SUPPLY OF KENYAN PYRETHRUM

A DISSERTATION

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By

Odada J.E.O.

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This thesis is my original work and has not been presented for a degree in any other University

Odada J.E.O

This thesis has been submitted for examination with our approval as University Supervisors.

Professor J.K. Maitha

B. F. Johnston

Professor B.F. Johnston.

A B S T R A C T

Kenya's pyrethrum industry provides self employment to over eighty thousand rural families. Over two thousand people find wage-employment in the Pyrethrum Marketing Board's factory. Others earn regular incomes from collection and transportation networks. Pyrethrum is Kenya's fourth most important export crop, accounting for about six per cent of Kenya's total foreign exchange earnings each year.

Knowledge of farmers' responsiveness to changes in economic variables is important in formulating agricultural policies. This study attempts to estimate Kenyan pyrethrum farmers' responsiveness to price changes.

Time series data on output, acreage and price are used to estimate aggregate and regional supply functions. Nerlove's Partial Adjustment model fits the Kenyan pyrethrum data better than the Fisher distributed lag model.

Empirical results suggest that Kenyan pyrethrum farmers are highly responsive to price changes and that the price-elasticity of pyrethrum supply varies from one region to another. Some policy implications are drawn from these results.

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

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TABLE OF CONTENTS

LIST OF TABLES

APPENDIX

CHAPTER I

INTRODUCTION

1.1 Background Information

Exports of primary products are of vital importance to the economies of the most of Less Developed Countries. Agricultural products account for the largest share in export earnings of such countries and form an important source of cash income. Problems of employment, public finance, balance-of-payments, income distribution, price and income stabilization are therefore directly related to the agricultural export sectors of the Less Developed Countries. In Kenya, for example, exports of primary products account for about 80 per cent of total export earnings. Kenya's principal agricultural export crops: coffee, tea, sisal and pyrethrum account for over 50 per cent of Kenya's total export earnings. Table 1 shows the value of exports of the four crops and their percentage shares in Kenya's total export earnings for the period 1963 - 1973.

Table 1. VALUE OF EXPORTS AND PERCENTAGE SHARES IN KENYA'S TOTAL EXPORT EARNINGS FOR COFFEE, TEA, SISAL AND PYRETHRUM

VALUE IN £'000.

	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
COFFEE, VALUE	11015	15396	14096	18780	15676	12808	16837	22259	19530	24769	35777
PERCENTAGE	25.1	32.7	29.9	32.3	29.3	22.2	26.6	31.1	26.8	27.3	29.2
TEA, VALUE	5665	6056	6085	8714	7396	10041	11271	12704	11876	16417	16964
PERCENTAGE	12.9	12.9	12.9	15.0	13.8	17.4	17.8	17.7	16.2	18.1	13.8
SISAL, VALUE	7532	6028	3852	3340	2064	1832	1717	1865	1515	2068	4777
PERCENTAGE	17.2	12.8	8.2	5.8	3.9	3.2	2.7	2.6	2.1	2.3	3.9
PYRETHRUM, VALUE	3025	2453	2230	2825	2911	3040	2794	2162	3332	4572	3661
PERCENTAGE	6.9	5.2	4.7	4.9	5.4	5.3	4.4	3.0	4.6	5.0	3.0
TOTAL PERCENTAGE	62.2	63.6	55.7	58.0	52.4	48.1	51.5	54.4	49.7	52.0	49.9

Source: Statistical Abstracts, 1964 - 1974.

We notice from table 1 that while Coffee and Tea are Kenya's leading export crops with respect to foreign exchange earnings, sisal and pyrethrum have been competing for the third position with sisal accounting for 6.5 per cent and pyrethrum 5.2 per cent of Kenya's total annual foreign exchange earnings on average for the eleven-year period between 1963 and 1973. Coffee, Tea and Sisal export earnings have, however, been fluctuating more widely than pyrethrum export earnings. This is an indication that pyrethrum could become Kenya's leading export crop in the near future because of the relative stability of the industry.

A striking feature of Kenya's agriculture is that a large percentage of the agricultural population is still dependent upon small-scale subsistence farming based on traditional farming techniques. The typical Kenyan African farmer cannot, due to capital limitation, practice highly mechanized large-scale farming as was practiced by the Colonial "White Settler." Kenya's peasant farming sector is still predominant and produces the largest share of Kenya's total agricultural output inspite of its low level of mechanization. It is becoming increasingly important for Kenya to adopt an agricultural development strategy which emphasizes improved output from the predominant small-scale farming sector. The pre-independence agricultural development strategy had greatly discriminated against the peasant farmer through credit and input distribution. Kenya's current Five-Year Development Plan (1974/78), in realization of the importance of the subsistence sector, emphasizes improved productivity in the small scale farms by encouraging peasant farmers to engage themselves in the production of high-valued cash crops which could raise their incomes and also at the same time raise the level of national foreign exchange earnings. Pyrethrum is Kenya's only important cash crop which is now produced almost entirely by Kenya's small scale peasant farmers. Over 90 per cent of Kenya's total output of pyrethrum comes from smallholders with an average farm size holding of about two acres. About 10 per cent of national pyrethrum output still grown on large scale farms comes mainly from the former scheduled areas of Nakuru and Nyandarua districts where average farm size still remains generally high as a result of the slow process of land re-distribution. Pyrethrum production is labour-intensive and thus provides gainful employment to the otherwise underemployed family labour in the high potential pyrethrum areas. Mechanical cultivation of pyrethrum as is practised in Nakuru and Nyandarua districts would be uneconomic in many other areas from the community point of view since in most pyrethrum-growing districts, labour is abundant relative to land and capital and therefore labour-intensive growing of the crop serves to increase gainful employment in the rural areas and also serves to reduce labour peaks by increasing output per acre and output per worker.

At present over 80,000 families are engaged in pyrethrum production while an additional 20,000 workers find employment in the industry. Approximately 2,000 workers are employed by the Pyrethrum Boards in Nakuru and in various centres around the country.

Pyrethrum had by 1973/74 proved itself to be the most profitable of Kenya's cash crops with respect to farmers' cash incomes. With the 1973/74 pyrethrum price of K.Shs.5.50 per kilogramme of dried flowers of 1.5 per cent pyrethrins contents, the crop offers a farmer an income of K.Shs.3,389.00 per hectare per year. The closely competing products namely, coffee, tea, maize, wheat and milk offer incomes of: KShs.2,258.00; KShs.1,810.00; KShs.659.25; KShs.546.90; and KShs. 746.50 per hectare per year respectively. Unless the relative prices of the various farm enterprises change drastically, pyrethrum growing will remain the most profitable farm enterprise.(1)

It is important to analyse farmers' responsiveness to changes in various economic variables in the agricultural sector for such responses are of vital importance in formulating policies with respect to planning for agricultural expansion, taxation, subsidies and price support programs. All these policies require thorough knowledge of supply and demand structures for the various agricultural products.

Some studies have been done on Kenya's agricultural crops, for example, Maitha's study of Kenyan Coffee |24|; Etherington's study of Smallholder Tea |10| ; and Maitha's studies on Kenyan Maize and Wheat |23|. No study has been done on Kenyan Pyrethrum which is indeed an important cash crop and the present study aims at filling this gap.

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(1) Figures obtained from Ministry of Agriculture Farm Management Guidelines.

This study aims at analysing Kenyan pyrethrum farmers' responsiveness to price changes and in summary includes:

(a) estimating an aggregate supply function for Kenya's pyrethrum with a view towards establishing the extent to which the farmers respond to the price indicator;

(b) estimating regional supply functions for the main producing provinces of Kenya with a view towards establishing whether or not there exist significant regional differences in farmers' response to price changes.

1.2 <u>The Industry</u>

Pyrethrum was introduced into Kenya in 1928 as an experimental crop by three European farmers: G.W. Walker, T.J. Anderson, and V.A. Beckley. Walker attempted to grow the crop on a commercial scale; but Anderson and Beckley raised it only for experimental purposes at the Scott Agricultural Laboratories of the Department of Agriculture at Nairobi |6|.

By 1931, it was evident that pyrethrum was suited to the cooler districts of Kenya. The pyrethrum industry in Kenya, therefore, really dates from 1932, when expansion from the purely experimental stage to commercial stage occurred. Further expansion was secured by the formation early in 1933, of the Pyrethrum Growers' Association, now defunct, which consisted of the enthusiastic pioneers. Since then growth has been rapid as is evidenced by an increase in the number of pyrethrum growers from 35 in 1934, to over 80,000 in 1975; and also by an increase in land committed to pyrethrum growing from less than 400 acres in 1934, to over 90,000 acres in 1975. Quantity of dried flowers has increased from 16.9 metric tonnes in 1934, to over 14,000 metric tonnes in 1974 |43|.

When the industry was still in its youth, many growers planted the crop under unsuitable conditions and their low yields were still profitable because of the initially high international prices of pyrethrum products. As the prices declined the unsuitable fields became uneconomic and many farmers abandoned the crop, particularly those farmers at low altitudes. Today the crop is confined to only a few districts of Kenya which lie between 6,500 feet and 9,500 feet above sea level and where the soil is well drained.

Pyrethrum is a semi-permanent crop. The cycle is marked on the one hand by cutting back old woody stems each year at the end of a dry season and on the other hand by a rotation of three years with annual crops in order to regenerate soil fertility and to avoid diseases. It is a cross-pollinating short-day crop. The period from bud formation to flower emergence is about six weeks. The insecticidal contents of pyrethrum, known as "pyrethrins," are found in the leaves and stems of the growing plant, but there the pyrethrins concentration is negligible compared to the pyrethrins concentration in the flowers. Approximately 90 per cent of pyrethrins are produced in the flowers. Pyrethrum is thus a crop valued particularly for it's flowers.

The crop needs a good soil-structure mainly to ensure water infiltration. Water supply has to be sufficient and a precipitation of 1000 millimeters equally distributed over the year is considered ideal. A short dry season is an advantage because it gives a wintering effect to the plant and the future blossom of flowers is greater. The mean temperature should be $16^{0}C$, but at the same time much sunshine is required. The ideal altitude for flowering is 2400 metres, but the lower limit is 2000 metres. Good land preparation is required to eradicate the perennial grasses and the land should be ploughed two or three times before planting. Planting holes should be dug about 15 centimetres deep. The crop has been propagated mainly by seedlings. To encourage a rapid multiplication and a large number of splits for vegetative propagation, today seedlings are split up and planted into nurseries which have been mainly established by the Pyrethrum Marketing Board of Kenya. Seedlings start flowering 9 to 10 months after planting in the field. Nursery plants, e.g. vegetatively propagated clones which are re-split 3 or 4 months after planting in the nursery start flowering 3 to 4 months later. Seedlings have to be planted as soon as possible after the beginning of the long rains. Four thousand (4000) plants per acre are required. The clones are then split up so that a plant population of 21,000 splits is used per acre. The spacing between the splits is 0.3 metres in the row and 0.6 metres between the rows.

Weeding has to be done thoroughly by hand. Herbicides are not recommended because they could have adverse effects on the pyrethrins contents of the flowers. Weeding starts about one month after planting and should thereafter continue every four to six weeks. Optimum weeding frequency has been established at 4 weeks.

Harvesting has to be done by hand. It starts four to five months after planting. The picking interval thereafter should be two to three weeks, always when a new flush of flowers is produced. Flowers are placed in an open basket and should not be pressed together otherwise fermentation may occur, reducing the pyrethrins contents of the flowers. Most pyrethrum growers dry their flowers in the sun to get the moisture content down to 10 to 12 per cent. Such are growers at relatively low altitudes such as Kisii, Narok, parts of Rift Valley and Central Provinces. High altitude growers such as those in Mount Elgon area of Western Province, Ainabkoi and Molo areas of Rift Valley Province, parts of Kiambu District of Central Province and the slopes of Mount Kenya in Eastern Province have to use mechanical dryers. One mechanical dryer costs about K.Shs.15,000. The dryers are in most cases owned by pyrethrum growers' societies so that each dryer can serve a number of growers.

So far fertilizer tests have not yielded any significant results. However,,farmers are advised to use phosphates and nitrogen fertilizers. While phosphate fertlizers will induce flowering of any pyrethrum clone, too much nitrogen fertilizer may simply stimulate a lot of vegetative growth without inducing flowering. One major limitation to expansion in the use of fertilizer appears to be lack of a thorough soil survey to determine precisely how much of a particular fertiliser is required in a particular area. At present the Pyrethrum Board has six extension officers who are supposed to advise over 80,000 growers. The problem here is that an extension officer may not effectively advise farmers due to the large number of farmers who need his advice. A second problem is that some of the extension officers are not equipped with the right technical know how to enable them to be of any use to the farmers with respect to pyrethrum husbandry. What is much more important than the sheer number of the extension staff is that the extension staff be fully trained on the crop husbandry so as to make them useful to the farmers.

Kenya accounts for over 65 per cent of the world's supply of pyrethrum extract, flowers and powder. Its share of the world market is, infact, closer to 70 per cent because of high rates of internal consumption in some producing countries. This gives Kenya an apparent monopoly in the supply of pyrethrum products because countries like Japan, France and the U.S. have invented synthetic substitutes to pyrethrum products which have in the recent years considerably reduced Kenya's monopoly in the supply of pyrethrum products.

To the extent that Kenya supplies about 70 per cent of the world's demand for natural pyrethrum products, Kenya is in this case faced with a downward-sloping demand curve and therefore cannot sell all she wants at a constant price. The price-elasticity of demand for the Kenyan pyrethrum cannot be as low as the apparent monopoly conditions would warrant because of the existence of easy substitutes for pyrethrum almost at all stages of processing. The prices that Kenya and other pyrethrum-producing countries charge for their products must be related to the world demand as well as to the prices of the synthetic substitutes.

The size of Kenya's domestic market for pyrethrum has been, and still remains, neglible; over 98 per cent of Kenya's pyrethrum output in any single period is exported and only about 2 per cent is consumed locally by the emerging local manufacturing industries for mosquito coils and aerosols. Pyrethrum marc, which is the stuff left over after extracting pyrethrins from the flowers, has in recent years found a market in Kenya as a cattle feed which has been established to be just as good as fodder. The export market still remains predominant and Kenya has little scope for market differentiation.

At present the world's leading producers of natural pyrethrum products are: Kenya, Tanzania, Ecuador, Rwanda and Japan, with smaller amounts being grown in New Guinea, Brazil, Zaire, Indonesia, India, U.S.S.R., Taiwan, Rhodesia, Yugoslavia, and South Africa. It is evident that the bulk of the world's pyrethrum production now grows on land near the equator from 6,000 feet to 8,000 feet above sea-level with rainfall of 35 inches to 60 inches evenly spread throughout at least seven months of the year.

Table 2 gives comparative production of different countries for the period 1967/68 to 1971/72.

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Table 2: COMPARATIVE PRODUCTION 1967/68 - 1971/72

METRIC TONNES OF DRIED FLOWERS

COUNTRY	1967/68	1968/69	1969/70	1970/71	1971/72
KENYA	11,059	7,300	5,909	9,747	14,400
TANZANIA	5,102	4,750	2,416	2,665	4,300
ECUADOR	1,609	1,744	1,457	1,241	1,100
JAPAN	950	838	700	600	380
RWANDA	120	200	640	800	1,000
OTHERS	700	620	600	850	600

Source: "Pyrethrum Flowers" Kenya's Ministry of Agriculture, 1973.

All the countries in Table 2 export their production in the form of extract. Kenya exports her production in three forms: refined extract suitable for direct inclusion in aerosols, ground flowers (powder) suitable for the manufacture of mosquito coils and dried flowers.

The major pyrethrum growing areas of Kenya today are: Kisii district of Nyanza Province; Nyandarua, Kiambu, Nyeri and Muranga districts of Central Province; Keiyo/Marakwet, Nakuru, Uasin Gishu, Narok and Kericho districts of Rift Valley Province; Embu and Meru districts of Eastern Province. Kisii district is the largest single producer in Kenya accounting for over 60 per cent of Kenya's total pyrethrum output.

Table 3 below gives the distribution of Kenya's output for the period 1970/71 to 1972/73.

Table 3. DISTRIBUTION OF OUTPUT

METRIC TONNES

PROVINCE	1970/71	1971/72	1972/73
NYANZA PROVINCE	5,860	8,556	5,577
CENTRAL PROVINCE	2,414	3,624	3,049
R. VALLEY PROVINCE	1,399	2,129	1,907
EASTERN PROVINCE	75	102	158
WESTERN PROVINCE	0	3	6
TOTAL	9,748	14,414	10,697

Source: "Annual Reports," Pyrethrum Marketing Board 1970 - 74.

In order to increase Kenya's flower output to a level consistent with current and anticipated demand for pyrethrum products, the Pyrethrum Marketing Board is making efforts to promote the crop in three new areas: Kericho district of Rift Valley Province, Mount Kenya slopes in Meru district of Eastern Province and Mount Elgon area in Bungoma district of Western Province. Already good progress is being realized in these new areas which have opened a new scope for expansion as the old areas like Kisii cannot be expected to provide sufficient scope for expansion due to over-population which has resulted in acute land shortage.

Pyrethrum had by 1973/74 proved itself to be one of the most profitable cash crops in most pyrethrum growing areas. It is obviously the most important cash crop in Kisii district of Nyanza Province.

repeat?

Table 4 below gives the relative importance of pyrethrum with respect to Kisii farmers' incomes for the period 1973/74:

Table 4. RELATIVE PROFITABILITY OF PYRETHRUM IN KISII

CROP	NO. OF GROWERS	£ DISTRICT INCOME	£ INCOME PER GROWER
PYRETHRUM	51,000	1,362,883.2	30.0
COFFEE	50,000	936,908.0	18.7
TEA	18,000	511,754.0	27.2

Source: Department of Agriculture (Kisii district), Annual Report 1973/74.

We notice from table 4 that pyrethrum accounted for 48 per cent of the total district income accruing to pyrethrum, coffee and tea. The other important agricultural products grown in Kisii include Passion fruits, Maize, Bananas, Milk and groundnuts. Of these products passion fruits, Maize and milk are produced directly in competition with pyrethrum, tea and coffee. Bananas and groundnuts are grown at relatively lower altitudes.

In Rift Valley Province there exist a greater number of farm activities competing with pyrethrum. In 1973/74, Dairy farming earned the Province it's largest cash income of KShs. 12,119150.00 followed by pyrethrum which earned the Province a total of KShs. 2,552,295.00 in the same year. The other competing crops include: tea, coffee, wheat, maize, Beans and Groundnuts. The role of pyrethrum as a cash earner in the Rift Valley Province varies with districts. Keiyo/Marakwet district has been for many years accounting for the largest share of pyrethrum income of the Rift Valley Province, followed by Baringo and Narok districts. However, pyrethrum production in Keiyo/Marakwet started declining in 1972/73 and the new area of Kericho seems to have the potential of becoming the most important pyrethrum producing district of Rift Valley.

Pyrethrum growing districts of Central Province include: Kiambu, Nyandarua, and Nyeri. In Kiambu; coffee, tea and dairy farming are the most important competing products. In Nyandarua, horticultural crops tend to dominate farm activities today. Their pyrethrum production has been declining as farmers shift to growing horticultural crops. In Nyeri, tea and coffee are the main competing crops.

The size distribution of pyrethrum plots has changed considerably in the last decade. In the late fifties and early sixties pyrethrum was grown predominantly on large scale farms averaging 50 acres. Now, in most regions, the crop is grown on smallholdings averaging 3 acres with individual producers marketing their crop through cooperative socities. It is in the Rift Valley, particularly Nakuru District, where there still exist the largest number of individual large scale growers of pyrethrum. Nyandarua District of Central Province is another area with a relatively large number of individual large-scale growers.

Profitability of pyrethrum depends, in any one period, on total output, price and pyrethrins contents of the flowers. High pyrethrins contents flowers fetch higher prices than low content flowers as can be seen in the table below for prices for the period 1969/70 to 1973/74.

Table 5. PRICE AND PYRETHRINS CONTENTS:

YEAR	PYRETHRINS CONTENTS %	PRICE (Sh/kg)
1969/70	1.3	4.44
	1.5	5.16
1970/71	1.3	4.81
	1.5	5.56
1971/72	1.3	4.86
	1.5	5.62
1972/73	1.3	5.25
	1.5	6.06
1973/74	1.5	5.48

Source: PMB Annual Report, 1969/70 - 1973/74

The crop production division of the Pyrethrum Board recommends the following input quantities per hectare of pyrethrum:

0.6 kg. of pyrethrum seeds; 6250 pyrethrum plants; $1\frac{1}{2}$ bags of the double superphosphate fertilizer; and 2 litres of Rogor E for control measures against thrips, aphids and red spider mites.

The principal fixed production costs therefore include:

Cost of 0.6 kg. of seeds	=	K.shs.	24.00
Cost of propagation for 4 months	=	K.shs.	480.00
Cost of fertilizer(double superphosphate)	=	K.shs.	1,562.50
Cost of controlling pesticides	=	K.shs.	80.00
Cost of Land preparation	=	K.shs.	288.00
Cost of planting(50 man-days @3/50)	=	K.shs.	175.00
Cost of weeding(4 times per year)	=	K.shs.	280.00

Variable production costs include:

Cost of picking at 80 cents per kilogramme of dried flowers; cost of drying at 20 cents per kilogramme of dried flowers; and transport cost at 20 cents per kilogram of flowers.

Net returns from pyrethrum show considerable variation because of fluctuations in output. The principal determinants of the level of output are the quality of husbandry and weather conditions. Output level varies from 625 kilogrammes to 1250 kilogrammes of dried flowers per hectare, with the majority of growers producing just below 750 kilogrammes of dried flowers per hectare.

Net returns from pyrethrum depend also on commissions charged by pyrethrum growers' cooperative socities. Those societies which handle the drying and transportation of flowers charge commissions ranging from 15 to 20 per cent of gross earnings from pyrethrum. Those societies handling transportation alone (where sun-drying is common) operate with commissions of 15 per cent and below.

Income based on the 1974/75 prices of K.shs.5.50 per kilogramme of dried flowers of 1.3 per cent pyrethrins contents would give the following net returns per acre:

Table 6. INCOME AT VARIOUS LEVELS OF OUTPUT

OUTPUT PER ACRE KG.	1.3% at 5.50	1.5% at 6.45	AVERAGE * COSTS PER ACRE	NET 1.3%	PROFITS 1.5%
	K.shs	K.shs	K.shs.	K.shs.	K shs.
250	1375.00	1610.00	860.00	515.00	750.00
300	1650.00	1935.00	920.00	730.00	1015.00
350	1925.00	2260.00	980.00	945.00	1280.00
400	2200.00	2580.00	1040.00	1160.00	1540.00
450	2475.00	2900.00	1100.00	1375.00	1800.00
500	2750.00	3225.00	1160.00	1590.00	2065.00
550	3025.00	3550.00	1220.00	1805.00	2330.00

* Average costs have been worked out as follows:

Ploughing	= K shs.	70.00
Harrowing	= K shs.	45.00
Planting	= K shs.	30.00
Planting Material	= K shs.	250.00
Spraying	= K shs.	50.00
Weeding(4 times a year)	= K shs.	115.00 — Give basis?
	K shs.	560.00

To this we add: Picking @ 80 cents per kg. of dried flowers; drying at 20 cents kg. of dried flowers; and transport @ 20 cents per kg. of dried flowers.

The costs shown apply to a new planting. The cost of planting material is K shs.1000 per acre and it is distributed over four years.

It is important to note that family labour can replace a significant part of the labour costs listed above, thus resulting in higher cash net returns. Sun-drying is common in Kisii and Western Province and this reduces drying costs considerably.

Taking the national average production rate of 640 kilogrammes of dried flower per hectare, one hectare of pyrethrum (at 1.3 per cent pyrethrins contents) would yield a net profit of about K shs.1500.00. Maize yields a net profit of K shs.940.00 per hectare. Wheat yields about K shs.800.00 per hectare. Tea yields K shs. 416.00 per hectare. Coffee yields K shs.103.00 per hectare. Not constant basis!

Horticultural crops have relatively high earnings per hectare and therefore provide a big threat to other cash crops particularly in Kiambu and Nyandarua districts of Central Province where these crops have large urban markets. English potatoes, for example, yields a net profit of K shs. 9,366.00 per hectare, whereas Beans yield a net profit of K shs.2,056 per hectare.

Farmers are interested in farm activities which yield quick returns and in this respect horticultural crops seem to have an advantage over other cash crops. Tea and pyrethrum do yield monthly income to the farmers because of the monthly interim payments to the farmers by KTDA and the Pyrethrum Marketing Board. Farmers, on the other hand, have to wait for one or two years before getting coffee payments and this has led to a rapid decline of the crop in several districts - particularly Kisii where the coffee socities appear to have failed to provide the necessary incentives to the farmers. Kisii farmers are relatively happy with pyrethrum and tea.

Relative to other cash crops in most pyrethrum growing areas, pyrethrum prices are generally high and the crop offers a producer surplus to the growers in the sense that private marginal cost curve of pyrethrum industry is higher than its social marginal cost curve. This can be illustrated by the simple diagram below.

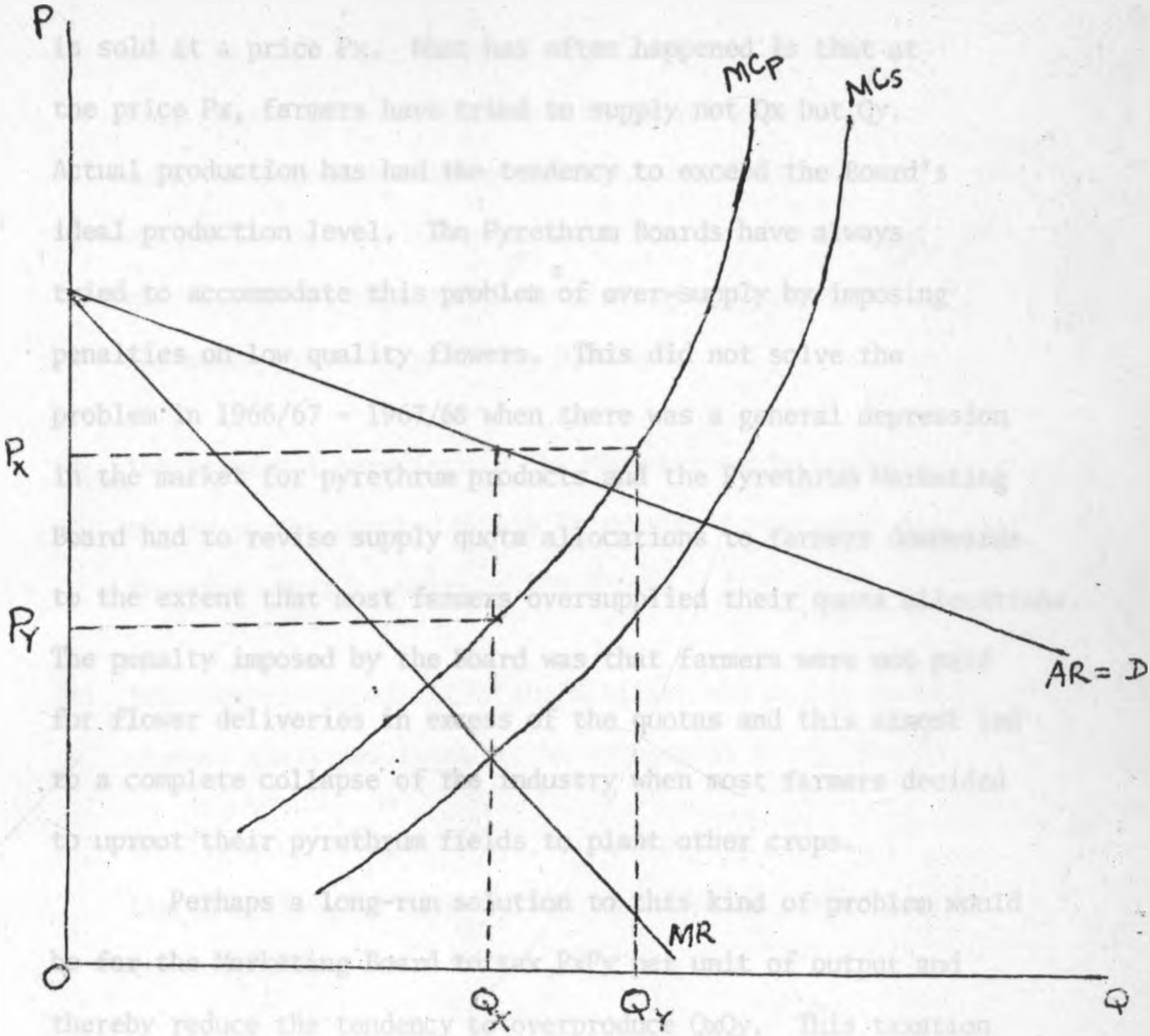

Figure 1.

In the diagram (Fig.1) above, the MCs curve represents the Social Marginal Cost and the MCp curve represents the private marginal cost. The profit-maximizing output is Qx and it is sold at a price Px. The producers need only be paid a price Py in order to supply Qx. Because they are paid a higher price Px, the producers would rather supply a larger quantity Qy. This is one of the biggest problems that the Kenyan Pyrethrum industry has had to accommodate for a long time. The pyrethrum Boards have been trying each year to adjust the Kenyan Industry supply quota and emergency stock level so that a quantity Qx is sold at a price Px. What has often happened is that at the price Px, farmers have tried to supply not Qx but Qy. Actual production has had the tendency to exceed the Board's ideal production level. The Pyrethrum Boards have always tried to accommodate this problem of over-supply by imposing penalties on low quality flowers. This did not solve the problem in 1966/67 - 1967/68 when there was a general depression in the market for pyrethrum products and the Pyrethrum Marketing Board had to revise supply quota allocations to farmers downwards to the extent that most farmers oversupplied their quota allocations. The penalty imposed by the Board was that farmers were not paid for flower deliveries in excess of the quotas and this almost led to a complete collapse of the industry when most farmers decided to uproot their pyrethrum fields to plant other crops.

Perhaps a long-run solution to this kind of problem would be for the Marketing Board to tax PxPy per unit of output and thereby reduce the tendency to overproduce QxQy. This taxation alternative would be easier to administer than the quota allocations.

By an Act of Parliament, two Boards were formed in 1964 to handle production and marketing of pyrethrum and pyrethrum related products in Kenya. The two Boards are: The Pyrethrum Board and the Pyrethrum Marketing Board of Kenya.

The Pyrethrum Board

This Board was formed to consist of:

(a) a chairman appointed by the Minister for Agriculture;

(b) one member appointed by the Minister to represent each of the provinces in which pyrethrum is licensed to be grown;

(c) not more than eight persons, appointed by the Minister from panels of names submitted by pyrethrum growers under arrangements made by the Minister, being persons who in his opinion are representative, on a basis as near as may be appropriate to production figures, of the main pyrethrum producing provinces;

(d) the permanent secretary to the Ministry of Agriculture, or any person deputed by him in writing to exercise his functions as a member of the Board;

(e) four members appointed by the Minister who in his opinion possess qualities likely to be of benefit to the Board;

(f) the Director of Agriculture, or any person deputed by him in writing to exercise his functions as a member of the Board;

(g) the Director of Settlement, or any person deputed by him in writing to exercise his functions as a member of the Board;

(h) the Chairman of the Marketing Board.

The 1964 Pyrethrum Act defines the functions of the Pyrethrum Board to include:

a) the licensing of pyrethrum growers in accordance with the annual quota determined by the Marketing Board;

b) investigation and research into matters connected with agronomy of the pyrethrum industry;

c) negotiation of the transfer of any of the functions above (b) to an East African Organization approved by the Minister.

The Pyrethrum Marketing Board was formed to consist of:

a) a chairman appointed by the Minister;

b) the permanent secretary to the Ministry of Agriculture, or any person deputed by him in writing to exercise his functions as a member of the Board;

c) three members appointed by the Pyrethrum Board from among the members thereof who are pyrethrum growers;

d) three members appointed by the Minister, being persons who in his opinion possess qualities likely to be of benefit to the Marketing Board.

The Pyrethrum Act(1964) defines the functions of the Marketing Board to include:

(a) the determination for each pool year of the quota of pyrethrum flowers permitted to be produced by growers licensed in that behalf by the Pyrethrum Board;

(b) the purchasing and taking delivery of all pyrethrum grown in, or imported into Kenya and the pyrethrum products derived therefrom, save that the Board shall have power to refuse to purchase or take delivery of pyrethrum grown in Kenya in excess of the quota determined under paragraph

(a) above,

(d) with approval of the Minister, the processing of pyrethrum, the appointment of contractors for the processing of pyrethrum, and negotiation of fees therefor;

e) the sale, export, marketing and regulation of the import of pyrethrum or pyrethrum products;

f) investigation and research into matters relating to the processing and marketing of pyrethrum and pyrethrum products;

(g) negotiation of sales and contracts relating to any pyrethrum products on behalf of any person, company, association or corporate body and the receipt of payment therefor.

The Pyrethrum Act(1964) accords full control of pyrethrum production and marketing to the Pyrethrum Boards as is evidenced by the following clauses of the Act:

(1) "No person shall grow pyrethrum upon any land unless the occupier of that land has been issued with a valid license."

(2) "No person shall grow pyrethrum in excess of quantity, or in excess of acreage specified in his license."

(3) "All pyrethrum flowers must be delivered by the growers themselves to the Marketing Board in Nakuru."

The composition and functions of the two Boards lead to an obvious duplication of staff. The Pyrethrum Board licenses growers each pool year in accordance with the production quota for that year worked out by the Marketing Board. This function could still be carried out by the Marketing Board itself for it is the Marketing Board which handles and analyses flower deliveries from all pyrethrum growers and is thus in a much better position to license the growers in accordance with their production potentials as already established from their past performance. Random licensing may lead to licensing low potential farmers who may end up with no deliveries to the marketing Board.

Pricing of pyrethrum flowers is in proportion to the pyrethrins contents of the flowers, the analysis of which is done at the Marketing Board's laboratories. The Marketing Board is therefore in a position to know which regions grow more high quality flowers and license more growers in such regions. Arbitrary licensing of growers may lead to serious fluctuations in pyrethrins output by licensing more low potential producers at the expense of those producers who could produce high quality flowers.

The employees of the two Boards are paid from the commissions charged by the Boards on farmers revenue. It would be in the interest of pyrethrum farmers if the size of the Boards' staff is kept as low as possible.

The Boards seem to have realized the possibility of duplication of staff and today there exists one chairman for the two Boards and the Pyrethrum Board has delegated most of it's functions to the Marketing Board.

The provision of the Act that "the Board shall have power to refuse to purchase or take any delivery of pyrethrum grown in Kenya in excess of the quota allocations" is likely to discourage farmers in high potential areas who by virtue of their good soils are likely to produce more than what they plan to produce in any single period.

Production and marketing of pyrethrum was initially handled by a British Company, East African Extract Company, working in conjunction with the British Pyrethrum Board. Shareholders of the company were Commonwealth Development Corporation (CDC) and the Mitchell Cotts. Kenya exported pyrethrum mainly in the form of dried flowers and, to a small extent, in the form of pyrethrum powder. The Extract Company had its processing factory in Nairobi until 1958 when a new processing factory was built in Nakuru.

In 1964 the Pyrethrum Board of Kenya acquired 58 per cent shareholdings in the processing company which changed its name into Pyrethrum Processing Company. The Mitchell Cotts group were bought out, and the Pyrethrum Board of Kenya continued to run the Processing Company jointly with the Commonwealth Development Corporation.

In 1966, the Pyrethrum Board of Kenya acquired the Commonwealth Development Corporation's shareholdings in the processing company and, together with the Kenya Government, became the sole owner of the Pyrethrum Processing Company. Today the processing factory in Nakuru is the property of the Pyrethrum Boards and the Kenya Government.

In the late sixties, Kenya started exporting pyrethrum extracts in addition to dried flowers and powder. Today, Kenya exports pyrethrum almost entirely in the form of fine extract which is used directly in the manufacture of aerosols. A small percentage is still exported in the form of powder to be used for the manufacture of mosquito coils.

Production of powder and extract involve highly specialised processing which requires specialized skills and large capital funds to set up a processing factory and keep it running. In Economic terms, there exist large economies of scale in processing and as a result of this, the Nakuru plant is Kenya's only processing factory. Plans to build a second processing factory in some major producing area such as Kisii or Central Province were rejected on the grounds of economies of scale of expertise and processing. Instead it was found more appropriate to expand the Nakuru factory which now operates with a capacity twice as great as the initial capacity. The expansion did not require much increase in the number of technical experts to run the extension as would have been the case if the extension had been built in some completely separate region.

The 1964 Pyrethrum Act accords all marketing rights to the Pyrethrum Marketing Board of Kenya. The farmers have to sell their crops direct to the Marketing Board in Nakuru. The Act prohibits private participation at both local and national levels.

Problems arose as the accounting facilities of the Marketing Board failed to cater for large numbers of small deliveries and the result was that pyrethrum growers were advised to organise themselves into Cooperative Societies so that individual farmers could make their deliveries to the Nakuru factory through their respective societies and the Marketing Board was left to handle the accounts of societies and not of individual growers. Over 86 per cent of total flower deliveries to Nakuru comes from Cooperative Societies. There still exist a few individual growers who prefer to deliver their flowers direct to the Marketing Board but most of these are large scale growers in Nakuru and Nyandarua districts who are to some extent favoured by the short distance through which they have to transport their flowers. Growers in more distant regions such as Kisii, Bungoma, Nyeri, Meru, Embu and most parts of Central Province tend to have organized themselves into cooperative societies to utilize the economies of scale of transportation.

In Kisii District the growers' Cooperative Societies have formed a larger marketing Cooperative Union known as the Masaba Cooperative Union through which twenty five pyrethrum growers' societies in the district market their flowers. The Union thus handles flowers from twenty five Societies with a total membership of about 51,000 growers. The Union employs about 66 people, including a manager.

The marketing of pyrethrum is complicated by the fact that farmers have to be paid for their flowers at rates proportional to the quality of their flowers (i.e. pyrethrins contents). The final analysis of pyrethrins contents is done in Nakuru on a Society basis and not for individual members deliveries. The Marketing Board therefore pays each society in proportion to the Society's flower quality. The Societies, however, cannot pay individual members in proportion to the quality of their flowers since they do not have facilities for detailed analysis at society level. While there is an incentive for a society to improve the quality of its flowers, there is no direct and effective incentive to an individual member of the society to improve the quality of his flowers through better husbandry and improved seed variety. An individual grower would increase the quantity of flower deliveries to the society because his share of the Board's payment to his society is proportional to the quantity, and not quality, of his deliveries to the society. What is required is a system of payment which would create a direct and effective incentive for an individual grower to improve the quality of his flowers. The present set up where societies make their deliveries in mixed bulks which do not indicate which flowers were delivered by which growers cannot create the necessary incentives to individual growers. There should be facilities for analysis at society level to enable the societies to record quantities as well as qualities of flowers delivered by individual members.

The recommended picking interval is two weeks and therefore, allowing another one week for drying, a society should be able to deliver flowers to Nakuru at three-week intervals. Some societies do handle such small quantities of flowers that they require longer intervals of delivery to Nakuru thereby losing a percentage of pyrethrins contents of the flowers before they go for final analysis in Nakuru. Such societies should be amalgamated to create societies with economically desirable scales of operation. Too large societies may also become inefficient due to diseconomies of scale.

any suggestions

That the farmers have to market the crop themselves is economically desirable in the sense that if the societies operate efficiently and make any profits then the profits would accrue to the farmers and not to middlemen as would be in the case of private participation. It is, however, also possible that the societies may operate inefficiently and make losses instead of profits. In this case the farmers' income would be reduced. Table 7 gives: sales, expenditures and profits of eight societies in Kisii District in 1972/73.

Table 7. SOCIETIES STATEMENTS OF ACCOUNTS 1972/73 (Kisii)

MEMBERSHIP	SOCIETY	SALES (SHS)	EXPENDITURE (Shs)	PAYMENT TO GROWERS (Shs)	PROFIT (Shs)
3,100	BIRINGO	1,370,232.00	132,456.40	1,193,964.20	43,811.40
2,400	TOMBE	1,402,440.00	128,189.00	1,207,254.00	66,997.00
1250	MOTAGARA	939,267.55	154,706.40	732,129.80	52,431.35
1900	MASIMBA	1,835,505.25	167,824.75	1,575,510.55	92,169.95
1800	KIAMOKAMA	1,984,626.00	147,035.40	1,706,394.25	131,196.35
1250	GESUSU	1,465.048.15	124,220.45	1,249,064.80	91,762.90
2000	RIGOMA	710,814.05	69,331.75	602,743.10	38,739.20
1450	KERINA	1,260,285.70	110, 345.10	1,069,687.85	80,252.75

Source: Ministry of Cooperatives, Societies Statements of Accounts 1972/73.

From Table 7, we see that there is no reason to believe that societies do operate efficiently. Birongo Society had less greater sales than Tombe Society but still Birongo incurred greater expenditure than Tombe and ended up paying less to its members and making less profits than Tombe. The expenditures show no relation to total sales and one is left with inefficiency as the only factor to explain differences between societies with respect to profits and payments to members. Most societies have, as their managers, persons who lack entrepreneural skills and are thus bound to be inefficient.

But have to service more members!

Even though most societies seem to be ending up with a surplus after paying their members, the surplus is only but an apparent profit to a society. The expenditures and commissions charged by societies on members income tend to be much greater than the profits that the societies make and one is left to wonder whether or not members could benefit much more if marketing at local level were left to private traders. Such middlemen would be working under the motivation of maximization of profits. There is no reason to believe that societies would work competitively to minimize their costs of operation as would private traders.

At national level, it is economically desirable that societies do retain some earnings to increase the level of national savings. To the individual pyrethrum grower, however, what is important is not how much surplus his society makes but rather what the society does with the surplus and to what extent it benefits the growers. Most societies tend to invest the surpluses in investment projects such as residential and commercial houses with long pay-back periods and the individual growers do not benefit from these investments. why?

Investment projects which will begin to pay after ten or twenty years may only benefit those growers who will still remain effective members of a society ten to twenty years later. The problem here is that some members contribute to such investments in terms of commission deductions by the societies but they leave pyrethrum growing and forget all about the societies before the investments begin to pay. In the end completely new growers who did not contribute to such investments end up enjoying the benefits of such investments. What is required is a well organized system of shareholding so that each member is given a share certificate for every investment undertaken by his societies to enable him to have a legal claim on the assets of the society. This does not happen in most cases because a few leaders of a society may cleverly use members contributions to the society to acquire business vaguely in the name of the society but still fail to pay any dividends to members.

Most societies are in fact inefficient not only in the handling of finances but also in the handling of flower deliveries. An example of the effect of societies inefficiency on individual farmers was in Kisii in 1967/68 when there was a general depression in the world market for pyrethrum products as a result of competition from synthetic products. Most individual pyrethrum growers and societies all over the country overproduced their quotas for that pool year and as a penalty, the Pyrethrum Marketing Board decided not to pay for any deliveries in excess of individual or society quotas. The Kisii Societies failed to determine precisely by how much each member had overproduced his quotas because the practice of allocating quotas to individual members was not taken seriously by the societies. The result was that the Board's penalty was distributed equally to all members of each society so that even those who had not actually produced in excess had to suffer the same penalty as those who had overproduced pyrethrum in that pool year. The resulting effective rate of payment was reduced so much by this penalty that farmers began to think that pyrethrum was not a profitable crop to grow because an individual who produced 1000 kilogrammes of dried flowers was paid for only about 500 kilogrammes which implied an effective reduction of price to the product by about one half. The following year over 50 per cent of Kisii farmers uprooted their pyrethrum fields to provide room for alternative crops in fear that the penalty would continue. The ease with which farmers can uproot pyrethrum plants and availability of substitutes calls for a very careful planning on the part of the Board and the societies. Even though pyrethrum was and still remains the most profitable crop in Kisii, a failure in the marketing system can result in a very quick and complete collapse of the industry. Table 8 shows the extent of overproduction in Kisii in the pool year 1967/68:

Table 8.

	SOCIETY	QUOTA (LBS)	DELIVERIES (LBS)	OVERPRODUCTION(LBS
1.	RIGOMA	361,000	453,040	92,040
2.	MASIMBA	350,000	400,342	50,342
3.	SIRONGA	225,000	405,555	180,555
4.	KEBIRIGO	225,000	415,572	190,572
5.	MOCHENWA	250,000	278,922	28,922
6.	MOTAGARA	295,000	333,719	38,719
7.	KIAMOKAMA	395,000	426,490	51,490
8.	KERINA	151,000	330,755	179,755
9.	ITIBO	195,000	401,634	206,634
10.	NYANTURAGO	330,000	518,269	188,259
11.	GESUSU	95,000	350,352	255,352
12.	TING'A	128,000	287,209	159,209
13.	MAKAIRO	151,000	282,980	131,980
14.	ESANI	200,000	268,939	68,939
15.	RAMASHA	200,000	247,034	47,034
16.	MAGOMBO	86,000	133,657	47,657
17.	NYANGUSU	57,000	311,417	254,417
18.	NYACHEKI	400,000	702,227	302,222
19.	BIRONGO	770,000	919,658	149,658
20.	GESIMA	375,000	458,482	83,482
21.	TOMBE	162,000	794,638	632,638
22.	IBACHO	425,000	499,332	74,332
23.	KEROKA	660,000	750,639	90,639
24.	NYAMASIBI	300,000	363,720	63,720

Source: Annual Report, Dept. of Agriculture, Kisii, 1968.

From table 8, we notice that total quota allocation for Kisii district in the pool year 1967/68 was 6,766,000 Lbs, while the district produced 10,334,572 Lbs, resulting in a total over-production of 3,568,572 Lbs., for which the farmers were not paid. This penalty constituted a total loss to the pyrethrum growers in Kisii district amounting to Kshs.9,635,144.40 (working with 1967/68 price of Kshs.2.70 per lb. of dried flower of 1.5% pyrethrins content). Since Kisii was by 1967/68 producing about 50 per cent of Kenya's total output of flowers, the total national loss must have been in the region of twice the loss for Kisii. The Pyrethrum Marketing Board is on the one hand a monopoly buyer of flowers and on the other hand a competitive seller of pyrethrum products (including dried flowers). The Board is simply a price taker in the world market even though Kenya supplies about 70 per cent of the world's pyrethrum products. This is because there is a high degree of competition from other pyrethrum producing countries and more particularly from the producers of synthetic products. The Board sells its products by way of contracts with consuming countries.

The synthetic products had their biggest impact on the Kenyan pyrethrum industry in 1967/68 when United States of America, which is the largest single consumer of Kenyan pyrethrum products, reduced its demand for pyrethrum products considerably. Table 9 shows Kenyas market distribution for the period 1962/63 - 1967/69:

Table 9: MARKETS FOR KENYAN PYRETHRUM:

YEAR	N. AMERICA	S. HEMISPHERE AND FAR EAST	N. EUROPE	S. EUROPE AND MIDDLE EAST	AFRICA
	%	%	%	%	%
1962/63	44	24	19	13	-
1963/64	36	35	19	10	-
1964/65	34	31	27	8	-
1965/66	42	21	19	14	4
1966/67	39	25	19	11	6
1967/68	28	26	23	14	9
1968/69	39	25	24	10	5

Source: P.M.B., "Annual Report."

America's intake of Kenya's pyrethrum products declined considerably in 1967/68. This was the time when synthetic producers (Japan, France and U.S.A.) made great inroads into the world market for aerosols. Their threat to the Kenyan industry was, however, short lived because the consuming countries (including the synthetic producing countries) soon realized that the synthetic products because of their high degree of toxicity had adverse residual effects on human life and environment. With the worldwide compaign for preservation of environment, the position of natural pyrethrum products was soon stregthened in the international markets. The synthetic products, however, still constitute a big threat to the Kenyan pyrethrum industry because they are produced by more manipulable techniques which may eventually lead to a cheaper source of aerosols with reduced toxicity. The current universal oil inflation has had a positive effect on the prospects of the pyrethrum industry and the Pyrethrum Boards of Kenya are now engaged in seed-fertilizer innovation compaigns which are intended to minimize costs of producing pyrethrum by increasing pyrethrum yields so that pyrethrum prices may remain competitive with those of synthetic products.

Sustaining the overseas markets for Kenyan pyrethrum products requires an uninterrupted flow of supplies and high quality services. Whenever the supplies fall short of market requirements considerable damage is caused to the indistry by way of dissatisfied customers and permanent loss of valuable business to competitive suppliers of natural pyrethrum products and synthetic products. Farmers are also likely to abandon pyrethrum production if the world market situation does not remain reasonably stable. The Kenyan industry has not up to the present time fully recovered from the internal destruction caused by the synthetic threat of the late sixties. Having been penalized for overproduction in 1960's, pyrethrum growers are still reluctant to increase their production fast enough to meet world demand in fear of the consequences of overproduction. Kenya has since been undersupplying her markets since the depression of the late sixties.

The Pyrethrum Marketing Board of Kenya has marketing and distribution agents overseas and, inorder to keep good contact with the consuming countries, the Board has established a nucleus of information centres in the major consuming countries. These centres are manned by technical and marketing personnel employed by the Board.

It is, however, important that the domestic market for Kenyan pyrethrum, which at the moment takes just less than 2 per cent of Kenya's pyrethrum, be expanded by educating the Kenyan domestic households to abandon their prevalent attitude of "let live" towards insect pests. This could lead to an expansion of the domestic aerosol manufacturing companies and consequently expand their capacity intake for pyrethrum. The use of pyrethrum Marc as a cattle feed and the manufacture of mosquito coils which started recently in Kenya constitute a significant move in the right direction. Markets could be expected to expand in future if more people could be educated to forget their attitude of "let live" towards insect missence on their farms and in their business premises.

what is this about? sure?

The Pyrethrum Marketing Board seems to realize this great market potential which exists in the use of pyrethrum products in erradicating insect missence on agricultural farms because there appears to be a deliberate attempt to confine the use of pyrethrum products to domestic households. The use of pyrethrum products in agriculture would require such large quantities that

Kenya may not even supply the domestic market and the fear is that synthetic manufacturers may move in to fill the gap and possibly throw natural pyrethrum products out of the market. A gradual tapping of this market will, however, be an advantage to the Kenyan industry which appears to have a higher supply potential than the market demand provided by domestic households.

So what is the problem

CHAPTER II

2.1 THE MODEL

Important propositions of economic theory include certain simple and well-known beliefs regarding people's reactions to prices which are important determinants of economic behaviour. It is, for example, most commonly believed that an increase in price will induce sellers to supply more of a commodity or a service, although the backward-bending supply curve of labour is a defensible concept on theoretical grounds.

Price-elasticity of supply of a commodity or a service has important economic policy implications. If, for example, the supply curve of an export crop is highly inelastic while the world price is unaffected by the quantity exported by the country concerned, an agricultural policy which reduces prices to growers of the crop would increase the country's foreign exchange earnings. Similarly, if supply curves are highly inelastic, increases in export duties on export crops will lead to large increases in government revenues.

If short-run supply functions of goods produced for the domestic market are inelastic, it might be argued that expanded export earnings will not foster economic development. The higher export earnings will lead to increased expenditure on locally produced goods, but the main result of this new expenditure will be increased prices rather than increased output. The price increases may lead to higher costs of production in both export and domestically-oriented industries.

On occasion, marketing boards for peasant crops in Africa have been defended on the grounds that the producers are naive or insufficiently experienced in marketing crops for the world market. The studies of Bateman, M.J. on Ghanaian Cocoa | 3 |; Dean, E. on Malawian Tobacco | 7| ; Gwayer, G.D. on East African Sisal | 14 | ; and Maitha, J.K. on Kenyan Maize and Wheat all constitute a "prima facie" arguement against this proposition because of the high elasticities they found for these crops.

The short-run income problems of farmers are those of commodity supply elasticity. Because of the low price-elasticity of demand for most agricultural products, most governments have taken to compensating farmers as the most handy policy instrument for solving farmers' short-run income problems. Before such an instrument is used, it is important to analyse how readily supply would adjust and how far prices would fall in a switch from support prices to free market prices. It is then that we can appreciate the importance of compensating farmers as an instrument for solving their income problems. With high price-elasticities of supply as determined for Ghanaian Cocoa, Malawian Tobacco, East African Sisal and Kenyan Maize and Wheat, a shift from the support price to free market price would reduce price by a relatively small amount and output by a relatively large amount. With low price-elasticities of supply, however, output would be reduced by a relatively small amount and price by a relatively large amount.

Supply elasticity thus has great relevance to policy mechanisms and magnitude of quantities important in farm income generation under a given demand regime. Not only are supply elasticities important in the questions of policy posed above, but also in ascertaining why supply presses so heavily on demand in the sequence of short-runs which characterize the continous depression of incomes and factor returns to levels below other major economic sectors.

The quantities involved are; however, more than elasticity coefficients; they infact involve the entire structure and foundation of commodity supply in agriculture. Heady, E.O. |15| points out clearly with mathematical illustrations that the supply elasticity itself is determined by other factors namely, the elasticity of the production function and the elasticity of factor supply. The continuous short-run depression of farm incomes does not arise simply because the supply function moves to the right faster than the demand function for even under such conditions, income and resource returns could be maintained at some previous or comparable equilibrium level under particular regimes of factor supply and production function elasticities. In the short-run, however, it is not terribly wrong to assume that factor supply and production function elasticities are fairly constant, and agricultural policy can be formulated in the light of commodity supply elasticity. This is the basic assumption which underlies the studies of commodity supply elasticity not based on the production functions.

One of the basic hypotheses to be tested in this study is whether Kenyan pyrethrum farmers attempt to produce more of the crop when the price of the crop rises. In other words, the question is whether the price-elasticity of pyrethrum supply is greater than zero. An alternative hypothesis is that Kenyan pyrethrum farmers produce less of the crop as the producer price of the crop goes up. It is also conceivable that farmers' production decisions are random, and hence unrelated to price, or that farmers produce, by habit, a given amount of the crop year after year.

Most previous studies of commodity supply functions have been based on Distributed Lag Models. A simple regression equation designed to explain the changes over time in the mean value of the dependent variable may be written as follows:

$$Y_t = \alpha + \beta X_t + \varepsilon_t \qquad (1)$$

where ε_t is a random error term assumed to have a normal distribution with zero mean and constant variance; and X_t is either non-stochastic or, if stochastic, independent of ε_t. Y_t is the dependent variable while α and β are constant parameters of the equation.

The simple regression equation (1) is based on the assumption that the dependent variable, Y_t, may depend on the current value of the explanatory variable, X_t, but not on any of the past values of X_t. This may be an over simplication of the truth, for some past values of the explanatory variable may significantly influence the current values of the dependent variable, Y_t. This is the argument on which a more general formulation of a regression equation is based. The general equation may be written as follows:

$$Y_t = \alpha + \sum_{i=o}^{m} \beta_i . X_{t-i} + \varepsilon_t \qquad (2)$$

where:

Y_t is the dependent variable; X_{t-i}: i = 0,1,2, ..., m are the explanatory variables which are assumed to be non-stochastic or, if stochastic, independent of the error term ε_t; α and βi are constant parameters of the regression equation; m is the order of the lag.

Equation (2) with the accompanying assumptions constitute a "Distributed Lag" model, because the influence of the explanatory variable on the mean value, E(Y), of the dependent variable, Y, is distributed over a number of lagged values of the explanatory variable, X.

For simplicity of exposition, one would be confined to the case of non-stochastic Xs and assume further that the βs have a finite sum to eliminate the possibility of explosive values of the mean value of Y. This latter assumption may be stated mathematically as follows:

$$\sum_{i=o}^{m} \beta_i < \infty \qquad (3)$$

Under the above assumptions about ε_t, X_i and β_i, it is possible to estimate equation (2) by Ordinary Least Squares technique.

The problem with estimating equation (2) is that if the Xs are correlated, the estimates of α and β_i are bound to be biased. Most frequently, some restrictions are placed on the regression coefficients β_i so as to reduce the number of regression parameters. The different restrictions on β_i result in different types of distributed lag models. A detailed list of different types of distributed lag models may be found in Johnston, J. |18| and Kmenta, J. |20|. The most commonly used restrictions are:

a) the restriction that the βs should be declining in a geometric progression to constitute what is commonly referred to as the Geometric Lag model;

b) the restriction that the βs should be declining in an arithmetic progression to constitute what is popularly known as the Arithmetic Lag Model.

Nerlove, M. |29| used two versions of the Geometric Lag. In the first version he advances the hypothesis that each year farmers revise their price expectations for the coming period in proportion to the error they made in predicting the current prices. He starts off with the assumption that acreage planted to a crop bears a linear relationship to the expected price. The assumption may be stated mathematically as follows:

$$X_t = a_o + a_1 P_t^* + u_t \qquad (4)$$

where: X_t is the acreage planted to the crop in year t; P_t^* is the price farmers expect to prevail in year t; u_t is a random error term; a_o and a_1 are constant regression parameters.

The rationale for using acreage and not output is that due to great seasonal variability of weather conditions, farmers tend to have little control over actual output and for that reason, acreage planted to a crop in any period is a better approximation of farmers' intended output for that period.

It is difficult to estimate equation (4) because the values of P_t^* cannot be observed. To overcome this problem, Nerlove |29| applies the hypothesis that farmers revise their price expectations each year in proportion to the error they made in predicting the current prices. This hypothesis may be stated mathematically as follows:

$$P_t^* - P_{t-1}^* = \beta(P_{t-1} - P_{t-1}^*) \qquad (5).$$

where:

β, $0<\beta\leq 1$, is the coefficient of expectations; P_{t-1}^* is the price farmers expected to have prevailed in year t-1; and P_{t-1} is the actual price that the farmers realized in year t-1.

Equation (5) may be re-written as follows:

$$P_t^* = \beta P_{t-1} + (1-\beta)P_{t-1}^* \qquad (6)$$

Similarly we may write:

$$P_{t-1}^* = \beta P_{t-2} + (1-\beta)P_{t-2}^* \qquad \text{and so on.}$$

We may therefore write:

$$P_t^* = \beta P_{t-1} + \beta(1-\beta)P_{t-2} + \beta(1-\beta)^2 P_{t-3} + \ldots \qquad (7).$$

Since $0 < \beta \leq 1$, P_t^* is a weighted average of past realized prices with the weights declining geometrically as we move back into the past. The significance of equations (4) and (7) is that previous prices influence farmers' decisions on acreage allocation to a crop but the more recent prices have a greater influence on farmers' decisions than the very distant previous prices.

Equations (7) and (4) may be combined to give:

$$X_t = a_o + a_1 \beta \sum_{i=1}^{m} (1-\beta)^{i-1} P_{t-i} + U_t \qquad (8)$$

Applying Koyck transformation |21| on equation (8) we obtain:

$$X_t = \pi_o + \pi_1 P_{t-1} + \pi_2 X_{t-1} + \nu_t \qquad (9)$$

where: $\pi_o = a_o \beta$; $\pi_1 = a_1 \beta$; $\nu_t = u_t - (1-\beta)U_{t-1}$; and $\pi_2 = (1-\beta)$.

Equation (9) can then be used to estimate the function from which one calculates farmers' responsiveness to price changes.

The problem which arises in an attempt to estimate equation (9) is that the new disturbance term, ν_t, is correlated with the lagged dependent variable, X_{t-1}, which is now included in the equation as one of the explanatory variables. This means that the Ordinary Least Squares estimates are bound to be in consistent | 35 | and one has to use alternative estimation techniques. However, the residual, ν_t, of equation (9) will be serially uncorrelated if the residuals, u_t, are positively serially correlated | 35 | . Hence, estimates of a_o, and a_1 derived from equation (9) may be better than those we would obtain if we could observe P_t^* independently.

The simplest method available for estimating equation (9) is the method of "INSTRUMENTAL VARIABLES" which is explained in great details in Kmenta, J |20|, Johnston, J. |18| and Wonnacott J.R. |35|. Since equation (9) involves two explanatory variables, we have to find two instrumental variables, say, Z_1 and Z_2 which satisfy the following conditions:

(a) $$\frac{\sum_t (Z_{1t} - \bar{Z}_1)\,\nu_t}{n} \xrightarrow{P} 0\ ;$$

(b) $$\frac{\sum_t (Z_{1t} - \bar{Z}_1)P_{t-1}}{n} \xrightarrow{P} \text{Non-zero}\ ;$$

(c) $$\frac{\sum_t (Z_{2t} - \bar{Z}_2)\,\nu_t}{n} \xrightarrow{P} 0\ ;$$

(d) $$\frac{\sum_t (Z_{2t} - \bar{Z}_2)X_{t-1}}{n} \xrightarrow{P} \text{Non zero.}$$

Conditions (a) and (c) emphasize the first desirable property of instrumental variables that they should be uncorrelated with the disturbance term. Conditions (b) and (d) emphasize the second desirable property of instrumental varaibles that each instrumental variable chosen should be correlated, as highly as possible, with the explanatory variable that it is chosen to replace.

Since P_{t-1} is non-stochastic, it would serve as an ideal instrumental variable for itself since it is also "perfectly" correlated with itself. Thus, $Z_{1t} = P_{t-1}$. P_{t-2} is also non-stochastic and therefore uncorrelated with the disturbance term ν_t. It is also likely that P_{t-2} is correlated with X_{t-1}. Thus, P_{t-2} can be taken as an instrumental variable for the lagged dependent variable, X_{t-1}. The final equation of instrumental variables to be estimated thus becomes:

$$X_t = \pi_o + \pi_1 P_{t-1} + \pi_2 P_{t-2} + \nu_t \qquad (10)$$

From estimates of π_o, π_1 and π_2, one can derive consistent estimates of a_o, a_1, and β.

Nerlove's Adaptive Expectations Model discussed above does not consider the possibility that factors other than price of the commodity under study could have significant influence on farmers' decision to commit land to the crop. One other factor which may influence changes in acreage planted to a crop is the fact that other crops also compete with it for land. When deciding how much land a farmer will plant to one crop, he will also consider how much of his limited land is going to be left for planting other crops. This implies that prices of alternative crops are also an important factor influencing a farmer's decision to allocate land to one particular crop. One way of incorporating this factor into the model is to deflate the price of the crop under study with a suitable index of the prices of other crops.

A second factor which may influence price expectations is the existence of price-support programmes which has introduced an entirely new element into the problem of how farmers form their expectations of future prices. The loan rates on various crops are generally known by farmers before they make their final decisions on what to plant. Actual prices at harvest may, of course, be higher than the support level and they may even fall below it when storage facilities are not available in the immediate vicinity of farmers. It nevertheless seems reasonable that the level of the support price will be the best available indicator, at planting of what the prices will be at harvest. Heady |15| points out that the Commodity Credit Corporation in the U.S. has probably been instrumental in raising the levels of expected prices for certain crops relative to price levels of other crops not included in the support programmes; or whose prices are supported at a lower percentage of parity.

In addition to raising the level of expected price, the commodity credit corporation has probably reduced the price uncertainty that farmers face.

The "Adaptive Expectations" model is just one version of a geometric lag model. Nerlove, M., |29| gave an alternative rationalization of the geometric lag model in what is known as the "PARTIAL ADJUSTMENT" Model. The model is based on the argument that farmers are always trying to bring the actual level of farm output to some desired level but, due to uncontrollable factors such as weather fluctuations, such efforts are never completely successful in any single period. Nerlove takes this argument to advance the hypothesis that farmers revise their output expectations each year in proportion to the error they made in predicting last period's output level. Under the assumption that acreage planted to a crop represents farmers' expected output, Nerlove assumes a linear relationship between acreage planted to a crop and the farm-gate price of the crop. This relationship may be written as follows:

$$X_t^* = a + b\,P_{t-1} + U_t \qquad (11)$$

where: X_t^* denotes the acreage the farmers would plant in year t if there were no difficulties of adjustments; P_{t-1} denotes the actual realized farm-gate price of the crop in year t-1; and U_t is a random disturbance term.

It is not possible to observe values of X_t^*, so Nerlove |29| uses his "Partial Adjustment" hypothesis which postulates that:

$$X_t - X_{t-1} = \gamma(X_t^* - X_{t-1}) \qquad (12)$$

where: X_t is the acreage actually planted in year t; X_{t-1} is the acreage planted in year t-1; and γ: $0 < \gamma \leq 1$, is the farmers' coefficient of adjustment - the constant proportion by which farmers adjust their acreage expectations.

Equations (11) and (12) constitute Nerlove's "PARTIAL ADJUSTMENT" model. The two equations may be combined to give:

$$X_t = \alpha_0 + \alpha_1 P_{t-1} + \alpha_2 X_{t-1} + \varepsilon_t \qquad (13)$$

where: $\alpha_0 = a\gamma$; $\alpha_1 = \gamma\, b$; $\alpha_2 = 1-\gamma$; and

$\varepsilon_t = \gamma\, U_t$.

Comparing equations (9) and (13) we note that the two models: "Adaptive Expectations" and "Partial Adjustment" do lead to the same description of the regression population, the only noticable difference being the specifications of the error terms ν_t and ε_t. Even though the two models lead to equivalent estimating equations, economists generally view them as conceptually different models. To quote Griliches |13| :

> "The adaptive expectations model attributes the lags to uncertainty and the discounting of current information. The partial adjustment model attributes the same lags to technological and pyschological inertia and to the rising cost of rapid change. Circumstances (or "experiments") are conceivable in which one could discriminate between these two hypotheses. For example, a government guaranteed price for next years crop should dispose of most of the information uncertainty. If lags still persist, they must be due to other slow adjustment reasons."

Use of the Partial Adjustment model, as defined by equation (13), is probably quite often a misspecification of expectations formation in the adaptive sense, while use of the adaptive expectations model, as defined by equation (9), may often be a misspecification of habit persistence in the partial adjustment sense. The reason for this is that the partial adjustment and adaptive expectations models are simply special cases of a more general model embodying the conceptual ingredients of both. Nerlove did not, however, specify under which conditions each of his two models would apply and Griliches tried to specify this. It is also conceivable that both models may apply in one case and the estimation of a_o, a_1, a and b would be impossible with known estimation techniques. Such would be the problem likely to be encountered in a case where information uncertainty and technological inertia apply simultaneously.

Fisher |30| used an "Arithmetic Lag" Model in which the regression coefficients in the general distributed lag decline in an arithmetic progression. Starting with a general distributed lag of the form:

$$A_t = a_o + \sum_{i=1}^{n} b_i P_{t-1} + U_t \qquad (14)$$

where: A_t = acreage planted in year t;

P_{t-1} = farm-gate price in year t-1;

n = the order of the lag;

b_i = Coefficients of the lag scheme;

U_t = random disturbance term.

Fisher takes the weights to be declining arithmetically:

$$b_i = \beta W_i \qquad (15)$$

where: W_i is proportional to $\frac{(n-i)}{n}$.

One advantage of the Fisher model over the Nerlovian models is that the Fisher model permits one to experiment with several lag terms and the "best" lag can be identified this way. In addition, the Fisher lag is free from difficulties encountered in the estimation of the Koyck distribution.

Maitha |23| experimented with Partial Adjustment lag and the Fisher lag and obtained short-run and long-run supply elasticities of the orders of 0.974 and 1.867 respectively, for Kenya's Maize using the Partial Adjustment model; and 0.31 and 0.36 respectively, for Kenya's wheat. The Fisher lag gave slightly lower short-run and long-run supply elasticities for both maize and wheat.

Krishna |22| estimated supply elasticities for: Cotton, Maize, Sugar-cane, Rice, Millet, Wheat and Barley in the Punjab region and obtained short-run supply elasticities ranging from 0.08 for wheat to 0.72 for Cotton and long-run elasticities ranging from 0.14 for Wheat to 1.62 for Cotton.

Stern |32| used the adaptive-expectations model to estimate supply elasticities for Jute grown in the province of Bengal and obtained short-run and long-run elasticities of the orders of 0.68 and 1.03 respectively.

All the studies mentioned above were concerned with annual crops which have no significant time lag between planting and the first realization of output. The results of the studies support the hypothesis that farmers attempt to produce more of their crops as the prices of the crops increase. The alternative hypothesis that farmers' production decisions are random is not supported by the results of the above studies.

Perennial crops have a considerable time lag (as long as five years in some cases) between planting and realization of first output. The output of such crops in any one year are the results of plantings in a number of preceding years. For such crops, the above models have to be modified to take into account the fact that output in any one year could be the result of plantings in a number of previous years.

Bateman |3| advanced the hypothesis that the major factor determining the expected long-run profitability of growing cocoa in Ghana is the farmers' expectations with regard to the pattern of future prices. He formulated the relationship between planting and farmers' price expectations as follows:

$$X_t = a_o + a_1 \bar{P}_t + a_2 \bar{C}_t + U_t \qquad (16)$$

where: $\bar{P}_t = \sum_{i=o}^{n} \frac{\{(P^*_{t+i})/(1+r)^i\}}{n+1}$, the mean value

of discounted future prices of cocoa that the farmers expected to prevail;

$$\bar{C}_t = \sum_{i=o}^{n} \frac{(C^*_{t+i})/(1+r)^i}{n+1}$$, the mean

value of the discounted prices of coffee (which was taken as the alternative crop to cocoa in most Ghanaian regions) that farmers expected to prevail;

X_t = the acreage planted to cocoa in year t;

r = the farmers' subjective rate of discount;

P^*_{t+i} = the expected real producer price of cocoa in year t+i;

C^*_{t+i} = the expected producer price of coffee in year t+i

Bateman assumes that expectations are formed in the adaptive sense:

$$\bar{P}_t - \bar{P}_{t-1} = \beta(P_t - \bar{P}_{t-1}) \qquad (17)$$

and

$$\bar{C}_t - \bar{C}_{t-1} = \gamma(C_t - \bar{C}_{t-1}) \qquad (18)$$

where. P_t and C_t are the real producer prices of cocoa and coffee respectively, in year t.

Bateman then makes the rather improbable assumption that the rates of adjustment of the expected prices is the same for cocoa and the alternative crop (coffee). That is to say: $\beta = \gamma$. Combining equations (16), (17) and (18), Bateman obtained:

$$X_t = a_o\beta + a_1\beta P_t + a_2\beta C_t + (1-\beta) X_{t-1} + \nu_t \qquad (19)$$

where:

$$\nu_t = U_t - (1-\beta) U_{t-1}$$

He then incorporates the fact that output of cocoa in any year is the result of plantings in a number of preceding years in the following equation:

$$Q_t^* = \sum_{i=k}^{\infty} b_i X_{t-i} \tag{20}$$

where:

Q_t^* = potential output of cocoa in year t;

b_i = the potential yields per acre in year t of cocoa planted in year t-i ;

k = the age at which cocoa trees first begin to bear.

Bateman then gives equation (20) a more specific form by using the information known about the pattern of yields over the life cycle of the cocoa tree:

$$Q_t = b_1 \left(\sum_{i=k}^{s-1} X_{t-i} \right) + b_2 \left(\sum_{i=s}^{\infty} X_{t-i} \right) \tag{21}$$

where: s = the year in which the second distinct increase in yield occurs.

b_1 = output per acre obtained after the first increase in yield;

b_2 = output per acre attained after the second increase in yield per acre.

One obvious problem with Bateman's model is that the long-run effect cannot be identified because β and γ enter the relation symmetrically. That is to say, it is impossible to obtain the separate values of β and γ from the final regression equation used by Bateman. Moreover, the assumption that the rates of adjustments of the expected prices is the same for cocoa and coffee is improbable. Yield per acre is assumed to remain constant over time. In the long run this assumption cannot hold due to technical progress.

Maitha |23| argues that in agriculture planned output can be represented by planted acreage or harvested acreage. Hence the acreage response to price can be taken as the supply response since the former indicates how much the farmers plan to produce. He argues further that since the amount of suitable land for coffee is limited, a farmer can be expected to respond differently to price changes, depending on the amount of suitable land available. Bateman's model does not take account of this. Maitha recommends a model which uses the stock of adult trees rather than one using new plantings because, in the first instance, new plantings do not enter the production function and secondly, because variations in bearing acreage do not only reflect plantings four years earlier, but also reflects removal and replanting rate.

One limitation of models using acreage instead of output is that in a country like Kenya, acreage statistics have been kept only for the large scale farms and not for the small scale farms. As a result one would be tempted to rely on the rather inaccurate acreage data as reported by the District Agricultural departments for the small scale farms.

2.2. Supply of Kenyan Pyrethrum

There are a number of factors to consider in undertaking a study of the supply of Kenyan pyrethrum. Firstly, the agronomic requirements of the crop are so demanding that so far only a few districts of Kenya have been found suitable for pyrethrum growing. These districts are found in the widely scattered Kenyan highlands. By the Pyrethrum Act, 1964, all pyrethrum flowers have to be delivered to the Nakuru factory by the growers themselves. There are bound to be considerable disparities between pyrethrum growing regions arising from the transportation cost element. For example, farmers on the slopes of mount Elgon in Bungoma district may not respond to changes in pyrethrum price to the same extent as farmers in Nakuru district because the latter have a transportation cost advantage over the former.

Secondly, the range of production alternatives available to pyrethrum farmers vary from one district (or province) to another due to the heterogeneity of Kenya's soil structure and rainfall distribution. Some regions have a soil type and rainfall distribution which are suitable for growing many other cash and food crops. The decisions of farmers to grow more or less of pyrethrum in such regions will depend on the relative profitability of pyrethrum with respect to the other cash crops and the relative ease with which pyrethrum can be grown.

Thirdly, different provinces of Kenya have got varying levels of population density which consequently results in varying levels of land per capita. How much more or less of pyrethrum a region will grow in response to price change will depend on the availability of suitable pyrethrum land in the region and the relative ease with which land already committed to other farm productive activities could be turned over to pyrethrum growing.

Fourthly, most farming communities in Kenya tend to derive satisfaction from being self sufficient in food supply. Specialization in agricultural production may in some regions be hindered by inefficiency of the food market. The distribution of essential foods such as maize is so bad in some regions that farmers in those regions tend to grow at least enough food for subsistence thus creating a limit to the amount of cash crops farmers could produce. Some areas, however, do have a farming mix which provides ample food supply. A pyrethrum grower in such a region can remain content with the cash income from pyrethrum because he can buy the food which he has not produced. Farmers in other areas cannot help growing some amount of food crops sufficient for subsistence because of the poor farming mix and inefficiency of food distribution in the areas. The decisions of the latter farmers to grow more or less of pyrethrum will depend on the relative importance of cash income in determining their utility.

The use of national data to estimate an aggregate supply function for the whole industry is therefore likely to ignore some significant regional dissimilarities which may be important in determining farmers' responsiveness to price and changes.

Availability of production alternatives and the importance of self-sufficiency in food production do introduce the concept of opportunity cost. A farmer will require considerable judgement in deciding how much of his limited land to commit to pyrethrum growing and how much will be left over to grow food and other cash crops. One way of incorporating an element of apportunity cost into a supply function is to introduce the concept of relative prices. Maitha|23|deflates the price of maize with the price of wheat and that of wheat with the price of maize. The implied argument in this specification is that maize and wheat are the clossest substitutes in farmes' decisions and that there do not exist other production alternatives which could significantly influence wheat farmers' decisions to grow more or less of the crop. This may not be very true because there are many other production alternatives available to maize and wheat farmers in Kenya. Dairy farming in Kenya for example has become a very important farm production alternative in the maize and wheat belt. The analytical distinction between "cash" crops and "food" crops could also be misleading because all production alternatives do compete for the limited household labour and land and food crops, as well as cash crops, must have some influence on farmers' decisions to grow any particular crop. Deflating the price of a cash crop with the price of one "competitive" cash crop would be based on the limiting assumption that food crops availability does not influence farmers' decisions to grow the cash crop under study. In an ideal situation, we need a suitable price index for all farm produce to deflate the price of the crop under study. This is not however, practically possible in the present study because of lack of comprehensive record of prices and quantities of all farm produce. What we do in the present study is to include the prices of as many alternative farm production alternatives as are available as additional explanatory variables in our supply functions with a view towards empirically determining the "most competitive" production alternatives to pyrethrum in the various provinces and then use the price of this production alternative to deflate the price of pyrethrum. In this way we shall have empirically established which is the closest competitor to pyrethrum in each province and at the national level.

Due to extreme variability of weather conditions, farmers tend to have no control over actual farm output. However, acreage planted to a crop in any period should reflect, to a reasonable extent, farmers' expected output of the crop for that period. On this ground, it is reasonable to use acreage instead of output in the supply function estimation.

Acreage data published by the Kenya's Central Bureau of Statistics only relate to large scale farms. For a crop like pyrethrum which is predominantly a smallholder crop one has to use department of Agriculture' district and provincial annual reports which give annual estimates of acreage under pyrethrum. Such data are, however, bound to be very inaccurate because they are simply rough estimates made by the district agricultural staff who take no trouble to measure the fields accurately.

The difficulty of compiling acreage data for pyrethrum is aggrevated by the "splitting" process. A typical small-scale pyrethrum grower in Kenya starts off with a Pyrethrum Marketing Board's loan of K.Shs. 250 in the form of 1000 planting material. This is enough to plant an initial one-quarter of an acre because each planting material which must have been in the nursery for four to five months may be split at the time of planting to give a maximum of five splits and this yields the recommended plant population of 5,000 splits. After another five to six months the splits can be further split to give the required plant population of 20,000 for one acre. Thus, within a year, a farmer who started off with a quarter of an acre under pyrethrum will, if he is keen enough to split, end up with one acre of pyrethrum. The splitting process continues so long as there is sufficient rainfall. Acreage estimation thus becomes difficult since not all farmers do split.

Some attempt is therefore made in the present study to use output data in the supply functions for the whole industry and for two provinces for which such data is available, allowing for weather factors by using a zero-one variable. The value "one" will be assigned to years in which weather appears to have been average or good for pyrethrum and the value "zero" to years in which weather appears to have been bad. A "zero" will not be assigned to a year unless there is clear indication that the size of the crop, as measured in metric tonnes, was reduced as a result of poor weather conditions.

Judgement as to the nature of the weather will be based on qualitative and quantitative statements contained in the Ministry of Agriculture annual reports, statistical abstracts and to some extent on the annual reports of the pyrethrum boards.

Let us consider a simple model for a "typical" pyrethrum grower in Kenya. The decision of a grower to commit land to pyrethrum growing depends upon his expectations with regard to future relative prices of pyrethrum and expected long-run equilibrium acreage of pyrethrum. This hypothesis may be written as follows:

$$A_t = f\{(PP/P_m)^*_t,\ A^*_t\} \qquad (2.2.1)$$

where:

A_t = observed acreage under pyrethrum in year t;

A^*_t = expected long-run equilibrium acreage;

$(PP/P_m)^*$ = expected relative price of pyrethrum in year t;

PP = observed price of pyrethrum

P_m = observed price of some competing crop. This crop has to be determined by empirical testing

We can reduce the generality of equation (2.2.1) by writing the model as follows:

$$A_t = a_o + a_1(PP/P_m)^*_t + \emptyset\,(A^*_t) \qquad (2.2.2)$$

where: a_o and a_1 are constant parameters, and $\emptyset$ is some other function whose specification we do not know.

We have to define what we mean by "expected long-run equilibrium acreage, A_t^*." We may assume that pyrethrum farmers formulate their expectations of future pyrethrum prices on the basis of past relative pyrethrum price levels, as we suggested in Nerlove's "Adaptive-Expectations" model |29|, Let $\frac{(PP)}{Pm}_t^*$ be the relative price of pyrethrum farmers expected to prevail in the current period, and $\frac{(PP)}{Pm}_t$ be the actual relative price that did prevail in the current period.

Nerlove's "Adaptive-Expectations" postulate that:-

$$\frac{(PP)}{Pm}_{t+1}^* - \frac{(PP)}{Pm}_t^* = \beta \left| \frac{(PP)}{Pm}_t - \frac{(PP)}{Pm}_t^* \right| \qquad (2.2.3)$$

where: β, $0 < \beta \leq 1$ is the constant coefficient of farmers' expectations.

People's expectations of the long-run level of relative prices are constantly changing; so are their expectations of long-run actual acreage devoted to a crop. We must, therefore, in an attempt to explain changes in prices, decompose the problem into:

(i) the effect of the changes in relative prices on the expected level of future relative prices;

(ii) the effect of a change in the expected level of future relative prices on the long-run equilibrium acreage.

The hypothesis is that in response to changes in relative prices of farm produce, farmers adjust their actual mix of farm activities in proportion to the difference between some desired long-run equilibrium

mix of activities and the current actual mix of activities.
Let: A_t represent acreage planted to pyrethrum in year t, A_{t-1} be the acreage planted to pyrethrum in the previous year and A_t^* be some desired long-run equilibrium acreage of pyrethrum. The above hypothesis postulates that:

$$A_t - A_{t-1} = \gamma(A_t^* - A_{t-1}) \qquad (2.2.4)$$

where: γ, $0 < \gamma \leq 1$ represents the coefficient of adjustment.

If $\gamma = 1$ then it would mean that there are no adjustment bottlenecks and farmers could easily adjust the actual acreage to the desired long-run equilibrium level in any single period. This is very unlikely in the Kenyan pyrethrum case due to a number of factors including availability of suitable land, rising cost of adjustment, inflexibility of farmers with respect to their farming practices and technology and labour constraints. It is reasonable in the case of Kenyan pyrethrum to expect that γ will be less than unity with the implication that the acreage adjustment process may only be partially successful in any single period. The magnitude of the constant γ will depend, among other factors, on the elasticity of supply of land, that is, the ease with which land already committed to other farming activities can be turned over to pyrethrum production.

Assuming a linear relationship between the expected level of future relative prices of pyrethrum and the desired long-run acreage under pyrethrum, we may write:

$$A_t^* = a_0 + a_1 \frac{(PP)}{P_m}{}_t^* + U_t \qquad (2.2.5)$$

where U_t is a random regression disturbance.

The fact that pyrethrum prices are announced by the Pyrethrum Marketing Board before planting eliminates information uncertainty and any lags that still persist must be attributed to adjustment bottlenecks. We effectively make the assumption that $\beta = 1$ so that equation (2.2.3) could be written as follows:

$$\left(\frac{PP}{P_m}\right)^*_t = \left(\frac{PP}{P_m}\right)_t \qquad (2.2.6)$$

Combining equations (2.2.6) and (2.2.4) gives:

$$A^*_t = a_o\gamma + a_o + a_1\left(\frac{PP}{P_m}\right)_t + U_t \qquad (2.2.7)$$

Solving for A^*_t in equation (2.2.5) and substituting the solution for A^*_t in equation (2.2.7) gives:

$$A_t = a_o\gamma + a_1\gamma\left(\frac{PP}{P_m}\right)_t + (1-\gamma)A_{t-1} + \nu_t \qquad (2.2.8)$$

where: $\nu_t = \gamma U_t$

There are five pyrethrum growing provinces namely, Nyanza, Central, Rift Valley, Eastern and Western. The crop is still relatively new in Western Province because the crop was introduced into the province only in the year 1970/71. Time series data for the province thus do not provide a good number of degrees of freedom for statistical analysis. We therefore have to estimate supply functions for Nyanza, Central, Rift Valley, and Eastern provinces.

Let us use the following notations for the regional supply functions:

AN_t = total acreage under pyrethrum in Nyanza Province in year t;

AC_t = total acreage under pyrethrum in Central Province in year t;

AR_t = total acreage under pyrethrum in Rift Valley Province in year t;

AE_t = total acreage under pyrethrum in Eastern Province in year t;

$\frac{(PP)}{P_i}t$ = relative price of pyrethrum with respect to price of the most competitive crop.

It is important to note that structural and evironmental differences between provinces may give rise to provincial variations in farmers sophistication and expectations about price. Different provinces have attained different levels of economic development. Population density also varies with provinces. These factors are likely to lead to provincial differences with respect to adjustment. We have to assign different coefficients of adjustment γ_i for the four provinces. The coefficient of farmers' expectations with respect to price is assumed to be equal to unity for all the provinces due to the fact that the Marketing Board announces pyrethrum prices to the growers before planting thus eliminating information uncertainty.

Let AN^*_t, AC^*_t, AR^*_t, AE^*_t be some desired long-run acreage of pyrethrum in Nyanza, Central, Rift Valley and Eastern Provinces at time t. We shall postulate that:

$$AN^*_t = \alpha_1 + \delta_1 (PP/P_i)_t + U_{t1} \tag{2.2.9}$$

where: PP = price of pyrethrum;

P_i = price of the most competitive crop in Nyanza Province.

$$AC_t^* = \alpha_2 + \delta_2 (PP/P_i)_t + U_{t2} \qquad (2.2.10)$$

where P_i is the price of a crop closely competing pyrethrum in Central province.

$$AR_t^* = \alpha_3 + \delta_3 (PP/_{P_k})_t + U_{t3} \qquad (2.2.11)$$

where P_k is the price of a competing crop in Rift Valley province.

$$AE_t^* = \alpha_4 + \delta_4 (PP/_{P_L})_t + U_{t4} \qquad (2.2.12)$$

where P_L is the price of a competing crop in Eastern province.

The U_{ti} are random error terms.

Partial Adjustment postulates that:

$$AN_t - AN_{t-1} = \gamma_1 (AN_t^* - AN_{t-1}) \qquad (2.2.13)$$

where γ_1 is the Nyanza pyrethrum farmers' coefficient of Adjustment;

$$AC_t - AC_{t-1} = \gamma_2 (AC_t^* - AN_{t-1}) \qquad (2.2.14)$$

where γ_2 is the Central province farmers' coefficient of adjustment;

$$AR_t - AR_{t-1} = \gamma_3 (AR_t^* - AR_{t-1}) \qquad (2.2.15)$$

where γ_3 is the Rift Valley farmers' coefficient of adjustment;

$$AE_t - AE_{t-1} = \gamma_4 (AE_t^* - AE_{t-1}) \qquad (2.2.16)$$

where γ_4 is the Eastern province farmers' coefficient of adjustment.

As was demonstrated previously in the "partial adjustment" model, it is possible to transform a relationship between long-run equilibrium acreage and observed relative price into a relationship between actual acreage, observed relative price and lagged acreage:

$$AN_t = \alpha_1\gamma_1 + \delta_1\gamma_1(PP/P_i)_t + (1-\gamma_1)AN_{t-1} + \gamma_1 U_{t1} \qquad (2.2.17)$$

$$AC_t = \alpha_2\,\delta_2 + \delta_2\delta_2(PP/P_i)_t + (1-\gamma_2)AC_{t-1} + \gamma_2\,U_{t2} \qquad (2.2.18)$$

$$AR_t = \alpha_3\gamma_3 + \delta_3\gamma_3(PP/P_k)_t + (1+\gamma_3)AR_{t-1} + \gamma_3\,U_{t3} \qquad (2.2.19)$$

$$AE_t = \alpha_4\gamma_4 + \delta_4\gamma_4(PP/P_L)_t + (1-\gamma_4)\,AE_{t-1} + \gamma_4\,U_{t4} \qquad (2.2.20)$$

Equations (2.2.17) through (2.2.20) indicate regressions for Nyanza, Central, Rift Valley and Eastern provinces of the form:

<u>NYANZA PROVINCE</u>

$$AN_t = \alpha_1' + \delta_1'(PP/P_i)_t + \theta_1\,AN_{t-1} + \nu_{t1} \qquad (2.2.21)$$

where: $\theta_1 = 1-\gamma_1$ and $\nu_{t1} = \gamma_1\,U_{t1}$

<u>CENTRAL PROVINCE:</u>

$$AC_t = \alpha_2' + \delta_2'\,(PP/P_i)_t + \theta_2\,AC_{t-1} + \nu_{t2} \qquad (2.2.22)$$

where: $\theta_2 = 1-\gamma_2$ and $\nu_{t2} = \gamma_2 U_{t2}$

<u>Rift Valley Province:</u>

$$AR_t = \alpha_3' + \delta_3'\,(PP/P_k)_t + \theta_3\,AR_{t-1} + \nu_{t3} \qquad (2.2.23)$$

where: $\theta_3 = 1-\gamma_3$ and $\nu_{t3} = \gamma_3\,U_{t3}$

EASTERN PROVINCE

$$AE_t = \alpha_2' + \delta_4' + (PP/P_L)_t + \theta_4 AE_{t-1} + \nu_{t4} \qquad (2.2.24)$$

where: $\theta_4 = 1-\gamma_4$ and $\nu_{t4} = \gamma_4 U_{t4}$.

The residuals ν_{ti} must be serially uncorrelated if statistically consistent and unbiased estimates of the parameters in equation (2.2.21) through (2.2.24) are to be obtained. In this model, the residuals ν_{ti} will be correlated with the lagged acreage if the residuals U_{ti} are not serially correlated. Logically, there is no basis for deciding on theoretical grounds between the assumption that the correlation between U_{ti} and U_{ti-1} is zero and the assumption that it is not zero. Only the Durbin-Watson statistic of the regression can enable us to decide one way or the other.

Acreage expansion may be the result of a deliberate effort by the government to step up production of a crop. Attributing acreage changes all to price may ignore significant influence of government policy on farmers' decisions. Pyrethrum growers, for example, obtain credit from the Marketing Board in the form of production inputs like planting material and fertilizer. Existence of such credit has probably been instrumental in raising the levels of expected pyrethrum relative prices. It has certainly reduced the price uncertainty that farmers' face and speeded up the adoption of high-yielding pyrethrum varieties and better techniques of production.

We use a policy "dummy" variable, assigning the value "zero" for years which show normal increases of pyrethrum acreage in response to price increases and the value "one" for years which show acreage increases which are out of proportion to the normal trend. We therefore estimate the following equations for the industry and the provinces:

Industry:

$$A_t = \alpha' + \delta'(PP/P_I)_t + \theta A_{t-1} + e D + \nu_t \qquad (2.2.25)$$

NYanza Province

$$AN_t = \alpha_1' + \delta_1'(PP/P_i)_t + \theta_1 AN_{t-1} + e_1 D + \nu_{t1} \qquad (2.2.26)$$

Central Province:

$$AC_t = \alpha_2' + \delta_2'(PP/P_j)_t + \theta_2 AC_{t-1} + e_2 D + \nu_{t2} \qquad (2.2.27)$$

Rift Valley Province

$$AR_t = \alpha_3' + \delta_3'(PP/P_k)_t + \theta_3 AR_{t-1} + e_3 D + \nu_{t3} \qquad (2.2.28)$$

Eastern Province

$$AE_t = \alpha_4' + \delta_4'(PP/P_L) + \theta_4 AE_{t-1} + e_4 D + \nu_{t4} \qquad (2.2.29)$$

where: D is the policy dummy variable, and

$$\theta_i = 1 - \gamma_i.$$

Fisher distributed lag of the form:

$$A_t = \alpha + \beta Px_2 + \gamma A_{t-1} + U_t \qquad (2.2.30)$$

where:

$$Px_2 = \frac{1}{3}\{2 P_{t-1} + P_{t-2}\}$$

is also tested for the industry.

An output function is also estimated using the Partial Adjustment model:

$$Q_t = a_o + a_1 PP_t + a_2 W_t + a_3 Q_{t-1} + \nu_t \qquad (2.2.2.31)$$

where: W_t = a dummy variable for weather

A number of alternative farm production alternatives tend to compete with pyrethrum in the various regions. In Nyanza Province, the alternatives include: dairy farming, maize, tea and coffee. Rift Valley has wheat, maize, and dairy farming. Eastern Provicne has maize, tea, coffee and dairy farming as alternatives to pyrethrum. It is therefore difficult to decide a 'pri-ori' which is the most competitive crop in any province. In this study we first include the prices of the competing crops as additional regressors with a view towards establishing which is the most competitive crop in each region.

The following equations are estimated:

Industry:

$$A_t = a_o + b_o PP_t + co\, A_{t-1} + do\, D + eo\, PMA_t + fo\, PMI_t + go\, PT_t + hoPW_t + i_o PC_t + \varepsilon_t \qquad (2.3.1)$$

Nyanza Province:

$$AN_t = a_1 + b_1 PP_t + c_1 AN_{t-1} + d_1 D + e_1 PMA_t + f_1 PMI_t + g_1 PT_t + h_1 PC_t + \varepsilon_{t1} \qquad (2.3.2.)$$

Central Province

$$AC_t = a_2 + b_2 PP_t + c_2 AC_{t-1} + d_2 D + e_2 PMA_t + f_2 PT_t + g_2 PC_t + \varepsilon_{t2} \qquad (2.3.3)$$

Rift Valley Province

$$AR_t = a_3 + b_3 PP_t + c_3 AR_{t-1} + d_3 D + e_3 PMA_t + f_3 PMI_t + g_3 PW_t + \varepsilon_{t3} \qquad (2.3.4)$$

Eastern Province

$$AE_t = a_4 + b_4 PP_t + c_4 AE_{t-1} + d_4 D + e_4 PMA_t + f_4 PMI_t + g_4 PT_t + h_4 PC_t + \varepsilon_{t4} \qquad (2.3.5)$$

where:

PP_t = pyrethrum price in year t;

PMA_t = maize price in year t;

PMI_t = Milk price in year t;

PT_t = Tea price in year t;

PC_t = Coffee price in year t;

D = Dummy variable

ε_{ti} = error terms;

a_i, b_i, c_i, d_i, e_i, f_i, g_i, h_i, and i_i are constant parameters.

CHAPTER III
EMPRICAL RESULTS

3.1. Data

Acreage data were obtained from various issues of district and provincial annual reports of the Department of Agriculture. Regional data on acreage were obtained from the Crop Production Division of the Pyrethrum Marketing Board. No acreage data were available for the period earlier than 1953. Output data were, however, available for a much longer period and in an attempt to use actual output (measured in metric tonnes) of dried flowers instead of acreage in national supply response function, we have used the data for the period 1940/41 to 1973/74. The output data were obtained from the Pyrethrum Marketing Board in Nakuru. Attempts to obtain output data for the various provinces failed because of the inconsistent record of such data by the Marketing Board.

Government policy and weather factors are accounted for in the analysis by dummy variables, assigning, in the case of weather, the value "zero" for years in which weather was considered bad and the value "one" for years in which weather was considered average or good for pyrethrum production. Quantitative and qualitative statements contained in the Statistical Abstracts and Farm Economic Surveys were used to assign the zero - one values. Needless to say a few arbitrary decisions had to be made. In the case of Government policy, the value "one" was assigned to the year when the government started emphasizing pyrethrum production in each region and all the years that follow.

Pyrethrum prices vary with the pyrethrins contents of the flowers. We, however, used prices paid for dried flowers of 1.5 per cent pyrethrins contents since the prices paid to flowers of different contents would be proportional to these prices. The prices were obtained from the Pyrethrum Marketing Board in Nakuru. Prices of competing crops were obtained from various issues of Statistical Abstract published by the Central Bureau of Statistics of the Ministry of Finance and Planning. Maize and wheat prices were obtained from the Kenya Farmers' Association in Nakuru. Milk prices were obtained from the Kenya Dairy Board in Nairobi.

Regression Results.

The following regression results were obtained for acreage response to price for the industry and the four provinces using the Partial Adjustment model:

Industry (Equation 2.3.1)

$$A_t = -\ 87165.22 + 12684.48\ PP_t + 0.78\ A_{t-1} + 21592.63D$$

1.07^* $\quad 1.46^*$ $\quad 2.92^*$ $\quad 1.30^*$

$$-\ 25491.39\ PMA_t + 4727.58\ PMI_t + 6223.27\ PT_t$$

1.39^* $\quad 0.33^*$ $\quad 0.90^*$

$$-\ 75925.09\ PW_t + 3560.25\ PC_t$$

1.27^* $\quad 0.58^*$

$\bar{R}^2 = 0.958$

D-W = 1.340

$\gamma = 0.22$

Nyanza Province (Equation 2.3.2)

$$AN_t = -91123.80 + 5951.48\, PP_t + 0.26\, AN_{t-1} +$$

$$\quad 2.40^* \qquad 1.58^* \qquad 0.81^*$$

$$16667.63\, D - 5305.02\, PMA_t + 7203.14\, PMI_t$$

$$\quad 2.76^* \qquad 1.83^* \qquad 0.15^*$$

$$- 5628.10\, PT_t + 533.22\, PC_t$$

$$\quad 0.82^* \qquad 0.22^*$$

$\bar{R}^2 = 0.913$

D-W = 1.360

$\gamma_1 = 0.74$

<u>Central Province (Equation 2.3.3)</u>

$$AC_t = -98.87 + 4113.00\, PP_t + 0.90\, AC_{t-1} + 554.10D$$

$$\quad 0.01^* \qquad 2.64^* \qquad 5.66^* \qquad 0.31^*$$

$$- 20479.10\, PMA_t - 1029.30\, PT_t - 929.29\, PC_t$$

$$\quad 1.51^* \qquad 0.88^* \qquad 1.77^*$$

$\bar{R}^2 = 0.936$

$D\text{-}W = 1.640$

$\gamma_2 = 0.100$

<u>Rift Valley Province (Equation 2.3.4)</u>

$$AR_t = -\underset{0.74^*}{12010.53} + \underset{1.95^*}{5315.59}\, PP_t + \underset{4.82^*}{0.84}\, AR_{t-1}$$

$$+ \underset{0.46^*}{2058.49}\, D - \underset{1.92^*}{22891.92}\, PMA_t + \underset{0.14^*}{509.75}\, PMI_t$$

$$- \underset{0.41^*}{6656.64}\, PW_t$$

$\bar{R}^2 = 0.944$

$D - W = 1.640$

$\gamma_3 = 0.160$

<u>Eastern Province (Equation 2.3.5)</u>

$$AE_t = -\underset{0.08^*}{1900.77} + \underset{1.96^*}{4539.39}\, PP_t + \underset{0.01^*}{0.64}\, AE_{t-1} + \underset{3.55^*}{17186.83}\, D$$

$$- \underset{0.17^*}{3283.65}\, PMA_t + \underset{0.43^*}{1671}\, PMI_t - \underset{1.67^*}{1174.00}\, PT_t$$

$$- \underset{1.03^*}{1409.70}\, PC_t .$$

$\bar{R}^2 = 0.945$

$D - W = 2.010$

$\gamma_4 = 0.360$

where: $*$ = t - Statistics;

D-W = Durbin Watson Statistic;

$\bar{R}^2$ = Adjusted Coefficient of multiple; determination

γ_i = Adjustment coefficients.

All the coefficients in the industry regression, with the only exception of the coefficient of lagged acreage, are insignificant at 95 per cent level of confidence. However, at 90 per cent level of confidence, the coefficients of pyrethrum price and maize price become significant. The positive coefficient of pyrethrum price and negative coefficient of maize price are indications that pyrethrum acreage responds positively to pyrethrum price and negatively to maize price which is consistent with prediction theory. Price of wheat, though insignificant at both 95 per cent and 90 per cent levels of confidence, also has a negative coefficient. Prices of milk, tea and coffee, however, do have positive coefficients which contradict prediction theory. These coefficients are all in significant at both 95 and 90 per cent levels of confidence, which is an indication that these prices do not have significant influence on pyrethrum acreage at the industry level. We therefore take maize as the most highly competitive crop to pyrethrum at the industry level. The insignificance of policy dummy coefficient at both 95 per cent and 90 per cent levels of confidence is an indication that government policy does not have significant influence on pyrethrum acreage at the industry level unless it is a policy which directly or indirectly changes the prices of pyrethrum and the most competitive crop, maize.

In the regression for Nyanza Province, the coefficients of maize-price, policy variable and the constant are significant at 95 per cent level of confidence. The coefficient of pyrethrum price becomes significant at 90 per cent level of confidence. Because of its negative coefficient, maize is taken as the most competitive crop in Nyanza Province. This is consistent with the fact that maize is the staple food of Nyanza Province most of whose districts tend to produce little marketable surplus of maize because of the predominance of subsistence farming in Nyanza Province. Government policy, though insignificant at industry level, turns out to be significant for Kisii district. Kisii district pyrethrum growers have infact been the most sensitive group to government policy of pyrethrum taxation. Their frequent strikes support this. Tea is the other crop that competes pyrethrum in Kisii district.

Coffee and dairy farming have insignificant influence on Kisii pyrethrum acreage. Most of Kisii farmers are infact gradually uprooting their coffee plantations because of the long delays in coffee payments. Farmers have to wait for as long as several months before they are paid for their coffee deliveries. Pyrethrum and Tea payments get to the farmers regularly and this is what farmers with immediate cash needs require. Delays in coffee payments is in most cases the result of inefficiency of Kisii Coffee Societies.

Regression for Central Province gives coffee as the most competitive crop. The coffee socities in Central Province seem to be more efficient and the fact that more coffee farmers in the province work on a relatively large scale gives them access to credit facilities for coffee production. Policy variable is not significant in Central Province. The staple food, maize, also turns out to be insignificant in the province, most probably because the Central Province people use potatoes as an equally important food crop and the production of this crop has recently been increased in the province under the Horticultural Crop Development Scheme.

Maize turns out to be the most highly competitive crop in Rift Valley. This is consistent with the experience of most large-scale farmers in the province who prefer growing maize to wheat inspite of the fact that the latter fetches higher prices because of the relatively low level of mechanization required for maize production.

Tea turns out to be the most competitive crop in Eastern Province. Its coefficient in the regression for Eastern Province is significant at the 95 per cent level of confidence. The other crops have insignificant coefficients both at the 95 per cent and the 90 per cent levels of confidence.

The Durbin Watson statistic test for serial correlation is inconclusive for the industry, Nyanza Province, Central Province and Rift Valley Province regressions at both 95 per cent and 90 per cent levels of confidence. For Eastern Province, we accept the null hypothesis that the disturbances are serially uncorrelated at the 5 per cent level of significance. The inconclusiveness of the D-W statistic test for all regions except Eastern Province leaves a lot to be desired about the possible existence of serial correlation in the regression disturbances. There are chances that the estimated parameters of regressions where the test is inconclusive are biased and inconsistent. This may be the result of including other prices as additional regressors and in the next section we test this proposition by regressing acreage on price, lagged acreage and policy dummy, leaving out the prices of competing crops.

The rate of adjustment of pyrethrum acreage to changes in product prices varies from one region to another. Nyanza Province has the highest rate of adjustment of 74 per cent per year. The rate of adjustment for the whole industry is 22 per cent per year while the rates of adjustment for Eastern Province, Rift Valley Province and Central Province are 36 per cent, 16 per cent and 10 per cent per year respectively.

The Fisher Lag gave the following results for equation (2. 2. 30):

$$A_t = 64.82 - 8.81 \ PX_2 + 0.77 \ A_{t-1}$$

$$1.50^* \quad 1.16^* \qquad 5.80^*$$

$\bar{R}^2 = 0.830$

$D - W = 1.888$

$\gamma = 0.230$

The negative coefficient of PX_2 is inconsistent. The insignificance of the coefficient of PX_2 is an indication that pyrethrum farmers tend to make their decisions on the basis of current prices announced by the Marketing Board and that previous prices have no significant influence on farmers' decisions with respect to acreage planted to pyrethrum.

Output equation (2. 2. 31) gave the following results for the Partial Adjustment model:

$$Q_t = -705.61 + 356.01 \ PP_t + 407.00 \ W_t + 0.82 \ Q_{t-1}$$

$$0.46^* \qquad 1.39^* \qquad 0.46^* \qquad 6.87^*$$

$\bar{R}^2 = 0.802$

$D - W = 1.75$

$\gamma = 0.18$

The adjusted coefficient of multiple determination, $\bar{R}^2$, shows that output equation does not fit the data.

It is in certain cases true that acreage planted to a crop may have to change over time, all other things being equal. We introduce a trend variable, T, to account for the effect of time on acreage.

Without trend variable we obtain the following results:

$$A_t = -50.91 + 10.42\,PP_t + 0.53\,A_{t-1} + 32.56\,D \quad (3.2.1)$$
$$\qquad 2.42^* \quad 2.84^* \quad 6.23^* \quad 6.39^*$$

$\bar{R}^2 = 0.959$

$D - W = 1.660$

$\gamma = 0.470$

With trend variable we obtain the following results:

$$A_t = -44.03 + 9.19\,PP_t + 0.30\,A_{t-1} + 29.02\,D + 1.42\,T \quad (3.2.2)$$
$$\qquad 2.72^* \quad 2.23^* \quad 5.94^* \quad 2.15^*$$

$\bar{R}^2 = 0.969$

$D\text{-}W = 1.950$

$\gamma = 0.700$

We notice from (3.2.2) that the introduction of trend variable improves the equation with respect to the Durbin Watson statistic and the coefficient of multiple determination. The significance of policy dummy and the trend variable coefficients at the 95 per cent level of confidence is an indication that the two variables significantly influence pyrethrum acreage.

3.2. Regression Results for undeflated Pyrethrum Prices:

Acreage expressed in thousand acres was used for the following equations:

Industry

$$A_t = \underset{\substack{(21.05)\\ 2.42^*}}{-50.91} + \underset{\substack{(3.68)\\ 2.84^*}}{10.46}\, PP_t + \underset{\substack{(0.08)\\ 6.23^*}}{0.53}\, A_{t-1} + \underset{\substack{(5.09)\\ 6.39^*}}{32.56}D \qquad (3.3.1)$$

$R^2 = 0.959$

$D - W = 1.660$

$\gamma = 0.470$

Nyanza Province

$$AN_t = \underset{\substack{(23.16)\\ 2.69^*}}{-62.20} + \underset{\substack{(4.03)\\ 2.80^*}}{11.28}\, PP_t + \underset{\substack{(0.23)\\ 0.30^*}}{0.36}\, AN_{t-1} + \underset{\substack{(5.59)\\ 3.43^*}}{19.18}\, D \qquad (3.3.2)$$

$\bar{R}^2 = 0.763$

$D\text{-}W = 2.070$

$\gamma_1 = 0.640$

Central Province.

$$AC_t = -11.32 + 2.59\,PP_t + 0.51\,AC_{t-1} + 13.26\,D \qquad (3.3.3)$$

$$\begin{array}{cccc} (10.86) & (1.98) & (0.14) & (3.69) \\ 1.04^* & 1.31^* & 3.54^* & 3.60^* \end{array}$$

$R^2 = 0.951$

D-W = 2.520

$\gamma_2 = 0.490$

Rift Valley Province:

$$AR_t = -4.42 + 1.26\,PP_t + 0.76\,AR_{t-1} + 4.24\,D \qquad (3.3.4)$$

$$\begin{array}{cccc} (26.82) & (4.45) & (0.20) & (4.43) \\ 0.16^* & 0.28^* & 3.77^* & 0.96^* \end{array}$$

$\bar{R}^2 = 0.835$

D-W = 1.20

$\gamma_3 = 0.24$

Eastern Province:

$$AE_t = -17.46 + 4.10\,PP_t + 0.41\,AE_{t-1} + 16.13\,D \qquad (3.3.5)$$

$$\begin{array}{cccc} (13.50) & (2.52) & (0.21) & (3.31) \\ 1.29^* & 1.62^* & 1.96^* & 4.86^* \end{array}$$

$R^2 = 0.801$

DW = 1.940

$\gamma_4 = 0.690$

where:

( ) = standard error

* = T - statistic

$\bar{R}^2$ = adjusted coefficient of multiple determination

D-w = Durbin-Watson Statistic.

It is noticable from equation (3.3.1) to (3.3.5) that exclusion of other prices from the set of regressors improves the regression results with respect to the adjusted coefficient of multiple determination and the Durbin Watson statistic.

The coefficient of pyrethrum price is significant in all regressions (except in the regressions for Central and Rift Valley Provinces) at the 95 per cent level of confidence. However, at the 90 per cent level of confidence, pyrethrum price becomes a significant explanatory variable in the regressions for the industry and all the four regions.

The coefficients of the policy dummy variable is significant for all the regressions at the 95 per cent level of confidence. This is an indication that government policy has significant influence on pyrethrum acreage at industry and provincial levels.

By the Durbin Watson test, we accept the null hypothesis that the disturbances are not serially correlated for all regressions, except for Rify Valley Province, at the 0.05 level of significance.

Exclusion of other prices from the set of regressors has had different effects on the rates of adjustment of pyrethrum acreage to changes in producer prices. The rate of adjustment for the whole industry, for instance, increases from 22 per cent to 47 per cent per year. The rate of adjustment for Nyanza Province falls from 74 per cent to 64 per cent per year; the rate of adjustment for Eastern Province increases from 36 per cent to 64 per cent per year; the rate of adjustment for Rift Valley Province increases from 16 per cent to 24 per cent per year; and the rate of adjustment for

Central Province increases from 10 per cent to 49 per cent year.

Table 10.

Short - Run and Long-Run Supply Elasticities

REGION	EQUATION	SHORT - RUN SUPPLY ELASTICITY*	LONG - RUN SUPPLY ELASTICITY*
INDUSTRY	(3.3.1)	0.9965	1.9732
INDUSTRY	(2.2.31)	0.2680	0.3645
NYANZA PROVINCE	(3.3.2)	0.5829	0.6530
CENTRAL PROVINCE	(3.3.3)	0.9964	1.8950
R.VALLEY PROVINCE	(3.3.4)	0.9998	1.9650
EASTERN PROVINCE	(3.3.5)	0.9950	1.1000

* The Price-elasticities were calculated at sample means.

We notice from the elasticity coefficients that farmers' responsiveness to price is relatively higher in the long-run than in the short-run. Rift Valley and Central Provinces have the highest short-run and long-run elasticity coefficients. This is consistent with the fact that the two provinces are the more developed and have more farm production alternatives. A slight decrease in pyrethrum producer price will signal farmers in the two provinces to change quickly to the other more lucrative alternatives.

Nyanza Province has the lowest Short-run and Long-run elasticities. This is most probably due to the fact that Kisii district, which is the only pyrethrum-producing district in Nyanza Province, is the most densely populated district in Kenya and has the greatest land limitation in the Republic.

3.3: Deflated Prices, Lagged Acreage and Dummy

Regression of pyrethrum acreage on relative pyrethrum price, lagged acreage and policy dummy gave the following results:

Industry: (Equation 2.2.25)

$$A_t = 25607.68 + 3259.77\ {}^{PP}/PMA_t + 0.42\ A_{t-1} + 6917.19\ D$$

(12985.9)	(936.17)	(0.17)	(7707.00)
1:97*	3.48*	2.49*	0.90*

$\bar{R}^2 = 0.913$

$D - W = 1.840$

$\gamma = 0.580$

Nyanza: (Equation 2.2.26)

$$AN_t = -11979.44 + 1059.64\ {}^{PP}/PMA_t + 0.54\ AN_{t-1} + 854.75\ D$$

(4781.16)	(355.87)	(0.17)	(2573.33)
2.51*	2.98*	3.13*	0.33*

$\bar{R}^2 = 0.893$

$D - W = 2.090$

$\gamma_1 = 0.460$

Central (Equation 2.2.27)

$$AC_t = -2260.78 + 8890.71\ {}^{PP}/PC_t + 0.41\ AC_{t-1} + 1272.73\ D$$

(2574.24)	(2601.99)	(0.17)	(2136.60)
0.88*	3.42*	2.34*	0.60*

$\bar{R}^2 = 0.889$

$D - W = 1.610$

$\gamma_2 = 0.590$

Rift Valley (Equation 2.2.28)

$$AR_t = -8331.31 + 1171.39\ {}^{PP}/PMA_t + 0.47\ AR_{t-1} + 1164.61\ D$$

(4383.33)	(317.80)	(0.15)	(2458.96)
1.90*	3.69*	3.08*	0.47*

$\bar{R}^2 = 0.917$

$D - W = 1.830$

$\gamma_3 = 0.530$

Eastern Province (Equation 2.2.29)

$$AE_t = -\ 90.29 + 4072.76\ {}^{PP}/PT_t + 0.34\ AE_{t-1} + 668.15\ D$$
$$\quad (1252.34) \quad (959.528) \quad (0.16) \quad (1105.84)$$
$$\quad 1.90^* \quad 3.69^* \quad 3.08^* \quad 0.47^*$$

$\bar{R}^2 = 0.886$

$D - W = 1.110$

$\gamma_4 = 0.660$

where:

( ) = standard error;

* = t - statistic;

D - W = Durbin Watson Statistic ;

γ_i = Coefficients of adjustment;

$\bar{R}^2$ = Adjusted coefficient of multiple determination.

The constant term is significant in the industry, Nyanza Province and Rift Valley Province regressions at the 0.05 level of significance.

The relative price and lagged acreage variables are significant in all the regressions at the 0.05 level of significance.

The Policy dummy variable turns out to be insignificant in all the regressions at both the 0.05 and 0.10 levels of significance.

The signs of the relative price coefficients are positive, indicating that pyrethrum acreage responds positively to relative pyrethrum producer prices.

The Durbin Watson test leads us to accept the null hypothesis that the disturbances are not serially correlated in the regressions for Industry, Nyanza Province and Rift Valley Province at the 0.05 level of significance. The test is inconclusive in the regressions for Central and Eastern provinces.

The adjusted coefficient of multiple determination, $\bar{R}^2$, is fairly high for all regressions, the fit being best for Rift Valley Province.

From equations (2.2.17) to (2.2.20) we notice that the coefficient of adjustment for each region is given by the formula:

$$\gamma_i = 1 - \theta_i \quad \text{for} \quad i = 1,2,3,4. \qquad (3.7.1).$$

The coefficient of adjustment for the whole industry is given by:

$$\gamma = 1 - \theta \qquad (3.7.2)$$

Deflating pyrethrum producers prices by the prices of competing crops has mixed effects on the regional rates of adjustment of pyrethrum acreage to changes in price. The rate of adjustment for the whole industry increases from 47 per cent to 58 per cent per year; the rate of adjustment for Nyanza Province falls from 64 per cent to 46 per cent per year; the rate of adjustment for Central Province increases from 49 per cent to 59 per year; the rate of adjustment for Rift Province increases from 24 per cent to 53 per cent per year, the rate of adjustment for Eastern Province falls from 69 per cent to 66 per cent per year. Eastern Province has the highest rate of adjustment while Nyanza Province has the lowest rate of adjustment.

3.4 Short-Run and Long-Run Elasticities:

The short-run elasticity is straight forward. It is simply the coefficient of price multiplied by the ratio $\frac{P}{A}$ where : P is the mean value of price and A is the mean value of acreage. The formula may be stated more precisely as follows:

$\varepsilon_{si} = \hat{\delta}_i \cdot (P/A)$ where $\hat{\delta}_i$ is the estimate of δ_i.

To know the long-run elasticity, we must determine δ, δ_1, δ_2, δ_3, and δ_4 in equations (2.2.9) to (2.2.12). From equations (2.2.21) to (2.2.24) we observe that:

$$\hat{\delta}_i = \delta_i \gamma_i \qquad (3.8.2)$$

This implies that :

$$\delta_i = \frac{\hat{\delta}_i}{\gamma_i} \qquad (3.8.3)$$

Formula for long-run supply elasticity thus becomes:

$$\eta_i = \frac{\hat{\delta}_i}{\gamma_i} \cdot \frac{P}{A} \qquad (3.8.4)$$

where η_i is the long-run price elasticity of supply for region i.

TABLE 11:

Short-run And Long - run Elasticities

REGION	EQUATION	SHORT-RUN[1] ELASTICITY	LONG- RUN [1] ELASTICITY
INDUSTRY	(2.2.25)	1.103	1.902
NYANZA	(2.2.26)	0.187	0.406
CENTRAL	(2.2.27)	0.993	1.874
R. VALLEY	(2.2.28)	0.750	1.602
EASTERN	(2.2.29)	0.639	0.908

(1) the price elasticities were calculated at sample means.

It can be observed that in the short-run there appears to be relatively low price response. The response becomes very significant in the long-run. Central and Rift Valley provinces still have the highest short-run and long run price elasticity of supply an indication of the relatively high level of agricultural development in the two provinces. It is important to note that different provinces have different short-run and long-run price elasticities of supply, a factor which may be important for regional pricing policy.

Comparing elasticity coefficients in Table 10 and those in Table 11, we notice that deflating the prices of pyrethrum by the prices of competitive crops slightly lowers the elasticity coefficients.

CHAPTER IV

SUMMARY AND POLICY IMPLICATIONS

It has been noted that Kenya supplies over 70 per cent of the World's pyrethrum demand. This should give Kenya a virtual monopoly in the supply of pyrethrum which can enable Kenya to influence pyrethrum prices in any desired direction. Kenya's monopoly has, however, been limited by the existence of strong competition from the synthetic substitutes to pyrethrum products. Developments in the last few years seem to have been in favour of the Kenyan pyrethrum industry. Firstly, scientific research in the last few years has discovered that synthetic substitutes to pyrethrum products have adverse toxic effects on human life and environment. This with the world-wide campaign of preservation of environment has minimized the potential threat to pyrethrum from the synthetic products. With the rapid seed-fertilizer innovation research going on in the ~~Mollo~~ Molo Pyrethrum Research Station, Kenya can hope to be able to greatly influence world pyrethrum prices in the near future.

Secondly, the World wide inflation has increased the costs of producing synthetic products while the Kenyan pyrethrum industry which is dependent upon the small scale farming sector with little demand for oil power has been least hit by the oil inflation. The oil inflation has simply raised pyrethrum growers' demand for cash to cope with the rising prices of industrial products and this must have had a positive effect on the pyrethrum industry as a major source of cash income to farmers.

By way of summary, conclusions may be drawn at this point with regard to one important question posed in Chapter II. The analysis was based on the assumption that Kenyan pyrethrum growers react to various prices just as economists have assumed that people in general react to prices. This assumption is supported by positive and significant coefficients of the relative price variable in the regressions for the industry and the four provinces.

On the basis of the analysis, certain predictions were made regarding the variables that would influence pyrethrum acreage and output and the direction of their influence. The results of statistical analysis are consistent with most of these predictions. Pyrethrum price was, for example expected to have a positive influence on pyrethrum acreage and output. This proposition is supported by the positive coefficients of pyrethrum producer prices in both acreage and output functions. Prices of other crops grown in the same areas with pyrethrum were expected to have negative influence on pyrethrum acreage. The statistical results are consistent with this prediction for major cash crops like coffee, tea, and wheat.

Maize is the staple food for most Kenyan communities. It was therefore expected to compete with pyrethrum for limited family labour and land. The negative coefficients ot maize price in the regressions support this prediction.

It was expected that government policy and time trend would have positive influence on pyrethrum acreage. The coefficients of these variables, though not statistically significant, are infact positive which is consistent with that prediction.

The argument as to whether or not past pyrethrum prices influence pyrethrum farmers' decisions to commit land to the crop was tested by the Fisher distributed lag. The statistical results turned out to be statistically insignificant and inconsistent with economic theory. We can therefore conclude that current pyrethrum acreage is not greatly influenced by past pyrethrum prices; it is rather influenced by current relative prices of pyrethrum with respect to prices of competing crops. This is an important result because it creates an issue which agricultural policy makers might like to address themselves to. It is evident that any increases in prices of competing crops are likely to have a negative effect on pyrethrum production unless pyrethrum prices increased in the same proportion. It is therefore extremely important for agricultural policy makers to carefully control increases in prices of crops under their control such as maize and wheat. There is very little as yet that the policy makers can do to increase pyrethrum prices as these prices are determined by conditions in the world market where they have little control. If the policy makers find it necessary to increase prices of the domestic crops, consideration must be given also to the prices of export crops which contribute foreign exchange earnings which is badly needed by Kenya. The policy makers might find it unavoidable to subsidize pyrethrum producer prices in the light of high increases in the prices of maize and wheat or else farmers will simply abandon pyrethrum and turn to the relatively attractive domestic crops where domestic policy tends to favour them. There is the implication of price responsiveness to pyrethrum production policy. The price responsiveness indicates the potential for breaking bottlenecks in agriculture through the price mechanism. Moreover, such price responsiveness also suggests that it is possible to shift the composition of agricultural output by changing relative prices within agriculture. Thus, development plans which stipulate agricultural production targets for specific crops should also consider the kind of changes in the respective producer prices that would be consistent with the required output increases. If, for example, foreign exchange is an important factor limiting Kenya's development, it would be necessary to promote both agricultural and nonagricultural production activities which earn the economy relatively greater foreign exchange. This would call for a careful domestic agricultural pricing policy geared towards promoting agricultural export production by creating sufficient incentives to farmers at the farm level. Rift Valley and Central Provinces of Kenya, for instance, have the highest price elasticities of pyrethrum supply. We cannot expect farmers in these provinces to stick to pyrethrum production in an environment of increasing relative attractiveness of maize and wheat production.

One of the most important functions of the Pyrethrum Board of Kenya as stipulated in the Pyrethrum Act 1964 is to control pyrethrum output by issuing licenses and supply quotas to pyrethrum growers. Statistical results show, however, that Kenyan pyrethrum growers are highly responsive to price. This emphasis on the control of pyrethrum production is therefore unnecessary particularly in view of the fact that Kenya supplies over 70 per cent of the World's demand for pyrethrum products. The high short-run and long-run aggregate and regional elasticities of pyrethrum supply are an indication that Kenyan pyrethrum growers are capable of adjusting the level of pyrethrum output to changes in pyrethrum price.

Price-elasticity of pyrethrum supply varies from one region to another; highest in Central Province, next highest in Rift Valley Province, next highest in Eastern Province and lowest in Nyanza Province. This opens up the possibility of instituting regional price differentials in favour of Central Province, Rift Valley Province, Eastern Province and Nyanza Province in that order. This would increase short-run output of pyrethrum. In the long-run this price differential should narrow until it disappears as the regional economic inequalities narrow. This policy statement does not, however, take regional differentials in transportation costs into account.

It was mentioned in the study that pyrethrum growers' societies differ greatly with respect to their final payments to members and their operational costs. This is an indication that most societies are operating inefficiently. This is expected because most societies are run by people who lack the essential entrepreneural knowledge. Thorough training should be given to society executives so as to improve their entrepreneural skills. Some societies work on uneconomically small scales which result in handling too small quantities of flowers which require considerable delays before delivering the flowers to the Marketing Board in Nakuru, thereby destroying pyrethrins contents of the flowers. Some other societies, of which the Masaba Union of Kisii district is an example, appear to be operating on too large scales for marketing efficiency. The Ministries of Agriculture and Cooperatives should try to find an optimal scale for an average society to improve their economic efficiency.

The expenditures of the Cooperative Societies should be thoroughly checked by the responsible Ministry. Some societies are fond of too frequent deductions on farmers' receipts under the cover of investing farmers' money to yield profits. Before such deductions are allowed the societies should submit detailed feasibility studies of their investment proposals to the relevant Ministry. It does not sound plausible for a society to invest the funds of fifty thousand farmers in a project like a residential building in the rural towns and hope that the fifty thousand farmers will make anything from a rent of three hundred shillings per month. Either the farmers are paid all their receipts from pyrethrum deliveries so that they choose to form smaller investment companies or the investments where large numbers of farmers become shareholders are carefully appraised to decide whether or not they can provide gainful employment of the funds.

Many farmers are wondering what the societies do with the many deductions because while they are told the money is invested for them, they never get any dividends and it all boils down to abstract investment.

As a measure to reduce loss of pyrethrins contents of pyrethrum flowers resulting from the inefficient running of some societies, the Pyrethrum Marketing Board could make arrangements for collecting the flowers from centres well distributed over the major pyrethrum-growing areas, like is done with the collection of tea leaves by the Kenya Tea Development. Authority.

To conclude, we may say that Kenya desparately needs foreign exchange and pyrethrum exports are looked at traditionally as vital to this goal. Production is very much an economic phenomenon and to set production goals without production incentives at the farm level in areas of high potential is to do the wrong job. Only a carefully planned and consistent pricing and marketing policy measures can achieve the stated targets. Allocation of essential farm inputs should be done by market-clearing prices to give all farmers equall access to the inputs. This would lead to modernization of pyrethrum production by an increasing large number of smallholders and serve as a strategy for income distribution to the rural population on which our economy depends in many ways.

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APPENDIX

I Acreage and Price Data, 1953/54 - 1973/74

t	PP [a]	AN [b]	AC [b]	AR [b]	AE [b]	AT [c]
1953/54	5.43	480	5300	4160	3150	13090
1954/55	5.44	540	6130	8380	3450	18500
1955/56	5.77	1510	7130	10210	5930	24780
1956/57	5.75	1009	7000	8440	4850	21299
1957/58	5.67	850	6730	6540	3000	17120
1958/59	5.61	560	5680	3570	2450	12260
1959/60	5.98	2240	6060	13670	5230	27200
1960/61	6.17	6970	9430	20350	6250	43000
1961/62	5.14	6000	8540	18500	5960	39000
1962/63	4.19	4600	6000	13170	4530	28300
1963/64	4.28	9600	10650	19150	7020	46420
1964/65	4.78	10940	12010	20420	8280	51650
1965/66	5.69	11260	19840	21220	9380	61700
1966/67	5.69	11300	19870	21530	10700	63400
1967/68	5.95	12870	20870	25990	14030	73760
1968/69	5.17	8290	9800	19260	6780	44130
1969/70	5.16	5940	8700	18290	5070	38000
1970/71	5.56	10240	10800	20580	6800	48000
1971/72	5.62	15980	16720	28560	9450	70710
1972/73	6.06	29250	18540	30590	10500	88880
1973/74	5.48	20120	14430	25070	8000	67620

Source: 35 - 42 .

Note: a = Price of pyrethrum measured in shillings per Kilogramme of dried flowers of 1.15% pyrethrins contents.

b = acreage measured in acres

c = AT refers to total acreage of pyrethrum for the whole industry.

II Relative Prices of pyrethrum 1953/54 - 1973/74

t	PP/PMA	PP/PT	PP/PC
1953/54	11.80	11.81	0.65
1954/55	12.65	12.66	0.67
1955/56	14.65	15.19	0.97
1956/57	13.69	13.69	0.78
1957/58	14.92	10.93	0.63
1958/59	19.34	9.77	0.52
1959/60	17.08	15.74	0.65
1960/61	15.82	15.82	1.13
1961/62	13.17	13.18	0.78
1962/63	16.11	12.12	0.71
1963/64	12.96	12.97	0.81
1964/65	13.27	13.28	0.92
1965/66	15.80	15.81	1.27
1966/67	14.22	16.23	0.98
1967/68	17.00	17.00	1.23
1968/69	16.67	14.68	0.84
1969/70	18.42	12.43	0.79
1970/71	19.85	19.86	1.29
1971/72	11.22	19.92	1.36
1972/73	10.56	20.12	1.69
1973/74	8.43	18.43	0.93

Source: Pyrethrum Marketing Board, Statistical Abstracts.

III Output and Weather DATA

t	Q	W
1940/41	5854.33	1
1941/42	5555.67	1
1942/43	4172.08	1
1943/44	6650.75	1
1944/45	7526.41	1
1945/46	6846.81	0
1946/47	3968.92	1
1947/48	1581.67	1
1948/49	1541.04	0
1949/50	2210.48	1
1950/51	2265.34	1
1951/52	2780.37	1
1952/53	2255.75	1
1953/54	2590.41	1
1954/55	935.60	0
1955/56	3476.23	1
1956/57	3932.34	1
1957/58	4594.68	1
1958/59	4911.62	1
1959/60	6603.01	0
1960/61	9310.24	0
1961/62	7892.12	1
1962/63	5268.59	1
1963/64	6254.98	1
1964/65	7873.73	1
1965/66	10695.36	1
1966/67	11233.75	1
1967/68	7305.60	1
1968/69	5908.80	0
1969/70	4413.50	1
1971/72	14413.50	1
1972/73	10697.50	0

Source: Pyrethrum Marketing Board, Nakuru.

112
66/70