for farm-yard manure. As Table 7:8 indicates, 40 per cent of the farmers interviewed applid inorganic nitrogen fertilizers in April; approximately 17 per cent in May; and approximately 43 per cent in December; while about 49 per cent of the sample applied farm-yard manure in September and another 49 per cent applied it in October. In interviewing the farmers, it was noted that the common practice, adopted by each farmer, was to apply chemical fertilizers once in one of the recommended wet months, and also to apply farm-yard manure once in either September or October. In most cases therefore a farmer used two nitrogen applications in the crop year.

Table 7:9 below shows the months when sample farmers sprayed coffee with copper fungicides in 1977/78.

TABLE 7:9 - MONTHS WHEN COPPER FUNGICIDE WAS APPLIED BY SAMPLE FARMERS - 1977/78

MONTHS	NUMBER OF FARMERS	PERCENTAGE
JANUARY	4*	11.4*
FEBRUARY*	4*	11.4*
MARCH*	13*	37.3*
APRIL*	12*	34.3*
MAY*	5*	14.3*
JUNE*	2*	5.7*
JULY*	-	-
AUGUST	3*	8.6*
SEPTEMBER	4*	11.4*
OCTOBER	5*	14.3*
NOVEMBER*	9*	25.7*
DECEMBER*	11*	31.4*

SOURCE : AUTHOR'S SURVEY

* : RECOMMENDED MONTHS OF COPPER APPLICATION AND NUMBER OF FARMERS APPLYING COPPER FUNGICIDE.

Table 7:9 shows that the recommended months to spray copper fungicides in Machakos district are November, December, February, March, April, May, June and July. However, very few farmers applied copper in the above months. In November some 26 per cent of the farmers in the sample sprayed their coffee; in December the per centage increased to around 31 per cent. Some farmers (approximately 11 per cent) sprayed their coffee in January which is an unrecommended month. Another 11 per cent approximately used copper in February. The per centage increased in March to around 37 per cent and declined slightly in April to approximately 34 per cent, in May, to approximately 14 per cent, and in June to approximately 6 per cent.

No farmer used copper in the recommended month of July, while approximately 9, 11, and 14 per cent of the farmers applied copper fungicides in the unrecommended dry months of August, September and October. The extremely low per centage of farmers who used copper in each of the recommended months shows the generally unsatisfactory way in which this input is applied. Normally, each recommended month should indicate that at least over 75 per cent of the farmers sprayed their coffee with copper fungicides.

Table 7:10, indicates the months when captafol fungicide was used by sample farmers.

TABLE 7:10 - MONTHS WHEN CAPTAFOL WAS APPLIED BY SAMPLE FARMERS, 1977/78

MONTHS	NUMBER OF FARMERS	PERCENTAGE
JANUARY	4 *	11.4 *
FEBRUARY*	7 *	20 *
MARCH*	10 *	28.6 *
APRIL*	12 *	34.3 *
MAY*	5 *	14.3 *
JUNE*	1 *	2.8 *
JULY*	-	-
AUGUST	1 *	2.8 *
SEPTEMBER	3 *	8.6 *
OCTOBER	4 *	11.4 *
NOVEMBER*	5 *	14.3 *
DECEMBER*	6 *	17.2 *

SOURCE : AUTHOR'S SURVEY

* : RECOMMENDED MONTHS OF CAPTAFOL FUNGICIDE APPLICATION AND NUMBER OF FARMERS USING CAPTAFOL.

Table 7:10 also gives the recommended months for use of Captafol fungicides as ; November, December, February, March, April, May, June and July. The above Table, however, shows that farmers do not seem to keep this schedule, indeed they appear to spray coffee with captafol somewhat randomly without differentiating between the recommended wet and the unrecommended dry months. Thus, in November, which is a recommended month for captafol use, only around 14 per cent of the farmers interviewed sprayed it on coffee. The percentage increased slightly to about 17 per cent in December and then dropped to about 11 per cent in January, which is an unrecommended dry month. In February however, the per centage increased to 20 per cent. March showed a high per centage (approximately 29 per cent) of farmers using captafol. This per centage increased significantly in April to about 34 per cent and then declined to approximately 14 per cent in May and some 3 per cent in June. As with the use of copper fungicides, no farmer applied captafol in the month of July. In the dry months of August, September and October, approximately 3, 9 and 11 per cent of the farmers respectively, still applied captafol. Again in Table 7:9, it can in general be observed that farmers were not following closely the recommendations for spraying in particular months. This situation should raise the concern of both the Coffee Research Foundation, which makes the recommendations, and the extension service involved in the coffee sector.

7:5 EVALUATION OF OFFICIAL RECOMMENDATIONS BY SAMPLE FARMERS

Tables 11 and 12 give some main reasons why interviewed farmers failed to use agro-chemical inputs in the recommended way. Table 7:11 shows a general evaluation of the use of agro-chemical recommendations by the sample farmers.

TABLE 7:11 - EVALUATION OF RECOMMENDATIONS BY SAMPLE FARMERS, 1977/78

EVALUATION	NUMBER OF FARMERS	PERCENTAGE
FARMERS WHO SAID RECOMMENDATIONS WERE OPTIMAL	32	91.4
FARMERS WHO SAID RECOMMENDATIONS WERE TOO LOW	4	11.4
FARMERS WHO DID NOT KNOW	2	5.7
TOTAL SAMPLE	35	100

SOURCE : AUTHOR'S SURVEY.

Although none of the farmers interviewed used exactly their recommended levels of agro-chemical inputs or the frequencies of application, approximately 91 per cent did indicate that official recommendations were optimal and that if well applied, could result in considerably increased coffee yields. A few of them, however pointed out that the recommendations were on the low side, especially those concerning fungicides. This expression of opinion was in fact not reflected in the observed use of fungicides, where general under-utilization was found to be the case in the 1977/78 crop year. Only two farmers said that they did not know whether the official recommendations were adequate or not.

Table 7:12, takes a closer look at the farmers who in Table 11 stated that they thought the agro-chemical recommendations were optimal. Hence their main reason for not following such recommendations is of some interest and is listed in Table 7.12.

TABLE 7:12 - REASONS WHY 32 FARMERS STATING RECOMMENDATIONS TO BE OPTIMAL (TABLE 7.11) FAILED THEMSELVES TO USE AGRO-CHEMICAL RECOMMENDATIONS WELL IN 1977/78

REASONS	NUMBER OF FARMERS	PERCENTAGE
LACK OF WORKING CAPITAL	28	87.5
NO SPECIFIC REASON	4	12.5
TOTAL	32	100

SOURCE : AUTHOR'S SURVEY

Table 7:12 shows that 28 farmers out of the 32 indicated that they failed to follow recommendations strictly, because of lack of working capital. Consequently they were unable to buy enough agro-chemical inputs at the times required. Four farmers, however, said they had no specific reason for not using recommendations well.

The main reason stated by the 4 farmers in Table 7:11 for considering recommendations to be too low, was that their experience in using them, led to the conclusion that they did not improve markedly coffee yields.
Hence these farmers assumed the recommendations were on the low side and preferred to use larger quantities of fungicides. Nitrogen fertilizers on the other hand were over-used because they were plentifully obtained at the farm.

In conclusion, it can be stated from the sample data analysis, that interviewed farmers in the Northern division of Machakos district, deviate substantially from recommendations in the use of agro-chemical inputs and frequencies of application. In contrast to nitrogen, which was usually over-applied, copper and captafol fungicides in the main were seriously under-utilized.

CHAPTER VIII

TESTS OF HYPOTHESIS

The general and related specific hypotheses, already described in Chapter 5, are tested and the results presented in this chapter.

8:1. TEST RESULTS OF THE FIRST GENERAL HYPOTHESIS

The first general and related hypotheses are postulated to test whether farmers in the population deviated significantly from official recommendations in the use and frequencies of application of agro-chemical inputs on mature coffee enterprises in the Northern division of Machakos district. The tests of hypothesis are presented in Tables 8:1 and 8:2 below.

TABLE 8:1 TESTS OF HYPOTHESIS FOR POPULATION AVERAGE LEVELS OF AGRO-CHEMICAL USE ON MATURE COFFEE ENTERPRISES, 1977 - 78

NULL HYPOTHESIS (concerning population means)	CALCULATED 'Z' VALUE	TABULAR 'Z' VALUE	RESULT OF Ho. TEST[1].	LEVEL OF SIGNIFICANCE
1. NITROGEN USED = NITROGEN RECOMMENDED[2]	2.28	1.96	REJECT	0.05
2. COPPER FUNGICIDE USED = COPPER FUNGICIDE RECOMMENDED	-3.16	-1.96	REJECT	0.05
3. CAPTAFOL FUNGICIDE USED = CAPTAFOL RECOMMENDED	-2.47	-1.96	REJECT	0.05

SOURCE : AUTHOR'S SURVEY.

1. : NULL HYPOTHESIS. (two-sided test)

2. : NITROGEN FROM FARM-YARD MANURE AND

The three null hypotheses shown in Table 8:1 were rejected at the 0.05 level of significance in favour of the alternative hypotheses that on average farmers in the population deviate significantly from recommendations in the use of nitrogen, copper, and captafol fungicides on mature coffee enterprises.

Table 8:2, below, shows the results of tests of hypothesis concerning the frequencies of agro-chemical application on mature coffee enterprises in the crop year 1977/78.

TABLE 8:2 - TESTS OF HYPOTHESIS FOR POPULATION AVERAGE FREQUENCIES OF AGRO-CHEMICAL APPLICATION ON MATURE COFFEE ENTERPRISES, 1977/78

NULL HYPOTHESIS (concerning population means)	CALCULATED 'Z' VALUE	TABULAR 'Z' VALUE	RESULT OF Ho. TEST[1]	LEVEL OF SIGNIFICANCE
1. FREQUENCY OF NITROGEN APPLICATION = OFFICIAL RECOMMENDATIONS[2]	-12.68	-1.96	REJECT	0.05
2. FREQUENCY OF COPPER FUNGICIDE APPLICATION = OFFICIAL RECOMMENDATIONS	-78.8	-1.96	REJECT	0.05
FREQUENCY OF CAPTAFOL FUNGICIDE APPLICATION = OFFICIAL RECOMMENDATION	-78.3	-1.96	REJECT	0.05

SOURCE : AUTHOR'S SURVEY

1 Ho = NULL HYPOTHESES (two-sided test)

2 = NITROGEN FROM FARM-YARD MANURE AND INORGANIC FERTILIZERS.

In Table 8:2, the null hypotheses stating that population average farmer frequencies of agro-chemical application equal the recommended frequencies were rejected at the 0.05 level of significance. The alternative hypotheses stating unequal population means were therefore accepted.

Therefore the first general hypthesis stating that on average small-holder coffee farmers in the Northern division of Machakos district use recommended levels of agro-chemical inputs and frequencies of application on mature coffee enterprise for the period studied, is rejected. Consequently it can be ascertained statistically that small-holder coffee farmers on average deviated substantially from the use of official recommendations, based on comparisons of corresponding sample mean estimates (see footnote on page 64 concerning interpretation).

8:2 TEST RESULTS OF THE SECOND GENERAL HYPOTHESIS

The second general and related specific hypotheses, given in chapter 5, are tested to see whether linear relationships exist between expenditures on agro-chemical inputs and total variable costs and total costs on mature coffee enterprise in the crop year 1977/78. As explained under methodology, two least squares simple regression models, one ordinary least squares through the origin are used to test the specific hypotheses. In the former ($Y = a + bx$), α, the population intercept constant is tested to find out whether it is zero. In the later ($Y = bx$), β, the population regression coefficient is tested to see whether it is zero.

Tests of significance for the alpha constant estimates using ordinary least squares are shown in Table 8:3. Specific agro-chemical expenditures, as dependent variables and corresponding cost total, as independent variables are explained in relation to each equation estimated.

TABLE 8:3 - TESTS OF SIGNIFICANCE FOR THE ALPHA REGRESSION INTERCEPTS FOR MATURE COFFEE ENTERPRISE DATA, 1977/78 [1]

ESTIMATED EQUATION	INTERCEPT CONSTANT a [3]	REGRESSION COEFFICIENT b [3]	TABULAR t VALUES AT 0.05 LEVEL OF SIGNIFICANCE D.F. = 33 [2]	DEFINITION OF DEPENDENT VARIABLE	DEFINITION OF INDEPENDENT VARIABLE
1 (a)	19.17 (0.83)	0.061 (0.057)	1.697	Y= TOTAL NITROGEN EXPENDITURE ON MATURE COFFEE ENTERPRISE	X = TOTAL VARIABLE COSTS ON MATURE COFFEE ENTERPRISE
1 (b)	180.41 (1.23)	0.088* (3.77)	1.697	Y= TOTAL NITROGEN EXPENDITURE ON MATURE COFFEE ENTERPRISE	X = TOTAL COSTS ON MATURE COFFEE ENTERPRISE
2 (a)	202.409 (1.29)	0.1307* (3.44)	1.697	Y= TOTAL EXPENDITURE ON FUNGI-CIDES ON ON MATURE COFFEE ENTERPRISE	X = TOTAL VARIABLE COSTS ON MATURE COFFEE ENTERPRISE
2(b)	155.023 (1.36)	0.017 (1.64)	1.697	Y= TOTAL EXPENDITURE ON FUNGI-CIDES ON MATURE COFFEE ENTERPRISE	X = TOTAL COSTS ON MATURE COFFEE ENTERPRISE.

SOURCE: AUTHOR'S SURVEY

1 : ICL. XDS3 COMPUTER PROGRAMME, UNIVERSITY OF NAIROBI.

2 : DEGREES OF FREEDOM (SEE FOOTNOTE ON PAGE 111)

3 : FIGURES IN BRACKETS ARE CALCULATED 't' VALUES.

4 : FUNGICIDES INCLUDE COPPER AND CAPTAFOL

* SIGNIFICANT AT 5 PER CENT LEVEL (ONE-SIDED TEST).

Table 8:3 shows that all the intercept constants in regression equations 1 and 2 are not significant at the 0.05 level. As a result the hypotheses, that the $\alpha^s = 0$, the population constants for mature coffee enterprise data are zero, are not rejected.
These findings permit the use of least squares through the origin regression to establish whether fixed proportional relationships between agro-chemical expenditures and cost totals on an enterprise basis are in evidence. Interest centres on the significance of the regression coefficient estimates in Table 8.4. Once again the dependent and independent variables are defined for each equation estimated in the table.

See Table 8.7 on page 110, (bottom)

Degrees of freedom for the α and b in the multiple linear regression equation are obtained by employing the formula n-k-1, where n is the sample size and k the number of regressors. In the simple correlation tests, on the other hand, the formula n-2 (n is the sample size) is used.

TABLE 8: 4 - TESTS OF SIGNIFICANCE FOR BETA REGRESSION COEFFICIENT[1] FOR MATURE COFFEE ENTERPRISE DATA, 1977/78

ESTIMATED EQUATIONS	REGRESSION COEFFICIENTS b^3	TABULAR 't' VALUES AT 0.05 LEVEL OF SIGNIFICANCE DF = 33[2]	DEFINITION OF DEPENDENT VARIABLES	DEFITION OF INDEPENDENT VARIABLES
1 (a)	0.145* (18.58)	1.697	Y=TOTAL NITROGEN EXPENDITURE ON MATURE COFFEE ENTERPRISE	X=TOTAL VARIABLE COSTS ON MATURE COFFEE ENTERPRISE
1 (b)	0.086* (15.63)	1.697	Y=TOTAL NITROGEN EXPENDITURE ON MATURE COFFEE ENTERPRISE	X=TOTAL COSTS ON MATURE COFFEE ENTERPRISE
2 (a)	0.057* (13.86)	1.697	Y=TOTAL FUNGICIDE EXPENDITURE ON MATURE COFFEE ENTERPRISE	X=TOTAL VARIABLE COSTS ON MATURE COFFEE ENTERPRISE
2 (b)	0.035* (14.58)	1.697	Y=TOTAL FUNGICIDE EXPENDITURE ON MATURE COFFEE ENTERPRISE	X=TOTAL COSTS ON MATURE COFFEE ENTERPRISE

SOURCE : AUTHOR'S SURVEY
1 : ICL. XDS3, COMPUTER PROGRAMME, UNIVERSITY OF NAIROBI.
2 : DEGREES OF FREEDOM
3 : FIGURES IN BRACKETS ARE CALCULATED 't' VALUES.
* : SIGNIFICANT AT 5 PER CENT LEVEL (ONE-SIDED TEST).

Thus all the regression coefficients estimated in Table 8:4 are significant at the .05 level. Thus the null hypothesis in each case, that β for the population equals zero, can be rejected. Fixed proportional relationships between the points of variables studied are inferred for the period under study.

The fixed proportionate relationships indicated mean that small-holders tended to incur total expenditures on nitrogen and fungicides on their mature coffee enterprises in fixed proportional relationship to total variable costs and total costs on the same enterprise. For instance equation 1a. states that an increase of 100 Shs. in total variable costs on the mature coffee enterprise was accompanied by an increase of 14.5 Shs. in nitrogen expenditure on the same enterprise and vice-versa. No consideration of size of enterprise is made in the analysis, since only total enterprise input and cost values are regressed. The fact that the linear relationship quoted goes through the origin, indicates that a fixed proportion of .145 (14.5 ÷ 100) exists at all levels for the two variables. Hence it should be noted that the individual enterprises studied had co-ordinate points around the line of regression. The latter therefore estimates an average relationship (trend) for the data.

The second general hypothesis, that, small-holder expenditures on a mature coffee enterprise basis on agro-chemical inputs do not show linear relationships with total variable costs and total costs, is therefore rejected. Evidence from the sample of small-holders in 1977/78 suggests the existence of fixed proportional relationships for the pairs of variables defined.

8:3 TEST RESULTS OF THE THIRD GENERAL HYPOTHESIS

8:3:1. CORRELATION RESULTS FOR MATURE COFFEE PER HECTARE AND PER ENTERPRISE DATA

Levels of agro-chemical use and frequencies of application on mature coffee per hectare and per enterprise were correlated with selected socio-economic variables viz: farmer's wealth; family labour on mature coffee (per hectare and per enterprise), coffee yield; mature coffee trees per enterprise; total variable cost and total cost on mature coffee (per hectare and per enterprise) coffee net family farm income, net farm income, and managerial earnings (per hectare and per enterprise); number of extension contact days; farmer's education level and age.

Simple correlations for mature coffee data per hectare are presented in Table 8:5, and those for total enterprise data are shown in Table 8.6.

8:3:2. CORRELATION RESULTS FOR MATURE COFFEE PER HECTARE DATA

The obvious general observation from Table 8:5 is that the correlation coefficients are fairly low,and many of them not significant. Variables such as farmer wealth; coffee yield per hectare; net family farm income, net farm income, managerial earnings from coffee per hectare, number of mature coffee trees per enterprise (actual size), extension contact days, education level and farmer's age, are not significantly correlated with per hectare levels of use of agro-chemicals and their frequencies of application. Some comments follow with respect to these particular findings.

Farmer's wealth may not be significantly correlated with per hectare levels of agro-chemical use and frequencies of application, because, being mostly in the form of fixed assets, it can not be easily converted into cash to increase the use of agro-chemicals or for that matter to offset the risk of higher inputs.

TABLE 8:5 - CORRELATION[I] RESULTS FOR MATURE COFFEE PER HECTARE DATA, 1977/78

VARIABLES[I]	WEALTH	FAMLB	PROCF	EQUPM	YIEHA	TOTVC	TOTCST	NFLHA	NFIHA	MAGHA	MATRS	EXTEN	YEARS	EDUCN
KGHAN	-0.052	0.390*	-0.181	0.204	-0.058	0.306	0.215	-0.041	-0.052	-0.059	-0.127	-0.031	-0.097	-0.062
FREQN	0.198	0.368	0.031	-0.156	0.057	0.092	0.092	0.090	0.099	0.108	0.235	0.052	0.015	0.099
KGHAC	-0.058	0.465*	-0.060	-0.213	0.006	0.334	0.198	0.021	0.010	0.013	-0.083	-0.062	-0.060	-0.004
FREQC	0.029	0.017	0.407*	0.441*	0.236	-0.017	-0.169	0.276	0.308	0.319	0.092	0.160	0.051	-0125
KGHAD	-0.269	0.456*	0.352*	0.245	0.143	0.520*	0.493*	0.123	0.042	0.039	-0.244	-0.062	-0.098	0.151
FREQD	-0.081	0.083	0.065	0.081	0.190	0.215	0.243	0.160	0.130	0.137	0.054	0.042	0.111	-0.081

SOURCE: AUTHOR'S SURVEY

I. LEVELS OF SIGNIFICANCE ARE OBTAINED FROM FISHER AND YATES STATISTICAL TABLES (12)

2. ICL. XDS3 COMPUTER PROGRAM, UNIVERSITY OF NAIROBI

* SIGNIFICANT AT 5 PER CENT LEVEL (IF VALUE IS $\geq$ .3246)

SIGNIFICANT AT 10 PER CENT LEVEL (IF VALUE IS $\geq$ .2746)

I: VARIABLES USED:

KGHAN = KILOGRAMMES OF NITROGEN USED PER HECTARE OF MATURE COFFEE

FREQN = FREQUENCY OF NITROGEN APPLICATION PER HECTARE OF MATURE COFFEE

KGHAC = KILOGRAMMES OF COPPER FUNGICIDE USED PER HECTARE OF MATURE COFFEE

FREQC = FREQUENCY OF COPPER APPLICATION PER HECTARE OF MATURE COFFEE

KGHAD = KILOGRAMMES OF CAPTAFOL USED PER HECTARE OF MATURE COFFEE

FREQD = FREQUENCY OF CAPTAFOL APPLICATION PER HECTARE OF MATURE COFFEE

WEALTH = WEALTH LEVEL OF FARMER

FAMLB = FAMILY LABOUR PER HECTARE OF MATURE COFFEE

PROCF = PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME

EQUIPM = VALUE OF EQUIPMENT USED ON COFFEE PER HECTARE

YIEHA = EXPECTED YIELD OF COFFEE PER HECTARE

TOTVC = TOTAL VARIABLE COSTS PER HECTARE

TOTCST = TOTAL COSTS PER HECTARE

NFLHA = NET FAMILY FARM INCOME PER HECTARE

NFIHA = NET FARM INCOME

MAGHA = MANAGERIAL EARNINGS PER HECTARE

MATRS = NUMBER OF TREES IN THE MATURE COFFEE ENTERPRISE (since there are a constant 1330 trees per hectare this variable becomes a size of enterprise measure)

EXTEN = EXTENSION CONTACT DAYS

YEARS = FARMER'S AGE

EDUCN = EDUCATION LEVEL OF FARMER

Achieved coffee yields per hectare reflecting no doubt short-term expectations, are probably not high enough in general to influence coffee small-holders in the use of agro-chemicals. Furthermore the failure of small-holders to adhere to recommendations in the use of agro-chemicals may well explain the lack of correlation with yield on a per hectare basis.

The three profitability measures, namely : net family farm income, net farm income, and managerial earnings per hectare of mature coffee, are probably not significantly correlated with per hectare of agro-chemical inputs and frequencies of application because of small-holder's failure to follow recommendations strictly.

The non-significant correlation coefficients between the size of enterprise (number of mature coffee trees per enterprise) and the levels of agro-chemical use per hectare and frequencies of application, is an indication that as mature coffee enterprise size increases or decreases the levels of agro-chemical use per hectare and frequencies of application do not appear to increase or decrease. Thus intensity of agro-chemical use does not seem to be related to size of coffee enterprise.

The findings that extension contact days, farmer education level and age are not correlated with per hectare agro-chemical use data, is not really surprising. Given that extension contact is still generally infrequent and often lacking in purpose and content there seems little reason that it should be associated with the use of agro-chemicals, especially when not following recommendations. It would also seem hard to reason a priori that farmer education level and age would show correlation with agro-chemical input levels.

Family labour (number of adult equivalents) per hectare is significantly and positively correlated with nitrogen, copper and captafol fungicides used per hectare, as well as the frequency of nitrogen application. Levels of agro-chemical use and the frequency of nitrogen application is therefore shown to vary directly with the family labour available.

The frequency of copper fungicide application and level of captafol used per hectare are both significantly and positively correlated with the income from coffee as a proportion of total farm income. Also the value of equipment used on mature coffee per hectare is significantly and positively correlated with the frequency of copper application.

Total variable costs and total costs on mature coffee per hectare are significantly and positively correlated with the level of captafol used per hectare on mature coffee. This particular result adds to the previous finding concerning the fixed proportional relationship concerning total enterprise expenditure on fungicides and total costs. It is interesting because it applies independent of farm size and therefore represents an intensity relationship. It is noteworthy that similar results do not show up in the case of the other agro-chemicals studied.

8:3:3 CORRELATION RESULTS FOR MATURE COFFEE ENTERPRISE DATA

It was decided to explore whether significant correlation existed on a mature enterprise basis between the levels of use of agro-chemicals and frequencies of application and the socio-economic variables. The results for this analysis are summarized in Table 8:6.

TABLE 8:6 CORRELATION[1] RESULTS FOR MATURE COFFEE ENTERPRISE DATA, 1977/78[2]

VARIABLES[3]	WEALTH	FAMLB	PROCF	EQUIPM	YIEFM	TOTVC	TOTCST	MATRS	NFLFM	NFIFM	MAGFM	EXTEN	YEARS	EDUCN
YGNFM	0.871*	0.417*	0.224	0.617*	0.775*	0.927*	0.932*	0.929*	0.566*	0.527*	0.182	0.128	0.078	-0.205
FREQN	0.449*	0.664*	0.028	0.147	0.305	0.349*	0.339*	0.346*	0.298	0.276	0.166	-0.022	0.073	-0.043
YGCPM	0.770*	0.337*	0.209	0.457*	0.619*	0.884*	0.892*	0.879*	0.315	0.287	-0.063	-0.104	0.035	-0.157
FREQC	0.025	0.077	0.407*	-0.207	0.245	0.083	0.083	0.102	0.335*	0.346*	0.371*	0.141	0.237	-0.144
YGLPM	0.612*	0.172	0.148	0.409*	0.648*	0.732*	0.706*	0.695*	0. 437*	0.419*	0.159	0.048	0.019	-0.185
FREQD	-0.087	0.016	0.077	0.146	0.143	0.072	0.069	0.057	0.161	0.163	0.182	0.073	0.147	-0.141

SOURCE: AUTHOR'S SURVEY

1. LEVELS OF SIGNIFICANCE ARE OBTAINED FROM FISHER AND YATES STATISTICAL TABLES (12)
2. ICL. XDS3. COMPUTER PROGRAM, UNIVERSITY OF NAIROBI.
* SIGNIFICANT AT .5 PER CENT LEVEL (IF VALUE IS $\geq$ .3246)
SIGNIFICANT AT 10 PER CENT LEVEL (IF VALUE IS $\geq$ .2746)

3. VARIABLES USED:

YGNFM = KILOGRAMMES OF NITROGEN USED PER MATURE COFFEE ENTERPRISE
FREQN = FREQUENCY OF NITROGEN APPLICATION PER MATURE COFFEE ENTERPRISE
YGCPM = KILOGRAMMES OF COPPER FUNGICIDE USED PER MATURE COFFEE ENTERPRISE
FREQC = FREQUENCY OF COPPER APPLICATION PER MATURE COFFEE ENTERPRISE
YGLPM = KILOGRAMMES OF CAPTAFOL FUNGICISE USED PER MATURE COFFEE ENTERPRISE
FREQD = FREQUENCY OF CAPTAFOL APPLICATION USED PER MATURE COFFEE ENTERPRISE
WEALTH = FARMER'S WEALTH LEVEL.
FAMLB = FAMILY LABOUR ON MATURE COFFEE ENTERPRISE
PROCF = PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME
EQUIP = VALUE OF EQUIPMENT USED ON THE MATURE COFFEE ENTERPRISE
YIEFM = EXPECTED TOTAL YIELD OF COFFEE FROM THE MATURE COFFEE ENTERPRISE
TOTVC = TOTAL VARIABLE COST FROM THE MATURE COFFEE ENTERPRISE
TOTCST = TOTAL COST FROM THE MATURE COFFEE ENTERPRISE
MATRS = NUMBER OF TREES IN THE MATURE COFFEE ENTERPRISE
(Since there are a constant 1330 trees per hectare this variable becomes a size of enterprise measure)
NFLFM = NET FAMILY FARM INCOME FROM THE MATURE COFFEE ENTERPRISE
NFIFM = NET FARM INCOME FROM THE MATURE COFFEE ENTERPRISE
MAGFM = MANAGERIAL EARNINGS FROM THE MATURE COFFEE ENTERPRISE
EXENT = EXTENTION CONTACT DAYS
YEARS = FARMER'S AGE
EDUCN = FARMER'S EDUCATION LEVEL

It should be noted in Table 8:6 that an enterprise size variable, number of trees in the mature coffee enterprise, has been included in the correlation analysis. This is because total enterprise data are used and therefore it is of interest to know whether increasing size of enterprise is correlated with other main variables. Correlations between total enterprise variables other than size may well indicate joint size and intensity relationship. Here it will be recalled that previous correlations, involving per hectare data do focus on simple average intensity relationships on farms.

Significant and positive correlations are shown in Table 8.6 between number of trees in the mature coffee enterprise and levels of use of nitrogen, copper and captafol fungicides regarding the mature coffee enterprise. Number of coffee trees is also significantly correlated with frequency of application of nitrogen, which is not the case with fungicide frequencies of application.

In specified cases other socio-economic variables significantly and positively correlated with levels of agro-chemical use and frequencies of application in Table 8:6 are: farmer wealth; family labour on the mature coffee enterprise; per centage of income from coffee as a proportion of total farm income; value of equipment apportioned to the mature coffee enterprise; total enterprise coffee yield; total variable cost and total costs for the mature coffee enterprise; total number of mature coffee trees; and net family farm income, net farm income and managerial earnings for the mature coffee enterprise. In contrast extension contact days, farmer's age and level of education were not significantly correlated with any of the levels of agro-chemical use and frequencies of application.

On a mature coffee enterprise basis, farmer's wealth was significantly correlated with:-

(a) levels of use of nitrogen, copper fungicide, and captafol; and

(b) nitrogen application frequency .

Family labour applied to the coffee enterprise is significantly correlated with levels of nitrogen and copper fungicide use, and the frequency of the nitrogen application. The per centage of income from coffee as a proportion of total farm income is only significantly correlated with frequency of copper application. Value of equipment apportioned to the mature coffee enterprise is significantly correlated with the levels of the three agro-chemicals, but not with their frequencies of application. Total coffee yield from the enterprise was also correlated with levels of agro-chemical use, but not frequencies of application.

Total variable costs and total costs on the mature coffee enterprise were both correlated significantly with levels of nitrogen, copper fungicide and captafol use; and frequency of nitrogen application.

The three profitability measures used: net family farm income, net farm income and managerial earnings per coffee enterprise, were found to be correlated significantly with certain levels of agro-chemical input used and their frequencies of application. For instance nitrogen used on the mature coffee enterprise was correlated with net family farm income and net farm income. The frequency of copper application was significantly correlated with all three profitability measures. The enterprise level of captafol used was significantly correlated with net family farm income and net farm income.

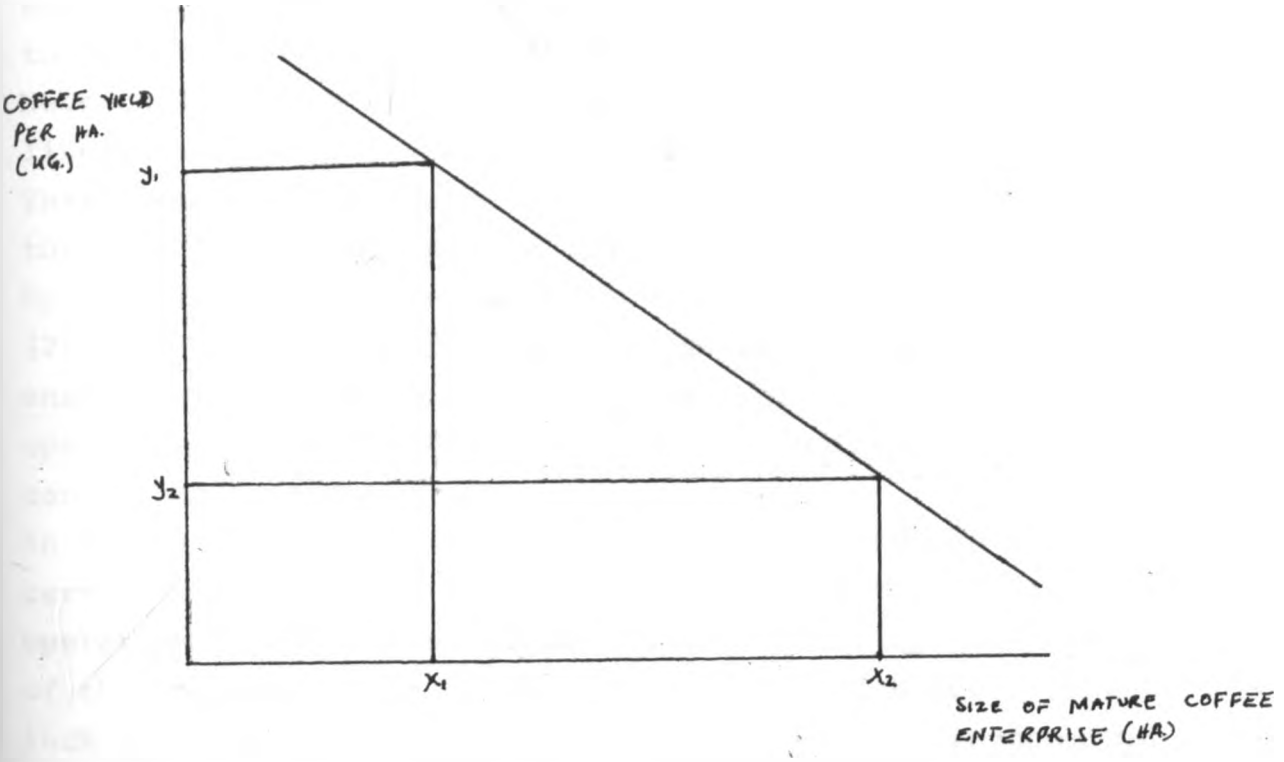
When correlation coefficients for per hectare mature coffee data are compared with those for mature coffee enterprise data, five socio-economic variables, namely: family labour; per centage of income from coffee as a proportion of total farm income; value of equipment apportioned to coffee; total variable costs and total costs are found to be significantly correlated with all or some levels of agro-chemical use and frequencies of application in both cases.

The common factor in the two types of analysis is that concerning intensity, although in the case of total enterprise data the effects of intensity and size cannot be separated, and therefore a straight comparison of the two sets of correlation results is really inappropriate. The next section looks more closely at the correlation between yield per hectare (yield intensity) and size of coffee enterprise.

8:3:4: COFFEE YIELD PER HECTARE CORRELATED WITH SIZE OF MATURE COFFEE ENTERPRISE IN HECTARES

The correlation analysis between size of mature coffee enterprise in hectares in the crop year 1977/78 and coffee yield per hectare produced in the same period, gave a negative correlation coefficient of -0.28, which is significant at the 0.10 level. Diagramatically this negative correlation implies a simple linear relationship of the form shown below.

DIAGRAM 8:1 COFFEE YIELD CORRELATED WITH SIZE OF MATURE COFFEE ENTERPRISE



The above correlation result is however somewhat inconclusive because of the .10 level of significance, which is not usually acceptable. If some credence is attached to the result, its importance lies in the fact that the small mature coffee enterprises tended to produce higher yields per hectare and could therefore be considered more intensive from the yield aspect.

It will be recalled, however, that yield per hectare was not significantly correlated with per hectare levels of use of agro-chemicals (See Table 8.5).
Consequently apart from noting the specific correlation coefficient, any attempt at separating out intensity and size effects other than what has been done already is likely to lead to inconclusive results.
Nevertheless, one important factor can be suggested as likely to influence yields of coffee per hectare on farms. That factor is management and it is reasonable to deduce that (1) yields per hectare can be favourably influenced by competent and intensive management, and
(2) such conditions are likely to arise on small coffee enterprises, where family labour can perform most of the operational work on coffee and close management supervision can be maintained.
In relation to this statement, it can be noted that in certain aspects, e.g. close supervision and timing of operations, application of management is really independent of the intensity with which inputs are used. Hence although lack of correlation was noted earlier between agro-chemical inputs and application frequency per hectare, and size of coffee enterprise,this does not contradict the postulate that intensive management on small coffee enterprises can lead to higher per hectare yields.

8:4 MULTI-LINEAR REGRESSION RESULTS

The socio-economic variables significantly correlated with levels of agro-chemical use and frequencies of application, were further used in multi-linear regression analysis.[I] The regression analysis was performed for both per hectare and per enterprise mature coffee data in the I977/78 crop year.
Respective results are presented in Tables 8.7 and 8.8.

8:4:I MULTI-LINEAR REGRESSION RESULTS FOR MATURE COFFEE PER HECTARE DATA

Table 8.7 presents the results of the first regression analysis (on per hectare data), using levels of agro-chemical and frequencies of application, as dependent variables. Thus, in equation I(a) the dependent variable is the level of nitrogen used, while in I (b) it is the frequency of nitrogen application. In equation 2(a) the level of copper fungicide use is the dependent variable, and in 2(b) the frequency of copper application is the dependent variable. In equation 3, the level of captafol use acts as the dependent variable.
Similar dependent variables, only this time concerning total enterprise data, are used in the second regression analysis summarized in Table 8.8.

I. The coefficient of determination (R^2) may be defined as the proportion of explained variation in the dependent variable accounted for by the use of selected independent variables in the regression.

In the first equation, 1(a) in Table 8.7, family labour and total variable cost on mature coffee per hectare were regressed against the level of the nitrogen applied on coffee per hectare, and a coefficient of determination (r^2) of 0.16 obtained[1]. The regression results, therefore, show that on a per hectare basis the two socio-economic variables, viz: family labour and total variable costs, had no significant influence on the use of nitrogen on mature coffee in 1977/78 coffee crop year. Also as might be expected none of the regression coefficients was significant at the 0.05 level.

In the second equation only one socio-economic variable, family labour per hectare, was regressed against frequencies of nitrogen application to give a coefficient of determination (r^2) of 0.13. The low r^2 value indicates that family labour per hectare alone cannot explain adequately the frequencies of nitrogen application in the year of study. Likewise, family labour and total variable cost per hectare of mature coffee were not found to influence the use of copper fungicides per hectare strongly, $r^2 = 0.22$, although as equation 2(a) shows, family labour per hectare had a significant regression coefficient at the .05 level.

In regression equation 2(b) two socio-economic variables, viz: per centage of income from coffee as a proportion of total farm income and the value of equipment used per hectare of mature coffee were regressed against the frequency of copper fungicide application. A coefficient of determination (r^2) of 0.24 was obtained indicating that these socio-economic variables did not adequately influence the frequencies of copper application on mature coffee. Lastly, equation 3 consists of three socio-economic variables: family labour per hectare; total variable cost per hectare; and per centage of income from coffee as a proportion of total farm income, regressed against the level of captafol used on the mature coffee per hectare.

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1. As indicated in the Chapter on methodology the possibility of multicolineality occurring was taken into consideration when selecting independent variables for regression analysis.

TABLE 8:7 - STEPWISE REGRESSION RESULTS FOR MATURE COFFEE PER HECTARE DATA, 1977/78 [1]

ESTIMATED EQUATION	INTERCEPT CONSTANT a.	REGRESSION COEFFICIENTS (bs) FOR x1.	x2	x3	x4	TABULAR 't' VALUES AT 0.05 LEVEL OF SIGNIFICANCE DF-30 [3]	R^2	DEFINITION OF DEPENDENT VARIABLES	DEFINITION OF INDEPENDENT VARIABLES WITH REGARD TO ALL EQUATIONS.
1 (a)	105.08 (1.68)	3.69 (1.59)	0.0046 (0.60)			1.697	0.16	Y=NITROGEN PER HECTARE ON MATURE COFFEE	X1= FAMILY LABOUR PER HECTARE OF MATURE COFFEE. X2= TOTAL VARIABLE COSTS PER HECTARE OF MATURE COFFEE X3= PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME X4= VALUE OF EQUIPMENT ON MATURE COFFEE PER HECTARE
1 (b)	1.565 (0.25)	0.039 (0.17)				1.697	0.13	Y=FREQUENCY OF NITROGEN APPLICATION ON MATURE COFFEE PER HECTARE	
2 (a)	3.88 (0.60)	0.509* (2.11)	0.004 (0.50)			1.697	0.22	Y=COPPER PER HECTARE ON MATURE COFFEE	
2 (b)	1.9244* (2.13)			0.317 (0.27)	0.000088 (1.65)	1.697	0.24	Y=FREQUENCY OF COPPER APPLICATION ON MATURE COFFEE PER HECTARE.	
3	1.2507 (0.35)	-0.092 (1.39)	0.00063 (0.95)	4.369* (2.04)		1.697	0.35	Y=CAPTAFOL PER HECTARE ON MATURE COFFEE	

SOURCE : AUTHOR'S SURVEY .
1 : ICL. XDS3 COMPUTER PROGRAMME, UNIVERSITY OF NAIROBI.
2 : FIGURES IN BRACKETS ARE CALCULATED 't' VALUES.
3 : DEGREES OF FREEDOM FOR NEAREST TABULAR VALUE.
* : SIGNIFICANT AT 5 PER CENT LEVEL (ONE-SIDED TEST).

As indicated in Table 8.7 these variables gave an r^2 of 0.35, which shows their low influence on the level of captafol used per hectare. However, one variable in the equation, the value of equipment on mature coffee per hectare, had a significant regression coefficient at the .05 level.

8:4:2 MULTI-LINEAR REGRESSION RESULTS FOR MATURE COFFEE TOTAL ENTERPRISE DATA

The coefficients of determination (r^2) in the regression analysis for the mature coffee total enterprise data are noticeably higher than those for the mature coffee per hectare data. These results are no doubt presaged by the reasonably high correlation coefficient values already obtained for this data. Notwithstanding these more positive findings, the regression equations for the mature coffee total data presented in Table 8:8 should still be viewed cautiously.

In regression equation 1(a), Table 8:8, family labour, value of equipment and total coffee yield on the mature coffee enterprise, were regressed against the level of nitrogen used. A coefficient of determination (r^2) of 0.70 was obtained, indicating that these socio-economic variables were found to influence considerably the level of nitrogen used. Two of the three socio-economic variables used in the model had also significant regression coefficients at the .05 level, namely : family labour and the value of equipment used. In regression equation 1(b), where family labour and percentage of income from coffee as a proportion of total farm income are regressed against frequency of nitrogen application, an r^2 of 0.45 was obtained, suggesting that the two variables influence to some extent the frequency of nitrogen application on mature coffee enterprise. In this equation however, only family labour on the mature coffee enterprise had a significant regression coefficient at the .05 level.

TABLE 8:8 - STEPWISE REGRESSION RESULTS FOR MATURE COFFEE TOTAL ENTERPRISE DATA, 1977/78[1]

ESTIMATED EQUATION	INTERCEPT CONSTANT a	REGRESSION COEFFICIENTS (bs)[2] FOR x1	x2	x3	x4	x5	x6	TABULAR 't' VALUES AT 0.05 LEVEL OF SIGNIFICANCE DF[3]=30	R^2	DEFINITION OF DEPENDENT VARIABLE	DEFINITION OF INDEPENDENT VARIABLES WITH REGARD TO ALL EQUATIONS
1 (a)	-32.75* (1.95)	17.647* (2.53)	0.0118 (1.46)	0.1471* (5.39)				1.697	0.70	Y=TOTAL NITROGEN ON MATURE COFFEE	X1 = FAMILY LABOUR ON MATURE COFFEE ENTERPRISE
1 (b)	0.6377* (2.24)	0.5505* (4.41)			0.000039 (0.85)			1.697	0.45	Y=FREQUENCY OF NITROGEN APPLICATION ON MATURE COFFEE ENTERPRISE	X2 = VALUE OF EQUIPMENT APPORTIONED TO MATURE COFFEE ENTERPRISE
2 (a)	-4.442 (1.65)	1.772 (1.58)	0.00065 (0.50)	0.0144* (3.31)				1.697	0.44	Y=TOTAL COPPER ON MATURE COFFEE ENTERPRISE	X3 = TOTAL EXPECTED COFFEE YIELD FROM COFFEE ENTERPRISE
2 (b)	0.745 (1.31)					1.4949* (1.70)	0.0000507 (1.03)	1.697	0.19	Y=FREQUENCY OF COPPER APPLICATION ON MATURE ENTERPRISE	X4 = TOTAL VARIABLE COST ON MATURE COFFEE ENTERPRISE
3	-1.747 (1.38)	0.0037) (0.40)	0.01207* (3.76)	0.01207* (3.76)				1.697	0.42	Y=TOTAL CAPTAFOL ON MATURE COFFEE ENTERPRISE.	X5 = PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME
											X6 = NET FARM INCOME FROM MATURE COFFEE ENTERPRISE.

SOURCE : AUTHOR'S SURVEY.

1 : ICL XDS3, COMPUTER PROGRAMME, UNIVERSITY OF NAIROBI

2 : FIGURES IN BRACKETS ARE CALCULATED 't' VALUES

3 : DEGREES OF FREEDOM FOR NEAREST TABULAR VALUES.

* : SIGNIFICANT AT 5 PER CENT LEVEL (ONE-SIDED TEST).

Family labour, value of equipment and total coffee yield per mature coffee enterprise were regressed against the level of copper use in equation 2(a), and the result was a coefficient of determination (r^2) of 0.44. Thus the variables used in this model accounted for 44 per cent of the variation in the copper fungicide use variable. Only total coffee yield in the equation had a significant regression coefficient at the .05 level. Regression equation 2(b) indicates that per centage of income from coffee as a proportion of total farm income and net farm income on mature coffee enterprise, when regressed against the frequencies of copper application, had an r^2 of 0.19, which does not adequately explain the variation in frequencies of copper application. Only one independent variable in this equation, the per centage of income from coffee as a proportion of total farm income, had a significant regression coefficient at the .05 level.

Finally, in regression equation 3, two socio-economic variables : value of equipment apportioned to the mature coffee enterprise and total coffee yield, were regressed against the level of captafol fungicide used. A coefficient of determination (r^2) of 0.42 was obtained.
Total coffee yield, which here can be seen more as an expected yield variable, had a significant regression coefficient at the .05 level. The regression coefficient for the value of equipment proved non-significant at the .05 level.

In conclusion, therefore, the third general hypothesis, that selected socio-economic variables are not linearly related with the levels of agro-chemical use and frequencies of application, can neither be totally rejected nor totally accepted, on the basis of the evidence given by the correlation and regression analysis. There were almost as many pairs of selected variables significantly correlated as pairs uncorrelated.

In the multi-variable regression analysis, evidence of linear relationships among the variables selected was again somewhat lacking, although not altogether absent in some estimated equatons. In fact significant regression coefficients were most frequently found for the total coffee enterprise data, which as already noted take into account the joint effects of enterprise size and intensity.

CHAPTER IX

SUMMARY AND RECOMMENDATIONS

Coffee, the most important cash crop, in value terms, in the Kenyan economy is grown by both the small-holders and the Estates. Whereas the former dominate the industry in total size, the Estates enjoy a higher coffee productivity per hectare as well as a bigger total national coffee output. The low coffee yield per hectare for the small-holders is, however, thought to be due to their poor use of officially recommended levels of agro-chemical inputs and frequencies of application. The study is, therefore, an attempt to first, measure and establish whether significant divergencies exist between the actual levels of agro-chemical use and the officially recommended ones, and second to explain (where possible) such levels of input use and frequencies of application by correlation and multi-linear regression analysis. However, before this was done, mature coffee enterprise revenue and cost data were compiled. Other selected socio-economic variables for the sample coffee enterprises were also defined and measured.

The research, undertaken in the crop year 1977/78, was centred in the Northern division of Machakos district, where a sample of 35 small-holder farmers with mature coffee was randomly selected and interviewed by use of an interview schedule. Below is the study summary and recommendations based on the empirical findings.

Average revenue from the coffee enterprise in the Northern division area of Machakos district is quite high. It accounted for 69 per cent of total farm revenue, making coffee by far the most important cash crop. The share of small-holder farmer's income from coffee is, therefore, big enough to warrant fears that in periods of low coffee world prices, farmers are likely to receive very low incomes. Consequently, it was thought that small-holder farmers in the area of study might wish to consider, as a safety factor, greater diversification of their sources of income by growing other crops climatically suited to the region.

Expenditure on coffee production involves costs of weeding, nitrogen application, pruning and desuckering, coffee picking and average annual depreciation of equipment used on the mature coffee enterprise. Cost of the weeding labour, which is mainly provided by family members, shows the largest cost contribution to the entire enterprise, followed by the cost of nitrogen and its application. Expenditures on sprays were found to be relatively low.

Picking of coffee is another costly undertaking, often demanding cash at hand to hire casual labour. Normally small-holders without sufficient money to hire such labour fail to pick all their coffee on time. As a result a significant proportion of their coffee is classified low grade. The profitability measures used in the study, namely : net family farm income, net farm income and managerial earnings, indicate that on average, the costs incurred in coffee production, whether per hectare or per enterprise, were more than covered in the crop year 1977/78.

The selected socio-economic variables, viz: farmer wealth, family labour, per centage of income from coffee as a proportion of total farm income, value of equipment apportioned to coffee, coffee yield, number of mature coffee trees, coffee enterprise total variable costs, coffee enterprise total costs, extension contact days, farmer educational level and age, were measured and discussed in detail. It was clearly shown that some of the above socio-economic variable measures are at inadequate levels for proper coffee husbandry. Extension contact days and family labour are particularly low at an average of 3 days within the crop year for the former and only 2 persons for the latter. Every farmer interviewed indicated that shortage of labour for the mature coffee enterprise was the major constraint facing them.

Farmer educational level was found to be exceptionaly low, 3 years of schooling on average, suggesting that most small-holder coffee farmers can not read the labelled instructions and understand the official recommendations for use of agro-chemicals without considerable help. As a result such farmers tend to depend on hiring people, or Co-operative Societies, to apply agro-chemicals for them. This procedure often causes delays in applying nitrogen fertilizers and fungicides, resulting in all too frequent low yields.

Since most coffee small-holders are not formally educated, the extension service needs to supplement their understanding constantly. Whenever possible small-holders should be taught how to apply the agro-chemicals themselves rather than have to depend on Co-operative Societies and contract arrangements. This involves being taught the proper levels of agro-chemical use, frequencies of their application and timing, so that they do not misuse these expensive inputs. Therefore the extension service should aim at educating coffee small-holders about the economic advantages of using agro-chemicals optimally.

Co-operative societies on the other hand should help coffee small-holders in the recruitment of labour during the busy seasons, especially for weeding and coffee picking (46). In addition these co-operative societies should help the extension service by organising more agricultural tours for their members in other coffee growing districts.

The average size of mature coffee enterprise in the area of study was 0.37 ha, with 502 coffee trees. The average yield per enterprise was quite low showing approximately 304 Kgs., equivalent to 992 Kgs. of coffee per hectare. The low coffee productivity per hectare or enterprise is probably accounted for by the poor use of agro-chemical inputs displayed by the small-holder farmers in the area of study. This is demonstrated by the measured deviations in the use of agro-chemicals and frequencies of application from official recommendations.

Measurements of deviations in agro-chemical use and frequencies of application from official recommendations have been discussed extensively in the text. It was clearly shown that on a physical basis, nitrogen was on average over-applied by approximately 63 per cent per coffee enterprise, while copper and captafol fungicides on a physical basis and on average were under-used by approximately 74 per cent and 82 per cent respectively in the crop year of study. The implications of these deviations are fairly

obvious. First farmer's average use of too much nitrogen is largely uneconomic; besides, too much nitrogen can become toxic to the coffee trees (29). Second, the average amount of fungicides used is too small, and the frequency of application too low to effectively control coffee diseases. Consequently, coffee trees are too frequently not healthy enough to produce optimally.

Average frequencies of application for the fungicides were below the official recommendations of eight times in the crop year. In the case of copper it was approximately 76 per cent below,and for captafol it was approximately 79 per cent below. Average frequency of nitrogen application in the year of study was approximately 52 per cent below the recommendation of four times.

From the standpoint of timing of agro-chemical applications within the crop year, nitrogen was the most appropriately used of the three types of inputs.In short, most enterprises applied nitrogen in the officially recommended months, viz: September or October for Farm-yard manure; and November, December, April and May for inorganic fertilizers. On the other hand fungicide (copper and captafol) were frequently applied in both recommended and un-recommended months. There was, nevertheless, a reasonable emphasis on fungicide application in the recommended wet months of March, April and May.

Despite their generally poor usage of agro-chemical inputs, most small-holders in the sample indicated that they were aware that if official recommendations were followed closely, coffee yields would be likely to increase substantially. Farmers indicated that due to inadequate working capital and uncertain income from coffee, they often could not afford the fungicide inputs at recommended levels. Indeed 59 per cent of the farmers interviewed said that lack of adequate working capital, with which to buy agro-chemical inputs, was their major reason for not following official recommendations.

TESTS OF HYPOTHESIS:

Three general hypotheses were tested statistically in the study. Results obtained from testing the first general hypothesis substantiated the earlier indication that small-holder coffee farmers on average in the Northern division are studied (Machakos district), deviated significantly from the officially recommended levels and frequencies of application for the three types of agro-chemical inputs investigated in 1977/78.

Regression coefficient test results (second general hypothesis) showed that fixed proportionate relationships were likely to exist (1) between total coffee enterprise expenditure on nitrogen and coffee enterprise total variable costs and total costs; and (2) between total coffee enterprise expenditure on both fungicides (copper and captafol together) and coffee enterprise total variable costs and total costs. These fixed proportionate relationships mean that the dependent variables in the corresponding regression models will vary in a constant and direct manner with the specified independent variables. Such findings suggest strongly that small-holder expenditures on agro-chemicals for coffee are related more to enterprise cost totals than to officially recommended levels. This could certainly explain why in their use of agro-chemical inputs small-holder coffee growers showed the deviations already commented on in 1977/78. If these results can be shown to be repeated for other crop years, then they point to a very important and, what would seem to be irrational form of economic behaviour on the part of small-holder coffee procedures, assuming of course that the official recommendations in the first place are reasonably accurate.

In bringing farmers into conformity it would certainly help if the frequencies of agro-chemical application could be re-examined and made fewer in number. This would no doubt be effective if agro-chemicals could be developed with this specific objective in mind.

One of the objectives of the study was to identify socio-economic variables which might help to explain the use of agro-chemical inputs and their frequencies of application in coffee enterprises. Simple correlation and multi-linear regression analysis on mature coffee enterprise data (per hectare and per enterprise) were used for this purpose.

Correlation results on per hectare data were not as good as expected. Indeed, only a few socio-economic variables, namely: family labour (per hectare), per centage of income from coffee as a proportion of total farm income, total variable costs and total costs (per hectare), were found to be significantly correlated with certain of the levels of agro-chemical use and frequencies of application (per hectare). Family labour (per hectare) was significantly correlated with the levels of nitrogen, copper and captafol fungicides used (per hectare), as well as with the frequency of nitrogen application.

Per centage of income from coffee as a proportion of income from the total farm was correlated significantly with frequency of copper fungicide application and with level of captafol used (per hectare). Coffee enterprise total variable costs and total costs (per hectare) were significantly correlated with level of captafol used per hectare. In contrast, farmer wealth level; coffee yield per hectare; net family farm income, net farm income, and managerial earnings (per hectare); size of mature coffee enterprise; extension contact days; farmer education level; and age, were insignificantly correlated with levels of agro-chemical inputs used and their frequencies of application within the year of study. The variables showing simple correlation were, therefore fewer than expected, while those remaining uncorrelated were quite numerous.

A correlation analysis conducted between coffee yield per hectare and size of mature coffee enterprise (number of hectares) gave a somewhat inconclusive negative correlation coefficient, significant only at the .10 level. Nevertheless this can be taken as indicating weakly that the smaller coffee enterprises gave higher yields per hectare than the larger ones.

Correlation coefficients for strengths of relationships between mature coffee enterprise size (number of coffee trees) and per hectare levels of agro-chemical use and frequencies of application showed lack of any significant relationships.

Multi-linear regression analysis on mature coffee enterprise per hectare data generally gave low coefficients of determination (r^2). As might be expected this shows that the weakly 'related' socio-economic variables identified by correlation analysis, did not forge strong regression relationships with levels of agro-chemical use and frequencies of application (dependent variables) on a per hectare basis in the crop year of study. In estimating regression equation 2(a) in Table 8.7, however, total variable costs per hectare had a significant regression coefficient when regressed against copper fungicide per hectare on mature coffee. The same was true for the per centage of income from coffee as a proportion of total farm income (independent variable) and captafol fungicide per hectare on mature coffee in multi-linear regression estimating equation 3 in the same Table.
Multi-linear regression results on mature coffee total enterprise data, on the other hand did give generally higher r^2 values. But while this was to be expected from the higher correlation coefficients obtained in the first place, one cannot say that very strong multi-linear relationships were described. Nevertheless in this analysis the first estimated equation gave significant regression coefficients for family labour, and expected total coffee yield (from the mature coffee enterprise) when related to the total mature coffee enterprise nitrogen used. In the case of frequency of nitrogen application and family labour on mature coffee enterprise, the latter's regression coefficient was significant in the same 11(b), Table 8.8, estimating equation. The above was also true for the total mature coffee enterprise variable costs (independent variable) and the level of

copper fungicide (dependent variable) regression coefficient in the second estimating equation in Table 8.8. Likewise, in the case of copper frequency of application and the total mature coffee enterprise costs, a significant regression coefficient for the latter was obtained. This was also true for the total expected coffee yield (independent variable) and the level of captafol applied (dependent variable) in the third estimating multi-linear regression equation in the same table.

In conclusion, while the main results of the study must be inferred cautiously there is every reason to suppose that important contemporary information has been disclosed reflecting on the unsatisfactory use of agro-chemicals, in coffee production, which should permit research and extension staff and small-holder coffee farmers to improve on the acceptance and implementation of related recommendations in the future.

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APPENDIX I

GROSS DOMESTIC PRODUCT, 1974-1977

(a) At Current prices

K£million

Gross Product at Factor cost	1974	1975	1976	1977*
A. Semi-Monetary Economy				
** Agriculture	131.30	173.54	190.30	221.37
** Forestry	5.57	7.30	9.40	10.77
** Fishing	0.18	0.20	0.29	0.33
Building and Construction	14.79	19.35	21.86	25.83
Water	5.28	6.78	8.90	11.11
Ownership of Dwellings	18.81	25.36	29.36	35.89
Total Product Semi-Monetary Economy	175.93	232.56	260.11	305.32
B. Monetary Economy				
1. Enterprises and non-profit Institutions:				
** Agriculture	123.08	135.39	219.64	378.58
** Forestry	5.42	5.93	6.33	7.18
** Fishing	1.45	1.65	2.36	2.64
Mining and Quarrying	3.14	3.32	4.15	4.64
Manufacturing	119.07	127.13	167.41	205.38
Electricity and Water	10.43	13.20	14.20	21.64
Building and Construction	43.39	44.39	46.20	51.98
Wholesale, and Retail Trade, Restaurants and Hotels	115.87	121.86	144.46	190.36
Transport, Storage and communications	53.73	60.25	69.25	69.28
Finance, Insurance, Real Estate and Business Services	46.80	54.67	68.03	78.49
Ownership of Dwellings	35.39	40.40	46.13	53.60
Other Services	19.33	21.69	24.84	27.88
Total	577.10	629.88	812.90	1,091.65
2. Private Households (Domestic Service)	7.27	8.86	10.93	14.04
3. Producers of Government Services:				
Public Administration	34.24	38.30	43.08	..
Defence	7.43	0.51	9.63	..
Education	55.00	66.49	76.91	..
Health	13.93	15.24	17.43	..
Agricultural Services	8.93	9.65	11.41	..
Other Services	15.67	18.53	20.45	..
Total	135.00	156.72	178.91	209.20
Total Product Monetary Economy	719.37	795.46	1,002.74	1,314.89
Total Gross Product at Factor Cost (Monetary and Semi-Monetary)	895	1,028.02	1,262.85	1,620.21
Gross Domestic Product Per Capita* K£	69.34	76.72	91.20	113.01

* Provisional.

** AGRICULTURAL SECTORS

SOURCE: KENYA STATISTICAL ABSTRACT, 1978.

DOMESTIC EXPORTS

Principal Commodities, 1974-77

(a) Value

K£'000

Commodity	1974	1975	1976	1977
Food, beverages and Tobacco				
* Live animals, chiefly for food ..	433	538	1,482	631
* Meat and meat preparation -total	4,675	5,135	8,386	7,597
* Tinned meat and preparations ..	2,820	3,164	1,917	4,305
* Bacon	309	309	430	447
* Other	1,546	1,662	6,039	2,845
* Milk and Cream	3,436	2,798	1,175	540
* Butter and ghee	902	535	572	651
* Eggs	44	46	62	104
* Fish and preparations	404	353	422	435
* Maize, unmilled	2,460	5,061	5,644	659
* Meal and flour of Wheat	86	8	29	30
* Fruit and vegetables-total	7,431	10,248	15,741	22,896
* Cashew nuts	1,614	1,140	998	126
* Pineapples, tinned	1,414	3,608	6,979	10,513
* Beans, peas and lentils	1,678	2,306	1,656	2,756
* Other	2,725	3,194	6,108	9,501
* Coffee, not roasted	38,387	35,204	93,303	204,336
* Tea	19,391	22,932	31,763	71,779
* Feeding stuffs for animals	576	638	1,366	1,193
* Other foods	5,130	2,580	4,623	4,448
* Beverages and tobacco	428	258	434	685
Total	83,783	86,334	165,002	315,984
Basic Materials, Mineral fuels and Lubricants				
* Hides and skins, undressed	4,441	5,414	8,561	8,023
* Oil seeds and oil nuts	502	643	818	1,355
* Timber (rough or simply worked)..	510	450	817	963
* Wool, raw	692	426	526	779
* Cotton, raw..	1,126	1,282	1,142	435
* Sisal fibre and tow,, ...	16,957	7,432	4,192	4,114
Metal scrap..	863	552	562	496
Flourspar	537	1,000	2,235	2,450
* Wattle bark	70	84	116	64
* Pyrethrum flowers	1,113	1,296	1,201	1,065
* Pyrethrum extract	4,560	3,506	5,727	4,975
Petroleum products	37,981	48,655	56,927	72,398
Petroleum by-products	7,633	9,897	12,039	11,361
Othe, not stated above	5,443	7,223	8,141	7,116
* Animal and vegetable oils and fats	1,C39	843	1,098	365
Total	83,477	88,613	104,102	116,000
Manufactured Goods				
Chemicals - total	14,596	12,377	15,940	14,582
Sodium carbonate	2,079	2,435	3,033	2,687
Wattle bark extract	1,434	1,722	2,686	1,833
Other	10,453	8,220	10,221	10,062
Leather	434	454	1,628	1,820
Textile yarns, fabrics, made-up textiles, etc	3,042	2,634	1,726	1,453
Wood carvings	623	390	486	560
Wood, other	578	727	608	1,140
Cement	4,541	6,006	8,069	8,566
Glassware	585	770	919	833
Paper and Paper Products	4,557	4,883	5,016	4,434
Steel doors and windows	115	199	215	92
Aluminium ware, domestic	147	207	464	247
Metal containers	1,288	818	709	463
Machinery and transport equipment	2,529	2,139	2,882	2,921
Footwear	377	266	516	343
Printed matter	1,315	1,631	1,187	957
Other manufactured goods	9,077	6,477	8,907	9,584
Total	43,804	39,978	49,272	47,955
Miscellaneous				
Live animals, n.e.s.	216	200	282	280
Gold	2	-	-	-
Total	218	200	285	280
Total	211,282	215,125	318,656	480,529

* CONSIDERED UNDER AGRICULTURE

SOURCE: KENYA STATISTICAL ABSTRACT, pg 61, 1978

APPENDIX 3

ESTIMATED SMALL-HOLDER COFFEE YIELDS PER HECTARE (1977/78) FOR INDIVIDUAL COFFEE DISTRICTS COMPARED WITH TWO PREVIOUS YEARS

DISTRICT	HECTARES	1977/78 PRODUCTION	YIELD PER HECTARE (KGS) 1977/78	1976/77	1975/76
KIAMBU	6,167	5,911	959	817	872
MURANGA	8,536	8,769	1,027	1,213	764
NYERI	6,085	5,449	896	993	622
MERU	12,457	11,498	923	875	612
EMBU	3,677	4,320	1,175	873	787
KIRINYAGA	5,616	4,843	862	795	739
KISII	6,745	2,330	345	492	378
BUNGOMA	2,186	532	243	397	259
KAKAMEGA	930	171	184	175	154
TAITA	451	70	155	153	153
MACHAKOS	2,432	3,675	1,511	1,230	944
S. NYANZA	747	137	183	269	153
SIAYA/KISUMU	117	7	60	145	94
KERICHO/ KAJIADO	138	6	43	15	51
KITUI	30	-	-	-33	133
TOTALS AND AVERAGES	56,600	47,744	844	842	638

SOURCE : COFFEE BOARD OF KENYA ANNUAL REPORT, Pg. 7, 1978.

APPENDIX 4

IMPORTANCE OF COFFEE IN RELATION TO OTHER CASH CROPS IN MACHAKOS DISTRICT IN 1977

CROP	OUTPUT IN MILLION TONNES	VALUE K£
1. COFFEE		
(a) SMALL-HOLDER SECTOR	3764	4,872,744.10
(b) ESTATE	-	791,736.85
2. SUNFLOWER	4866.70	608,337.50
3. COTTON	-	250,686.00
4. SISAL	3408	223,800.00
5. SUGAR CANE	8725	43,625.00
6. WATTLE	381.04	8,315.00
7. TOBACCO	18.6	5,580.00
8. CASTOR SEEDS	26	1,521.00
		6,806,345.90

SOURCE : MACHAKOS DISTRICT COFFEE ANNUAL REPORT, 1978.

APPENDIX 5

COFFEE HECTARAGE BY CO-OPERATIVE IN MACHAKOS DISTRICT 1976 - 1977

COPERATIVE	HECTARAGE IN 1976	HECTARAGE PLANTED IN 1977	TOTAL HECTARAGE IN 1977
1.MATUGULU [1]	1,281.0	169.0	1,450.0
2.MBILINI [1]	473.6	67.6	541.0
3.MUISUNI [1]	338.9	45.1	384.0
4.KILALANI [1]	262.4	46.6	309.0
5.KAKUYUNI [1]	239.1	143.9	383.0
6.KITWII [1]	380.4	64.6	445.0
7.MITABONI	209.6	78.6	288.5
8.MUPUTI	119.4	52.6	172.0
9.KITHIMANI	43.5	18.8	62.3
10.KIKIMA	288.3	152.8	441.1
11.NEW IVETI	613.6	172.1	785.7
12.KITHANGATHINI	172.9	75.1	248.0
13.MUA HILLS	25.0	6.0	31.0
TOTAL	4.447.7	1,093.1	5,540.6

SOURCE : MACHAKOS DISTRICT COFFEE ANNUAL REPORT, 1977.

1 : REFERS TO CO-OPERATIVE SOCIETIES IN THE NORTHERN DIVISION (THE STUDY AREA OF MACHAKOS DISTRICT).

APPENDIX 6

CALCULATION OF OPPORTUNITY COST FOR FARM YARD MANURE, 1977/78

The Co-operative society sold 7 tonnes of farm-yard manure, transport inclusive at Shs.480.00.

1 tonne is therefore Shs. 68.60

1 tonne is 12 bags

1 bag is 6 debes

Farmers apply one to two debes per tree in a crop year. If a small-holder farmer applied 2 debes and the total number of trees was 150, the opportunity cost can be estblished by following the procedure given below:-

Number of debes = 150 x 2

= 300 debes

Number of bags = $\frac{300}{6}$ (@ 6 debes per bag)

= 50 bags.

Number of tonnes used in the crop year : $\frac{50}{12}$ (@ 12 bags per tonne)

= 4.2 tonnes

Total value = 4.2 x 68.60 (@ 68.60 Sh. per tonne)

= 288.10 Sh.

APPENDIX 7

PROCEDURE FOLLOWED IN CALCULATING RECOMMENDED LEVELS OF AGRO-CHEMICAL INPUT USE PER MATURE COFFEE ENTERPRISE

I. NITROGEN:

The optimal level of pure nitrogen applied on one hectare of mature coffee will depend on the expected yield.* Such levels are established by the Coffee Research Foundation and availed to the extension officers, who in turn are supposed to help small-holders to know the quantity of nitrogen to use in any particular crop year. The computations below indicate how these officially recommended levels of pure nitrogen were obtained on a per enterprise basis.

A small-holder farmer, for example, with 150 mature coffee trees and on per hectare basis expecting a total yield ranging between 1000 and 1500 kg. of clean coffee will use 15.8 kg. of pure nitrogen in the crop year. This is obtained by following the procedure given below:-

The officially recommeded level of pure nitrogen for one hectare of mature coffee, whose expected yield ranges between 1000 and 1500 kg. per hectare = 140 kg. pure nitrogen.

Number of trees in one hectare = 1330

Recommended level of nitrogen per tree $= \frac{140}{1330}$

$= 0.105$ kg.

Recommended level of nitrogen for 150 trees

$= 0.105 \times 150$

Total recommended level of nitrogen = 15.8 kg.

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* Since the study was done ex-post the expected coffee yield was regarded as what the farmer actually obtained in the crop year 1977/78.

APPENDIX 7

II. COPPER AND CAPTAFOL

The officially recommended level of copper and captafol use are based on one hectare of mature coffee. The amount applied does not depend on the expected yield as is the case of nitrogen application. The procedure below was used to obtain the recommended level of copper and captafol fungicide by small-holders with less than one hectare of coffee trees:-

COPPER FUNGICIDE

Recommended level of copper use per hectare of mature coffee = 5.5 Kg.

Number of trees in one hectare of coffee = 1330

Recommended copper fungicide per tree

$$= \frac{5.5}{1330}$$

$$= 0.0041$$

A farmer with 150 coffee trees will therefore use

$$0.0041 \times 150$$

= 0.62 Kg. Copper in one application.

APPENDIX 7 (Cont.)

CAPTAFOL FUNGICIDE

Recommended level of captafol use per hectare of mature coffee = 2.2 Kg.

Number of trees in one hectare hectare = 1330

Recommended captafol per tree $= \frac{2.2}{1330}$

$= 0.00165$

A farmer with 150 mature coffee trees will therefore use 0.00165

= 0.248 Kg. of Captafol in one application.

APPENDIX 8

ESTIMATED ESTATES COFFEE YIELDS PER HECTARE (1977/78) INDIVIDUAL COFFEE DISTRICT COMPARED WITH TWO PREVIOUS YEARS

DISTRICT	HECTARES	1977/78 TOTAL PRODUCTION TONNES	YIELD PER HECTARE (KGS)		
			1977/78	1976/77	1975/76
UPPER/ LIMURU LIMURU	1,800	1,498	832	2,087	1,470
KIAMBU	5,394	7,999	1,483	1,027	1,559
THIKA	4,966	6,118	1,232	2,186	1,462
RUIRU	4,695	6,939	1,478	1,944	1,703
MUTUBIRI	1,566	2,739	1,749	1,611	1,819
MAKUYU	1,247	1,386	1,112	1,289	1,062
DONYO SABUK	1,471	2,540	1,727	1,811	1,538
NYERI	2,666	1,428	536	1,226	997
KABETE	592	615	1,038	1,406	991
TRANS NZOIA/ KIPKAREN	1,998	193	97	3,511	442
SONGHOR/KORU	453	37	81	112	126
NAKURU	2,946	1,718	583	706	593
NANDI/ KAIMOSI	138	37	271	823	193
FORT TERNAN LUBWA	675	68	100	120	155
MACHAKOS	281	370	1,318	503	958
TOTAL & AVERAGES	33,685	1,091	1,786	1,786	1,317

SOURCE : COFFEE BOARD OF KENYA ANNUAL REPORT. P. 7, 1978.

LISTING OF SAMPLE DATA BY FARM IS SHOWN BY APPENDIX TABLES 9 - 30

APPENDIX 9

RECOMMENDED NITROGEN AND DEVIATIONS PER MATURE COFFEE ENTERPRISE, 1977/78

SAMPLE NO.	ENTERPRISE RECOMMENDED LEVEL (KG.)	AMOUNT USED (KG.)	DEVIATIONS FROM RECOM.[1] (KG.)
1	19.17	14.55	- 4.62
2	17.8	0	-17.8
3	18.6	5.72	-12.88
4	12.5	46.33	33.83
5	10.8	8.73	- 2.07
6	13.5	7.27	- 6.23
7	25.2	40.74	15.54
8	6.01	19.4	13.39
9	89.4	135.8	46.4
10	180.4	317	136.6
11	180.4	317	136.6
12	105.2	58.3	-46.9
13	33.6	64.7	31.1
14	16.8	44.04	27.24
15	115	65.07	-49.93
16	24.4	84.56	60.10
17	15.6	12.61	2.99
18	25.2	7.76	-17.44
19	20.6	45.9	25.3
20	72.1	139.8	67.7
21	50.4	91.7	41.3
22	43.9	80.5	36.6
23	22.4	45.84	23.44
24	6.01	22.8	16.79
25	42.1	200.8	158.7
26	18.02	17.2	- 0.82
27	27.3	46.02	18.72
28	12.03	36.9	24.87
29	10.7	43.14	32.44
30	57.2	77.9	20.7
31	19.05	13	- 6.06
32	6.3	9.9	3.6
33	21.17	34.14	12.97
34	16.8	54.3	37.5
35	8.9	6.79	- 2.11

SOURCE : AUTHOR'S SURVEY.

1 : DEVIATION FROM OFFICIAL RECOMMENDATIONS.

APPENDIX 10

RECOMMENDED NITROGEN AND DEVIATION PER HECTARE OF MATURE COFFEE, 1977/78

SAMPLE NO.	RECOMMENDED LEVEL PER HECTARE (KG)	AMOUNT USED (KG)	DEVIATION FROM RECOMMENDATIONS[1] (KG)
1	170	132.2	-38.8
2	140	0	-140
3	140	44	-96
4	80	308.8	228.8
5	80	67.1	-12.9
6	80	45.4	-34.6
7	80	131.4	51.4
8	80	277.1	197.1
9	170	261.1	91.1
10	80	140.8	60.8
11	80	140.1	60.8
12	140	77.7	-62.3
13	80	154.09	74.09
14	140	367	227
15	300	171	-129
16	80	281.8	201.8
17	80	66.36	-13.64
18	140	43.1	-96.9
19	140	327.8	187.8
20	80	155.33	75.33
21	80	145.68	65.68
22	80	149.18	69.18
23	170	352.6	182.6
24	40	325.7	245.7
25	80	386.15	306.15
26	170	171.9	1.9
27	140	242.2	102.2
28	80	246	166
29	80	331.84	251.84
30	170	236.45	66.45
31	140	100	-40
32	80	141.28	61.28
33	80	131.3	51.3
34	80	258.66	178.66
35	170	135.8	-34.2

SOURCE: AUTHOUR'S SURVEY

1 : DEVIATION FROM OFFICIAL RECOMMENDATIONS

APPENDIX 11

FREQUENCY OF NITROGEN APPLICATION PER MATURE COFFEE ENTERPRISE 1977/78

SAMPLE NO.	TOTAL RECOMMENDED FREQUENCY[1].	ACTUAL FREQUENCY APPLICATION [2].	DEVIATION FROM RECOM.[3]
1	4	1	-3
2	4	O	-4
3	4	1	-3
4	4	1	-3
5	4	1	-3
6	4	1	-3
7	4	1	-3
8	4	1	-3
9	4	1	-3
10	4	3	-1
11	4	3	-1
12	4	3	-1
13	4	3	-1
14	4	3	-1
15	4	2	-2
16	4	2	-2
17	4	1	-3
18	4	1	-3
19	4	3	-3
20	4	3	-1
21	4	2	-2
22	4	2	-2
23	4	4	O
24	4	3	-1
25	4	3	-1
26	4	2	-2
27	4	3	-1
28	4	3	-1
29	4	2	-2
30	4	2	-2
31	4	2	-2
32	4	3	-1
33	4	1	-2
34	4	1	-3
35	4	1	-3

SOURCE : AUTHOR'S SURVEY

1 : FREQUENCY

2 : ACTUAL FREQUENCY OF APPLICATION

3 : DEVIATION FROM OFFICIAL RECOMMENDATIONS.

APPENDIX 12

COPPER FUNGICIDE APPLICATION PER HECTARE OF MATURE COFFEE, 1977/78

SAMPLE NO.	TOTAL RECOMMENDED COPPER (HA) (KG)	LEVEL USED (HA)[1] (KG)	DEVIATION FROM RECOM.[2] (KG)
1	44	.9	- 35
2	44	28.8	- 15.2
3	44	3.8	- 40.2
4	44	0	- 44
5	44	15.2	- 28.8
6	44	3	- 41
7	44	16.1	- 27.9
8	44	3.8	- 40.2
9	44	22.2	- 21.8
10	44	11.1	- 32.9
11	44	4	- 40
12	44	11.8	- 32.2
13	44	33.2	- 10.8
14	44	10.4	- 33.6
15	44	0	- 44
16	44	0	- 44
17	44	11.1	- 32.9
18	44	14.2	- 29.8
19	44	6.6	- 37.4
20	44	3.1	- 40.9
21	44	0	- 44
22	44	5.4	- 38.6
23	44	22.8	- 21.2
24	44	57	13
25	44	7.6	- 36.4
26	44	10	- 34
27	44	15.6	- 28.4
28	44	20	- 24
29	44	23	- 21
30	44	18	- 26
31	44	23	- 21
32	44	14.2	- 29.8
33	44	15.2	- 28.8
34	44	9.4	- 34.6
35	44	20	- 24

SOURCE : AUTHOR'S SURVEY

1 HA. : HECTARE

2 : DEVIATION FROM OFFICIAL RECOMMENDATIONS.

APPENDIX 13

COPPER FUNGICIDE APPLICATION ON MATURE COFFEE ENTERPRISE, 1977/78

SAMPLE NO.	TOTAL ENTERPRISE RECOMMENDED COPPER (KG)	LEVEL USED (KG)	DEVIATIONS FROM RECOM.[1] (KG)
1	4.9	1	-3.9
2	5.6	3.4	-2.2
3	5.8	0.5	-5.3
4	13.76	0	-13.76
5	5.9	2	-3.9
6	7.44	0.5	-6.9
7	13.8	5	-8.8
8	3.2	0	-3.2
9	23.2	2	-21.2
10	99.2	49.9	-49.3
11	99.2	25	-74.2
12	34	3	-31
13	19.8	5	-14.8
14	5.2	4	-1.2
15	16.8	4	-12.8
16	16.8	0	-16.8
17	8.5	0	- 8.5
18	7.8	2	- 5.8
19	6.4	2	- 4.4
20	39.6	6	-33
21	27.6	2	-25.6
22	24	3	-21
23	5.7	3	- 2.7
24	3.2	3.99	0.8
25	23.1	4	-19.1
26	5	1	- 4
27	8.5	3	- 5.5
28	8.2	3	- 5.2
29	5.9	3	- 2.9
30	18.1	6	-12.1
31	7.8	3	- 4.8
32	5.6	1	- 4.6
33	11.6	4	- 7.6
34	9.2	2	- 7.2
35	2.2	1	- 1.2

SOURCE : AUTHOR'S SURVEY

1 : DEVIATION FROM OFFICIAL RECOMMENDATIONS.

APPENDIX 14

COPPER FREQUENCY OF APPLICATION ON MATURE COFFEE ENTERPRISE 1977/78

SAMPLE NO.	TOTAL RECOMMENDED FREQUENCY[1]	ACTUAL FREQUENCY OF APPLICATION[2]	DEVIATION FRO RECOM.[3]
1	8	2	-6
2	8	4	-4
3	8	1	-7
4	8	O	-8
5	8	2	-6
6	8	2	-6
7	8	1	-7
8	8	O	-8
9	8	2	-6
10	8	3	-5
11	8	1	-7
12	8	5	-3
13	8	2	-6
14	8	4	-4
15	8	2	-6
16	8	O	-8
17	8	O	-8
18	8	1	-7
19	8	2	-6
20	8	3	-5
21	8	1	-7
22	8	2	-6
23	8	3	-5
24	8	3	-5
25	8	2	-6
26	8	2	-6
27	8	2	-6
28	8	2	-6
29	8	2	-6
30	8	2	-6
31	8	1	-7
32	8	2	-6
33	8	2	-6
34	8	2	-6
35	8	2	-6

SOURCE : AUTHOR'S SURVEY.

1 : TOTAL RECOMMENDED FREQUENCY.

2 : ACTUAL FREQUENCY OF APPLICATION.

3 : DEVIATION FROM OFFICIAL RECOMMENDATIONS.

APPENDIX 15

CAPTAFOL LEVEL OF USE ON MATURE COFFEE ENTERPRISE, 1977/78

SAMPLE NO	TOTAL RECOMMENDED LEVEL PER ENTERPRISE (KG)	ACTUAL LEVEL APPLIED PER ENTERPRISE (KG.)	DEVIATION FROM OFFICIAL RECOMMENDED LEVEL (KG.)
1	1.9	O	- 1.9
2	2.6	1	- 1.6
3	2.3	4.8	2.5
4	2.7	1	- 1.7
5	2.32	O	- 2.32
6	2.96	1	- 1.9
7	6.1	1	- 5.1
8	1.29	O.9	- 1.2
9	9.2	O	- 9.2
10	39.2	4.9	-34.3
11	39.2	2	-37.2
12	13.6	2	-11.6
13	7.9	O.2	- 7.7
14	2.08	1	- 1.08
15	6.72	4	- 2.7
16	6.4	O	- 6.4
17	3.2	O	- 3.2
18	3.12	O	- 3.12
19	2.5	1	- 1.5
20	15.8	1	-14.8
21	11	1	-10
22	9.6	2	- 7.6
23	2.3	O.99	- 1.3
24	1.28	1.5	O.2
25	9.2	1	- 8.2
26	2	1	- 1
27	3.4	1	- 2.4
28	3.2	2	- 1.2
29	2.3	O	- 2.3
30	7.2	1	- 6.2
31	3.1	1	- 2.1
32	2.2	O.5	- 1.7
33	4.6	2	- 2.6
34	3.6	1	- 2.6
35	O.88	1	O.1

SOURCE : AUTHOR'S SURVEY.

APPENDIX I6

CAPTAFOL LEVEL OF USE ON MATURE COFFEE PER HECTARE, I977/78

SAMPLE NO.	TOTAL RECOMMENDED LEVEL PER HA. (KG)	ACTUAL LEVEL APPLIED (HA) (KG)	DEVIATION FROM OFFICIAL RECOMMENDED LEVEL (KG)
I	I7.6	O	-I7.6
2	I7.6	9	- 9.6
3	I7.6	3.6	-I4
4	I7.6	6.6	-II
5	I7.6	O	-I7.6
6	I7.6	6.2	-II.4
7	I7.6	3.2	-I4.4
8	I7.6	I2.6	- 5
9	I7.6	O	-I7.6
IO	I7.6	2.I	-I5.5
II	I7.6	O.8	-I6.8
I2	I7.6	2.5	-I5.I
I3	I7.6	O.4	-I7.2
I4	I7.6	8.2	- 9.4
I5	I7.6	IO.4	- 7.2
I6	I7.6	O	-I7.6
I7	I7.6	O	-I7.6
I8	I7.6	O	-I7.6
I9	I7.6	7	-IO.6
20	I7.6	I.I	-I6.5
2I	I7.6	I.5	-I6.I
22	I7.6	3.6	-I4
23	I7.6	7.5	-IO.I
24	I7.6	2I.3	+ 3.7
25	I7.6	I.8	-I5.8
26	I7.6	IO	- 7.6
27	I7.6	5.2	-I2.4
28	I7.6	I3.2	- 4.4
29,	I7.6	O	-I7.6
30	I7.6	3	-I4.6
3I	I7.6	7.6	-IO
32	I7.6	7	IO.6
33	I7.6	7.6	-IO
34	I7.6	4.6	-I3
35	I7.6	20	2.4

SOURCE: AUTHOR'S SURVEY

APPENDIX I7

CAPTAFOL FUNGICIDE FREQUENCY OF APPLICATION ON MATURE COFFEE ENTERPRISE, I977/78

SAMPLE NO.	TOTAL RECOMMENDED FREQUENCY OF APPLICATION	TOTAL ACTUAL FREQUENCY APPLIED	DEVIATION FROM OFFICIAL RECOMMENATIONS
I	8	O	-8
2	8	4	-4
3	8	3	-5
4	8	2	-6
5	8	O	-8
6	8	2	-6
7	8	I	-7
8	8	3	-5
9	8	O	-8
IO	8	3	-5
II	8	I	-7
I2	8	5	-3
I3	8	I	-7
I4	8	2	-6
I5	8	2	-6
I6	8	O	-8
I7	8	O	-8
I8	8	O	-8
I9	8	2	-6
20	8	I	-7
2I	8	I	-7
22	8	2	-6
23	8	3	-5
24	8	3	-5
25	8	2	-6
26	8	2	-6
27	8	2	-6
28	8	2	-6
29	8	O	-8
30	8	2	-6
3I	8	I	-7
32	8	2	-6
33	8	2	-6
34	8	2	-6
35	8	2	-6

SOURCE: AUTHOR'S SURVEY

APPENDIX I8

SIZE OF INDIVIDUAL MATURE COFFEE ENTERPRISES, I977/78

SAMPLE NO.	NO. OF MATURE COFFEE TREES	SIZE OF ENTERPRISE(HA)
I	I50	0.II
2	I70	0.I2
3	I77	0.I3
4	209	0.I5
5	I80	0.I3
6	225	0.I6
7	420	0.3I
8	I00	0.07
9	700	0.52
I0	3000	2.25
II	3000	2.25
I2	I000	0.75
I3	560	0.42
I4	I60	0.I2
I5	5I0	0.38
I6	406	0.3
I7	260	0.I9
I8	240	0.I8
I9	I96	0.I4
20	I200	0.9
2I	839	0.63
22	730	0.54
23	I76	0.I3
24	I00	0.07
25	700	0.52
26	I4I	0.I
27	260	0.I9
28	200	0.I5
29	I79	0.I3
30	448	0.33
3I	I8I	0.I3
32	I05	0.07
33	352	0.26
34	280	0.2I
35	70	0.05

SOURCE: AUTHOR'S SURVEY

APPENDIX I9

COFFEE PRODUCTION PER HECTARE AND PER ENTERPRISE FOR THE SAMPLE OF FARMERS STUDIED, I977/78

SAMPLE NO.	YIELD PER HA. (KG)	YIELD PER ENTERPRISE (KG)
I.	I992	224.6
2	I422.5	I8I.8
3	I489	I9I.I
4	732.3	II3.6
5	682.2	92.3
6	547.7	92.6
7	736.2	232.5
8	950.9	7I.5
9	I575.4	829.I
IO	430	970
II	636.I8	I435
I2	I347	IOI2.8
I3	458.7	I93.I
I4	I275.9	I53.5
I5	2227.5	854.I
I6	I32.I2	40.3
I7	559.2	IO9.3
I8	I245.9	224,8
I9	IO37	I52.8
20	585	528.I
2I	374.I	236
22	458.2	25I.5
23	I792.2	237.I
24	272.6	20.5
25	9I8.6	483.5
26	I963.5	208.I
27	I23I.9	240.8
28	762.5	II4.6
29	573.3	77.I
30	I562.2	526.3
3I	I393.6	I89.2
32	859.2	67.8
33	508.8	I34.6
34	3II.9	65.6
35	I694	89.I

SOURCE: AUTHOR'S SURVEY

APPENDIX 20

SAMPLE FARMER AVERAGE VALUE OF EQUIPMENT ON MATURE COFFEE PER HECTARE AND PER ENTERPRISE, 1977/78

SAMPLE NO.	EQUIPMENT VALUE PER ENTERPRISE (SHS)	EQUIPMENT VALUE PER HA. (SHS)
I	98	868.90
2	627	4905.35
3	2I2	I592.99
4	2I9I	I3942.70
5	73	539.40
6	300	I773.30
7	625	I979.I5
8	I547	20575.I0
9	27II	5I50.90
I0	3I34	I389.40
II	3566	I580.90
I2	8I9	I089.30
I3	3453	8200.85
I4	I76	I463.00
I5	3223	8405.05
I6	2839	9300.I5
I7	I686	8624.50
I8	378	2094.75
I9	260	I764,30
20	2685	I423.I0
2I	III2	I762.75
22	425	774.30
23	5II	3865.30
24	466	6I97.80
25	749	I423.I0
26	309	2905.20
27	376	I923.40
28	289	I92I.85
29	83	6I6.70
30	499	9348.60
3I	I96	I095.30
32	206	2609.30
33	2055	7764.60
34	99	470.20
35	20I	38I8.99

SOURCE: AUTHOR'S SURVEY

APPENDIX 2I

SAMPLE FARMER VALUE OF LAND UNDER MATURE COFFEE; MATURE COFFEE TREES AND BUILDINGS INCLUDING FARMER'S HOUSE, 1977/78

SAMPLE NO.	VALUE OF LAND UNDER MATURE TREES (SHS)	VALUE OF COFFEE TREES (SHS)	VALUE OF BUILDINGS AND HOUSES (SHS)
I	4000	3000	5400
2	9000	3400	5000
3	4700	3540	I2000
4	4500	4I00	8000
5	4500	5600	6000
6	5000	4500	3500
7	9000	8400	7000
8	4000	2000	II000
9	I9350	I400	20000
IO	55000	60000	20000
II	66000	60000	45000
I2	20000	20000	9000
I3	I3000	II200	I5000
I4	4000	3200	I5000
I5	II000	I0200	25000
I6	8000	8I20	7000
I7	6000	5200	5000
I8	6000	4800	30000
I9	5000	3920	5000
20	30000	24000	30000
2I	I8000	I6780	I5000
22	I8000	I4600	I2000
23	3700	3520	I2000
24	2500	2000	8000
25	I6000	I4000	I5000
26	4000	2820	4000
27	6000	5200	2000
28	5500	4000	I9000
29	5000	3580	I300
30	I4000	8960	27000
3I	4700	4760	I000
32	2500	2I00	4500
33	8000	7040	8000
34	7500	5600	3000
35	2000	I400	3000

SOURCE: AUTHOR'S SURVEY

APPENDIX 22

SAMPLE FARMER TOTAL WEALTH; TOTAL FARM INCOME AND PER CENTAGE OF INCOME FROM COFFEE AS A PROPORTION OF TOTAL FARM INCOME IN I977/78 CROP YEAR

SAMPLE NO.	FARMER WEALTH (SHS)	TOTAL FARM INCOME (SHS)	% OF INCOME FROM COFFEE
I	5,470	5,579	73
2	3,66I	3,984	82
3	5,I30	5,205	75
4	5,I82	5,322	24
5	24,I73	I,925	75
6	25,848	3,084	57
7	37,825	6,562	72
8	4I,429	6,207	22
9	47,96I	I7,860	90
IO	226,524	2I,790	87
II	243,44I	32,460	86
I2	5I.3I9	2I,432	90
I3	85,I93	I2,376	3I
I4	53,676	3,78I	83
I5	86,0I3	20,258	80
I6	98,279	8,406	9
I7	3I,686	2,994	69
I8	65,800	8,II2	57
I9	22,500	4,272	87
20	I78,995	I9,430	65
2I	83,332	7,4I3	77
22	75,375	6,398	95
23	22,87I	6,892	83
24	32,876	6,562	7
25	66,949	I4,05I	85
26	I6,535	5,70I	89
27	22,646	6,428	9I
28	64,I39	5,536	50
29	27,7I3	2,328	8I
30	73,429	20,304	63
3I	2I,896	5,6I5	82
32	46,656	3,058	54
33	34,455	4,I48	76
34	22,87I	I,902	84
35	I2,50I	2,8II	77

SOURCE: AUTHOR'S SURVEY

APPENDIX 23

SAMPLE FARMER AGE; EDUCATION LEVEL AND EXTENSION CONTACT DAYS 1977/78

SAMPLE NO.	AGE (YEARS)	EDUCATION LEVEL (YEARS)	NUMBER OF EXTENSION CONTACT DAYS
1	65	0	1
2	65	0	5
3	55	0	3
4	39	5	1
5	28	7	1
6	70	0	3
7	35	6	2
8	30	5	0
9	46	0	4
10	50	0	1
11	45	0	3
12	40	4	3
13	23	11	0
14	45	0	2
15	60	2	8
16	40	0	3
17	45	4	4
18	21	11	1
19	37	5	4
20	65	4	6
21	48	0	3
22	70	0	3
23	65	0	3
24	32	4	2
25	50	4	6
26	70	0	2
27	60	0	2
28	48	6	2
29	47	3	2
30	50	4	3
31	60	0	5
32	33	5	1
33	21	11	3
34	32	5	2
35	38	0	5

SOURCE : AUTHOR'S SURVEY.

APPENDIX 24

SAMPLE FARMER MATURE COFFEE ENTERPRISE COSTS OF COPPER AND CAPTAFOL FUNGICIDES 1977/78

SAMPLE NO.	COPPER FUNGICIDE KSHS.	CAPTAFOL FUNGICIDE KSHS.
1	19.95	O
2	69.55	49.85
3	9.90	24.85
4	O	49.85
5	39.70	O
6	9.90	49.85
7	79.40	199.00
8	O	49.85
9	39.70	O
10	992.30	198.85
11	496.15	99.50
12	59.55	99.50
13	99.25	99.50
14	79.50	49.70
15	79.40	199
16	O	49.85
17	O	O
18	39.70	O
19	42	48.70
20	126	54.50
21	42	54.50
22	63	109
23	63	54.50
24	82	68.70
25	84	48.70
26	21	48.70
27	63	54.50
28	63	109
29	63	63
30	126	54.50
31	63	54.50
32	21	24.55
33	84	109
34	42	48.70
35	21	54.50

SOURCE : AUTHOR'S SURVEY.

APPENDIX 25

SAMPLE FARMER MATURE COFFEE ENTERPRISE COSTS OF FAMILY, AND HIRED WEEDING LABOUR 1977/78

SAMPLE NO.	COST OF FAMILY WEEDING LABOUR KSHS.	COST OF HIRED WEEDING LABOUR KSHS.
1	480	0
2	747	0
3	1080	120
4	1080	540
5	297	297
6	540	540
7	360	720
8	297	50
9	396	792
10	1890.50	3780
11	2241	4482
12	1494	100
13	1782	594
14	900	0
15	1782	200
16	1188	60
17	900	0
18	1188	0
19	600	0
20	900	150
21	900	100
22	900	0
23	600	48
24	198	120
25	792	445
26	594	76
27	600	120
28	900	60
29	396	35
30	540	186
31	300	80
32	300	0
33	1440	120
34	594	0
35	450	0

SOURCE : AUTHOR'S SURVEY

APPENDIX 26

SAMPLE FARMER MATURE COFFEE ENTERPRISE COSTS OF PRUNING; DESUCKERING; AND PICKING, 1977/78.

SAMPLE NO.	COST OF PRUNING KSHS.	COST OF DESUCKERING KSHS.	COST OF PICKING KSHS.
1	75	45	253.40
2	85	51	205
3	88.50	53.10	223.50
4	104.50	62.70	128.20
5	90	54	104.15
6	112.50	67.50	104.50
7	210	126	262.20
8	50	30	80
9	350	210	935.15
10	1500	1200	1093.95
11	1500	1200	950.40
12	500	300	1142.25
13	280	168	217.85
14	80	48	173.10
15	250	153	963.35
16	203	121.80	45.50
17	130	78	123.30
18	120	72	253.60
19	98	58.80	172.35
20	600	360	583.45
21	419.50	251.70	266.16
22	365	219	283.65
23	88	52.80	267.50
24	50	30	30
25	350	210	545.30
26	70.50	42.30	234.77
27	130	78	271.60
28	100	60	129.32
29	89.50	53.70	87.03
30	224	134.40	593.60
31	90.50	54.30	213.90
32	52.50	31.50	76.50
33	176	105.60	148.10
34	140	84	74.05
35	35	21	100.55

SOURCE : AUTHOR'S SURVEY.

APPENDIX 27

TOTAL VARIABLE COSTS AND TOTAL COSTS ON PER HECTARE OF MATURE COFFEE 1977/78

SAMPLE NO.	TOTAL VARIABLE COSTS (PER HA.) KSHS.	TOTAL COSTS (PER HA.) KSHS.
1	9137.54	13208.70
2	10536.30	18463.50
3	12820.20	18651.20
4	15090.72	22069.10
5	7241.10	11152.80
6	9372.40	13519.90
7	6968.60	11293.10
8	7348.90	17139
9	7422.06	12131.40
10	6078.70	10357.80
11	6351.30	10250.60
12	5916.63	9966.30
13	9050.53	14027.80
14	15131.65	19700.60
15	11180.60	16314.90
16	8426.82	13633.15
17	8576.60	18043
18	9945.35	14405.60
19	10208.75	14318.19
20	4117	8476
21	4158	7753.80
22	4903.30	8693.30
23	12734.40	17038.35
24	11656.10	16573.10
25	8119.10	12289.86
26	12398.70	16859.40
27	9665.50	13867.30
28	12369	17052.60
29	8861.10	12925.15
30	9076.50	15933.10
31	8094.60	12161.80
32	9242.25	14984
33	9680.10	13837.50
34	7113.85	11008.34
35	16118.65	21615.30

SOURCE : AUTHOR'S SURVEY.

APPENDIX 28

TOTAL VARIABLE COSTS AND TOTAL COSTS ON MATURE COFFEE ENTERPRISE 1977/78

SAMPLE NO.	TOTAL VARIABLE COSTS	TOTAL COSTS
1	1030.55	1489.70
2	1346.75	2360.00
3	1706.15	2482.15
4	2371.40	3486
5	968	1509.40
6	1585.55	2287.20
7	2200.60	3566.25
8	552.55	1288.65
9	3906.35	6384.95
10	13711.30	23363.40
11	14326.20	23121.60
12	4448.60	7493.45
13	3810.75	5906.25
14	1820.35	2370
15	4287.30	6256.10
16	2572.30	4161.70
17	1354.20	2848.90
18	1794.65	2599.50
19	1504.45	2110.05
20	3714.60	7647.55
21	2623	4891.30
22	2691.30	4771.50
23	1685.15	2254.70
24	876.40	1246.10
25	4273.20	6468.35
26	1314.45	1787.35
27	1889.50	2710.90
28	1860	2564.30
29	1192.70	1739.55
30	3058.35	5366.95
31	1101.60	1655.10
32	729.65	1182.95
33	2561.95	3662.25
34	1497.65	2317.55
35	848.35	1137.65

SOURCE : AUTHOR'S SURVEY.

APPENDIX 29

PROFITABILITY MEASURES ON MATURE COFFEE PER HECTARE

1977/78

SAMPLE NO.	REVENUE PER HECTARE KSHS.	NET FARM FAMILY INCOME (HA) KSHS.	NET FARM INCOME INCOME (HA) KSHS.	MANAGERIAL EARNINGS (HA). KSHS.
1	36,367.07	32,448.01	26,959.10	23,176.58
2	25,743.71	20,469.50	13 483.10	9 840.45
3	29 430.05	24 083.90	14 783.30	10 888.70
4	8 289.90	1 230.70	-9 231.10	-13 339.49
5	10 753.05	6 645.55	3 243.70	- 347.30
6	10 563.79	4 926.32	518	- 2 850.30
7	15 143.79	9 679.25	7 305	3 902.15
8	18 480.35	11 226.50	5 667.15	1 357.95
9	30 564.34	24 749.60	22 637.20	18 462.30
10	8 443.48	2 921.15	2 083.24	-1 057.72
11	12 440.0	6 667.95	5 674.46	2 233.80
12	29 908.73	22 285.80	19 134.40	15 879.70
13	9 135.43	4 107.55	-1 422.15	-5 333.80
14	26 110.80	19 026.50	10 121.30	6 458.40
15	42,727.16	36 068.95	30 113.55	26 397.25
16	2 627.24	-2 407.90	-7 837.30	-11 469.70
17	13 265.16	6 279.15	516.40	-3 662.90
18	26 059.00	23 127.05	15 382.55	11 681.0
19	25 732.19	20 398.20	14 786.90	11 076.65
20	20 074.47	11 530.30	9 321.95	5 595.10
21	9 154.77	7 488.85	4 804.10	1 496.10
22	11 150.35	9 009.15	6 066.66	2 502.95
23	436 370.14	36 288.50	30 073.80	26 648.50
24	6 609.30	-1 618.90	-6 119.60	-9 900.10
25	22 443.70	16 930.00	13 674.07	10 204.99
26	5 088.62	42 135.53	35 168.59	31 308.76
27	30 134.78	24 412.15	19 858.95	16 307.30
28	18 522.50	12 820.80	5 397.70	1 355.30
29	14 035.88	9 563.10	4 977.45	1 122.70
30	38,247.71	29,909.25	26,910.80	22,450.15
31	34,102.65	29,098.35	25 614.55	21 890.20
32	21 033.75	14 941.10	9 760.40	6 171.60
33	11 952.50	8 348.35	1 061.15	-1 849.15
34	7 619.09	4 638.95	369.65	-3 363.85
35	41 448.49	33.878.90	23 936.20	19 916.75

SOURCE : AUTHOR'S SURVEY

APPENDIX 30

PROFITABILITY MEASURES ON MATURE COFFEE ENTERPRISE

1977/78

SAMPLE NO.	TOTAL ENTERPRISE REVENUE KSHS.	NET FARM FAMILY INCOME KSHS.	NET FARM INCOME KSHS.	MANAGERIAL EARNINGS KSHS.
1	4 101.55	3 659.55	3 040.50	2 613.90
2	3 290.55	2 616.40	1 723.40	1 257.80
3	3 916.65	3 205.15	1 967.40	1 449.10
4	1 302.70	- 193.40	-1 450.60	-2 096.20
5	1 455.30	899.40	439.00	-47
6	1 787.10	833.40	87.80	-482.20
7	4 782.25	3 056.60	2 306.85	1 232.26
8	1 389.65	844.10	462.10	102.10
9	16 086.00	13 026.11	11 914.31	9 717.53
10	19 045.45	6 589.05	4 699.05	-2 385.85
11	28 061.65	15 040.55	12 799.55	5 038.65
12	19 480.25	16 756.25	14 386.77	11 939.62
13	3 846.50	1 729.50	- 598.80	-2 245.80
14	3 141.15	2 288.90	1 217.60	776.95
15	16 348.10	13 830.95	11 547.30	10 122.25
16	802.05	- 735.05	-2 392.45	-3 501.28
17	2 094.50	1 227.50	100.95	- 716.05
18	4 702.45	4 173.30	2 775.80	2 107.85
19	3 739.06	3 006.05	2 179.05	1 632.35
20	12 663.52	10 403.30	8 410.80	5 048.20
21	5 775.08	4 724.17	3 030.57	943.77
22	6 120.12	4 944.87	3 329.82	1 373.82
23	5 774.54	4 802.09	3 979.69	3 526.42
24	496.94	- 121.72	- 460.12	- 744.37
25	11 818.48	8 910.53	7 196.88	5 371.05
26	5 088.62	4 467.00	3 728.40	3 319.20
27	5 891.61	4 772.30	3 882.20	3 187.90
28	2 785.34	1 927.94	811.68	203.81
29	1 889.04	1 287.06	669.90	151.10
30	12 883.44	10 074.69	9 064.69	7 562.15
31	4 641.04	3 960.19	3 485.89	2 979.04
32	1 660.56	1 179.56	770.56	487.23
33	3 163.24	2 209.49	441.19	- 489.40
34	1 604.02	976.62	77.82	- 708.18
35	2 181.50	1 783.10	1 259.10	1 048.25

SOURCE : AUTHOR'S SURVEY.