ATLANTIC ZONE PROGRAMME

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PRODUCING PINEAPPLE IN THE ATLANTIC ZONE OF COSTA RICA: AGRONOMIC AND MARKETING ASPECTS

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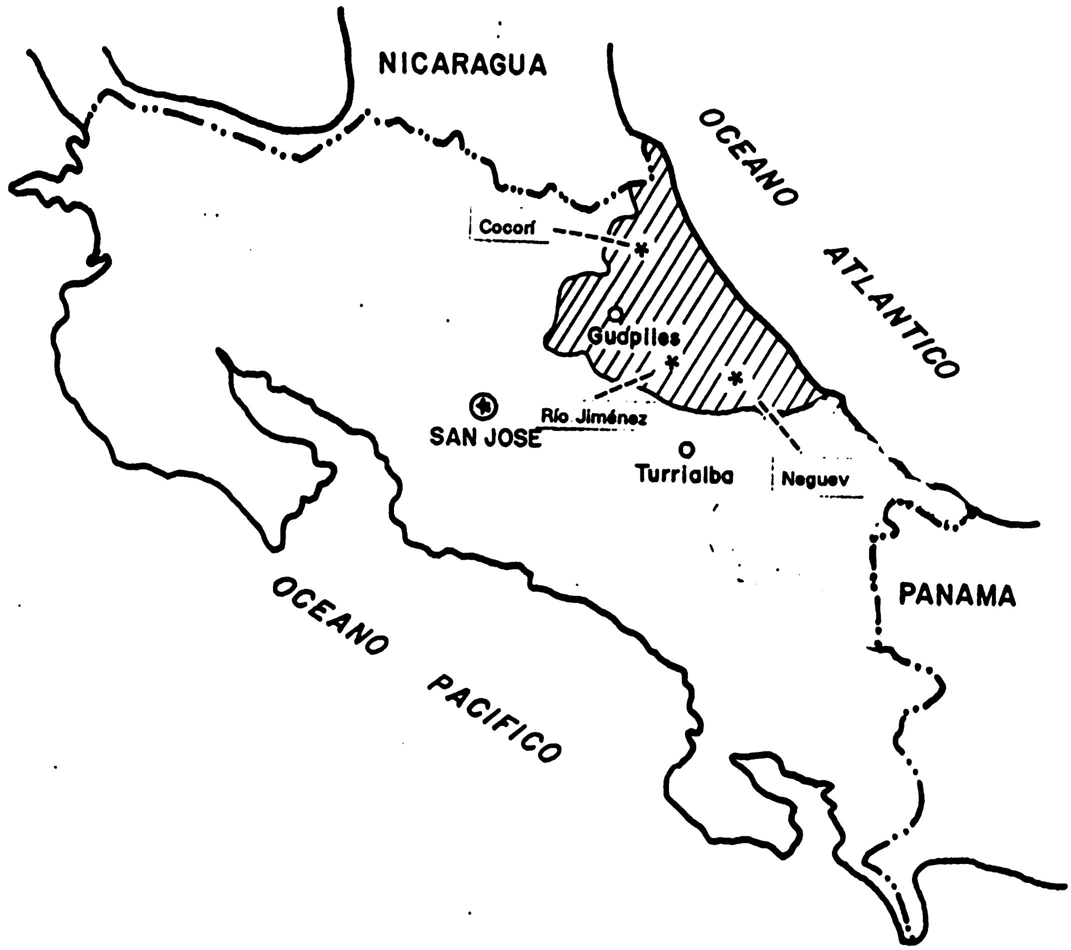

Figure 1. Location of the study area.

PREFACE

General description of the research programme on sustainable Landuse.

The research programme is based on the document "elaboration of the VF research programme in Costa Rica" prepared by the Working Group Costa Rica (WCR) in 1990. The document can be summarized as follows:
To develop a methodology to analyze ecologicaly sustainable and economically feasible land use, three hierarchical levels of analysis can be distinguished.
1. The Land Use System (LUS) analyses the relations between soil type and crops as well as technology and yield.
2. The Farm System (FS) analyses the decisions made at the farm household regarding the generation of income and on farm activities.
3. The Regional System (RS) analyses the agroecological and socio-economic boundary conditions and the incentives presented by development oriented activities.

Ecological aspects of the analysis comprise comparison of the effects of different crops and production techniques on the soil as ecological resource. For this comparision the chemical and physical qualities of the soil are examined as well as the polution by agrochemicals. Evaluation of the groundwater condition is included in the ecological approach. Criterions for sustainability have a relative character. The question of what is in time a more sustainable land use will be answered on the three different levels for three major soil groups and nine important land use types.

Combinations of crops and soils

	Maiz	Yuca	Platano	Piña	Palmito	Pasto	Forestal I II III
Soil I	x	x	x		x	x	x
Soil II						x	x
Soil III	x			x	x	x	x

As landuse is realized in the socio-economic context of the farm or region, feasibility criterions at corresponding levels are to be taken in consideration. MGP models on farm scale and regional scale are developed to evaluate the different ecological criterions in economical terms or visa-versa.

Different scenarios will be tested in close cooperation with the counter parts.

The Atlantic Zone Programme (CATIE-AUW-MAG) is the result of an agreement for technical cooperation between the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), the Agricultural University Wageningen (AUW). The Netherlands and the Ministerio de Agricultura y Ganadería (MAG) of Costa Rica. The Programme, that was started in April 1986, has a long-term objective multidisciplinary research aimed at rational use of the natural resources in the Atlantic Zone of Costa Rica with emphasis on the small landowner.

Preface

The period of 27 september 1992 till 5 january 1993 was the time I worked for the Atlantic Zone Programme. Relatively a short time but long enough to know the rules of the project.

I specially want to thank Donatus Jansen, Jetse Stoorvogel and John Belt for their help and cooperation. Further I want to thank Ulises Gómez for joining me during my visits of farmers. Fortunately there were some hours left to enjoy the Costa Rican sociability which I joined under good leadership of Carlos Aragón. Last but not least I want to thank the following students for playing guitar, cooking my meal, disturbing me during my work, joining me travelling around in Costa Rica, teaching me dancing salsa, and joining me getting drunk;
Susan, Harald I, Harald II, Eelco, Joris, Erik, Sam and Pepijn.

Jan Leendert den Daas

Summary

Pineapple is becoming of more importance in the Atlantic Zone. A growing number of farmers choose for cultivation of pineapple because of the following qualities of pineapple:

-) Cultivation is possible on acid soils. In the region of Rio Frio and Neguev this quality is important.
-) The soil fertility requirements are low. Because a high acidity mostly goes with a low fertility of the soil, the same soils are used for pineapple cultivation.
-) Important are the high prices for the fruits. Throughout the year those prices fluctuate but the mean price is relatively high.

The last three years different developments and changes in the cultivation of pineapple took place in the Atlantic Zone. They are summarized below:

-) The number of farmers increased from 11 to 94.
-) The cultivated area increased from 52.75 to 112.5 hectares.
-) The variety mostly cultivated is Monte Lirio. This variety is produced just for the national market. Three years ago the farmers mainly produced Cayena Lisa for the export and the canning industry.

The farmers cultivate just small areas with pineapple because of the high costs of the investments at the start of the first cycle. The next crop requires less inputs. Growing a ratoon crop lowers the price for inputs per year. The produced fruits however are of lower quality and lower prices are paid. In general a ratoon crop does not pay.

The cultivation of pineapple withdraws big amounts of Nitrogen and Potassium from the soil, at 86 Kg and 153 Kg per hectare per year respectively, mainly lost by removing crop residues and fruits from the field. If farmers want to fill up this outflow they have to do extra investments in fertilizers and labour. This additional costs will lower the profits.

Resumen

La piña esta empezando a tomar importancia en la Zona Atlántica. Un creciente número de agricultores escogen el cultivo de la piña por las siguientes cualidades de la piña:

-) El cultivo es posible en suelos ácidos. En la región de Río Frío y Neguev esta cualidad es importante.
-) Los requerimientos de nutrientes del suelo son bajos. Por la alta acidez en este suelos, los mismos suelos son usados para el cultivo de la piña.
-) Es importante el alto precio de la fruta. A través de los años estos precios fluctúan, pero el precio es relativamente alto.

En los últimos tres años diferentes desarrollos y cambios en el cultivo de la piña a tomado un lugar en la Zona Atlántica. Estas están resumidas a continuación:

-) El número de agricultores aumentó de 11 a 94.
-) La área cultivada aumentó de 52.75 a 112.5 hectáreas.
-) La variedad más cultivada es Monte Lirio, esta variedad es producida para el mercado nacional. Tres años atrás los agricultores produjeron Cayena Lisa para exportar y la industria enlatadora.

Los agricultores cultivan áreas pequeñas con piña por el alto costo de inversión al comenzar el primer ciclo. La próxima corta requiere menos inversión. Creciendo a "ratoon crop" baja el precio de inversión por año. La fruta producida, sin embargo es de menor calidad y son pagadas a precios menores. En general "ratoon crop" no es rentable.

El cultivo de la piña sin grandes cantidades reservadas de Nitrógeno y Potasio del suelo, de 86 Kg y 153 Kg por hectárea, por año respectivamente, principalmente perdidas por remover residuos de la corta y frutas del campo. Si los agricultores quieren llenar esta corriente, deben de hacer inversiones extras en fertilizantes y labores. Este costo adicional podría bajar las ganancias.

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Chapter 1 **INTRODUCTION**

This study gives an indication of the agronomic and marketing aspects of pineapple in relation with the physical production and marketable amount. The area of investigation was the Atlantic Zone in Costa Rica.

An inventory was made of the different marketing channels, price fluctuations and the supply and demand of pineapple.
Also a calculation was made for the costs of pineapple production. With an analysis of costs and assets, the return on investments was calculated. With these results the financial profitability of fertilizer applications and other inputs was investigated. The effects of fertilizer applications and the efficiency of those applications on both the physical production as the marketable amount were investigated as well.

The nutrient balance gives an indication of sustainable land use of pineapple-farmers in the Atlantic Zone.
To calculate the losses of nutrients that leave the field by the cultivation of pineapple, an inventory is made of the nutrient flows into and out of the field. The effect of other variables like putrid and the amount of nutrients left on the field with crop residues, are tested as well. Farmers from the Neguev-region and the region of Rio Frio have cooperated in this investigation. Those farmers were mainly the same as in the preceded investigation of pineapple (TÖNJES,1992). The selection of those farmers was random.

Chapter 2 **PINEAPPLE**

2.1 General aspects

Pineapple (*Ananas comosus* (L.) Merr. Syn.*A.sativus* Schult.f.) is a member of the family of monocotyledons, the genus of Bromeliaceae. It was domesticated in central and the south of America.
It is not only cultivated for its edible fruits for local consumption, but also for its flesh and juice for canning and export, or for the export of whole fresh fruits harvested before they are fully ripe. Most of the commercial crop of pineapples is canned in the producer countries.
Some cultivars are grown in small amounts for the extraction of leaf fibers.
The most important cultivars grown in commercial fruit production in Central America are;

-) 'Cayenne'; of great importance for canning and export. The fruit is well shaped, large, yellow flesh color and fine flavor. From this group the 'Cayena Lisa' is widely grown (PURSEGLOVE,1985).
-) 'Spanish'; of great importance for the local fruit market. The variety 'Monte Lirio' has a white colored flesh and a small heart. It is less sensitive for diseases and is easy to propagate (PIMA,1990).
-) 'Abacaxi'; not very suitable for export of the fresh fruit unless harvested half-ripe. The flesh is yellow with small fibers and good flavor. The plant is resistant to heart and root rot (PURSEGLOVE,1985). The variety 'Pan de Azúcar', also known as 'Sugar Loaf' or 'Azucarona' is generally grown for local markets but in Costa Rica of no importance.

The best mean temperature for cultivation is between 24 and 26°C. Very little growth occurs below 20°C and above 36°C. Pineapple is tolerant to drought due to the special water storage cells and its CA-Metabolism.
Pineapples are best suited to tropical lowlands and to areas that have more than 635 mm rainfall per annum. The soil needs to be well drained, waterlogging will not be tolerated. Moderately acid soils with a PH of 5-5,6 are preferred.

2.2 Cultivation aspects

Pineapples are propagated vegetatively by planting the crown of leaves from the top of the fruit, or from shoots called 'slips' which grow on the peduncle just below the fruit, or from 'suckers' produced in leaf axils lower down the stem (Fig. 2.1). The crop is grown at densities between 40.000 and 45.000 plants per hectare (PURSEGLOVE,1985). In the Atlantic Zone a density of 35.000 plants per hectare is generally used.

Figure 2.1: Pineapple planting material.

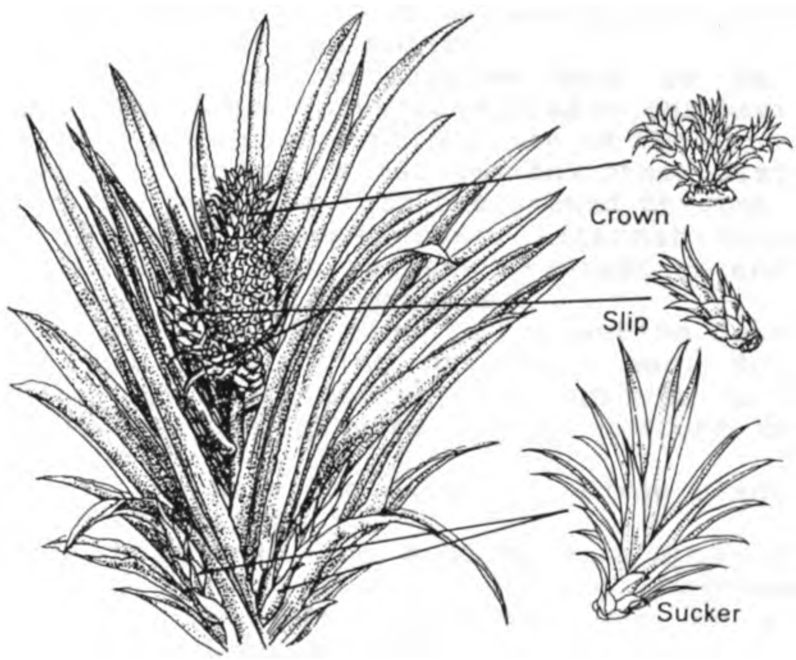
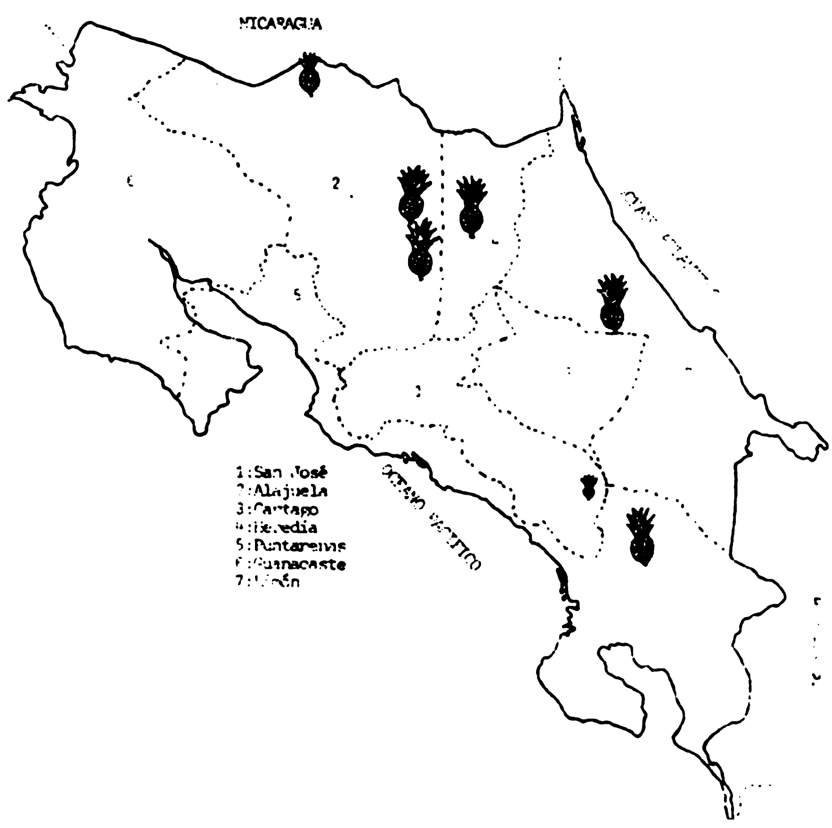


Figure 2.2: Zones of production of pineapple in Costa Rica.



Under irrigation pineapples are planted in double rows 60 cm apart with 80 cm between the double rows and 30 cm between plants in the row. In rainfed cultivation, a spacing of double rows of 60 cm apart with 90 cm between the double rows and 30 cm apart in the rows is applied when rainfall is limited. When rainfall is sufficient a closer planting space is possible. In the Atlantic Zone often the plants are inserted in single rows, with 100 cm between the rows and 40-50 cm between plants in the row, because of the low fertility of the soils.
Before planting, the propagules have to be cured to control mealybug (*Pseudococcus brevipes=Dysmicoccus brevipes* (Cockerell)). If pineapples are grown continuously on the same plot, the soil has to be fumigated to kill nematodes and other destructive organisms. The plants are inserted into the ground through paper mulch. Black polytene is used in some areas. Alternatively, the crop may be mulched with sugar cane bagasse. Fumigation and mulching are only done by large commercial growers.
The time taken from planting to harvesting depends on;

-) the type of planting material used. Suckers produce much faster (after 17 months) than crowns do (after 23 months). However, crowns produce a more uniform crop. Shoots are in between.
-) size of the planting material; large planting material gives earlier fruiting,
-) use of hormones. When a hormone is applied plants bear fruit after 12 months or even earlier. Hormones also guarantee a homogenous ripened field and can be applied to plan a constant production over the year.

The normal crop cycle is four years from the time the crop is planted until the land is planted with a new crop. This includes;

-) the first crop; harvest after 18-24 months (COBLEY,1986), when hormones are supplied the harvest could be more than 6 months earlier,
-) one ratoon crop; harvest after 22-36 months when hormones are applied,
-) field preparation for the new crop; takes about 6-9 months (PURSEGLOVE,1985) but is much shorter in the Atlantic Zone (1-3 months).

A second ratoon crop is sometimes harvested, which requires a year. In the Atlantic Zone the crop cycle lasts about three years without the field preparation for the new crop (ANON,1984). Most of the farmers have at least one ratoon crop.
The yield of fresh fruit per hectare is 38-75 tons for the first crop, the ratoon crop may give only half of this amount (PURSEGLOVE,1985). In the Atlantic Zone an average yield of 51 tons for the first crop and 30 tons for the ratoon crop is common (ANON,1984). The ratoon crop produces faster than the first crop but both the quantity and quality are lower.
In commercial production, very large amounts of fertilizers and pesticides are applied to the crop. Pineapple will however also produce under low fertility conditions.

2.3 Production zones in Costa Rica

The most important production zones in Costa Rica are in Buenos Aires de Puntarenas (65%), in San Carlos, Grecia, Los Chiles, San Ramon y Upala in the province of Alajuela (28.7% with 16% just in San Carlos), Sarapiqui (5.03%) in Alajuela, Siquirres, Martina en Central in the province of Limón (1.2%) and at last Pérez Zeledon in the province of San José (Fig. 2.2) (VILLALOBOS,1990).
The highest production of pineapple is in the province of Puntarenas. The cultivation is focused on the production of the cultivar Cayena Lisa. The farmers produce for PINDECO which exports the fruits. Eighty-eight percent of the total production is for PINDECO.
Just 1.77% of the total production of Cayena Lisa is situated in the province of Limón. The farmers mainly produce for Hortifruti (PIMA,1990).
Monte Lirio is mainly produced in Alajuela (San Carlos) and in Heredia.
In april 1989 Costa Rica had a total of 865 farmers who cultivated pineapple with 11 in the province of Limón. Of the latter, the largest estates (>10ha) are located in Siquirres. The area cultivated with pineapple in Limón was 52.75 hectares in the year 1989, compared to a total area in Costa Rica of 4,218.7 hectares (1.25%).

The production in the province of Limón was about 1,846.25 tons, whereas total production in Costa Rica was 159,770.50 tons of fresh fruits (1.2%)(Table 2.1).

Table 2.1: Production of Pineapple for several provinces (1989).

Province	# Farmers	(%)	%-C.L.[1]	%-M.L.[2]
Alajuela	652	76.2	6.8	24.2
Heredia	160	18.7	0.3	4.7
Limón	11	1.3	1.3	---
San José	20	2.3	---	0.5
Puntarenas	13	1.5	62.2	---
Total:	856	100.0	100.0	

[1]) C.L.: Cayena Lisa.
[2]) M.L.: Monte Lirio.

Province	# hectares	(%)	Production (tons)	(%)	Production (tons/ha)
Alajuela	1,310.80	31.07	45,878.00	28.7	35
Heredia	212.50	5.03	7,439.25	4.7	35
Limón	52.75	1.25	1,846.25	1.2	35
San José	20.00	0.47	700.00	0.4	35
Puntarenas	2,662.60	62.16	103,907.00	65.0	39
Total:	4,218.70	100.0	159,770.50	100.0	

(Source: Ministerio de Agricultura y Ganadería. VILLALOBOS, 1990)

In Puntarenas the cultivation of pineapple is more intensified than in the other provinces. The area under production for pineapple is big, the production is the highest from Costa Rica and only the cultivar "Cayena Lisa" is cultivated. In Puntarenas pineapple is produced by big estates with a high input level, while in the province of Limón most of the producers are small farmers, mainly producing the cultivar Monte Lirio.
The production level of pineapple is almost the same in the provinces of Alajuela, Heredia, Limón and San José (35 ton/ha) and just a little higher in the province of Puntarenas (39 ton/ha).

2.4 Developments in the Atlantic Zone

The last three years the number of farmers of pineapple in the Atlantic Zone increased almost nine times, from 11 to 94.
A growing number of farmers choose for the cultivation of pineapple because of the low fertility requirements of the crop. Another reason is the rising price for the fruits on the markets (Table 2.2).

Table 2.2: Mean prices of pineapple for different years on different markets in value of that year (in colones).

	Piña I		Piña II		Piña III	
Year	Feria	CENADA	Feria	CENADA	Feria	CENADA
1988	36.42	11.66	27.00	9.83	16.25	4.94
1989	43.37	14.49	31.61	13.02	18.12	---
1990	59.81	22.14	44.46	17.83	25.02	---

(Source: Departamento de Economía de Mercados, 1992)

The cultivated area of pineapple increased as well, although less than the number of farmers. The area cultivated with pineapple expanded from 52.75 to 112.5 hectares (Table 2.3). Momentary a tendency is visible of a growing number of farmers with smaller areas for pineapple cultivation. In 1989 a mean area of 4.8 hectares per farmer was common. In 1992 the area per farmer is much smaller with a mean of 1.2 hectares. This average area might grow when farmers that recently have begun to grow pineapple will extend their acreage with planting material of their own.
The main part of the farmers in the Neguev-region produce the variety Cayena Lisa. Those farmers produce especially for the canning-industry of Hortifruti. Hortifruti pays an higher price for the fruits than the salesmen do. The canning industry processes just fruits of the variety Cayena Lisa because of the high acid content. These fruits are most suitable for canning.
Farmers who produce for the canning industry or for export harvest smaller fruits to supply the demand. Three months after hormone application harvesting is possible. To produce bigger fruits the time between hormone application and harvest is two times longer.

Another important development is the variety-choice. In 1989 most of the farmers cultivated the variety Cayena Lisa. In 1992 just farmers in the Neguev-region produced Cayena Lisa. The main part of the farmers in the Atlantic Zone however produce the variety Monte Lirio. The preference of the consumers on the national market goes out for this more sweet tasted variety. Another point is that this variety is less sensitive for diseases than the variety Cayena Lisa.

Table 2.3: Total number of farmers and total hectares for pineapple cultivation in the Atlantic Zone (1992).

Region	Number of farmers	Total # Ha	Mean	Variety
Batán	---	---	---	---
Cariari	3	1.5	0.5	Monte Lirio
Merylan	---	---	---	---
Neguev	11	5	0.42	Cayena Lisa(95%) Monte Lirio (5%)
Rio Frio	80	106	1.32	Monte Lirio
Talamanca	---	---	---	---
Total:	94	112.5		

(Source: Instituto de Desarrollo Agrario, 1992)

Pineapple can be grown on a wide range of soils.
The most important nutrients for pineapple are Nitrogen and Potassium. Nitrogen application results in a higher yield and Potassium results in bigger fruits and a higher production per hectare. A Phosphorus application at the start of the cropping period contributes to a quick development (MARITZA,1983).
Once the plants have started to bear fruit, Nitrogen applications can have negative consequences for the fruit quality (ROMERO,1973).

The micro-nutrients are of great importance for the pineapple plant, especially the elements Zinc and Iron (MAG,1991). Zinc deficiency results in a yellowing of the leaves with some epidermal sclerosis. Iron deficiency results in chlorosis of the leaves, followed by a reddish colour on the young fruits.
High Calcium and Manganese content of the soil results in chlorotic plants caused by an antagonistic action on Iron which results in Iron-deficiency.
In the Atlantic Zone pineapple cultivation is situated mainly on the poor acid soils. The sampled soils for pineapple cultivation in Rio Frio and Neguev have a pH value between 3.74 and 4.73 (TÖNJES,1992). The low pH has an effect on the availability of elements in the soils. At low pH, deficiencies of Potassium and Molybdenum are liable. There is some reduction of Sulphur, but Sulphur-bacteria are still active (LANDON,1984). The fixation of Nitrogen by bacteria is reduced and nitrification of organic matter is significantly retarded. Aluminium ions are released from clay lattices and become established on the clay complex. Phosphorus ions can be fixed by Iron and Aluminium to form compounds which are therefore not readily available to the plants. In acid soils, the limiting factor is often the (near-)toxic concentration of Aluminium ions in the soil solution. All micro-nutrients, except Molybdenum, are better available at lower pH.
Recommended fertilizer applications are given in Table 3.1. The recommendation is limited to the first crop, for the ratoon crop usually the fertilizer applications are about one half to one third of those for the first crop.

Table 3.1 : Recommended fertilizer application for pineapple till the first harvest (fertilizer to be applied close to each plant).

Time (months)	Fertilizer formula (N-P-K)	Gram fertilizer per plant
1	12-24-12/10-30-10	10
2.5-3	20-3-20/18-5-15-6.2	10
3.5-5	20-3-20/15-3-31	12

(Source: Ministerio de Agricultura y Ganaderia, 1991)

The soils for pineapple cultivation in the sampled zones have a very low content of nutrients. The concentration of nutrients does not differ very much between the sample sites. Mainly there are low values of Magnesium, Potassium, Phosphorus, Copper, and Zinc. The values for the cation-exchange capacity (CEC) and the fraction organic matter (O.M.) lay in the range of the medium values (Table 3.2).

Table 3.2: Critical values of available nutrients.

meq/100ml, ug/ml,%	High values	Medium values	Low values	σ^2 of the 20 farmers	Mean values farmers
Ca (meq/100ml)	>20	4.1-20	≤4	0.30	0.92
Mg (meq/100ml)	>5	1.1-5	≤1	0.09	0.21
K (meq/100ml)	>0.6	0.21-0.6	≤0.2	0.14	0.09
P (ug/ml)	>20	10.1-20	≤10	3.98	9.95
Fe (ug/ml)	>100	10.1-100	≤10	30.43	715.70
Cu (ug/ml)	>20	2.1-20	≤2	4.06	24.55
Zn (ug/ml)	>10	2.1-10	≤2	2.99	6.38
Mn (ug/ml)	>50	5.1-50	≤5	20.91	43.15
CEC (meq/100ml)	>25	5.1-25	≤5	8.25	30.75
O.M. (%)	>10	4-10	<4	2.40	8.58

(Source: BERTSCH,1987)

4.1 Characterization of the national market

Eight different marketing channels are known for the sales of pineapple (Fig. 4.1):

1) Farmer -> Middleman -> Consumer.
2) Farmer -> Middleman -> Retailer -> Consumer.
3) Farmer -> CENADA -> Retailer -> Consumer.
4) Farmer -> Feria (Farmer market) -> Consumer.
5) Farmer -> Processing industry -> Consumer.
6) Farmer -> Packer -> Industry -> Consumer.
7) Farmer -> Packer -> Export -> Consumer.
8) Farmer -> Traditional market -> Consumer.

(VILLALOBOS, 1990)

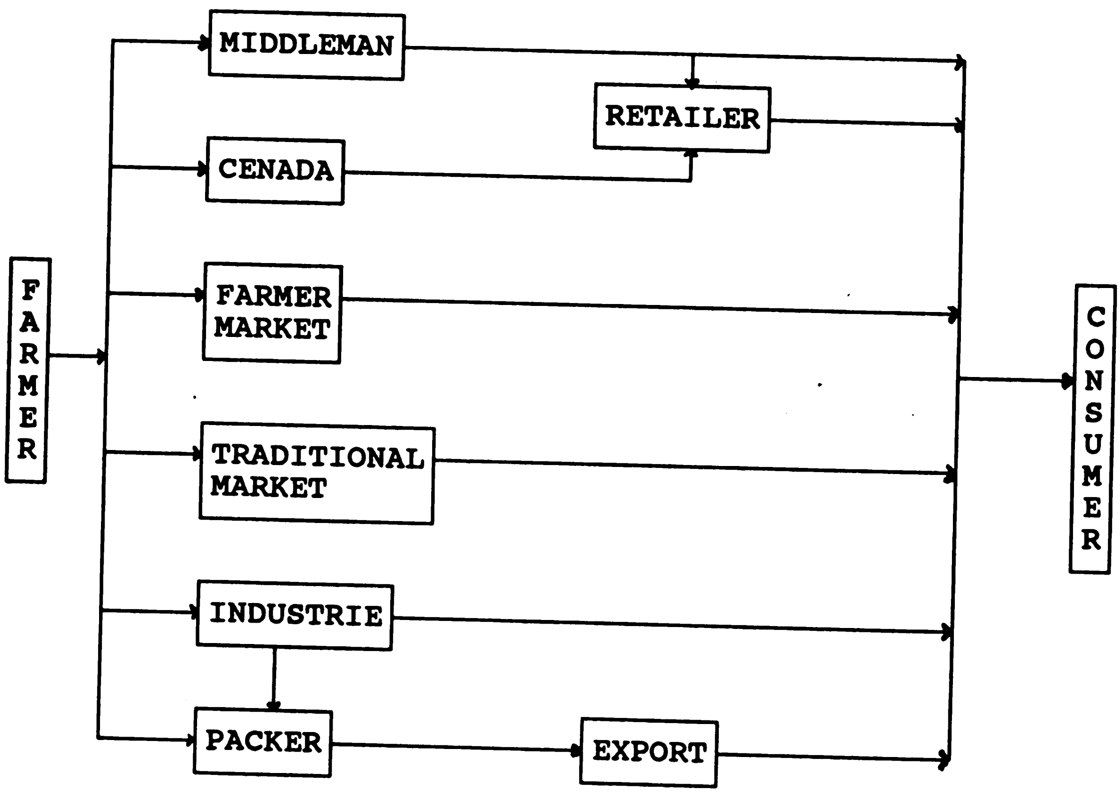
On national level two important market-centers are distinguished. The Feria and the CENADA. The Feria are farmer markets, gathering for the sale of goods and the CENADA is a wholesale-market where bigger amounts are traded. Prices on the Feria are almost twice as high as on the CENADA (Fig. 4.2) but the amounts sold on the Feria are of less importance for the total quantity of pineapple sold by the farmers on national level. Especially the bigger farmers sell their pineapples on the Feria in case the offered amount is too small to be traded on the CENADA. Through middlemen however selling pineapples on the CENADA is possible. The different markets where farmers sell their product are represented in Table 4.1.

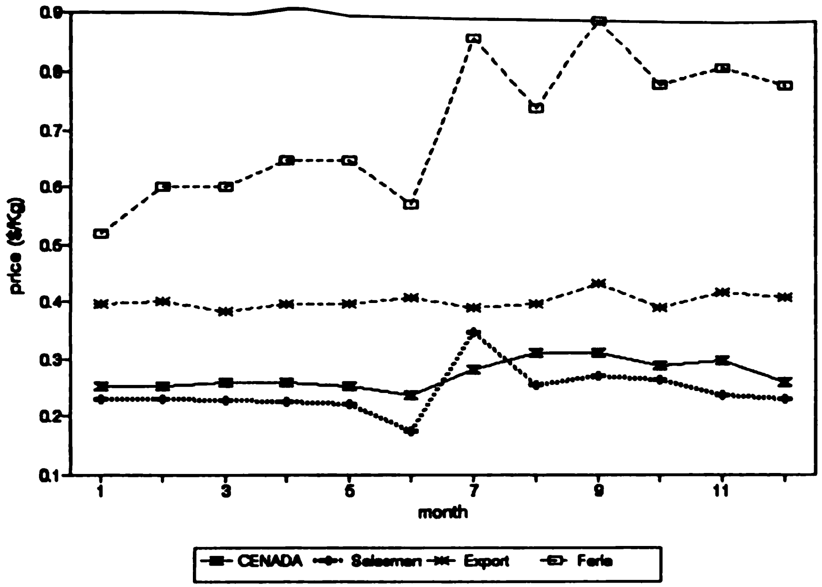
Table 4.1: Different markets where farmers sell their product.

Market	Number of farmers	(%)
National market not specified	410	45.86
CENADA	156	17.45
Middlemen	126	14.09
Ferias	85	9.50
Mercado Borbón	48	5.37
Industry	25	2.82
International markets	22	2.46
Propica	16	1.78
Local markets	6	0.67
TOTAL	894	100.00

(Source: Ministerio de Agricultura y Ganadería, 1990)

Figure 4.1: Marketing channels of pineapple.





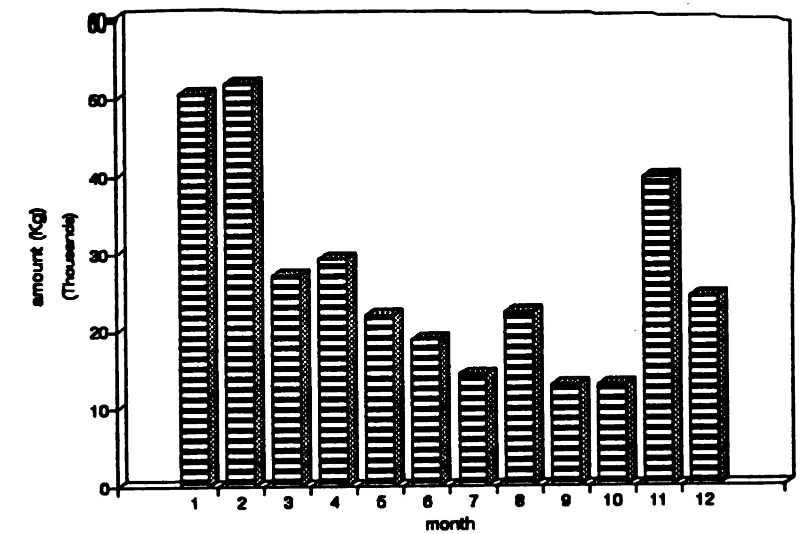


Figure 4.3b: Total supply of pineapple on the CENADA
1987, 1988, 1989

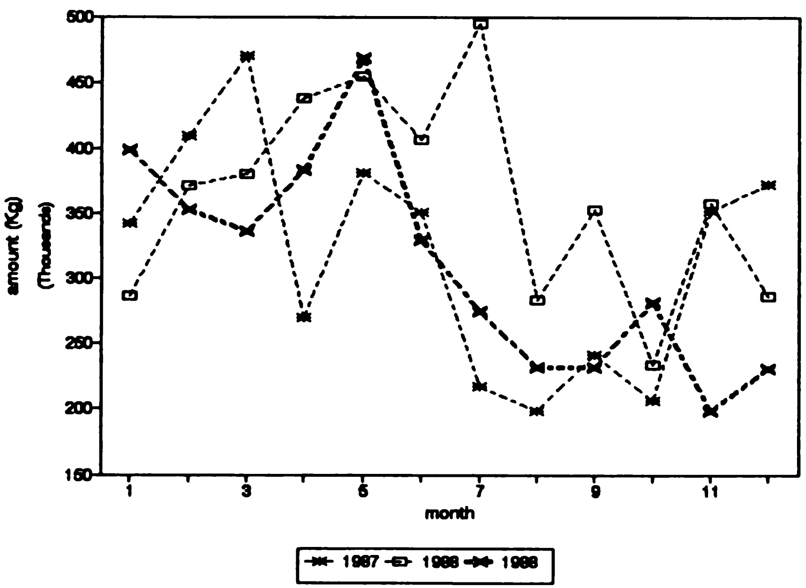
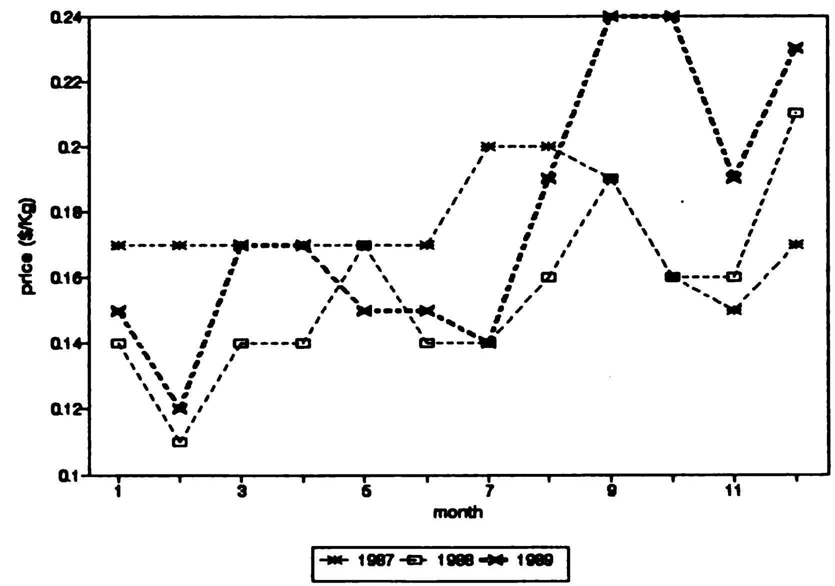


Figure 4.3c: Prices of pineapple on the CENADA
1987, 1988, 1989



Ferias are dominated by middlemen, although official policy is to promote direct selling by farmers. Especially the smaller farmers face difficulties regarding the Feria;

1) no possibilities for transporting the fruits,
2) too small quantities and too limited product diversity which does not pay the rent of a marketstall,
3) time problems, visiting a marketplace takes a whole day.

An alternative is to sell the pineapples together with other cultivated products in small amounts on the 'Mercados Traditionales' but this place is of less importance for the total traded amount of pineapple.
The highest supply of the CENADA is from December till May (Fig. 4.3.a-b). This indicates that the farmers who produce pineapple for the local market do not plant their crop to supply the demand but follow the tendency like most of the farmers do, to plant the crop at the beginning of the rainy season.
If farmers have no opportunity to transport the harvested fruits to one of the marketplaces they sell their product to one of the middlemen. The price they get for the fruits is low and the visits of the middlemen are not very frequent and often not announced. The middlemen have a position which looks like a situation of an oligopsony (where there are only a few buyers, each able to influence price (COLMAN,1989)).
By selling the pineapples to middlemen they get lower prices for their product than by selling on the CENADA or the Feria (Fig. 4.2). Benefits of selling the fruits to middlemen are diminishing risks and transport costs and less problems with time constraints and limited volume.

4.2 Criteria for characterization of the fruits

On the national market for fresh pineapple a classification in three quality classes is used, first quality (I), second quality (II) and third quality (III), with weights more than 2.43 Kg, between 1.89 and 2.43 Kg and between 1.5 and 1.89 Kg respectively (PIMA,1990).
For exportation of fresh fruits, especially to Europe, another classification is used. The fruits are divided into classes A,B and C. Fruits in class A have a weight of more than 1.5 Kg For class B a weight between 1.1 and 1.5 Kg and class C a weight between 0.9 and 1.1 Kg.
Pineapples exported to Europe are mainly of the variety Cayena Lisa. On the market of fresh fruits the most important criteria of quality are color, weight and the condition of the crown. Consumers in Europe prefer a yellow or orange flesh which goes with a green outside when the fruit is not mature. The leaves of the crown must be green while brown edges on the leaves will lower the value of the fruit.

The fruits that are preferred for exportation have weights between 0.9 and 1.3 Kg although even fruits of more than 2 Kg are exported. Especially the smaller fruits are important because of the lower transport costs.

For the national market and also by salesmen other criteria are used. Especially the variety Monte Lirio is important here. The most important factor for qualification is the size of the fruit. Big fruits are preferred and the bigger the fruit the higher the price per Kg. Second of importance is the color (smooth white flesh) and after this the health and the quality are important (no damaged or attacked fruits). Finally the 'grados brits' ,sweetness of the fruit, is important. These criteria however are arbitrary and difficult to quantify.

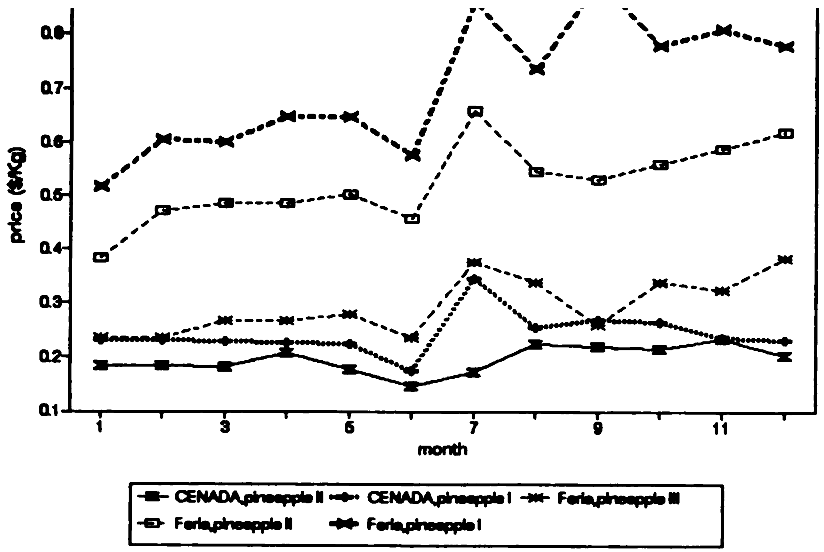
4.3 Price analysis

The price for pineapples of quality I is the highest on both the CENADA and the Feria (Fig. 4.4). In the Atlantic Zone just a small part of quality I is produced. Mainly pineapples of quality II are produced. The quantity of quality I sold on the market is high compared to quality II and quality III (Fig. 4.5). The prices for all the three qualities fluctuate throughout the year on both the CENADA and the Feria. From June till December the prices are higher than the rest of the year (Fig. 4.3c). This results from a diminished supply in those months. Pineapples of quality A are cultivated by big estates for exportation of the fresh fruit or for the canning industry.
The price farmers get for their product if they sell it for the export-market, is between the prices on the Feria and those on the CENADA (Fig. 4.2).

4.4 Characterization of demand

Just as for other products the demand for pineapple is mainly influenced by the price. If prices rise the demand will diminish. Other important factors which influence the demand of pineapple are:

-) Income of the people: Income influences the consumer behavior. Those effects can have consequences for the elasticity of demand. The demand for pineapple rises 1% with the income of people (PIMA,1990). The people spent 1% of this extra income for extra pineapple consumption.
-) Growth of the population: The population of the Atlantic Zone grows with 2.86% per year (LOK,1992). If the preference of the consumers for pineapple doesn't change, the demand for pineapple will grow with the same rate.



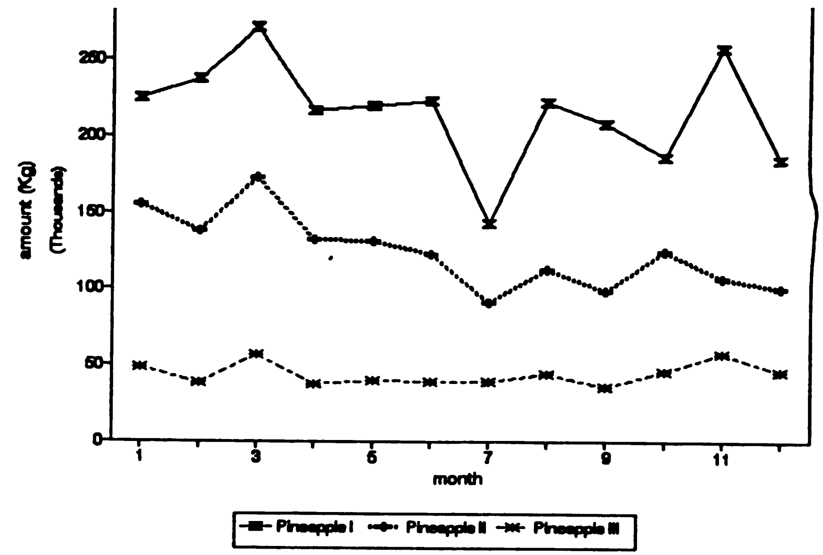


Figure 4.6: Relation supply and price

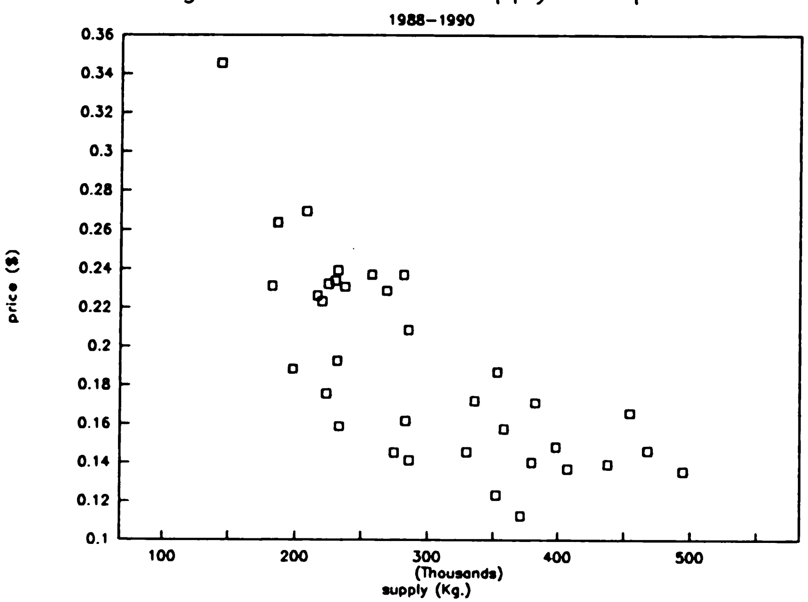
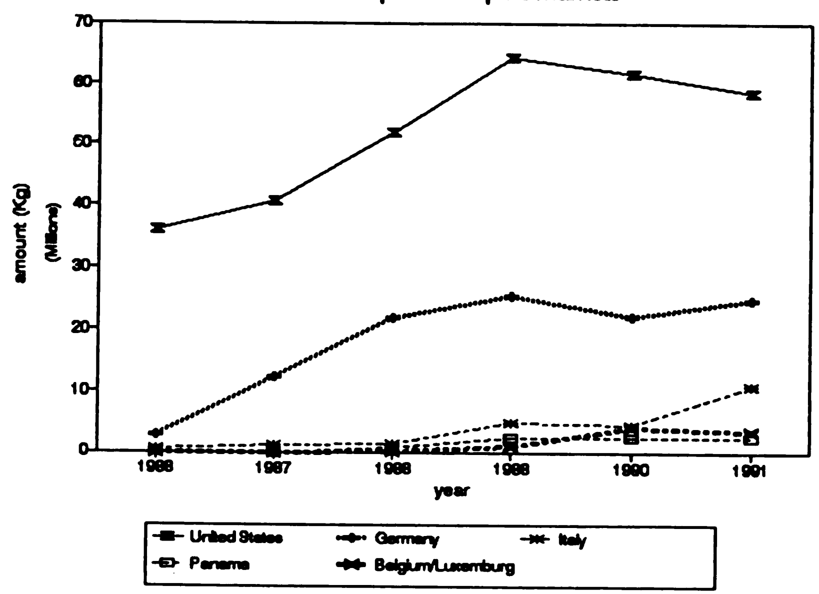


Figure 4.7: Growth of the export of pineapple and most important export-markets



-) Complementary goods: The prices of complementary goods have direct consequences on the consumption of pineapple. An example of complementary goods are the fruits besides pineapple in a fruit salad. If the prices of the other fruits in the salad are rising the whole salad including the pineapple parts is getting more expensive, with consequences for the consumption of pineapple.

-) Substitution goods: If prices of substitutes are falling, the consumption of the substitutes generally will increase and the consumption of pineapple decrease.

-) Taste and preference of the consumer: This aspect is very difficult to quantify but is very important for the demand of pineapple.

4.5 Characterization of the supply

The supply is relatively high in the first five months of the year. Therefore the price is relatively low (Fig. 4.3b-c and Fig. 4.6). This results from the fact that the first harvest mostly takes place from December till June. The second harvest (from the ratoon crop) mainly takes place from November till May the next year. The quantity and quality of this second yield are often lower than the first yield.
On the average this results in a lower supply in the months June till November. The prices of lower quality fruits will rise as well in those months.

4.6 Characterization of the export market

In Table 4.2 the total exported amount and the value in dollars are represented.

Table 4.2 : Export of fresh pineapples from Costa Rica in weight and in dollars per year.

Year	Total weight (Kg)	Total value ($) *	Growth (%)	Mean price ($/Kg)
1986	40,922,178	14,853,681	-----	0.36
1987	54,702,156	21,538,620	33.7	0.39
1988	77,377,603	31,156,150	41.5	0.40
1989	100,226,206	39,705,939	29.5	0.39
1990	95,879,996	38,437,563	-4.3	0.40
1991	100,285,822	38,943,229	4.6	0.39

(Source: Servico de Informacion Comercial, Exportaciones de Costa Rica, 1992)
*) In value of that year.

The export from pineapple increased until 1988. After 1988 the export stabilized at a total of about 100 million Kg.
Most of the pineapples are exported to the United States (58.2% with a value of 20.7 million dollars) and Germany (24.8% with a value of 11.4 million dollars) (Table 4.3).

Table 4.3: Export of pineapple from Costa Rica to different countries in Kg and value in dollars (1991).

Country	Total weight (Kg)	Total value ($)	% of total export
United States	58,400,725	20,677,121	58.23
Germany	24,851,642	11,377,522	24.78
Italy	10,816,678	5,040,344	10.79
Belgium/Luxembourg	3,256,617	1.190,688	3.25
Panama	2,259,000	238,086	2.25
Canada	406,241	323,628	0.41
Scotland	154,878	50,823	0.15
The Netherlands	55,169	17,510	0.06
Rest	84,872	27,507	0.08
TOTAL	100,285,822	38,943,229	100.00

(Source: Servico de Informacion Comercial, 1992)

Other important export markets are Italy, Belgium/Luxembourg and Panama with respectively 10.8 , 3.3 and 2.3 percent of the total export (Fig. 4.7). The export to Italy is still growing and becomes of more importance every year. Hortifruti exported 40,905 Kg from the Atlantic Zone in 1991.

Costa Rica imports pineapple especially from Nicaragua (Table 4.4). The imported amount however is just a very small part compared to the total amount produced and exported.

Table 4.4: Import from pineapple from Nicaragua.

Year	Amount (Kg)	Year	Amount (Kg)
1982	386.320	1985	265.200
1983	80.800	1986	246.440
1984	236.660	1987	83.000

(Source: Dirección General de Estadística y Censos, 1989)

After 1987 the import of pineapple from Nicaragua has decreased because of measurements by the government to protect the national production. Because the fruits from Nicaragua are produced at lower costs, they can be sold at lower prices. The production in Costa Rica however is sufficient for the national market.

5.1 General aspects

When land is put under cultivation on a more permanent basis the soil fertility tends to decline at a rate that is largely governed by the nature of those land use types and their management.

The nutrient balance for pineapple will give an indication of the nutrient-cycle for pineapple cultivation and give a better insight into the present state, and the near-future effects on the soil nutrient stock. The balance is calculated as the sum of inputs minus the sum of outputs.

The following inputs can be distinguished;
1) nutrient applications by fertilizing,
2) animal manure,
3) deposition by rain and dust,
4) biological N-fixation,
5) sedimentation.

In this calculation the nutrient input by fertilizers is qualified for 20 farmers. For the cultivation of pineapple no animal manure or other organic fertilizers are applied.

In humid regions the wet deposition is higher than the dry deposition. Just the wet deposition is considered in this study. Values of 1.5, 0.15 and 4.9 Kg $ha^{-1}yr^{-1}$ for N, P and K are used (STOORVOGEL,1992).

The biological N-fixation is very small in relation to the nutrient application by fertilizers. The area under leguminous crops is negligible. A fixed contribution of 2 Kg N ha^{-1} yr^{-1} was assumed.

The effect of sedimentation was omitted, because on the relative high situated plots where pineapple mostly is cultivated, the value for sedimentation is very low.

The output from the system consists of the following parts;
1) harvested product leaving the field,
2) crop residues leaving the field,
3) erosion,
4) leaching,
5) denitrification.

Of these, the outputs by the harvested product and the residues leaving the field are quantified.
In Table 5.1 the nutrient concentrations in the harvested product and in the crop residues are represented.

Table 5.1: Nutrient concentrations in fruit, crown, leaves, stem and shoot (fresh-weight)(TÖNJES,1992).

	Fruit Kg/ton	Crown Kg/ton	Leaves Kg/ton	Stem Kg/ton	Shoots Kg/ton
N	0.687	1.858	1.942	1.628	1.813
P	0.088	0.262	0.157	0.162	0.230
K	1.660	2.637	2.548	2.784	2.881

The pineapple fields mostly are situated on horizontal plots to minimize the influence of erosion. Losses of 500 Kg ha^{-1} yr^{-1} of soil are used in this study.

Leaching of nutrients released from soil material may be an important factor in fertile soils but in the soils used for cultivation of pineapple this factor is very small. Leaching is influenced by factors like rainfall, texture, soil N and K content, and fertilizer input. The fraction of mineralized soil N and total fertilizer N submitted to leaching was set at 50%. P-leaching was omitted because most of the soils have a P-fixation of more than 70% and P is very immobile in the soil. The K-leaching has been determined as a function of the exchangeable K and clay content (based on SMALING et al.,1992).

Denitrification is dependent of drainage and fertilizer application. Below a pH-value of about 5.5, bacterial activity is reduced and nitrification of organic matter is significantly retarded. In general a denitrification of 3% of all mineralized and fertilized N is used. In Figure 5.1 the flows of nutrients are represented.

5.2 Inputs by fertilizer applications

In Table 5.2 the amount of nutrients applied per hectare per farmer is represented for pineapple cultivation. The differences between the farmers are very big. The P fertilizer applications are sometimes inefficient (Fig. 5.2a-c). The farmers which apply larger amounts of nutrients (>100 Kg), supply them just one or two times per cultivation-cycle in high amounts. The applied amount of fertilizer K is very low compared to the applied amount of fertilizer N. The differences in K uptake and the production of dry weight are mainly caused by differences in the K content of the different soils (Fig. 5.2c).
The nutrient applications at the start of the cultivation-cycle are very ineffective as well. In that stadium the plants are not able to take up this nutrients. After three months the roots are developed and applications become more effective.

Figure 5.1: Nutrient-cycle of pineapple.

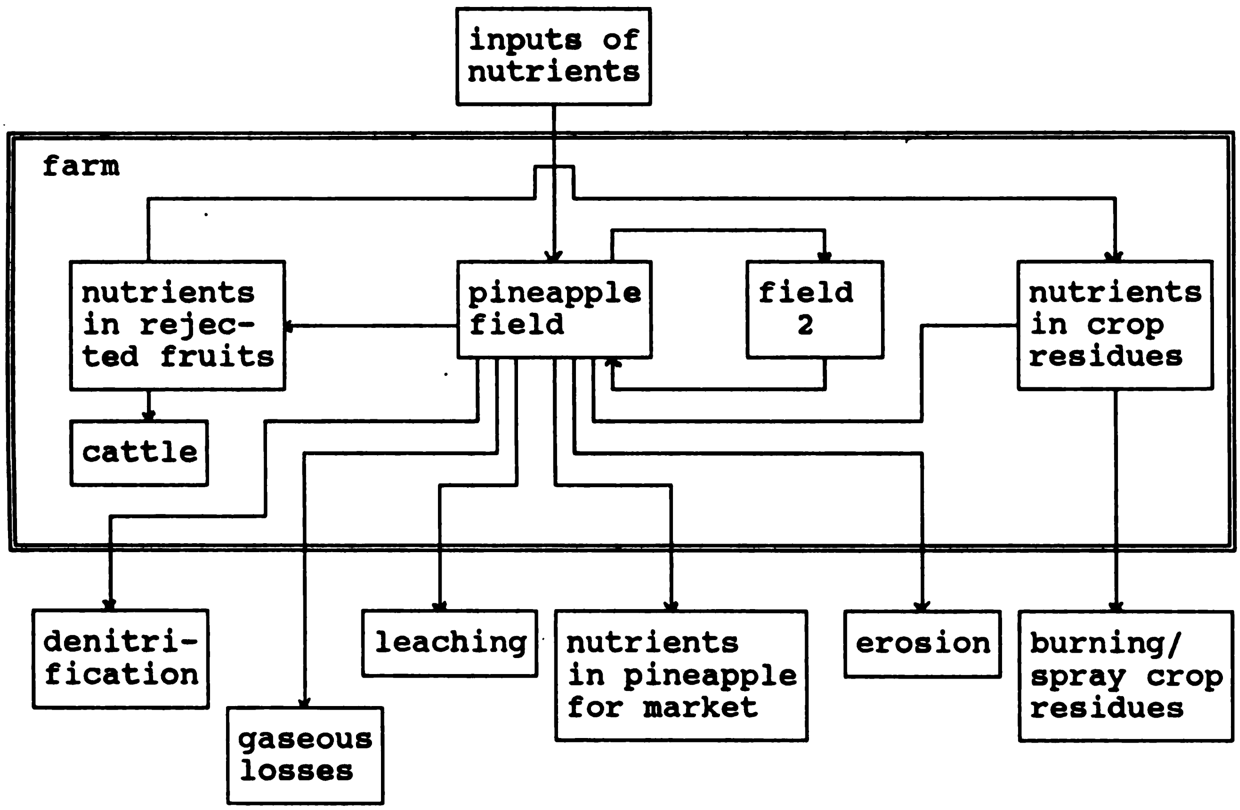


Table 5.2: Amount of nutrients applied by farmers per hectare per cycle.

Farmer number	# Ha.	N (Kg)	P (Kg)	K (Kg)	Mg (g)	Co,Mn, Cu,Bo, Zn,Mo, Fe (g)
1	1.0	541.2	128.7	42.8	8.00	1.2600
2	0.75	0.9	0.4	0.6	17.76	8.8800
3	2.5	892.4	266.4	88.8	0.0	0.0
4	1.0	183.8	8.2	14.3	408.00	64.2600
5	0.5	18.2	18.2	18.2	0.34	0.0536
6	1.0	46.2	0.0	0.0	0.0	0.0
7	0.25	41.4	124.3	41.4	0.0	0.0
8	1.0	28.4	85.1	28.4	0.0	0.0
9	0.5	143.5	20.4	6.8	0.0	0.0
10	0.5	85.1	255.2	85.1	0.0	0.0
11	5.0	0.6	0.2	0.4	12.00	1.8900
12	1.0	21.3	8.5	14.9	425.25	66.9769
13	2.0	1.9	0.8	1.3	37.89	5.9674
14	0.5	77.1	0.0	0.0	0.0	0.0
15	1.0	16.8	9.0	3.0	0.0	0.0
16	1.0	91.1	0.0	0.0	0.0	0.0
17	2.0	13.6	40.8	13.6	0.0	0.0
18	1.0	0.0	0.0	0.0	0.0	0.0
19	1.5	0.8	0.3	0.5	15.14	2.3845
20	0.5	0.6	0.2	0.4	12.00	1.8900
Total:	24.5	2204.8	966.6	360.5	936.38	153.562
Mean:	1.23	110.2	48.3	18.0	46.82	7.6781

Fig.6.2a: Efficiency of N application

Influence on production of dry weight and N uptake

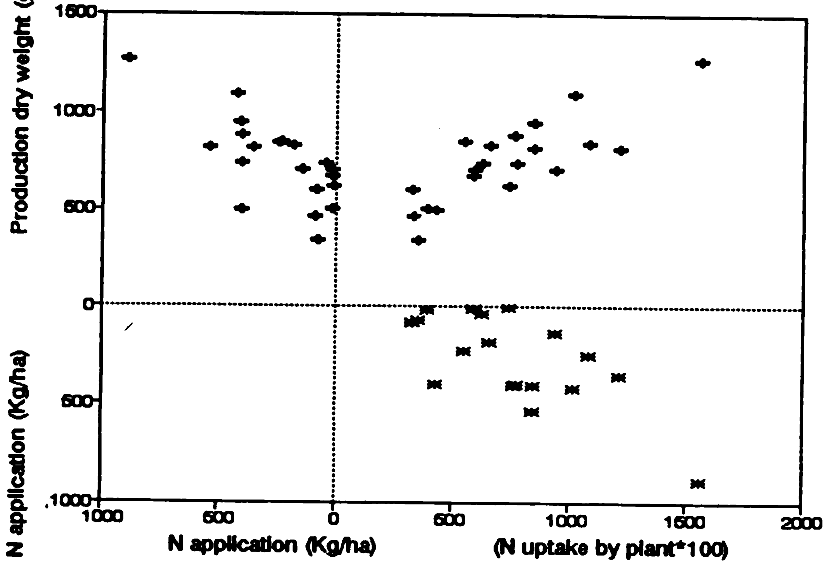


Fig.6.2b: Efficiency of P application

Influence on production of dry weight and P uptake

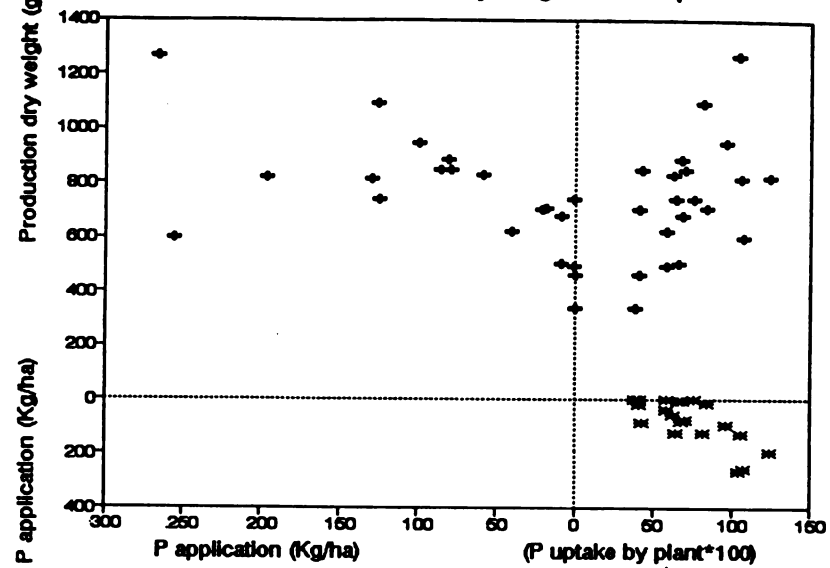
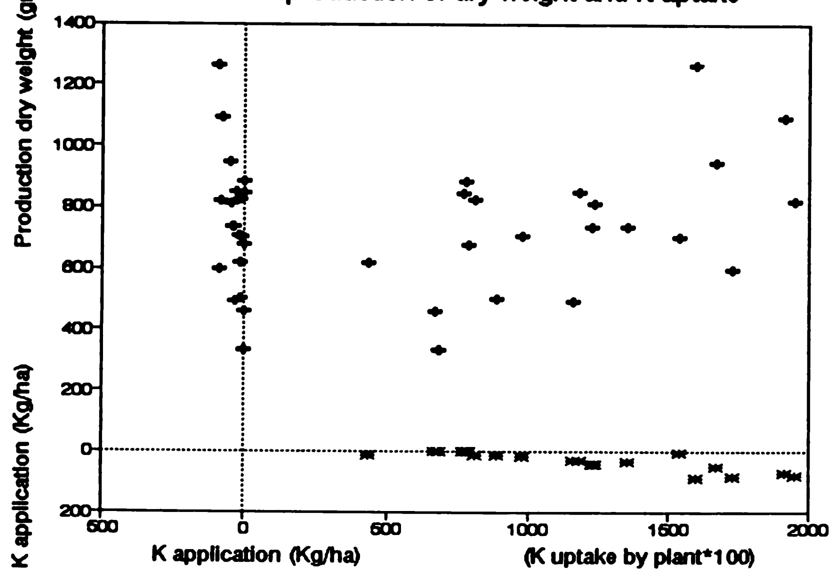


Fig.6.2c: Efficiency of K application

Influence on production of dry weight and K uptake



The effect of fertilizer applications on the different plant parts are represented in Figures 5.2d-f. A rising tendency is perceptible. By increasing applications of Nitrogen, Phosphate and Potassium the percentage of the nutrient in the different parts of the plant is increasing too. More fertilizers are removed with crop residues at higher fertilizer application.

5.3 Outputs

The outputs quantified here are the harvested fruits and the crop residues leaving the field. Not all the fruits are suitable for the market. An alternative application for rejected fruits is as fodder for cattle. Just a small part of the farmers use rejected fruits, the main group leave the fruits in the field when a ratoon crop is grown.
Because the fruits of the ratoon crop have a lower quality than the fruits from the first crop, a part of the farmers have only one harvest per planting. After this harvest the farmers remove all the crop residues from the field. Other methods are spraying or burning. By burning the main part of N get lost, K and P however in smaller amounts. The total amount of nutrients leaving the field with fruits and plant-residues per hectare per cycle are represented in Table 5.3a-b.
In Appendix 1 the specified figures are given.

The erosion per hectare per year was set at 500 Kg soil. Because no direct values for N were available the lost amount of N by erosion is calculated as fraction of the organic matter. Erosion results in losses of 4.29 Kg N ha^{-1} yr^{-1}, 0.005 Kg P ha^{-1} yr^{-1} and 0.0002 Kg K ha^{-1} yr^{-1}. The value for K is calculated with the mean values of the exchangeable K.

Losses by leaching for N are calculated as 50% of the total fertilizer and soil N (as function of the organic matter) and results in losses of 27.9 and 2.6 Kg N ha^{-1} yr^{-1} respectively.
The clay content of the soil has a value of 31 (STOORVOGEL,1992). The amount of fertilizer losses is 70% of the applications and 0.9% for the exchangeable K. The clay content and exchangeable K are used to determine the leaching for the soil K. Leaching of fertilizer and soil K results in losses of 6.4 and 1.0 Kg P ha^{-1} yr^{-1} respectively.

Losses by denitrification are calculated as 1.7 Kg N ha^{-1} yr^{-1}.

5.4 Residues left on the field

The fruits and plant-residues left on the field are no inputs or outputs. But by leaving those residues on the field the nutrient losses can be diminished considerably.

Figure 5.2d: Effect of fertilizing on nutrient content in different plant parts
Nitrogen application

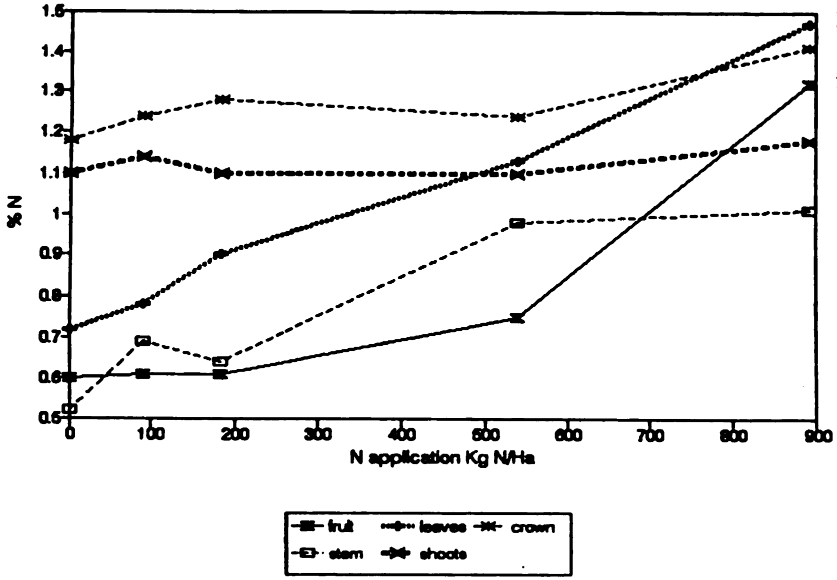


Figure 5.2e: Effect of fertilizing on nutrient content in different plant parts
Phosphate application

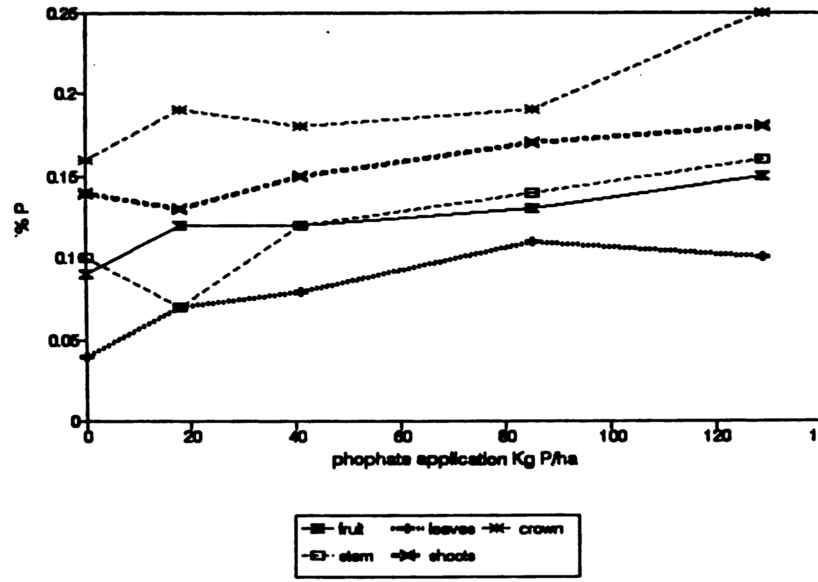


Figure 5.2f: Effect of fertilizing on nutrient content in different plant parts
Potassium application

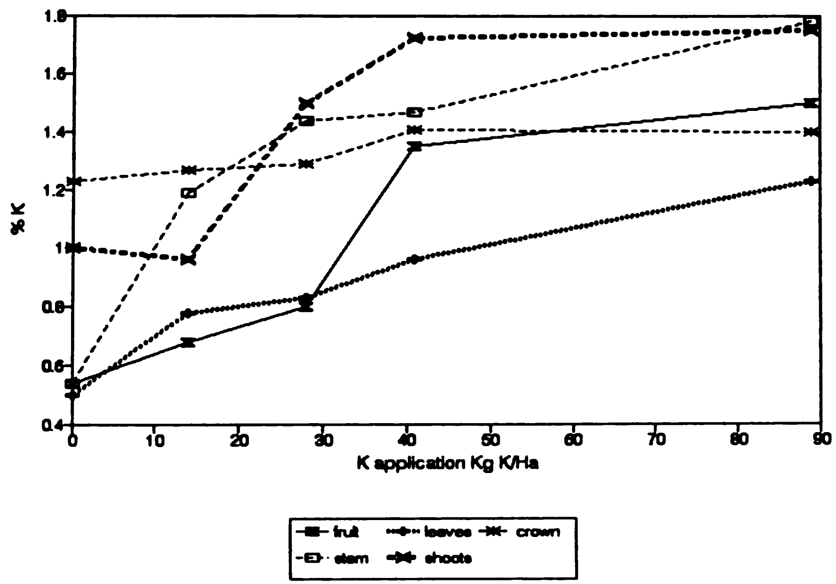


Table 5.3a: Total amount of nutrients leaving the field with fruits and plant residues per hectare per cycle.

Farmer number	Plant-density	Months in cultivation cycle	N (Kg)	P (Kg)	K (Kg)
1	42500	18+6+6	319.1	48.8	430.0
2	50000	12	222.1	30.8	626.2
3	30000	12	477.3	31.8	526.6
4	30000	18	154.3	13.4	195.9
5	25000	14+12	295.0	40.7	531.6
6	30000	12+12+12	202.6	19.7	234.1
7	28000	11+7	190.3	22.6	269.7
8	25000	12+12	61.1	5.1	140.6
9	20000	15	173.5	7.3	273.5
10	20000	14	50.5	7.0	128.9
11	17000	14+12+10	314.8	31.3	411.4
12	30000	12+12	185.3	29.4	437.0
13	23000	12+12+12+12	194.7	20.6	291.1
14	20000	12+10	88.3	9.3	162.5
15	22000	14	126.3	14.7	179.9
16	25000	14	80.9	9.9	171.8
17	10000	18+18	102.6	8.0	69.8
18	25000	14+12	356.0	29.1	688.4
19	28000	12+12	355.9	40.6	713.4
20	16000	12+12	173.3	15.8	318.8
Mean:	25825	23.65	215.3	21.8	340.1

Table 5.3b: Total amount of nutrients leaving the field with fruits and plant residues per hectare per cycle.

	Ca (Kg)	Mg (Kg)	S (Kg)	Fe (Kg)	Cu (g)	Zn (g)	Mn(Kg)
1	98.9	69.0	50.4	7.2	1154.1	2135.8	24.4
2	73.5	48.3	36.4	4.1	590.3	1360.3	15.4
3	237.0	109.5	59.2	5.3	828.7	1125.3	22.9
4	88.7	34.1	23.3	7.7	563.1	398.2	7.0
5	170.4	75.5	67.6	8.8	1313.4	1197.4	6.8
6	69.4	35.7	24.9	22.0	753.1	1017.6	5.0
7	72.2	34.6	56.5	7.4	735.5	1386.0	5.8
8	22.0	16.9	8.4	14.3	275.5	274.1	3.4
9	43.8	26.6	12.7	2.7	268.6	238.5	5.7
10	16.9	15.0	5.9	4.9	286.6	326.3	2.6
11	249.1	131.9	57.0	14.3	1468.3	711.1	12.1
12	78.0	61.2	34.5	6.1	826.6	770.5	2.0
13	73.7	31.8	22.5	1.4	311.4	305.0	5.0
14	25.7	21.9	8.2	1.0	177.5	535.5	2.2
15	73.3	52.6	22.2	23.2	641.8	977.2	10.3
16	42.8	18.3	13.2	16.5	248.2	297.9	6.6
17	28.5	10.0	14.7	3.0	244.8	243.2	4.2
18	120.7	73.7	62.1	5.2	615.7	1074.4	11.3
19	159.9	73.2	130.0	15.1	829.1	1729.8	13.5
20	90.6	34.2	25.9	2.9	436.4	492.0	10.1
$\bar{X}$	91.8	48.7	36.8	8.7	628.4	829.8	8.8

This is especially important for K. A part of these nutrients will leach, especially K, but an important part will be available for the ratoon crop after some time.

Farmers who have just one harvest per planting, clear the field after harvest and plant a new crop. For these farmers the biggest export from nutrients out of the field is calculated. These losses should be compensated by fertilizer applications.
The amount of nutrients in the soil has an important effect on the nutrient amount in the plants. The relation between the amount of nutrients in the soil and the amount in the plant is represented in Figures 5.3a-c.

The farmers who take 1 or 2 ratoon crops from the first planting leave the residues on the field until the last harvest. They cut off the leaves of the plant and leave two shoots per plant for the next crop. After the last harvest they remove all the residues from the field as well. This indicates the importance of management for the nutrient balance. The total amount of nutrients left on the field with fruits and plant-residues per hectare per year are represented in Table 5.5a-b. In Appendix 2 the specified figures are given.

5.5 The nutrient balance quantified

For the twenty farmers the sum of the inputs minus the sum of the outputs can be calculated (Table 5.4). In Figures 5.4a-c the inputs and output of N, P and K per hectare per cycle are represented. In Fig. 5.4d the average input and output per hectare per year are represented. The cultivation of pineapple withdraws 86 Kg N and 166 Kg K per hectare per year, implying that there is net nutrient depletion of the soil nutrient pools.
Especially the losses of K are high. This is because the different parts of pineapple plants have high percentages of K. By removal of the crop residues from the field high losses of K take place. An important part of the losses of P are compensated by fertilizer applications. Leaching of this P is small because of the high value for P-fixation. The mean value of P application is mainly determined by high inputs by just a small part of the farmers. Very important however are the low percentages of P in the different plant parts (Table 5.1). By removal of crop residues from the field just small losses of P appear (Table 5.4).

5.6 Soil, inputs and cultivation versus production

The production is calculated in 4 ways;
1) the production of fruits per hectare per cycle,
2) fruits sold per hectare per cycle,
3) production of fruits in Kg per hectare per cycle,
4) Kg fruits sold per hectare per cycle.

Figure 5.3a: Nitrogen in soil and plant
Nitrogen in fruits and soil (N as fraction of the organic matter)

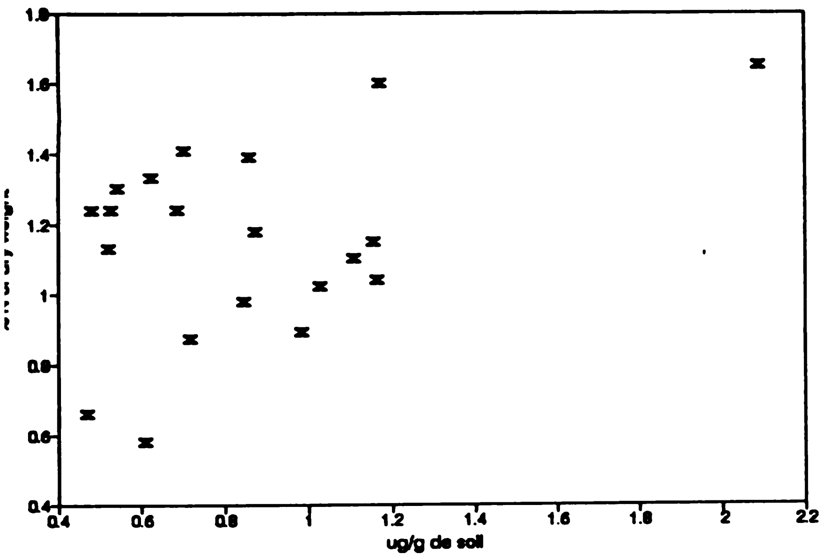


Figure 5.3b: Phosphate in soil and plant
Phosphate in fruits and soil (P-Olsen)

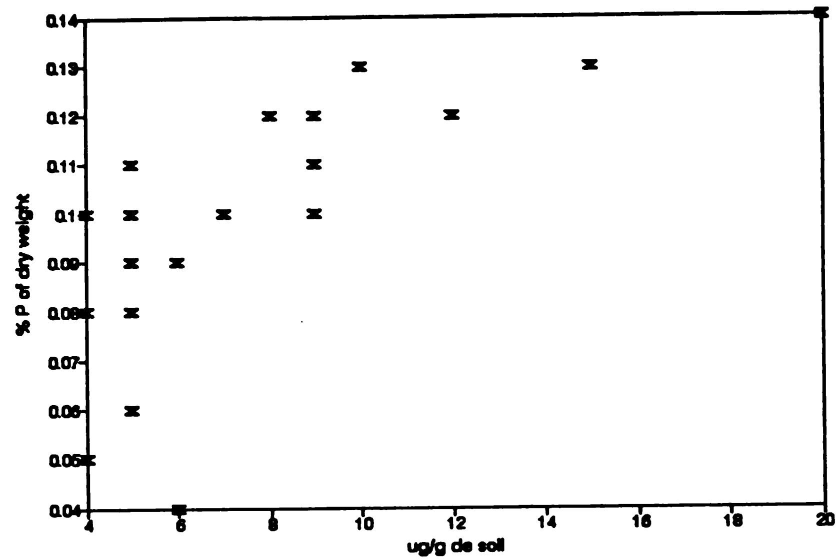


Figure 5.3c: Potassium in soil and plant
Potassium in fruits and soil (K-exchangeable)

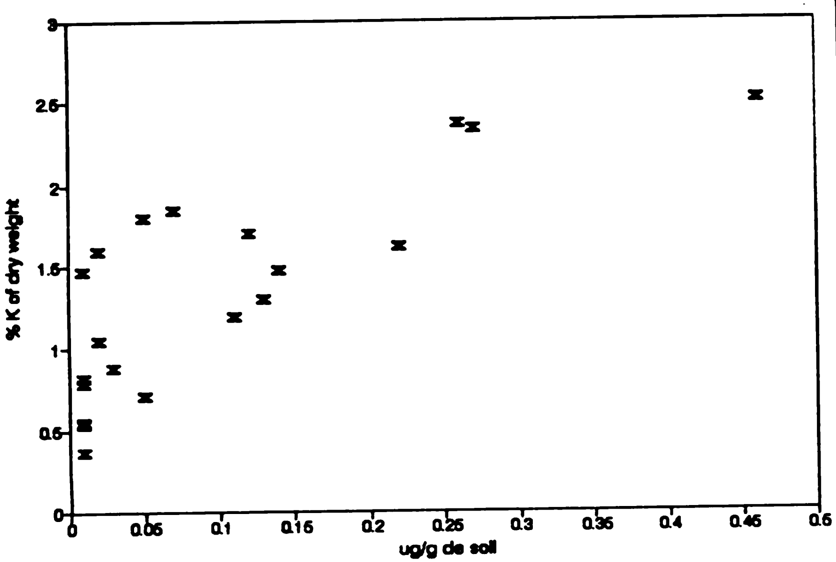


Table 5.4: The nutrient balance for pineapple cultivation in Atlantic Zone.

Nut	Inputs, Kg ha^{-1} yr^{-1}					Outputs, Kg ha^{-1} yr^{-1}				Tot
	1	2	3	4	5	1+2	3	4	5	
N	55.9	0	1.5	2	0	-109.2	-4.29	-30.5	-1.7	-8
P	24.5	0	0.2	0	0	-11.1	-0.005	--	0	+1
K	9.1	0	4.9	0	0	-172.6	-0.0002	-7.4	0	-16

Inputs:
1) Nutrient application by fertilizing.
2) Animal manure.
3) Deposition by rain and dust.
4) Biological N-fixation.
5) Sedimentation.

Outputs:
1+2) Harvested product and crop residues leaving the field.
3) Erosion.
4) Leaching.
5) Denitrification.

Table 5.5a: Total amount of nutrients left on the field with fruits and plant-residues per hectare per cycle.

Farmer number	Months in cultivation cycle	N (Kg)	P (Kg)	K (Kg)	Ca (Kg)
1	18+6+6	480.1	50.0	351.2	216.0
2	12	0.0	0.0	0.0	0.0
3	12	0.0	0.0	0.0	0.0
4	18	0.0	0.0	0.0	0.0
5	14+12	103.7	14.5	171.1	72.5
6	12+12+12	479.4	25.3	304.0	184.9
7	11+7	140.2	13.6	169.2	38.0
8	12+12	90.2	6.4	190.2	35.6
9	15	0.0	0.0	0.0	0.0
10	14	0.0	0.0	0.0	0.0
11	14+12+10	402.8	31.8	377.1	452.3
12	12+12	93.3	15.4	205.9	43.8
13	12+12+12+12	283.6	30.3	392.2	111.3
14	12+10	50.0	4.7	101.0	18.9
15	14	0.0	0.0	0.0	0.0
16	14	0.0	0.0	0.0	0.0
17	18+18	58.2	3.5	30.1	20.3
18	14+12	200.3	14.2	366.0	75.7
19	12+12	189.6	22.2	372.1	93.9
20	12+12	105.6	10.6	188.7	55.6
Mean:	23.65	133.85	12.13	160.94	70.94

Table 5.5b: Total amount of nutrients left on the field with fruits and plant-residues per hectare per cycle.

Farmer number	Mg (Kg)	S (Kg)	Fe (Kg)	Cu (g)	Zn (g)	Mn (Kg)
1	125.2	86.8	17.7	641.2	1712.3	39.2
2	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0
5	30.6	29.2	3.5	172.4	264.4	2.7
6	78.3	72.3	75.0	523.5	775.8	9.5
7	22.2	43.8	1.7	260.3	484.0	4.9
8	26.7	16.1	30.2	303.3	313.9	5.2
9	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0
11	228.7	101.4	25.0	755.3	296.2	20.1
12	32.7	17.1	3.0	135.8	321.7	0.9
13	45.7	32.8	1.6	293.0	353.8	7.4
14	14.1	6.2	0.6	34.2	113.5	1.1
15	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0
17	6.2	11.6	2.2	66.2	64.5	2.5
18	45.2	40.0	3.0	134.5	424.0	7.0
19	41.4	90.9	9.3	257.0	819.7	5.8
20	18.4	14.6	0.6	107.5	203.7	6.5
Mean:	35.77	28.14	8.67	184.2	307.4	5.64

Figure 5.4a: Input and output of Nitrogen for 20 farmers in Kg per cultivation-cycle

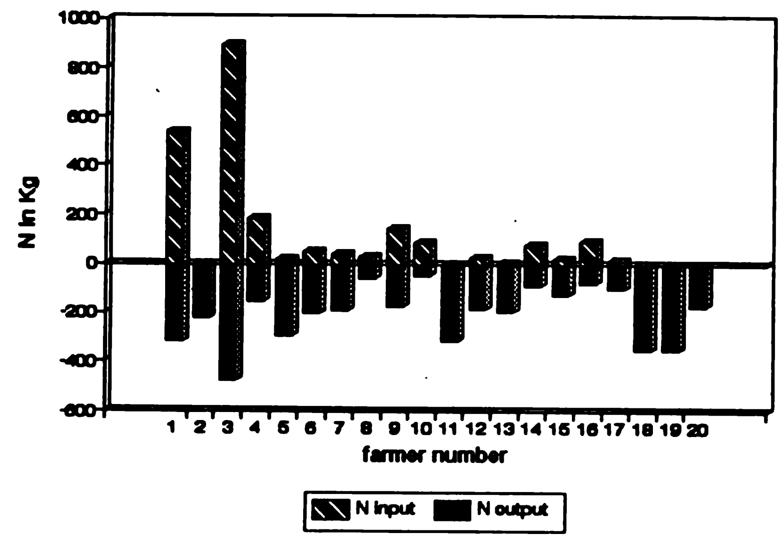


Figure 5.4b: Input and output of Phosphate for 20 farmers in Kg per cultivation-cycle

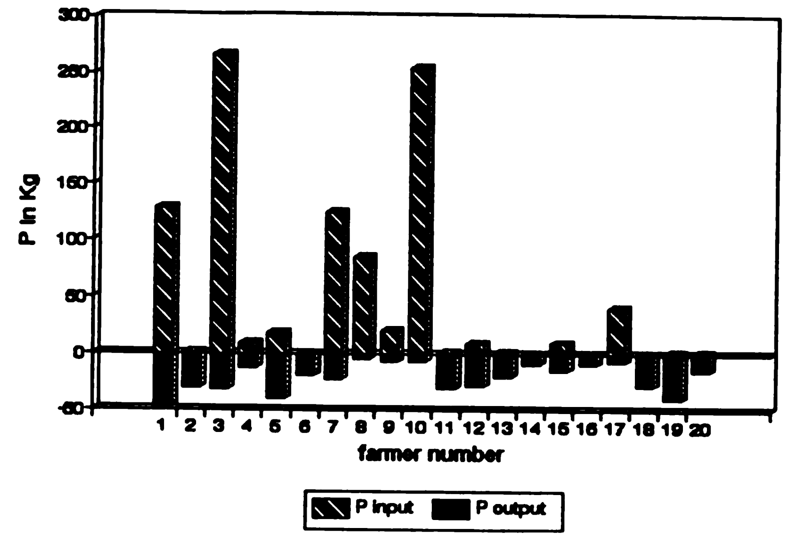


Figure 5.4c: Input and output of Potassium for 20 farmers in Kg per cultivation-cycle

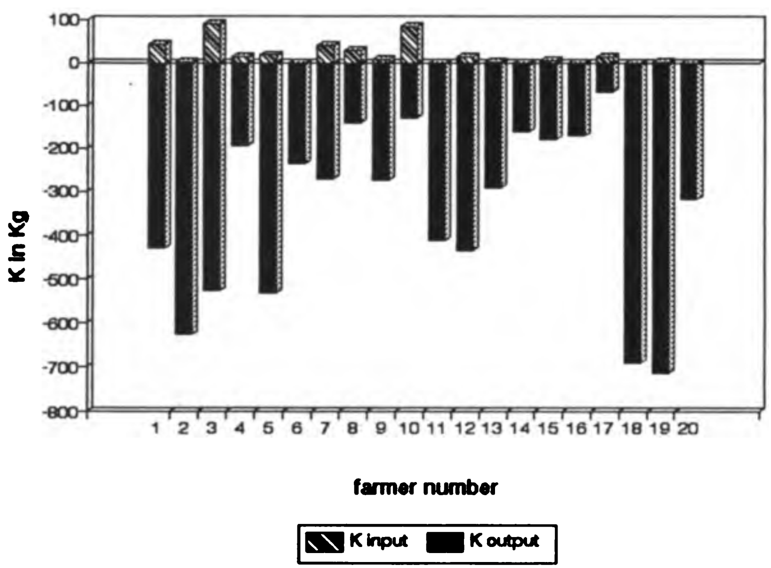
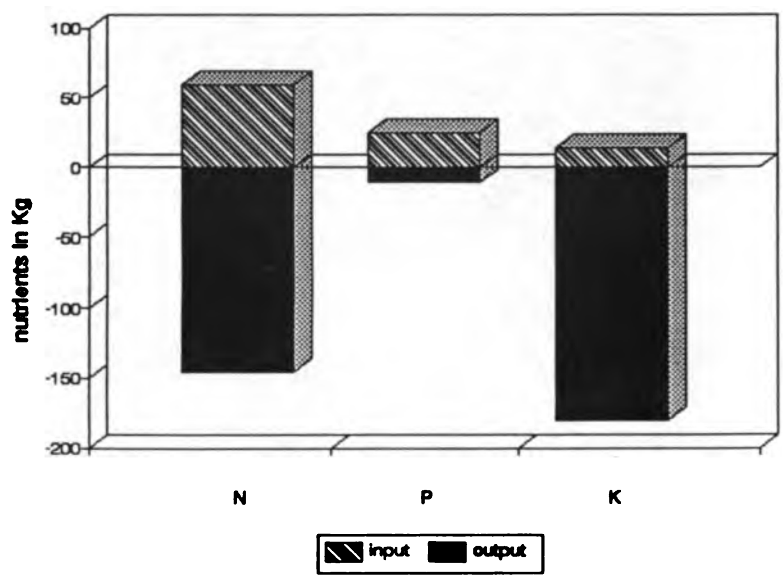


Figure 5.4d: Average input and output of N, P and K in Kg per hectare per year



To determine which factors have effect on those types of production, four multiple regressions with the different dependent productions versus 18 independent variables are calculated.
In Appendix 3 both the dependent as the independent variables are represented.

The category 'sold fruits' represents the amount of fruits of good quality. The 'produced fruits' encloses the rejected fruits too.
In Table 5.6 the 4 dependent variables and the correlated variables are represented.

Table 5.6: Multiple regression with 4 dependent variables and 18 independent variables*; Stepwise.

Stepwise method						
Variable	Multiple R	R square	Adjusted R square	Standard error	F	F sig.
Dependent variable: production fruits per hectare per cycle						
P-left	0.80191	0.64306	0.62323	11886.30	22.429	0.0
Podrido	0.85257	0.72687	0.69474	10699.13	22.621	0.0
Density	0.89686	0.80436	0.76767	9333.84	21.927	0.0
Dependent variable: fruits sold per hectare per cycle						
Herbic.	0.58044	0.33691	0.30008	19232.68	9.146	0.01
P-left	0.85390	0.72915	0.69729	12648.20	22.883	0.0
Podrido	0.89112	0.79409	0.75549	11367.50	20.569	0.0
Dependent variable: production in Kg per hectare per cycle						
P-left	0.84190	0.70880	0.69262	19799.95	43.813	0.0
Podrido	0.89230	0.79620	0.77222	17044.30	33.208	0.0
K-exch.	0.92201	0.85010	0.82200	15067.35	30.247	0.0
pH	0.94127	0.88600	0.85560	13571.06	29.144	0.0
Dependent variable: Kg fruits sold per hectare per cycle						
P-left	0.84165	0.70837	0.69217	18715.14	43.722	0.0
Duration	0.89885	0.80793	0.78534	15628.46	35.755	0.0
K-exch.	0.92715	0.85961	0.83329	13772.76	32.656	0.0

* Explanation of dependent and independent variables in Appendix 3.

With the help of analysis of variance the correlation between the dependent and independent variables is calculated. In Table 5.7 the calculated values are represented.

Table 5.7: Multiple regression with 4 dependent variables and 18 independent variables*.

Analysis of variance

Dependent variable: production fruits per hectare per cycle

	DF	Sum of Squares	Mean Square
Regression	3	5730905975.59013	1910301991.8634
Residual	16	1393928800.95987	87120550.0599

Variable	B	SE B	Beta	T	Sig T
P-left	3056.553158	446.805078	0.840821	6.841	0.0000
Podrido	-0.812828	0.318912	-0.303599	-2.549	0.0215
Density	0.629131	0.249919	0.288056	2.517	0.0229
(Constant)	10040.414693	7401.250487		1.357	0.1937

Dependent variable: fruits sold per hectare per cycle

	DF	Sum of Squares	Mean Square
Regression	3	7973609451.69555	2657869817.2319
Residual	16	2067520570.10445	129220035.6315

Variable	B	SE B	Beta	T	Sig T
Herbicide	249.339931	41.718394	0.693678	5.977	0.0000
P-left	3185.821405	534.657099	0.738225	5.959	0.0000
Podrido	-0.873861	0.389005	-0.274941	-2.246	0.0391
(Constant)	16722.615106	5935.988609		2.817	0.0124

Dependent variable: production in Kg per hectare per cycle

	DF	Sum of Square	Mean Square
Regression	4	21470249454.5528	5367562363.6382
Residual	15	2762603703.7192	184173580.2480

Variable	B	SE B	Beta	T	Sig T
P-left	5791.028439	661.599539	0.863798	8.753	0.0000
Podrido	-1.648147	0.464797	-0.333797	-3.546	0.0029
K-exch.	-70039.585010	27396.075710	-0.235383	-2.557	0.0219
PH	28207.998519	12980.085120	0.192096	2.173	0.0462
(Constant)	-61765.330710	52457.616990		-1.117	0.2574

Dependent variable: Kg fruits sold per hectare per cycle			
	DF	Sum of Squares	Mean Square
Regression	3	18583461754.69148	6194487251.56383
Residual	16	3035022038.25852	189688877.39116

Variable	B	SE B	Beta	T	Sig T
P-left	6191.829262	740.162382	0.977834	8.366	0.0000
Duration	-1326.128659	391.262452	-0.382077	-3.389	0.0037
K-exch.	-67400.604300	27772.674610	-0.239820	-2.427	0.0274
(Constant)	57196.607216	9269.401775		6.170	0.0000

* Explanation of dependent and independent variables in Appendix 3.

The amount of P left on the field with crop residues is positive correlated with all the dependent variables. The higher the amount Phosphate left on the field, the higher the production. This is considered for both the total production of fruits as the production of usable fruits. The applied amount of P is not correlated with one of the production variables. The same conclusion can be drawn for the applications of N and K.

An other important variable is 'podrido'. A big part of the losses can be accounted to plants attacked by 'podrido'. 'Podrido' is caused by bad drainage. Pineapple is very sensitive for waterlogging. In the lower parts of the field most of the plants are putrified. 'Podrido' has a negative effect on the production and especially on the total production of fruits. Plants mostly get attacked by 'podrido' at the beginning of the growing cycle. Those plants don't bear fruits at all so this variable does not influence the quality of the fruits. Most of the farmers have problems with 'podrido'. The problems are bigger in Rio Frio because their fields are situated relatively lower than in other areas. The soils in the Neguev are mainly well drained so 'podrido' is here of less importance.

The variables, plant density, herbicide use and pH are positive correlated with the production. The sampled soils have very low pH-values (3.74-4.73). The optimum pH-value for pineapple cultivation is about 5 which explains the positive correlation.

The duration of the cultivation cycle is negative correlated with the Kg of fruits sold per hectare per cycle. The usable amount decreases with the number of ratoon crops. The weight of fruits from the ratoon crop is lower than the weight of fruits from the first harvest. A longer cultivation cycle gives no positive response on the total weight of marketable fruits.

The exchangeable K in the soil is negative correlated with the production. These levels however give no direct indication of the capacity of the soil to release currently unavailable K over a period of time. By higher levels of pH the exchangeable K is higher as well. Possibly another variable which is correlated with the exchangeable K is responsible for the negative correlation between the production in Kg and the exchangeable K as suggested here.

Chapter 6 **COSTS AND ASSETS**

6.1 Introduction

An important aspect of the cultivation of pineapple is the profitability. Besides the fact that pineapple is an easy crop to cultivate, the low fertility requirements by the crop and the tolerance for acid soils, an important motivation for the farmers to grow pineapple are the relative high prices for the fruit in relation to other fruits. For sustainable land use the farmer has investment in labour and inputs. With an analysis of the costs and assets, the profitability for the different farmers can be calculated. The outflow of nutrients however has to be compensated which requires further investments in fertilizers.

First the profit for the pineapple cultivation practiced in the Atlantic Zone is calculated. After that an estimation is made of the profitability in case the outflow of nutrients by removing crop residues and fruits is compensated for fertilizer application.

6.2 Costs

The costs of the cultivation of pineapple can be divided into four groups. These four groups are split up in sub-groups. The following costs can be distinguished:

1) Labour;
   - -) field preparation,
   - -) cure of planting material,
   - -) planting,
   - -) applications of fertilizers, herbicides, pesticides, insecticides and hormones,
   - -) weeding,
   - -) harvesting,
   - -) the same work as mentioned above, done by day-labourers.

2) Materials;
   - -) planting material,
   - -) chemicals for field preparation,
   - -) fertilizers, herbicides, pesticides, insecticides and hormones,
   - -) tractor use.

3) Others;
   - -) transport of the fruits,
   - -) transport of planting material,
   - -) transport of materials.

4) Unforeseen expenses and interest (10%).

The costs for labour are calculated with the opportunity costs. For the opportunity costs a value of $ 1.50 per hour is used (VILLALOBOS,1990). The costs of day-labourers are different for the farmers. A summary of the different costs in dollars is represented in Table 6.1a-c.

The costs per cycle, per cultivation, per hectare per cultivation and the costs per hectare per year are calculated. The mean costs per hectare per year are about 1500 dollars. This is for the first cycle. The crop in the second cycle is planted with planting material from the first cycle which means lower costs. The number of hours for field preparation for the second cycle is lower than for the first so the total costs for the second cycle are lower.

The first crop implicates most of the inputs. For the ratoon crop just a small amount of inputs are applied. Most farmers leave the crop on the field without very much attention.
A big problem is the investment to be made at the start of the cultivation of pineapple. This is the main reason that just small areas are under cultivation.

6.3 Assets

The assets for pineapple cultivation consists of the sale of fruits and planting material. Because the prices of the fruits fluctuate throughout the year, the time of harvesting is important for the income of the farmer. In Chapter 4 the fluctuation of prices is discussed. For the ratoon crop the assets are lower than for the first harvest because of the lower prices for the smaller fruits.

6.4 Income

Farmers become income from selling fruits and in some cases from selling shoots as planting material for other farmers. In Table 6.2 the net and gross income of farmers per cycle per hectare is represented. The net income for the first cycle and second cycle differ because of the lower costs for the second one (less investments).
One of the main reasons for the negative income of some farmers are the high losses by plant rot. The farmers who have a short cultivation cycle with just one harvest have fruits of better quality than the farmers with one or more ratoon crops. The prices for those fruits are higher and so are the assets. The number of produced fruits is higher when the cultivation-cycle is longer. The difference between the farmers with a long cultivation-cycle and those with a cultivation-cycle of 12 months however is small (Fig. 6.1). Farmers have a long cultivation cycle to lower the average costs per year. If farmers are able to de higher investments they can harvest one crop per cycle which gives a higher return on investments.

Table 6.1a: Costs in dollars of farmers for different inputs per hectare.

Farmer number	Costs fertilizer use	Costs herbicide use	Costs hormone use	Costs pesticide use
1	468.6159	7.212	21.1203	10.6311
2	11.3072	72.1205	5.9373	43.7379
3	865.3372	70.8474	0.2741	139.7057
4	367.8811	29.5197	0.8283	0.0
5	19.8562	12.8114	0.0740	0.0
6	29.8846	91.3689	4.9695	18.1283
7	134.6028	11.5124	0.0	0.0
8	92.0848	16.6215	0.0926	36.2566
9	110.4418	11.8078	5.4814	0.0
10	276.2544	7.3800	0.1316	47.8952
11	7.6400	19.4892	0.1100	0.0
12	270.7424	43.2723	4.9696	0.0
13	32.0574	42.7047	0.5482	0.0629
14	49.8078	101.5210	0.3704	0.0
15	18.8763	33.2428	0.1852	0.0
16	58.9030	21.3524	0.0926	0.0
17	44.1747	286.1492	2.0707	0.0
18	0.0	4.5075	15.8067	0.0
19	9.6391	73.8513	8.9196	0.0
20	12.6666	0.0	0.1960	0.0

Table 6.1b: Costs in dollars of farmers for different inputs per hectare.

Farmer number	Costs of labour	Costs planting material	Costs cure planting material	Costs field preparation
1	3030.5240	1731.4810	17.4086	74.0741(m)
2	1736.2960	2592.5920	22.4096	20.3041(c)
3	1641.7776	555.5552	0.0	74.0741(m)
4	2130.4940	666.6667	0.0	9.8399(c)
5	2662.2220	370.3704	0.0	4.5838(c)
6	1542.2220	444.4444	0.0	48.8450(c)
7	1114.0736	829.6296	0.0	37.5108(c)
8	1068.1480	555.0000	0.0	36.5858(c)
9	1370.3706	370.3704	0.0	4.5838(c)
10	814.8146	370.3704	0.0	3.8198(c)
11	1896.9602	251.8518	30.8182	3.8198(c)
12	957.5925	1111.1110	0.0	0.0
13	3394.0735	21.2963	0.0	22.2222(m)
14	1481.4820	296.2962	0.0	8.6032(c)
15	776.2962	488.8889	0.0	16.2817(c)
16	865.1852	555.5556	0.0	17.3311(c)
17	1118.6480	185.1852	17.9607	65.1267(c)
18	2250.3700	833.3333	0.0	0.7640(c)
19	1643.7033	414.8148	0.0	5.7355(c)
20	2120.0000	355.5556	0.0	7.6398(c)

(m): mechanical
(c): chemical.

Table 6.1c: Total costs in dollars of cultivation of pineapple for different farmers.

Farmer number + # Ha	# months per cycle	# harvests per cycle	costs of cycle	costs per cultivation	costs per hectare	costs per hectare per year
1/1.0	30	3	5361.06	1787.02	5361.06	2144.42
2/0.75	12	1	3378.53	3378.53	4504.71	4504.71
3/2.5	12	1	8368.93	8368.93	3347.57	3347.57
4/1.0	18	1	3205.23	3205.23	3205.23	2136.82
5/0.5	26	2	1534.96	767.48	3069.92	1416.89
6/1.0	36	3	2179.86	726.62	2179.86	726.62
7/0.25	18	2	531.83	265.92	2127.33	1418.22
8/1.0	24	2	1804.79	902.40	1804.79	902.40
9/0.5	15	1	936.53	936.53	1873.06	1498.44
10/0.5	14	1	760.34	760.34	1520.67	1303.43
11/5.0	36	3	11053.44	3684.48	2210.69	736.90
12/1.0	24	2	2387.69	1193.84	2387.69	1193.84
13/2.0	48	4	7025.93	1756.48	3512.97	878.24
14/0.5	22	2	969.04	484.13	1938.08	1057.13
15/1.0	14	1	1333.77	1333.77	1333.77	1143.23
16/1.0	14	1	1518.42	1518.42	1518.42	1301.50
17/2.0	36	2	3438.63	1719.32	1719.32	573.11
18/1.0	26	2	2688.12	1344.06	2688.12	1240.67
19/1.5	24	2	3235.00	1617.50	2156.66	1078.33
20/0.5	24	2	1248.03	624.01	2496.06	1248.03
Mean:	23.65	1.9	3182.09	1835.79	2578.67	1506.36

Table 6.2: Net and gross income of farmers for the first and the second cycle on the same field, in dollars per hectare.

Nr	Income out of fruits +shoots	Income-costs, first cycle	Income-costs, second cycle	Nr	Income out of fruits +shoots	Income-costs, first cycle	Income -costs second cycle
1	6774	1413	3144	11	3402	1192	1444
2	11644	7140	9732	12	3703	1316	2427
3	7318	3971	4527	13	1426	-886	-674
4	2543	338	1004	14	1939	1941	2309
5	6272	2201	2572	15	4282	2948	3437
6	3271	1091	1535	16	4527	3009	3564
7	6969	4841	5671	17	2202	-678	-307
8	3370	1566	2121	18	3246	5	422
9	4753	2880	3251	19	6809	2383	2798
10	2968	1447	1817	20	2289	2082	2437

The returns of investments are represented in figures 6.2a-c.
By increasing investments the gross return increases as well. Important however is the development of the net return of investments. The net return of investments increases with increasing costs. In figure 6.2c the net income is calculated when the prices for fruits decrease with 20%. The net income of some more farmers fall below zero and for other farmers the profits are much lower.
For most of the small farmers the high prices for pineapple are very important to produce a paying crop. Important here is the time of harvesting because prices are lower in the first five months of the year (see characterization of the supply, Chapter 4.5).

6.5 Estimation of profits by compensation nutrient outflow

If farmers apply the amount of nutrients to compensate the lack of nutrients that is removed from the field with crop residues and other outputs, the profits get lower. The mean income for one hectare per cycle is $ 2000 and for the second cycle $ 2600. The negative flows of N and K are 86 and 166 Kg per hectare per year respectively. They can be compensated by applications of fertilizers. The mean cost for those applications are $ 100 for N and $ 400 for K.

Figure 6.1: Total production of fruits per duration of cultivation-cycle for 18 farmers

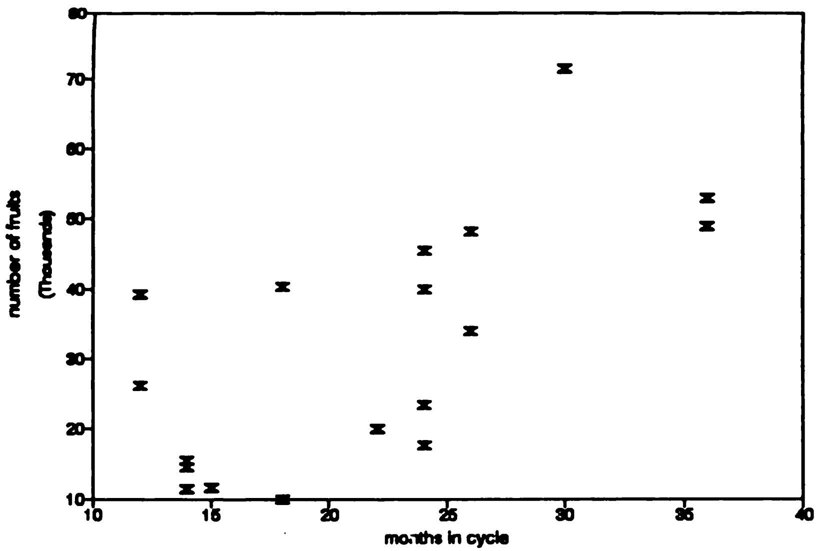


Figure 6.2a: Costs and benefits of the inputs gross return of investments

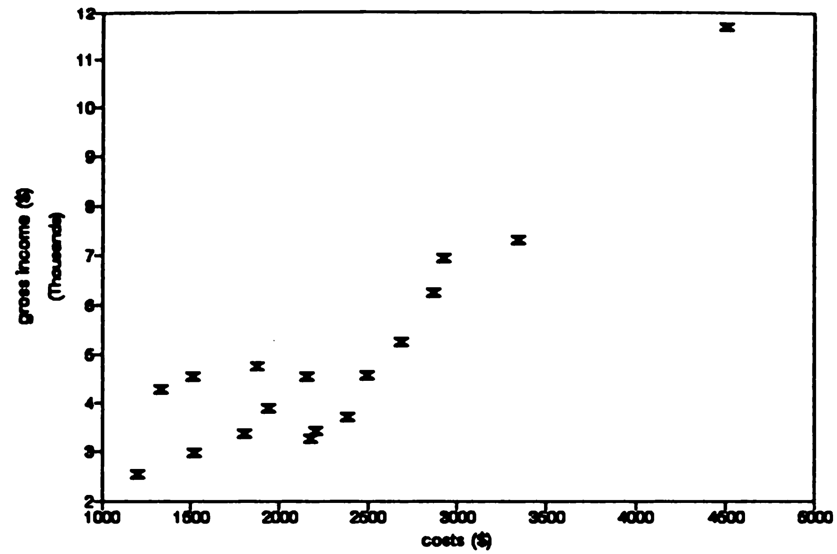


Figure 6.2b: Costs and benefits of the inputs net return of investments

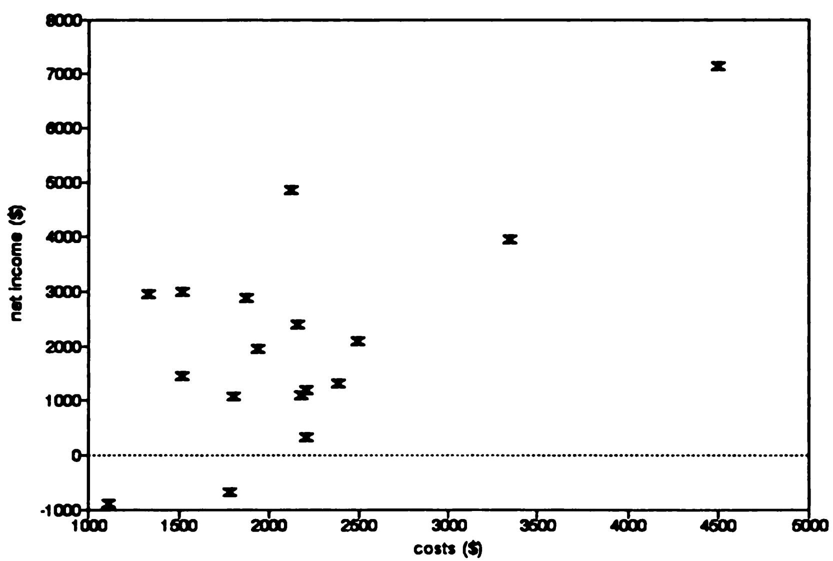
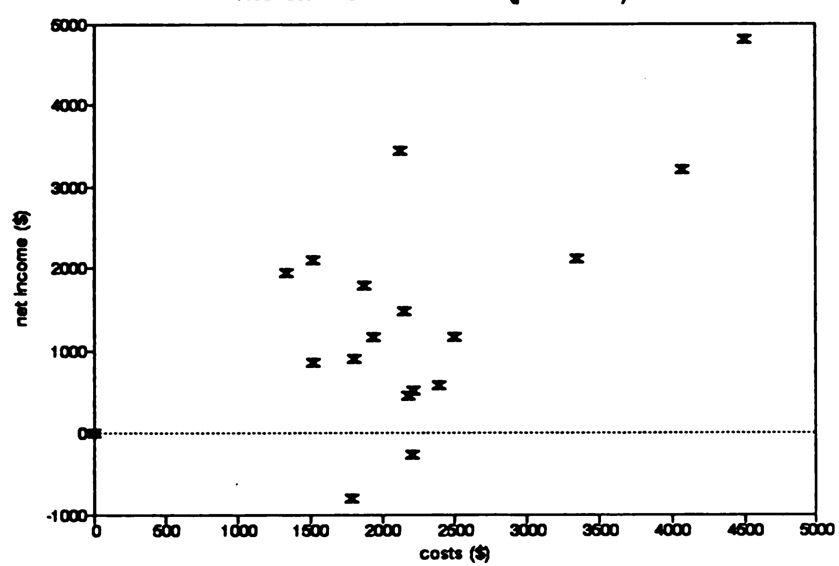


Figure 6.2c: Costs and benefits of the inputs by decreasing prices of pineapple net return of investments (price-20%)



In this calculation the leaching percentages for N and K are 50% and 70% respectively.
The costs of total labour for extra fertilizer applications are 323*$1.5= $478. The transport of extra fertilizers takes about $60 per hectare per year.
An average extra investment of about 1000 dollars has to be done which lowers the mean income for the first cycle to $ 1000 and for the second cycle to $ 1600. When the prices for the fruits fall with 20% the mean income for the farmers is about $1430. The extra investment will almost annul this profit.
The outflow of nutrients from the field can not just be compensated with fertilizer applications. Leaving crop residues to increase the content of organic matter is very important too.

Chapter 7 Conclusions

Some of the reasons for cultivating pineapple are the high prices for the fruits, the low fertility requirements ,tolerance for acid soils and pineapple has the name to be a very easy crop to cultivate. A growing number of farmers invest in a pineapple cultivation. Different problems (can) arise;

* The growth in the export market is decreasing. The production can therefore exceed the demand. This can cause lower prices for the fruits.

* Exhaustion of the soil takes place because of intensive land use and losses of Nitrogen and Potassium. Big nutrient losses are caused by transporting crop residues and fruits from the field.

* High losses occur when pineapple is cultivated on badly drained soils, due to plant-rot.

* The harvests of most farmers coincide because most plant their crop at the start of the rainy season. The high supply in this period lowers the prices.
  By changing the plant date and using hormones in the right period, the time of harvest can be manipulated and in this way the supply can be adjusted to the demand.

* The price for the fruits often is determined by the middlemen that have a dominant position as buyer of fruits from small farmers. Benefits of middlemen are diminishing risks and transport costs and less problems with time constraints and limited volume.

* The response to P fertilization is sometimes low, due to inefficient fertilizer applications.

* Because of the high costs for inputs, a lot of farmers have a long cultivation cycle to lower the average costs per year. Harvesting one crop per cycle gives a higher return on investments. Most of the farmers however are not able to do those investments.

These developments can cause lower profits than farmers expect and make the cultivation of pineapple more complicated then they thought it would be.

APPENDIX 1

TOTAL AMOUNT LEAVING THE FIELD (FRUITS AND PLANT-RESIDUES):

(per hectare) FIRST HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	34000	0	34000	0	100000
2	40825	50000	40825	40825	75000
3	27000	30000	27000	27000	292500
4	12000	30000	12000	12000	105000
5	14500	0	14500	0	0
6	24310	0	24310	0	0
7	22840	0	22840	0	0
8	12620	0	12620	0	0
9	12300	20000	12300	12300	50000
10	12140	20000	12140	12140	45000
11	13150	0	13150	0	0
12	16400	0	16400	0	0
13	1110	0	1110	0	0
14	12300	0	12300	0	0
15	15300	22000	15300	15300	77000
16	16250	25000	16250	16250	62500
17	6175	0	6175	0	0
18	14250	0	14250	0	0
19	19165	0	19165	0	0
20	10700	0	10700	0	0

SECOND HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	23250	0	23250	0	0
2					
3					
4					
5	36875	50000	36875	36875	125000
6	15250	0	15250	0	0
7	19480	22680	19480	19480	73710
8	5920	12500	5920	5920	12500
9					
10					
11	25150	0	25150	0	0
12	25400	45000	25400	25400	123750
13	3150	0	3150	0	0
14	8850	25000	8850	8850	25000
15					
16					
17	4225	15000	4225	4225	75000
18	20727	35000	20727	20727	354900
19	27316	39200	27316	27316	387296
20	13440	19200	13440	13440	165696

THIRD HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	16200	23800	16200	16200	83300
2					
3					
4					
5					
6	10500	15500	10500	10500	96875
7					
8					
9					
10					
11	20800	34000	20800	20800	68000
12					
13	1150	0	1150	0	0
14					
15					
16					
17					
18					
19					
20					

FOURTH HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13	700	16650	700	700	239094
14					
15					
16					
17					
18					
19					
20					

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES

(in grammes) FIRST HARVEST:

Farmer number:	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	84496.7	16641.97	155608.4	17025.79	14625.48	12363.72	801.2945	452.4583	757.5781	5936.385
2	222144.6	30797.58	626209.9	73493.44	48260.67	36365.57	4075.284	590.3168	1360.343	15443.03
3	477259.3	31839.72	526638.2	237023.7	109496.4	59240.11	5250.441	828.7415	1125.294	22915.01
4	154269	13389.59	195874.9	88668.76	34120.15	23251.72	7680.237	563.1089	398.2229	6971.737
5	20129.13	2593.673	46334.56	3991.227	2916.284	1517.86	365.7426	284.761	190.1402	354.9897
6	30540.36	5999.27	69573.98	8314.603	6312.213	2350.266	876.0634	294.9039	387.8792	1054.998
7	41327.45	6243.245	71598.72	22544.99	9047.335	11484.84	3345.083	290.4248	550.0868	962.1252
8	12276.08	1366.759	34226.34	3311.892	2732.482	657.237	375.8271	90.48502	85.36584	550.4104
9	173501.5	7348.181	273491.6	43978.48	26593.9	12688.49	2725.684	268.633	238.4779	5705.528
10	50533.32	7040.01	128904.1	16882.08	14960.57	5873.193	4909.628	286.5692	326.2643	2569.215
11	24043.18	3257.991	48575.88	4220.834	3518.19	1129.256	355.4818	242.0012	124.4291	416.3585
12	15965.09	2180.003	47624.01	3848.211	4252.372	3279.623	632.2892	247.0175	113.8065	210.7162
13	1845.775	170.1586	4353.618	692.1488	406.7212	312.596	11.59952	19.77532	12.50872	32.09165
14	16292.11	2187.936	27380.37	1923.622	2855.328	770.6442	196.7068	82.96362	243.338	424.4333
15	126291.7	14712.81	179900.8	73333.49	52600.39	22157.21	23152.17	641.7616	977.1647	10341.77
16	80947.44	9937.355	171762.5	42758.26	18290.03	13218.31	16506.98	248.177	297.8511	6621.96
17	11116.91	1650.806	17263.54	1528.911	1088.331	1144.845	139.3728	93.04095	101.0324	289.9408
18	20917.79	2486.896	54563.32	4308.773	3373.83	1503.589	330.3407	172.7485	192.2532	494.356
19	23608.75	2197.095	61396.3	6381.792	4333.321	2149.278	710.6211	176.7072	190.8926	1462.2
20	17814.76	1074.505	30105.96	8310.412	4280.198	3241.415	951.7629	118.9024	103.4491	853.7584

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES

(in grammes) SECOND HARVEST:

Farmer number:	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	38328.79	8197.106	85718.8	6514.366	6818.186	4741.028	401.1695	282.8761	475.6089	2803.899
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	274897	38078.77	485262.1	166383	72612.65	66119.3	8436.165	1028.611	1007.217	6405.741
6	19158.39	3763.426	43644.72	5215.866	3959.739	1474.355	549.5667	184.9973	243.322	661.8146
7	149012	16356.64	198077.2	49645.73	25504.72	45039.74	4059.569	445.052	835.9421	4821.231
8	48816.98	3689.358	106375.5	18689.71	14127.66	7722.936	13965.33	185.0094	188.7644	2832.487
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	45983.73	6231.063	92903.67	8072.546	6728.706	2159.756	679.8759	462.8387	237.9766	796.3053
12	169375.5	27240.27	389381.6	74205.32	56977.19	31243.97	5482.776	579.5462	656.7095	1765.356
13	5238.009	482.8824	12354.86	1964.206	1154.209	887.0967	32.91756	56.11914	35.49773	91.07091
14	71966.38	7118.301	135130.4	23758.94	19007.43	7440.136	801.6235	94.53803	292.1343	1729.442
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	91468.26	6374.638	52445.29	26997.56	8862.238	13543.83	2904.554	151.7242	142.1543	3942.013
18	335118.9	26655.22	633841.3	116402.6	70334.43	60623.6	4845.538	442.9298	882.1784	10764.01
19	332249.7	38373.96	651983.4	153517.8	68868.38	134859.7	14394.78	652.3536	1538.926	12076.17
20	155498.6	14764.47	288700.2	82282.97	29952.73	22610.66	1923.563	317.486	388.566	9286.175

APPENDIX 1

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES
(in grammes) THIRD HARVEST:

Farmer number:	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	196267.9	23971.89	188653.3	75321.89	47551.3	33334.91	6045.765	418.8054	902.5909	15623.95
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	152897.6	9944.906	120930.3	55886.5	25416.75	21080.21	20525.93	273.1942	386.4158	3245.044
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	244724.1	21815.86	269890.7	236832.1	121604.1	53732.02	13227.25	763.4927	348.7051	10849.76
12	0	0	0	0	0	0	0	0	0	0
13	1912.289	176.2904	4510.505	717.0911	421.3778	323.8607	12.01752	20.48794	12.95949	33.24811
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES
(in grammes) FOURTH HARVEST:

Farmer number:	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0
13	185721.1	19749.59	269873.3	70330.02	29826.35	21014.48	1293.576	214.9938	244.0805	4833.469
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES
(in grammes) TOTAL AMOUNT:

Farmer number:	months in cult.cycl	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	30	319093.4	48810.97	429980.5	98862.04	68994.97	50439.65	7248.229	1154.14	2135.778	24364.24
2	12	222144.6	30797.58	626209.9	73493.44	48260.67	36365.57	4075.284	590.3168	1360.343	15443.03
3	12	477259.3	31839.72	526638.2	237023.7	109496.4	59240.11	5250.441	828.7415	1125.294	22915.01
4	18	154269	13389.59	195874.9	88668.76	34120.15	23251.72	7680.237	563.1089	398.2229	6971.737
5	26	295026.1	40672.44	531596.6	170374.2	75528.93	67637.16	8801.908	1313.372	1197.357	6760.731
6	36	202596.3	19707.6	234149	69416.97	35688.7	24904.83	21951.56	753.0953	1017.617	4961.856
7	18	190339.5	22599.88	269675.9	72190.72	34552.05	56524.58	7404.652	735.4767	1386.029	5783.356
8	24	61093.06	5056.117	140601.9	22001.6	16860.14	8380.173	14341.15	275.4944	274.1303	3382.897
9	15	173501.5	7348.181	273491.6	43978.48	26593.9	12688.49	2725.684	268.633	238.4779	5705.528
10	14	50533.32	7040.01	128904.1	16882.08	14960.57	5873.193	4909.628	286.5692	326.2643	2569.215
11	36	314751	31304.91	411370.3	249125.5	131851	57021.03	14262.61	1468.333	711.1108	12062.42
12	24	185340.6	29420.27	437005.6	78053.53	61229.56	34523.6	6115.065	826.5636	770.516	1976.073
13	48	194717.2	20578.92	291092.3	73703.46	31808.66	22538.04	1350.111	311.3762	305.0464	4989.88
14	22	88258.5	9306.237	162510.8	25682.56	21862.75	8210.781	998.3302	177.5017	535.4724	2153.875
15	14	126291.7	14712.81	179900.8	73333.49	52600.39	22157.21	23152.17	641.7616	977.1647	10341.77
16	14	80947.44	9937.355	171762.5	42758.26	18290.03	13218.31	16506.98	248.177	297.8511	6621.96
17	36	102585.2	8025.444	69708.83	28526.48	9950.569	14688.68	3043.927	244.7651	243.1866	4231.954
18	26	356036.7	29142.12	688404.6	120711.4	73708.26	62127.19	5175.879	615.6783	1074.432	11258.36
19	24	355858.5	40571.05	713379.7	159899.6	73201.7	137009	15105.4	829.0608	1729.819	13538.37
20	24	173313.4	15838.97	318806.2	90593.38	34232.93	25852.07	2875.326	436.3883	492.0151	10139.93

TOTAL AMOUNT OF NUTRIENTS LEAVING THE FIELD WITH FRUITS AND PLANT-RESIDUES
(in grammes) TOTAL AMOUNT PER YEAR:

Farmer number:	months in cult.cycl	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	30	127637.4	19524.39	171992.2	39544.82	27597.99	20175.86	2899.292	461.6559	854.3111	9745.694
2	12	222144.6	30797.58	626209.9	73493.44	48260.67	36365.57	4075.284	590.3168	1360.343	15443.03
3	12	477259.3	31839.72	526638.2	237023.7	109496.4	59240.11	5250.441	828.7415	1125.294	22915.01
4	18	102846	8926.396	130583.3	59112.5	22746.76	15501.14	5120.158	375.406	265.482	4647.825
5	26	136165.9	18771.9	245352.3	78634.24	34859.51	31217.15	4062.419	606.1719	552.6265	3120.337
6	36	67532.11	6569.2	78049.65	23138.99	11896.23	8301.611	7317.186	251.0318	339.2057	1653.952
7	18	126893	15066.59	179783.9	48127.15	23034.7	37683.05	4936.435	490.3178	924.0193	3855.571
8	24	30546.53	2528.058	70300.93	11000.8	8430.071	4190.086	7170.577	137.7472	137.0651	1691.449
9	15	138801.2	5878.545	218793.3	35182.79	21275.12	10150.79	2180.548	214.9064	190.7823	4564.423
10	14	43314.28	6034.294	110489.2	14470.35	12823.35	5034.166	4208.253	245.6307	279.6551	2202.184
11	36	104917	10434.97	137123.4	83041.84	43950.33	19007.01	4754.203	489.4442	237.0369	4020.806
12	24	92670.28	14710.14	218502.8	39026.77	30614.78	17261.8	3057.532	413.2818	385.258	988.0363
13	48	48679.29	5144.731	72773.08	18425.87	7952.164	5634.509	337.5277	77.84406	76.26161	1247.47
14	22	48141	5076.129	88642.25	14008.67	11925.14	4478.608	544.5438	96.81908	292.0758	1174.841
15	14	108250	12610.98	154200.7	62857.28	45086.05	18991.9	19844.71	550.0814	837.5698	8864.372
16	14	69383.52	8517.733	147225	36649.93	15677.16	11329.98	14148.84	212.7231	255.301	5675.965
17	36	34195.06	2675.148	23236.28	9508.825	3316.856	4896.225	1014.642	81.58838	81.06222	1410.651
18	26	164324.6	13450.21	317725.2	55712.96	34019.2	28674.09	2388.867	284.1592	495.8915	5196.167
19	24	177929.2	20285.53	356689.9	79949.81	36600.85	68504.51	7552.699	414.5304	864.9094	6769.184
20	24	86656.68	7919.487	159403.1	45296.69	17116.47	12926.04	1437.663	218.1942	246.0075	5069.967

TOTAL AMOUNT ON THE FIELD (FRUITS AND PLANT-RESIDUES):
(per hectare)

AFTER FIRST HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	500	42500	500	34500	19500
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	1750	25000	1750	16250	12500
6	190	30000	190	24500	165000
7	1500	28000	1500	24340	68320
8	625	25000	625	13245	12500
9	0	0	0	0	0
10	0	0	0	0	0
11	310	17000	310	13460	0
12	600	30000	600	17000	37500
13	370	23000	370	1480	107900
14	450	20000	450	12750	0
15	0	0	0	0	0
16	0	0	0	0	0
17	375	10000	375	6550	35000
18	750	25000	750	15000	83750
19	435	28000	435	19600	107800
20	500	16000	500	11200	0

AFTER SECOND HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	340	29250	340	23590	78575
2					
3					
4					
5	0	0	0	0	0
6	250	22500	250	15500	125125
7	0	0	0	0	0
8	0	0	0	0	0
9					
10					
11	650	34000	650	25800	38000
12	0	0	0	0	0
13	1200	6350	1200	4350	19862.5
14	0	0	0	0	0
15	0	0			
16	0	0			
17	0	0	0	0	0
18	0	0	0	0	0
19	0	0	0	0	0
20	0	0	0	0	0

AFTER THIRD HARVEST:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11	500	16650	500	1650	33300
12					
13					
14					
15					
16					
17					
18					
19					
20					

TOTAL IN CULTIVATION-CYCLE:

Farmer number:	Number of fruits:	Number of leaves:	Number of crowns:	Number of stems:	Number of shoots:
1	840	71750	840	58090	98075
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	1750	25000	1750	16250	12500
6	440	52500	440	40000	290125
7	1500	28000	1500	24340	68320
8	625	25000	625	13245	12500
9	0	0	0	0	0
10	0	0	0	0	0
11	1460	67650	1460	40910	71300
12	600	30000	600	17000	37500
13	1570	29350	1570	5830	127762.5
14	450	20000	450	12750	0
15	0	0	0	0	0
16	0	0	0	0	0
17	375	10000	375	6550	35000
18	750	25000	750	15000	83750
19	435	28000	435	19600	107800
20	500	16000	500	11200	0

TOTAL AMOUNT OF NUTRIENTS LEFT ON THE FIELD WITH FRUITS AND PLANT-RESIDUES
Farmer (in grammes) AFTER FIRST HARVEST:
number:

	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	273627.9	27874.98	196769.6	125218.6	72428.35	49340.26	10402.45	367.0729	994.2982	22534.36
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	103677.9	14535.01	171143.1	72525.46	30634.51	29214	3491.601	172.4487	264.3852	2670.001
6	278917.7	14865.33	175795.3	109116.3	45603.55	43167.52	45466.68	311.7329	458.9732	5523.801
7	140181.7	13569.43	169212.8	38015.63	22160.18	43794.45	1688.074	260.2689	483.9513	4903.236
8	90166.58	6426.997	190232.2	35587.35	26696.6	16068.93	30158.49	303.2521	313.8655	5209.976
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	104238.6	8026.884	94147.47	118807.4	58669.61	28520.92	6585.966	196.0618	78.73508	5062.493
12	93265.36	15411.61	205910.7	43766.75	32660.67	17079.88	2972.549	135.7818	321.7125	935.4973
13	217737.6	23418.78	293696.1	84182.62	34499.04	24840.87	1161.47	223.5971	265.0978	5641.157
14	50033.86	4707.726	101024.6	18894.07	14139.72	6177.33	595.7493	34.18281	113.5126	1147.439
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	58221.94	3542.768	30149.57	20285.43	6175.104	11618.82	2167.865	66.20316	64.53704	2511.232
18	200343.2	14229.94	366041.7	75684.88	45150.67	39953.31	3023.043	134.5428	423.9624	7020.135
19	189574.7	22246.8	372097	93858.31	41414.94	90881.82	9272.672	256.9777	819.6979	5761.745
20	105570.9	10633.4	188670.7	55611.37	18416.32	14647.49	574.9418	107.5371	203.673	6477.184

TOTAL AMOUNT OF NUTRIENTS LEFT ON THE FIELD WITH FRUITS AND PLANT-RESIDUES
Farmer (in grammes) AFTER SECOND HARVEST:
number:

	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	206459	22145.1	154410.5	90827.8	52791.64	37422.4	7287.4	274.1597	717.9809	16677.38
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	200470.2	10433.26	128183.1	75803.71	32678.42	29193.02	29550.56	211.7655	316.8762	3996.883
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	211738.1	16741.68	192973.4	238335.1	117928.4	56733	13168.14	391.1781	159.0234	10192.94
12	0	0	0	0	0	0	0	0	0	0
13	65815.73	6866.899	98460.59	27128.13	11233.78	7991.276	426.0889	69.44272	88.7506	1792.807
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

TOTAL AMOUNT OF NUTRIENTS LEFT ON THE FIELD WITH FRUITS AND PLANT-RESIDUES
Farmer (in grammes) AFTER THIRD HARVEST:
number:

Farmer number	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0
11	86801.21	7077.719	90013.55	95125.23	52135.26	16178.47	5206.116	168.0729	58.43975	4892.813
12	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0

TOTAL AMOUNT OF NUTRIENTS LEFT ON THE FIELD WITH FRUITS AND PLANT-RESIDUES
Farmer (in grammes) TOTAL AMOUNT:
number:

Farmer number	N	P	K	Ca	Mg	S	Fe	Cu	Zn	Mn	months in cult.cycl
1	480086.9	50020.09	351180.1	216046.4	125220	86762.65	17689.85	641.2327	1712.279	39211.74	30
2	0	0	0	0	0	0	0	0	0	0	12
3	0	0	0	0	0	0	0	0	0	0	12
4	0	0	0	0	0	0	0	0	0	0	18
5	103677.9	14535.01	171143.1	72525.46	30634.51	29214	3491.601	172.4487	264.3852	2670.001	26
6	479387.9	25298.6	303978.5	184920	78281.96	72360.54	75017.24	523.4984	775.8494	9520.684	36
7	140181.7	13569.43	169212.8	38015.63	22160.18	43794.45	1688.074	260.2689	483.9513	4903.236	18
8	90166.58	6426.997	190232.2	35587.35	26696.6	16068.93	30158.49	303.2521	313.8655	5209.976	24
9	0	0	0	0	0	0	0	0	0	0	15
10	0	0	0	0	0	0	0	0	0	0	14
11	402778	31846.29	377134.5	452267.8	228733.3	101432.4	24960.22	755.3128	296.1982	20148.24	36
12	93265.36	15411.61	205910.7	43766.75	32660.67	17079.88	2972.549	135.7818	321.7125	935.4973	24
13	283553.3	30285.68	392156.6	111310.7	45732.81	32832.15	1587.559	293.0399	353.8484	7433.964	48
14	50033.86	4707.726	101024.6	18894.07	14139.72	6177.33	595.7493	34.18281	113.5126	1147.439	22
15	0	0	0	0	0	0	0	0	0	0	14
16	0	0	0	0	0	0	0	0	0	0	14
17	58221.94	3542.768	30149.57	20285.43	6175.104	11618.82	2167.865	66.20316	64.53704	2511.232	36
18	200343.2	14229.94	366041.7	75684.88	45150.67	39953.31	3023.043	134.5428	423.9624	7020.135	26
19	189574.7	22246.8	372097	93858.31	41414.94	90881.82	9272.672	256.9777	819.6979	5761.745	24
20	105570.9	10633.4	188670.7	55611.37	18416.32	14647.49	574.9418	107.5371	203.673	6477.184	24

<u>Dependent variables:</u>

1)	**Prod. fruits**	Amount of fruits produced per hectare per cycle.
2)	**Prod. fr. sold**	Amount of fruits sold per hectare per cycle.
3)	**Prod. Kg fruits**	Total production of fruits, in Kg per hectare per cycle.
4)	**Prod. fr. sold**	Kg fruits sold per hectare per cycle.

<u>Independent variables:</u>

1)	**N-app. on leave**	Fertilizer N application on leaves, in Kg per hectare per cycle.
2)	**N-app. soil**	Fertilizer N application to soil, in Kg per hectare per cycle.
3)	**Total N-app.**	Total fertilizer N application, in Kg per hectare per cycle.
4)	**Total P-app.**	Total fertilizer P application, in Kg per hectare per cycle.
5)	**Total K-app.**	Total fertilizer K application, in Kg per hectare per cycle.
6)	**Pesticide use**	The use of pesticides, in $ per cycle.
7)	**Hormone use**	The use of hormone, in $ per cycle.
8)	**Herbic.**	The use of herbicide, in $ per cycle.
9)	**PH**	The pH-value of the soil.
10)	**% O.M.**	The organic matter content of the soil (%).
11)	**K-exch.**	The exchangeable K of the soil in meq/100g.
12)	**Duration**	The duration of the cycle in months.
13)	**Labour hours**	The amount of labour, in hours per cycle.
14)	**Density**	The plant density, in plants per hectare.
15)	**Podrido**	The total losses by putrid, in plants per hectare per cycle.
16)	**N-left**	The total amount of N left on the field with crop residues, in Kg per hectare per cycle.
17)	**P-left**	The total amount of P left on the field with crop residues, in Kg per hectare per cycle.
18)	**K-left**	The total amount of K left on the field with crop residues, in Kg per hectare per cycle.

STATISTICAL ANALYSIS

	Dependent variables:				Independent variables:							
Farmer number:	prod. fruits /ha.,yr.	prod. fr. sold /ha.,yr.	prod. Kg fruits /ha.,yr.	prod. Kg fr. sold /ha.,yr.	N-app. on leave Kg/ha,cy	N-app. soil Kg/ha,cy	total N-app. Kg/ha,cy	total P-app. Kg/ha,cy	total K-app. Kg/ha,cy	pesticide use $/cycle	hormone use $/cycle	herbicide use $/cycle
1	74290	71450	141151	135755	0.4	540.6	541.2	128.7	42.8	10.6	21.12	7.2
2	40825	39300	58114	55944	0.9	0	0.9	0.4	0.6	43.7	5.94	72.1
3	27000	26000	51165	49270	0	892.4	892.4	266.4	88.8	139.7	0.27	70.8
4	12000	10000	21420	17850	0	183.8	183.8	8.2	14.3	0	0.83	29.5
5	53125	48275	80750	73378	0	18.2	18.2	18.2	18.2	0	0.07	12.8
6	50500	49060	77518	75307	0	46.2	46.2	0	0	18.1	4.97	91.4
7	43820	40320	83039	76406	0	41.4	41.4	124.3	41.4	0	0	11.5
8	19165	17500	29092	26565	0	28.4	28.4	85.1	28.4	36.3	0.09	16.6
9	12300	11625	19680	18600	0	143.5	143.5	20.4	6.8	0	5.48	11.8
10	12140	11400	16996	15960	0	85.1	85.1	255.2	85.1	47.9	0.13	7.4
11	61260	53000	110574	95665	0.6	0	0.6	0.2	0.4	0	0.11	19.5
12	42400	40000	65720	62000	0	21.3	21.3	8.5	14.9	0	4.97	43.3
13	6980	5500	12773	10065	1.9	0	1.9	0.8	1.3	0.06	0.55	42.7
14	21600	20000	35424	32800	0	77.1	77.1	0	0	0	0.37	101.5
15	15300	14400	27158	25560	0	16.8	16.8	9	3	0	0.19	33.2
16	16250	15500	24294	23173	0	91.1	91.1	0	0	0	0.09	21.4
17	10775	96000	23274	20736	0	13.6	13.6	40.8	13.6	0	2.07	286.1
18	35727	33912	72526	68841	0	0	0	0	0	0	15.81	4.5
19	46916	45396	91486	88522	0.8	0	0.8	0.3	0.5	0	8.92	73.9
20	24640	23320	29568	27984	0.6	0	0.6	0.2	0.4	0	0.2	0

Independent variables:

Farmer number:	PH	% O.M.	K-exch. meq/100g soil	cycle duration months	labour hours /cycle	plant-density pl./ha	loss by podrido pl/ha,cy	N left on field Kg/ha,cy	P left on field Kg/ha,cy	K left on field Kg/ha,cy
1	4.17	5.3	0.01	30	2522	42500	14630	192	20	140.5
2	3.92	5.23	0.01	12	1172	50000	9175	0	0	0
3	4.31	8.74	0.01	12	1847	30000	3000	0	0	0
4	4.26	11.7	0.05	18	1441	30000	18000	0	0	0
5	4.01	8.58	0.02	26	1796	25000	15312	47.9	6.7	79
6	4.24	11.62	0.01	36	1041	30000	11500	159.8	8.4	101.3
7	3.95	6.08	0.01	18	752	28000	5260	93.5	9	112.8
8	3.89	6.86	0.13	24	722	25000	15045	45	3.2	95.1
9	3.98	11.08	0.46	15	922	20000	7700	0	0	0
10	3.87	8.47	0.14	14	550	20000	7860	0	0	0
11	4.38	11.54	0.01	36	1643	17000	14665	134.3	10.6	125.7
12	4.73	9.83	0.22	24	1236	30000	22800	46.6	7.7	103
13	3.85	10.3	0.07	48	2291	23000	34995	70.9	7.6	98
14	4.03	4.84	0.26	22	1000	20000	8075	27.3	2.6	55
15	4.14	6.24	0.03	14	524	22000	6700	0	0	0
16	3.95	7.02	0.12	14	584	25000	8750	0	0	0
17	3.93	20.9	0.11	36	893	10000	8838	19.4	1.2	10
18	3.8	5.46	0.02	26	1519	25000	17137	92.5	6.6	168.9
19	3.79	4.68	0.05	24	1110	28000	14342	94.8	11.1	186
20	3.74	7.18	0.27	24	1430	16000	7680	52.8	5.3	94

List of Abbreviations

AUW	Agricultural University Wageningen
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CENADA	Centro Nacional de Abastecimiento y Distribucion de Alimentos
Hortifruti	Hortalizas y frutas
IDA	Instituto de Desarollo Agrario
MAG	Ministerio de Agricultura y Ganadería
PIMA	Programa Integral de Mercadeo Agropecuario
PINDECO	Pineapple Development Corporation

List of References

ANON, 1984. Caracterización ambiental y de los sistemas de cultivo en fincas de la región de Rio Frio, Horquetas, Sarapiqui, Heredia-Costa Rica. Universidad de Costa Rica. Facultad de agronomia. San José, Costa Rica.

BERTSCH, F.H., 1987. Manual para interpretar la fertilidad de los suelos de Costa Rica. Escuela de Fitotecnica. Programa de Comunicación Agrícola. San José.

BODDEWYN, J., 1966. A construct for comparative marketing research. Journal of marketing research, vol. 3: 149-153.

BURGOS, C., 1977. Descripcion de los sistemas de cultivos y algunas características de los agricultores de Guápiles, Pococí, Costa Rica. CATIE. Turrialba, Costa Rica.

CAMPUS, R.R., 1987. Cuantificación de la demanda de hortifrutícolas y analisis de precios en los Mercados Municipales de Costa Rica. PIMA. Heredia.

COBLEY, L.S., 1986. An introduction to the botany of tropical crops. Second edition. Longman. New York.

COLMAN, D. & T. YOUNG, 1989. Principles of agricultural economics; markets and prices in less developed countries. First edition. Cambridge University Press. Cambridge.

EE, S.B. van & J.M.M. HELMER, 1989. La fruticultura en el norte de la Zona Atlántica de Costa Rica. Field Reports No. 36. Atlantic Zone Programme (CATIE, MAG & AUW). Turrialba, Costa Rica.

EIJK, D. van der, F.C.T. GUIKING, B.H. JANSEN, H. REULER van, E.M.A. SMALING & J. WOLF, 1990. A system for quantitative evaluation of the fertility of tropical soils (QUEFTS). Geoderma, 46: 299-318.

EIJK, D. van der, F.C.T. GUIKING, B.H. JANSEN, H. REULER van, E.M.A. SMALING & J. WOLF, 1988. A system for quantitative evaluation of soil fertility and the response to fertilizers. In: B.T. BOUMA & A.K. BREGT (eds), 1989. Land qualities in space and time. Proceedings of a symposium organized by the International Society of soil Science, Wageningen, the Netherlands, 22-26 August 1988.

FRESCO, L.O., 1988. Farming system analysis: an introduction. Tropical crops communication No. 13. Department of Tropical Crop Science. Agricultural University Wageningen. Wageningen. The Netherlands.

KAMP, E.J. van der, 1990. Aspectos economicos de la ganaderia en ipequeña escala y de la ganaderia de carne en la zona atlantica de Costa Rica. Field Reports No. 51. Atlantic Zone Programme (CATIE, MAG & AUW). Turrialba, Costa Rica.

LANDON, J.R., 1984. Tropical soil manual. Booker Agriculture International Limited. New York.

LOK, R., 1992. Demographic profile of the northern part of the Atlantic Zone.(in prep.). Atlantic Zone Programme (CATIE, MAG & AUW). Turrialba, Costa Rica.

LOW, J. & I. MAC DONALD, 1984. Tropical field crops. Evans Brothers Limited, London.

MAG, 1991. Aspectos tecnicos sobre cuarenta y cinco. Cultivos agricolas de Costa Rica. Boletín Técnico No.7. Direccion general de investigacion y extension agricola. San José, Costa Rica.

MARITZA, G.M., 1983. La piña. Guia técnica para el cultivo de la piña. Estación experimental 'Dean Padgett B.'. Dirección General de Técnicas Agropecuarias Fondo Simon Bolivar, Ministerio de Desarollo Agropecuario y Reforma Agraria (MIDINRA), Instituto Interamericano de Cooperación para Agricultura (IICA). Nicaragua.

NIJHOF, K., 1987. The concentration of macro-nutrients in plant parts of tropical perennials. Staff working paper SOW-87-16. Center for World Food Studies. Wageningen, The Netherlands.

PIMA, 1986. Consumo industrial de frutas y hortalizas en Costa Rica. Departamento tecnico. Heredia.

PIMA, 1990. Estudio de comercialization de piña. Departamento tecnico. Heredia.

PURSEGLOVE, J.W., 1985. Tropical crops. Monocotyledons. Fifth impression, revised and updated. Longman Inc..New York.

ROBERTSON, G.P., P.SOLLINS & G.UEHARA, 1986. Nutrient cycling in relation to soil type in the humid tropics. W.K.Kellogg Biological Station, Michigan State University. Michigan, U.S.A.

ROMERO, A., 1973. Nutrición mineral de la piña en el campo vs. producción y calidad de la fruta. Universidad de Costa Rica, Faculdad de Agronomía.

SCHIPPER, R.A., 1988. Exploratory survey in the Atlantic Zone of Costa Rica: development economics: some agricultural aspects, Field Reports No. 4. Atlantic Zone Programme (CATIE, MAG & UAW). Turrialba, Costa Rica.

SMALING, E.M.A., J.J. STOORVOGEL & P.N. WINDMEYER, 1992. Calculating soil nutrient balances in Africa at different scales. II. District scale. Fert. Res. (In Press).

STOORVOGEL, J.J., 1992.Optimizing land use distribution to minimize nutrient depletion: a case study for the Atlantic Zone of Costa Rica. (in press). Atlantic Zone Programme (CATIE, MAG & UAW). Guápiles, Costa Rica.

SUNSHINE, C.A., 1985. Costa Rica. The Caribbean: survival, struggle and sovereignty: 187-194.

TÖNJES, J.J., 1992. The pineapple in the Atlantic Zone of Costa Rica. (in prep.). Atlantic Zone Programme (CATIE, MAG & UAW). Turrialba, Costa Rica.

VILLALOBOS, E.S., 1990. La Piña (Ananas comosus L.): estudio de mercado. Ministerio de Agricultura y Ganaderia; Direccion General de Mercadeo Agropecuario; Departamento de Economia de Mercados. San José.