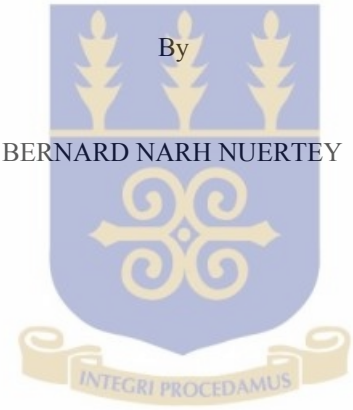
STUDIES ON OIL PALM BASED CROPPING SYSTEMS IN GHANA

By

BERNARD NARH NUERTEY



STUDIES ON OIL PALM BASED CROPPING SYSTEMS 'IN GHANA

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BERNARD NARH NUERTEY

Thesis submitted to the Board of Graduate Studies, in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in crop science.

OCTOBER, 1999

DECLARATION

I certify that the field work related to this thesis "Studies on oil palm based cropping systems in Ghana" was carried out by me, Bernard Narh Nuertey, of the Department of Crop Science, U.G at the Oil Palm Research Institute, Kusi in Ghana. This thesis has never been presented on any occasion at any University for the award of a degree.

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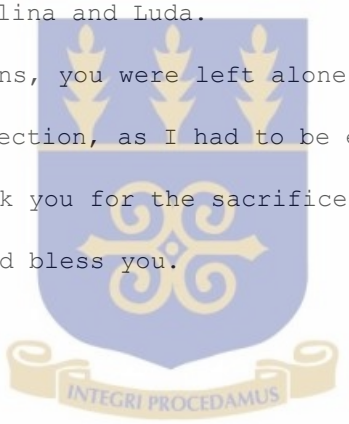
DEDICATIOI

Dedicated to my wife Betty, and children - Ma, Nelia, Nana, Galina and Luda.

On many occasions, you were left alone at home without my protection, as I had to be elsewhere for this work. Thank you for the sacrifices made. And may the almighty God bless you.



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May almighty God bless you all. Amen.

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ABSTRACT

A survey was conducted in 1994 to gather informatior on the practice of intercropping food crops in oil palm on small-scale farms in the oil palm zones of southern Ghana. The objective was to identify and study intercropping systems used in oil palm production. Data was collected by interviewing a total of 72 oil palm farmers from the oil palm growingregions,(Eastern, Central,Western,Ashanti,Brong-Ahafo,and Volta) at their farm locations. The responses indicated that the small-scale oil palm farmers in Ghana commonly intercrop oil palm with maize, cassava and plantain especially during the first three years of the crop. The three staple crops, maize, cassava and plantain were intercropped in oil palm between 1994 and 1997 at the Oil Palm Research Institute, Kusi, Ghana to assess their effects on the growth, development and yields of oil palm. Intercropping was compared to the standard system of cover cropping oil palm with pueraria.

Nutrient dynamics, soil moisture retention, and solar interception by the oil palm were also examined. The performances of the food crops were also assessed as well as the ability of the cropping systems to control weeds was assessed. An economic analysis was also carried out.

There were seven treatments, consisting of:

(i) sole oil palm with pueraria cover crop;

(ii) oil palm + maize + cassava;

(iii) oil palm + maize + plantain,

(iv) oil palm + maize + maize;

(v-vii) sole crops of maize, cassava and plantain respectively.

These were arranged in a randomnized complete block design and replicated four times.

Intercropping oil palm with maize, cassava and plantain had no adverse effect on the growth, development and yield of the oil palm. The Oil palm + maize + maize intercrop and oil palm cover- cropped with pueraria positively influenced soil moisture retention, nutrient uptake and accumulation and light interception by the oil palm more than what pertained with oil palm + maize + cassava and oil palm + maize + plantain.

Yields of the intercropped food crops compared favourably with yields of these crops when solely cropped.

The sole oil palm with pueraria cover crop and oil palm + maize + maize association controlled weeds better than the oil palm + maize + cassava and oil palm + maize + plantain associations. Intercropping oil palm with maize, cassava and plantain was found to be economically beneficial to the small-scale oil palm farmer.

CHAPTER ONE

1.0: INTRODUCTION

The oil palm industry has developed over the last two decades into a huge and important industry, which comes next only to Cocoa in the agricultural sector of Ghana's economy. Small-scale farmers who occupy about 70% of the estimated total area of 145,500 hectares under oil palm (Anonymous, 1989; Anonymous, 1990) dominate Oil Palm cultivation in Ghana. The development estates account for the remaining 30% of the oil palm production area. In Ghana, oil palm iscultivated as a monocrop by the development estates and their affiliated small holders as well as out-growers.

The practice of the development estates has been to inter plant the oil palm rows with Pueraria *sp*, a leguminous cover crop. The leguminous cover crop is expected to conserve soil moisture, suppress weed growth and control soil erosion. It also improves soil fertility by fixing atmospheric nitrogen into a form for use by plants.

There is also evidence that the leguminous cover crop may compete with the oil palm and may do so more than even intercropped food crops (Hartley 1988) .

In spite of the many benefits of the leguminous cover crop, the small scale farmers do not plant them under the oil palm. This is partly due to lack of immediate economic returns accruing from them. They instead, intercrop the oil palm with food and other cash crops for three to four years. Integration of food and tree crop farming has become necessary also because most of the areas around the large estates (BOPP, TOPP, etc.) which were once exporting food crops have become net deficit areas. Some farmers are therefore forced to remove palm fronds to create space for intercrop food crops.

The standard 8.8-m triangular spacing used for oil palm provides wide spaces between the young palms. There is therefore considerable waste of solar radiation and weed problems from transplanting to canopy closure which takes between three and five years.(Chee et al., 1992).

Farmers may seem justified then by grng food and/or cash crops between oil palm trees until canopy closure. The question to which solution needed be found is whether intercropping of food crops in establishing oil palm is more beneficial than sole cropping in small holdings or otherwise. The type of crop used as intercrop changes from one locality to another depending on the food culture of the people.

There is no information on the compatibility of all these food crops grown in association with the oil palm with respect to the use of resources for growth and development.

The objectives of this study therefore were:

(i) to identify the food crops commonly intercropped with oil palms in Ghana;

(ii) to assess the effects of these food crops when intercropped with oil palm on the growth, development and yield of the oil palm;

(iii) to assess the performance of food crops intercropped in oil palm;

(iv) to assess the effects of the intercropped food crops on the use of nutrients, water and light by the oil palm;

(v) to study the effects of the intercropped food crops on weed suppression and control; and

(vi) to evaluate the economics of intercropping food crops with oil palm.

2.0: LITERATURE REVIEW

2.1: The physiology of growth and development of oil Palm

Oil palm productivity is influenced by the total dry matter production of each palm. Dry matter production is highly dependent on the photosynthetic rate of the palm (Dolmat, 1996).

2.1.1 The role of leaves in dry matter accumulation Of plants

Various concepts are used to characterise the role of leaves in dry matter accumulation in relation to growth analysis of plants.

(i) Leaf area (LA) : This is the area of the leaf surface Usually used to quantify the photosynthetic component. Leaf area expansion is initially more related to air temperature (Milthorpe, 1959), subsequently, LA expansion is more responsive to solar radiation (Blackman and Black, 1959). Nutrient deficiency reduces growth in general and leaf area in particular. Corley and Mok (1972) showed that N & K increases LA. Restriction in water supply wasdemonstrated to affect leaf expansion (Boyers 1970; Acevedo et al. 1971). A range of techniques for measuring the area of leaves is available and has been described by Bleasdale (1973). Leaf development can be plotted with time and related to dry matter production.

(ii) Net Assimilation Rate (NAR) : It is defined as the rate of increase in plant dry weight per unit leaf area over a given period (Gregory, 1926). NAR expresses growth in terms of foliar surface and therefore allows us

to see if any treatments make the leaves more efficient or if the efficiency merely changes with time. NAR declines with leaf age (Watson, 1947; Hermandez-Gil and Schaedle, 1973) limited by solar radiation (Blackman and Black, 1959) and governed by temperature (Gregory, 1926 and Milthrope, 1959) .

(iii) Leaf Area Index (LAI): Defined as the ratio of leaf area to ground area covered (Watson, 1947 and Harper, 1983) . LAI varies according to leaf orientation (Pearce et al., 1967). Kriedemann and Smart, (1971) demonstrated that vertically oriented foliage makes good use of both diffuse and direct sunlight and can therefore achieve greater LAI. Corley and Mok, (1972) showed that high N levels give rise to faster LAI development. Similar effects have been observed with irrigation. (Ochs and Vanderwegen, 1969) . High values of LAI may not necessarily be desirable because the lower leaves in the canopy are shaded and their efficiency is reduced. LAI values usually fall between 1 and 8. There is normally restriction in growth of some crops when LAI declines rapidly.

(iv) Leaf area duration (LAD): This is a measure of persistence of the leaf canopy. If leaf area index is plotted against time, the area under the curve is a measure of the duration of the leaves. Corley (1973) has suggested that provided leaves are not removed by pruning, their life depend in part on the intensity of light reaching them through the canopy.

(v) Crop growth rate (CGR) : The rate of increase of dry matter production per unit of time. Growth rates can be compared at different times in the season for different treatments. CGR is affected by a range of factors including temperature (Milthrope, 1959) , radiation levels, (Blackman and Black, 1959), water (Acevedo et al. 1971) and nutrient supply (Corley and Mok, 1972) the type and age of the plant (Watson, 1947) These factors affect the size and efficiency of the leaf canopy and hence the ability of the crop to convert solar energy into useful growth.

2.1.2 DRY MATTER ACCUMULATION AND DISTRIBUTION IN oil PALM

The dry matter produced is used for both vegetative and reproductive growth. In the oil palm, vegetative growth assumes priority over the reproductive growth (Hartley, 1988) . Thus the requirements of vegetative growth must necessarily be satisfied before dry matter is diverted into fruit production.

For economic production of the oil palm therefore it is imperative that management practices which would enhance the availability of such factors influencing vegetative growth and development of the oil palm are adopted.

2.2: Factors influencing growth and development of Oil palm

Many factors affect the rate of photosynthesis of the palm. These are predominantly climatic, edaphic and agronomic practices.

2.2.1: Climatic factors

Oil palm is now grown in most tropical countries where the climate is favourable. Differences in climatic factors affect productivity. Rainfall, temperature and light intensity are the main climatic factors, which affect the growth and development of the oil palm.

2.2.1.1: Rainfall and water balance

The annual rainfall distribution relative to potential evapotranspiration with the buffering effect of soil water reserves defines the water available for plants (Surre, 1968) . In the Sub-region of West Africa, the seasonality of rainfall and the long drought which lasts 2 to 4 months in a year result in huge water deficits. The amount and distribution of rainfall and therefore soil moisture availability influence leaf production. There is evidence that within West Africa, annual leaf production is low in areas with rainfall of 1250 mm and below.

Broekmans (1957) showed that in Nigeria palms of the same genetic origin gave varied averages of leaf Production when planted in areas with varied annual rainfall. At Umuahia, with an annual rainfall of 2108 mm, the average annual leaf production was 23.1. While at Ibadan, with an annual rainfall of 1219 mm, the yearly mean leaf production was 20.5 in the adultpalm.

De Berchoux and Quency (1980) noted that stem growth was fastest in plantations sited where water supply was

satisfactory against slowest stem growth on plantations sited where there was limited water supply.

Quency and de Taffin (1981) observed that the insufficient water supply in West Africa mainly affects the sex ratio of the palms and thus determines the number of bunches produced.

Olivin (1968) found good correlation between the mean annual water deficit and the average production level. Surre (1968) and IRHO, (1969) also reported direct relationships between the magnitude of water deficit estimates and bunch yield. Desmarest (1967) and IRHO (1967) demonstrated that, in the Cote d'Ivoire yields of fresh fruit bunches could be raised by irrigation from 7.5 T Ha'^{1} to 2 6t/ha.

This was collaborated by the work of Ochs and vander Wegen (1969) who also reported yield increases of 13 T ha^{-1} by applying irrigation in the Cote d'Ivoire.

Rees (1989) thought irrigation may not be economically feasible considering the large areas involved in oil palm cultivation and the cost of the necessary equipment coupled with their maintenance costs.

Therefore husbandry practices that conserve soil moisture might be the best option.

2.2.1.2: **Temperature**

There are indications that temperatures below 20°c for any extended period are generally deleterious to oil palms(Hartley, 1988) . Henry (1957) showed that growth of young seedlings at 25°C is seven times and at 20°C three times as rapid as at 17.5°C. There is little definitive information on temperature effects on growth and development of oil palm.

Rees (1989) attributed this lack of information to the fact that field temperatures are not controllable and therefore renders work on temperature effects only academic. He however agreed that the knowledge on temperature fluctuations could be an important consideration when siting new plantations.

Hartley (1988) found temperature differences to be the most distinguishing climatic factor between Yangambi, Zaire and the Far East. Yanganbi had a minimum of between 19.3°C and 20.3°C while the Far East had a minimum of 23JC. The former had a lower yield than the latter.

2.2.1.3: Light use for oil palm growth and Development

Another environmental factor which has a large influence on the photosynthetic output of the oil palm tree is light.

Solar radiation is often measured as sunshine hours only. From several observations, Hartley (1988) inferred the importance of solar radiation for growth and bunch production of the oil palm.

Corley (1973) showed that the number of leaves produced depends on the light intensity reaching the oldest leaves of the canopy.

Thus, under heavy shade, the growth of the leaves is very much depressed. Milthorpe (1956) showed that yield of crops depends largely on the rate of development and maintenance of leaf surface.

In the oil palm where each frond axil subtends only one inflorescence, the rate of frond production sets an upper limit to the rate of inflorescence production. Bunch production therefore depends on the number and size

of fronds and the proportion of them providing inflorescence.

Shading adult palm reduces the production of female inflorescence. Sparnaaij, (1960) demonstrated this by pruning the leaves of adjacent palms to increase the production of female inflorescence. A positive though not strong correlation has been found between sunshine data in the preceding 12 months and yield some 28 months later (Hartley, 1988).

In countries such as Nigeria and Ghana and other West African countries with marked seasonal differences in hours of sunshine, the differentiation of female inflorescence as shown by the sex ratio at flowering two years later, is much higher during the months with many hours of sunshine than during the months with few (Broekmans, 1957).

The exact requirements, either in terms of radiation or sunshine hours for optimum yield are unknown. Records however kept for some high oil palm production areas in terms of annual averages of daily sun-hours range from

over 6 hours in parts of Malaysia, Zaire and Brazil, to 4.6 hours in Nigeria and even lower in Cameroun (Hartley 1988).

Rees (1988) reported on the seasonal radiation distribution at the Nigerian Institute for Oil Palm Research (NIFOR) which has three wet-season months of only 2.3 and 2.4 hours compared with the lowest monthly value in Kuala Lumpur of 4.9 hours.

At NIFOR, the total incident light (PAR) was 2.43×10^9 Jui'^{2} annum'^{1} unevenly distributed so that the highest monthly value was about 1.4 times higher than that of the lowest mouth. The annual totals for some sites in Malaysia are higher than this.

Corley et al (1971) and Corley (1973) observed incident light (PAR) for Layang-layang and coastal West Malaysia as value of 2 .55 x 10^9 Jui"^{2} annum $^{-1}$ and 3.2 x 10^9 Jui^{-2} for Layang - layang and Coastal West Malaysia annum"^{1} respectively.

Rees (1962), Rees and Tinker (1963) measured intercepted light by adult palms in Nigeria and indicated that the proportion intercepted was 87% at a leaf area index of

4.9, some 13% was not trapped and therefore lost. This may be due to the wide spacing of the oil palm.

2.2.2: Soil factors affecting the growth, development And yield of the oil palm

Besides the inherent fertility of the soil, mineral nutrient absorption by the oil palm is highly dependent on such soil physical properties as aeration, moisture status and soil pH(Jacquemard, 1998).

2.2.2.1: Soil physical factors

According to Hartley (1988) for optimum oil palm production, the soil must be deep and loamy with a well-developed structure. Soil should have a loose friable consistency and must be without impervious layers in the top 1.5 meters. Drainage must be good to ensure aeration. The soil must however be capable of holding ample moisture for the oil palm (Olivin, 1968; Ochs and Olivin, (1969).

Growth and development of the oil palm is impaired on soils with high water table especially the young plants which cannot tolerate stagnant water. Heavy, badly

drained soils and coarse sandy soils, which are easily depleted of moisture, are not suitable. Dolmat et al. (1982) and Rasmussen et al, (1981) showed that peat soils could be suitable provided they are well drained and deep enough to provide sufficient anchorage for the root system of the oil palm. In areas with marked dry seasons like some parts of West Africa, Olivin and Ochs (1978) postulated that a soil of good water holding capacity and of good moisture retention is valuable.

vander Vossen (1969) observed that the oil palm best flourishes in areas of acid soils with pH between 4 and 6.

2.2.2 .2: **Mineral nutrient requirement**

The oil palm needs large quantities of nitrogen (N) , phosphorus (P) , potassium (K) and magnesium (Mg) which are important for both vegetative and fruit production (Dolmat, 1996).

These nutrient requirements of the oil palm vary with age (Foster and Chang, 1977), variety (Poon ET al., 1970), level of production and management practices which among

others include planting density and cover management (Hartley 1988).

Yield potential of the environment also dictates nutrient requirement. Therefore when yield is restricted by such factors as inadequate rainfall, shallow soil depth and poor drainage, nutrient requirement is also depressed (Foster et al., 1985). The natural nutrient supply of any soil is only of limited capacity. Extra supplies in the form of fertilisers are practically always needed. These are applied from the very first year of planting in the field.

Soil analysis indicates the quantity of elements at the disposal of the palm. Soil nutrient supply capacity indices are shown in Table 2.1. Fertiliser is applied to bring the soil nutrient supply capacity from low to the high profile as and when necessary.

Table 2.1: Soil Nutrient Availability Indices

Nutrient	High	Medium	Low
N (Total)%	> 0.2	0.1 - 0.2	0 - 0.1
P (available) (mg/kg Soil)	> 20	10 - 20	0 - 1 0
I< (available) (mg/kg Soil)	>100	50 - 100	0 - 5 0
Organic Matter Content (%)	> 3	1.5 - 3	< 1.5

Foliar analysis identifies and quantifies the deficiency of individual nutrients so that fertiliser adjustments can be calculated.

The leaf nutrient concentrations are indicative of the nutrient status of the palm trees. Critical leaf nutrient levels are presented in Table 2.2. Below or above these sufficiency levels, fertiliser use needs to be increased or withheld.

Table 2.2: Critical Levels of Oil Palm Leaf Nutrient Status

AREAS	N	P	K	Ca	Mg	Sources
Ivory Coast & Benin	2.50	0.15	1.00	0.60	0.24	IRHO (1960)
Nigeria	2.50	0.16	1.00	–	0.28	WIFOR (1956)
Malaysia	2.40	0.15	1.00	0. 60	0.24	Ollagnier(1963)

2.3: Oil palm cropping systems

Two broad types of cropping systems are identified with the production of oil palm in Ghana. The oil palm is either cultivated as a monocrop with various cover crops and/or in association with food crops (Sparnaaij, 1991).

2.3.1: Monocrop oil palm with leguminous cover crops

Oil palm is cultivated as a monocrop by the development estates and their affiliated small holders as well as out-growers. The practice of these development estates has been to inter plant the oil palm in inter rows with leguminous cover crops. These cover crops include *Pueraria phaseoloides*, *Pueraria javanica*, *Calapogonium mucunoid.es*, *Calapogonium caesuleum*, *Centrosema pubescens* and *Mucuna cochichinensis* (Hartley, 1988). The natural

plant cover consisting of broad leaves and grasses persists as weeds where no effort is made to incorporate the leguminous cover crops. Gray and Hew (1968)and Tan and Ng (1973) have established that leguminous covers are beneficial to the oil palm as compared to the other inter row covers such as grasses.

Legume covers are established during the planting of the oil palm and their benefits are numerous. They enrich the soil with organic matter and improve the nutrient status especially Nitrogen. Foster (1976) observed that legume cover is beneficial to a tree crop in the initial years because it does not compete with it for the soil nitrogen while in the fourth to sixth year, the legume cover releases considerable amount of nitrogen and organic matter to the soil as it dies out. The total N supplied by a legume crop to an oil palm plantation is equivalent to 3 to 4 kg of ammonium sulphate applied per palm per year for three years (Hartley, 1988) . Broughton (1976) found that leguminous covers increased oil palm leaf contents of N, P and Mn over those obtained with other types of covers.

Tan and Ng (1981) and Hew and Tara (1972) made similar observations.

There is also the added control of soil erosion and water run-off especially in hilly terrain as well as the improvement of soil physical properties. Leguminous cover crops are sown before planting of the oil palm and therefore provide some protection to the bare soil against erosion by reducing the impact of the heavy rains, which erode the topsoil.

Zaharah et al (1986) and Agamuthu and Broughton (1985) showed evidence that Pueraria phaseoloides contributed about 150 kg N per hectare per year to oil palm plantations. Chemara (1968) discovered that the presence of a leguminous cover more effectively raised the leaf N concentration in young oil palms than the application of 2 kg of ammonium sulphate per palm per year.

Song and Yap (1976) postulated that the reduction in soil erosion are due in part to improved aggregation of the soil particles and increased water infiltration rates. This they claimed resulted from the increased readily decomposable organic matter added to the soil by

the legume cover. In addition, the extensive root system of legumes acts as a permeable barrier thus reducing the rate of run-off. Agamuthu and Broughton (1985) estimated the leaching losses under legume covers to be 63 kg N per hectare per year less than the losses under other plant covers.

Soil moisture is conserved from reduced by evaporation as the legume cover protects the soil surface from the direct effect of sunlight.

One good method to suppress noxious weeds such as Chromolaena odorata especially during the immature phase is to grow the legume cover crop in the inter rows. Vigorous and luxuriant weed growth poses a serious competition to the main crop. Rajaratnam et al., (1977) reported of competition for nutrients between the oil palm and weeds. Gray and Hews (1968) reported yield reductions due to weeds of 6% to 20% in a mature oil palm. Teo et al (1991) observed an increase in yield of about 11.8% when a noxious weed, Ischaemun muticum was totally removed.

There are however some negative effects of cover crops on the oil palm. Ochs and Daniel (1976) observed

that in drier climates legume covers can cause a decrease in yields of oil palm due probably to competition with the crop for water during the dry season.

Aya and Lucas (1977) considered the initial poor establishment of legumes a hindrance to the control of erosion and viewed the subsequent vigorous growth as providing strong competition for water and nutrients.

2.3.2: Intercropping oil palm with food crops

Andrews and Kassam (197 6) defined intercropping as growing two or more crops simultaneously on the same field. Crop intensification is said to be both in time and space dimensions. The practice of intercropping is common among small-scale farmers in tropical Africa especially West Africa (Onochie, 1977).

The oil palm is grown as cash crop by these category of farmers who also intercrop it with food crops (Hartley, 1988). Crop combinations are many and varied. These combinations depend on the food culture of the area. Other factors such as climate, soil, age of palm and socio-economic determine the choice of crops grown.

2.3.3: Influence of climate on choice of intercrop

Oil palm is generally grown in the forest belt in West Africa. The area is characterised by bimodal rainfall amounting to or more than 2000 mm. The growing period is more than 200 days extending from March/April to October/November. Food production in this area is based on associations of maize, cassava, plantains, cocoyams and vegetables that are the dominant staples (Okigbo and Greenland, 1976, Steiner, 1982). These are also the crops mainly intercropped with oil palm in combinations determined only by the farmer.

Onwubuya et al., (1988) noted that Nigerian peasant farmers pruned oil palm groves to the spear leaf in order to allow sufficient light for food crops. The same is practised in Ghana.

On the plantations, the small-scale farmers intercrop oil palm with food crops but this is limited to the early stages when the oil palms have not yet developed a closed canopy. This is because the majority of the food crops grown as intercrops with oil palm such

as maize, plantain and cassava are not suited to growing under shade except cocoyam (Hartley, 1988) .

2.3.4: Soil conditions and choice of intercrop

Wilson and Ademiran (1976) observed that cassava is an important staple of the tropical rain forest zone because it is very tolerant to low soil pH, low soil fertility and low moisture regimes, which characterise the tropical rain forest zone. Maize and plantain are also dominant components adapted to the small-scale farmers' situation in these zones as they grow well on freely drained soils (IITA, 1977) .

2.3.5: Socio-economic factors and choice Of intercrops

Socio-economic factors have also been shown to influence the decision of small-scale farmer to practice intercropping. Norman (1974) established that personal tastes, tradition and religious convictions condition social factors. Getalum (1977) emphasised the fact that in Ethiopia crop production is for home use and food that habits are based on ethnic differences, cultural biases

and education as well as religious convictions. Economic factors however are based on magnitude of inputs and outputs, dependability of returns, prices and ease of transport.

Bradfield (1986) stressed those transportation facilities and costs are other major factors affecting the feasibility of crop production in a given area. Quite typically if roads are either unavailable or passable only at certain seasons of the year, farmers may adopt the cropping systems of crops that mature during the dry seasons of the year when the roads are passable.

If there are no roads at all, the farmers usually opt for A combination of subsistence crops.

His taste and what crop brings in maximum revenue to sustain his family until his palms mature (Norman 1974) guide the small-scale farmer's decision among others.

2.4: Growth and yield of intercropped oil palm

In the West African sub-region especially in Ghana, most small-scale farmers intercrop their oil palm with food crops during the early years of establishment.

Various studies have shown that tree crops can be successfully grown in association with food crops before their canopies are fully developed.

Sparnaaij (1957) in Nigeria reported that intercropping of oil palm with maize, cassava and plantain during the early years of tree establishment generally had no adverse effect on the growth and yield of the palm.

It has also been reported in Indonesia that growing food crops in association with rubber and oil palm do not have adverse effect on the young rubber or oil palm (Tan, 1960; Srepadyo and Tan, 1968) . The findings of Onwubuya and Eneh (1987) and Nigeria Institute for Oil Palm Research (NIFOR, 1988) also agree with Sparnaaij (1957) that intercropping oil palm with food crops generally has no adverse effect on the growth and development of the oil palm. They observed that more leaves were produced per palm in the intercropped treatments than in the treatment with cassava.

Mean height, girth and sex ratio of oil palm were also highest in the combination with maize.

Results from the work of Ofo et al., (1988) also confirmed some of the earlier findings. Cropping system involving cassava had significantly lower number of leaves, smaller girths and shorter palms than the rest involving maize, melon and maize + melon combinations. The palms grown with a mixture of legumes also had low numbers of leaves, shorter trees and small girths. Oil palm intercropped with maize, melon and maize + melon also produced a significantly higher sex ratio (ratio of female to total inflorescence) than any of the crop combinations in which cassava and sole cropped oil palm with legume was involved.

Christian (1959) in Ghana showed that leguminous covers might be more competitive with palms than intercropped food crops.

Work at NIFOR (1988) showed results of soil studies, which indicated decreases with time in soil, pH and which significantly, increased. Hartley (1988) also reported of increased adverse effects of palm shade on intercropped food crops with time as light interception by the oil palm increased.

2.5 Growth and yield of food crops intercropped with oil palm

Hartley, (1988) observed that in oil palm shading and competition for light are the major factors for yield suppression of food crops by oil palm and other tree crops. The extent of shading and radiation distribution within canopies varies with tree species and is related to tree growth stage (Rosenberg, 1974, and Vandermeer, 1989),

Work on intercropping has shown that yield advantages can be achieved as reported by Wilson and Agboola (1979) for cassava + maize and Onwubuya and Eneh (1987) for oil palm and some annual crops.

Ofoh et *al.*, (1988) by intercropping some food crops with oil palm found that irrespective of the cropping system there were no significant differences in the yields of the food crops. However yields from the sole cropped maize, cassava and melon were highest.

CHAPTER THREE

3.0: MATERIALS AND METHODS

3.1: A survey of oil palm based cropping Systems in Ghana

A survey of oil palm-based cropping system was carried out to identify and study intercropping systems used in oil palm production. It was also necessary to understand the socio-economic background of farmers and to relate such information to their practices.

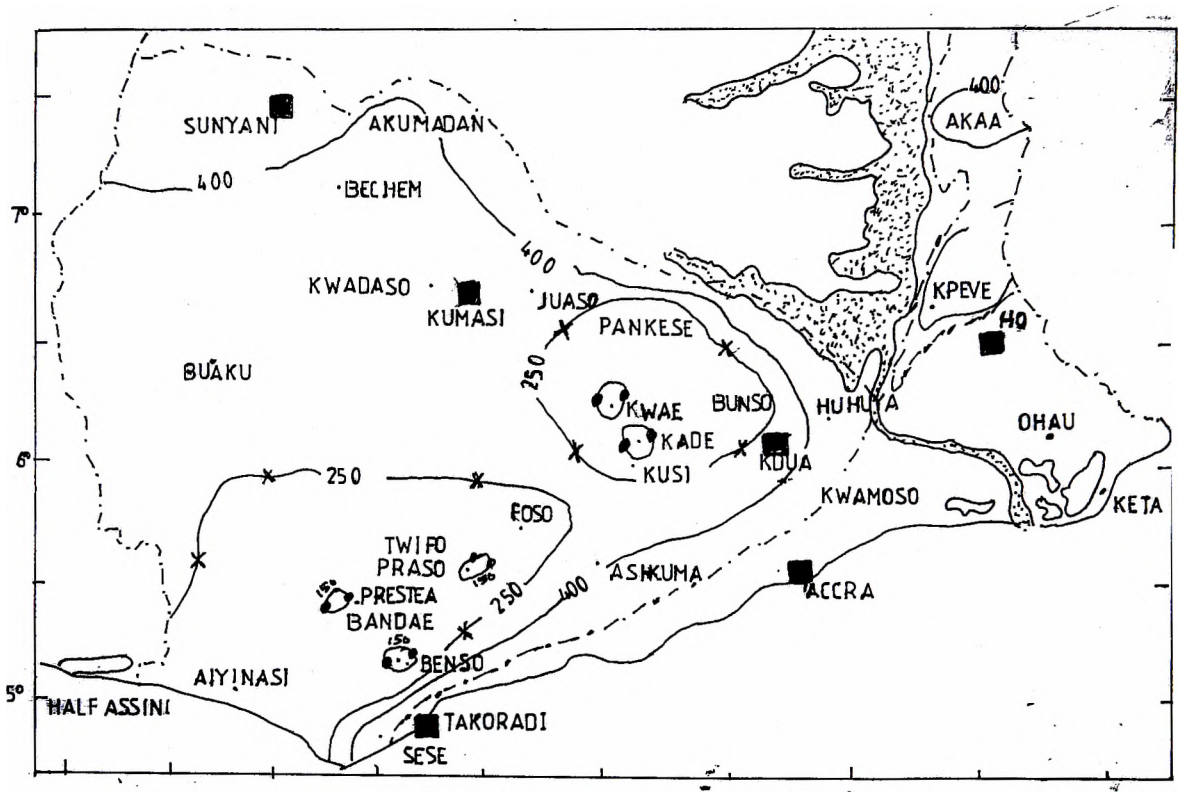
The objective was to identify food crops suitable for intercropping with oil palm. It was also to provide to relevant information for designing agronomic trials aimed at improving and sustaining oil palm production within the socio-economic context of the small-scale farmer.

Climatic conditions confine economic oil palm cultivation to the lowland tropical rain forest and moist semi-deciduous forest zone in the southern part of Ghana, van der Vossen (1969) using values of mean annual water deficit delineated this area into three climatic zones for economic oil palm cultivation (figure 3.1).

These areas described by van der Vossen (1969) cover six regions, namely Eastern, Ashanti, Western, Central, Brong Ahafo and Volta (Figure 3.1). Farm visits were carried out in these six-oil palm-producing regions. In each region, two districts were selected. Each district was divided into two sub-districts and three farms were visited in each sub-district.

Farmers were interviewed using a detailed questionnaire. Questions were on agronomic practices, age of farmers, and their level of education, type of dependants and income from oil palm and food intercrops. Agronomic questions centred on land preparation, time of intercropping, duration of intercropping, plant population, choice of food intercrop, intercropping pattern, time of canopy closure, yield of food intercrop and oil palm yield. Other questions were on the age of farm, size of farm and variety of oil palm grown.

Fig.3.1: Areas climatically suitable for oil palm production in the forest zone of Ghana.



KEY

	LIMIT OF THE FOREST ZONE
-**+- 150	150 MEAN ANNUAL WATER DEFICIT (mm) OPTIMUM RAINFALL FOR OIL PALM PRODUCTION
250	250 MEAN ANNUAL WATER DEFICIT (mm) FAVOURABLE RAINFALL AREA FOR OIL PALM PRODUCTION «•
400-r—	400 MEAN ANNUAL WATER DEFICIT (mm) SUITABLERAINFALL AREA FOR OIL PALM PRODUCTION
WSA	REGIONAL CAPITAL

Source: van der Vossen (1969)

3.2: Physiological and agronomic studies on Oil palm based cropping systems

3.2.1: Experimental Site

The experiment was conducted from 1994 to 1997 at the Oil Palm Research Institute (OPRI), Kusi (06.00N, 001.45w) , which is about 450 meters above sea level.

The experimental area was fairly flat but gently slopping in the North-South and East-West directions. The natural vegetation of the area is semi-deciduous forest type.

The original vegetation was cleared in 1967 and planted to oil palm, which was felled in 1991. A regrowth of bush dominated by *Chromolaena odorata* and relics of *Pueraria phaseoloid.es* and *Carica papaya* was the vegetation cleared for this experiment. Soils in the experimental area are sedentary. The soils of the Nzema series (Acrtdol, FAO) occur in upper to middle slopes and colluvial soils of the Kokofu series on the lower parts (Asiamah and Senayah, 1991).

The area is in a zone characterised by relatively high

Rainfall which falls in two seasons. The major rainy Season occurs from April to July. The minor rainy season Begins in September to the end of October or Mid-November. Average annual rainfall is about 1425 mm.

3.2.2: Experimental treatments, design and crop Management

The experiment was consisted of 7 treatments arranged in a randomised complete block design with 4 replications. The planting material was tenera (D x P ex OPRI) . 12 months old seedlings were transplanted in the field in April 1994. Each plot measured 35.2 x 22.7 m and had 12 seedlings. Planting was done at a spacing of 8.8 m triangular or the equivalent of 148 palms per hectare.

The treatments were as follows:

(i). oil palm + pueraria: oil palm interrows were seeded with a leguminous cover crop, Pueraria phaseoloides The cover crop was seeded at 0.5 kg per plot in April 1994 after transplanting of the seedlings. This is standard estate practice, which served as the main control in this experiment (plate 3.1)

(ii) . Oil palm + maize + cassava: oil palm interrows were cropped with maizeand cassava during the major seasons.

Maize (var. Okomasa ex CRI) was planted on 20th April 1994, at 0.7m x 0.5m with three seeds per stand but thinned to two at one week after emergence resulting in a plant population of 3780 per plot.

There were 27 rows per plot. The cassava, a mixture of Nzema, and Ankra was planted on 6th May 1994, about two weeks after emergence of maize and spaced at lm within rows thus giving a plant population of 945 plants/ha. Maize and cassava rows were spatially arranged on the same row as oil palm and in rows 0.7m, 1.4m, 2.1m and 2.8 metres equidistant away from the palm row. The maize was harvested on 24th August. Cassava was harvested in March the following year. The cycle was repeated every year for the three years of experimentation (plate 3.2.)

(iii). oil palm + maize + plantain: the oil palm interrows were cropped with maize and plantain in the major season in 1994. The maize wasplanted and

harvested in the same manner and time as in the previous treatment and at the same plant population.

The plantain, false horn variety 'Apantu pa', was planted at 3 m triangular in the interrows of the oil palm thus giving 88 plants per plot or ha"[1].

The nearest plantain rows with reference to the oil palm rows were 1.2 m equidistant away from the oil palm rows.

After the first cycle maize, the plantain was maintained up to the first Raton crop ending January 1997 (Plate 3.3)

(iv). Oil Palm + Maize + Maize: oil palm interrows were cropped with maize in the major season and followed by maize in the minor season. Major season maize was planted on 20th April and harvested on 24th August as for treatment (ii). The minor season maize was planted on 6th September 1994 and harvested on 3rd January 1995.

Spacing and plant population for both major and minor season maize was the same as in treatment (ii).

The cycle was also repeated every year for the three years of experimentation 1994, 1995 and 1996 (plate 3.4)

(v). Sole crop of maize, cassava and plantain were also grown as controls on similar plot sizes and were planted and harvested in the same way as those in the Associations.

Fertilizer was applied to oil palm seedlings six months after transplanting, and thereafter, in September every year. Nitrogen was applied at 42g, P at 48g and K at 250g per tree (Anon, 1988) . No fertilizer was applied to the food crops (maize, cassava and plantain.)

The food crop plots were weeded two times in a season. The leguminous plots in treatment 1 were slashed and a circle of lm around the palm was clean-weeded every three months. Plantain was mulched with chopped dried weeds at the pre-harvesting period. The pseudostem and leaves were used for mulching after harvesting.

Plate 3.1: Oil Palm with Pueraria Cover Crop (T_1)

Plate 3.2: Oil Palm Intercropped with cassava (T_2)

Plate 3.3: Oil Palm intercropped with plantain (T_3)

Plate 3.4: Oil Palm intercropped with maize (T_4)

3.2.3: Data Collection

3.2.3.1: Rainfall Data

Temperature and rainfall data were collected for the site. Monthly and annual water deficits were calculated from the rainfall data using the formula:

$$D = R + P - Pe$$

Where D = water deficit; R = theoretical soil moisture reserve at the end of the previous month;

P = precipitation or rainfall for the month;

Pe = potential evapotranspiration for the month

(Surre, 1968).

3.2.3.2: Growth, development and yield of oil palm

(i) Leaf area per palm (LA)

LA = b (n X LW). Where n = number of leaflets;

Lw = mean of length x mid - width for a sample of the largest leaflets, and b, the correction factor = 0,55

(Hardon et al; 1969).

(ii) Leaf area index (LAI)

Having estimated the leaf area (LA) of a palm, it was related to the ground area. LAI was thus estimated:

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

(iii) Frond dry weight (FDW)

A non-destructive method as described by Corley (1971) was used to estimate this parameter which also allows for estimation of Dry matter production rates. A pair of callipers was used to measure the width and depth of petiole, that is the point of insertion of the lowest leaflet. The values obtained were put into a formula to estimate the FDW (Corley 1971)thus:

$$FDW = 0.1026 \text{ width} \times \text{depth} + 0.2362 \text{ (Kg)}$$

(iv) Rate of leaf production (RLP)

Six months after transplanting the oil palm seedlings to the field, leaf number one, which is the youngest fully expanded leaf was identified and tagged. All functional

leaves were then counted up to the tagged leaf.

Subsequent counts were made at six - monthly intervals. After the identification and tagging of leaf No.1, the leaves between the current and the previous reference leaves were counted. The total number of leaves counted was related to time for the growth rate of leaf production. The calculation was thus:

$$RLP = \frac{N_z - Ni}{T_2 - Ti}$$

Where N_2, Ni were total leaf counted at the periods T_2, Ti **Respectively.**

(v) Sex ratio

Male and female inflorescences produced on the palms were counted at bi-weekly intervals. Counted inflorescence was marked to avoid re-counting.

Sex ratio was then calculated from the floral production data obtained using the formula of Corley et al. (1971):

$$\text{Sex ratio} = \frac{\text{No of female inflorescence}}{\text{Total inflorescence (Male + Female).}}$$

Flowering started in August 1995 and it was monitored up to December 1997.

(vi) Yield of oil palm.

Weekly individual yield recording was carried out as soon as palms came into bearing. The weights and numbers of the fresh fruit bunches (FFB) harvested were recorded for individual palms at each harvesting round. The data obtained was used to estimate yield per hectare.

3.2.3.3: Nutrient dynamics, soil moisture retention and solar interception by the oil palm.

(I) Soil fertility status

To assess the dynamics of soil nutrient accumulation, soil sampling was undertaken before land clearing and after every cropping cycle at 0 - 15 cm and 15 - 30 cm depths. 4 soil samples each from plots having a common treatment were bulked and mixed to form a composite. Sub-samples of the composite were air dried, ground and passed through a 2-mm mesh sieve for analysis.

Soil pH was determined in a 1:1 soil and water suspension using a pH meter with glass electrode. Organic-Carbon was determined by the Walkey-Black dichromate method. Total nitrogen was determined by the

Kjedjahl method. Available phosphorus was determined by the Bray's No.1 method and potassium by flame photometry.

(ii) Leaf nutrient dynamics

To determine the dynamics of oil palm nutrient uptake, leaf samples of the oil palm lamina from the central leaflets of leaf No.17 were taken at six-monthly interval.

The leaf samples were cleaned with cotton wool and distilled water, oven-dried at 60° C for 72 hours, ground and analysed for N, P and K. Nitrogen was determined by the kjeldahl's method, Phosphorus by the vanado-molybdate method and potassium by flame photometry.

(iii) Soil moisture status during the dry season

To assess which cropping system had best conserved soil moisture, especially during the dry season, soil moisture status was determined monthly over the dry season, November - March. Soil samples were taken at the depths of 0 - 15cm and 15 - 30cm. Sampling dates were delayed for at least six rainless days whenever the rains fell on

sampling dates. Soil samples were collected in aluminium cans, which were covered immediately. The samples were then weighed before and after oven drying at 80°C for 48 hours. Gravimetric soil water content (%) as mass of water (g) related to mass of oven dry soil (g) and multiplied by 100.

(iv) Light interception by the oil palm

To study the influence of the various cropping systems on light interception by the oil palm canopies, two tube *solarimeters* were used. Each *solarimeter* was connected to a *Microvolt integrator* (NV^2) . One tube *solarimeter* was installed above the canopy of the palm about one meter above leaf No.1 (plate 3.5) and the other were placed directly beneath the canopy (plate 3.6). The tubes were installed and set or reset on the plots at 0930 hours. Daily readings were taken hourly from 1030 hrs to 1530 hrs. Measurements from the two *solarimeters* were used to estimate percentage interception of solar irradiance by the oil palm. Solar irradiance above canopy was used as basis for comparism.

Plate 3.5 Tube Solarimeter installed above the Canopy of oil palm (arrowed)

Plate 3.6 Tube Solarimeter installed beneath the canopy of the oil palm (arrowed)

3.2.3.4: The performance of food crops intercropped with oil palm.

3.2.3.4.1 Maize

Data on growth, development and yield of maize were taken monthly until the maize was harvested.

A maize row were arranged on the same row as oil palm and coded 0, and on rows 0.7 m, 1.4 m, 2.1 m and 2.8 metres equidistant away from the palm row.

(i). Leaf Area (LA) Per Plant

Thirty plants were randomly selected and tagged in each plot. The length and the greatest width of leaves on these plants were measured at each sampling time. Maize leaf area was then estimated from the quotient of the leaf length and the greatest width multiplied by the constant 0.75 (Moll and Krampath, 1977). The formula was thus:

LA = Length x width x 0.75.

(ii). Rate Of Leaf Production (RLP)

At each sampling time all functional leaves on each tagged plant were counted. The total number of leaves counted at the different time periods was used to estimate RLP.

$$RLP = \frac{N_2 - Ni}{T_2 - Tx}$$

Where N_2, Ni were total leaves counted at the periods T_2, Ti respectively.

(iii). Plant Height

The heights of the thirty-tagged plants in each plot were taken monthly. Height was taken from the ground level to the tallest leaf tip and mean height per plant calculated.

(iv). Grain Yield

Rows in each plot were harvested separately. Yield parameters recorded were 1000 seed weight and grain yield per unit area.

3.2.3.4.2 Tuber yield of intercropped cassava

Like the maize, the various rows of cassava were harvested separately. The fresh tuber weights were recorded for each plot. Growth and development measurements of cassava could not be taken due to the mixed population of cassava varieties planted. While some plants were short and branched profusely so close to the soil level (i.e. Nzema var.) others were tall and almost did not branch (i.e. Ankra var.).

The two varieties grown and identified were however supposed to have same yield potential of 25t.ha^{-1}.

3.2.3.4.3 Growth, development and yield of plantain

Growth and development measurements started at three Months after planting of plantain and thereafter continued monthly until flowering. Ten plants per plot were randomly selected for measurements. The Data collected were:

(i). Plant height at flowering

Height of the plants was taken from soil level to the point where the peduncle emerged from the pseudostem.

(ii). Girth of the pseudostem

The girth of the pseudostem was measured at a height of 1 m from ground level using a measuring tape.

(iii). Rate of leaf production (RLP)

This was determined as described for maize using leaf production over time.

$$RPL = \frac{N_2 - N_I}{T_2 - T_1}$$

Where N_2/N_1 were total leaves counted at the periods T_2,Ti respectively.

(iv). Leaf area (LA) per plant

Plantain leaf area was determined as the product of the leaf length and the greatest width multiplied by the constant 0.81.

(v). Type and rate of wind damage

The type and incidence of lodging were assessed from weekly counts of lodged plantain suckers and especially after rains.

Counted lodged plantain suckers were immediately cut into pieces and disposed of as mulching material which ensured avoidance of duplication of counts. Cumulated count of lodging was recorded for each plot.

(vi). Yield and components of yield

At harvesting, bunches were weighed and the number of hands per bunch as well as the number of fingers per hand and peduncle weight were recorded. Finger weight was also recorded. The total fruit weight was obtained as the bunch weight minus the peduncle weight. Yield of plantain between February 1995 and January 1996 was recorded for 1995. Bunches harvested between February 1996 and February 1997 was entered for 1996

3.2.3.5: Weed growth and succession

Weed samples were taken on the eve of each weeding exercise. Weed species and their intensities were recorded with a quadrat of 100 cm x 50 cm. The average over two locations randomly selected in each plot was

determined. The quadrat was placed and weeds within it were cut, identified and sorted into species.

They were then oven-dried for 48 hours at 80°c for dry weight determination. The data was used to study the weed control efficiency by the various systems between 1995 and 1996. Relative weediness (DW) of species was calculated as follows:

$$DW = \frac{\text{Treatment's species Weed Dry Weight} \times 100}{\text{Total Treatment Weeds Dry Weight}}$$

3.2.3.6: Agroeconomic analysis of intercropping Food crops with oil palm.

The cost benefit analysis of intercropping food crops with oil palm was by comparing production cost and revenue for sole oil palm with that of intercropped oil palm. Records were kept of cost of inputs, equipments and labour used for the experiment. Labour cost at the period of study was used as well as the current market prices of produce.

(i) Production Costs of the cropping systems

Total cost was calculated as X= a+ b+ c+ d+ e.

Where variables a,b,c,d and e were:

a - cost of planting materials/seeds

b - labour cost throughout the cropping cycle

c - harvesting costs

d - storage costs, if there were any and

e - marketing costs

(ii) Value of produce (V)

The economic yields of the oil palm and food crops were multiplied by the mean market prices for the three years to give value in monetary terms. The computation was:

$$V = pa^{Ya} + pb^{Yb}$$

Where pa, pb are constants measuring the value in monetary terms of unit amounts of A and B, assuming that quality of produce remains same and that there was no change in cost price.

(iii) Net returns (Benefits)

All costs were deducted from the revenue and the resulting Net Returns for oil palm 'with' and 'without' intercropping compared.

BENEFITS = REVENUE - COSTS

(iv). Economic assessments

The cost benefit ratio, which is the return per cash invested, was calculated by relating Gross Income to Total cost of production or cash invested. This was obtained from the formula:

$$\text{Cost benefit ratio} = \frac{\text{Gross Return}}{\text{Total cost of cultivation}}$$

The income equivalent Ratio (IER) which is the relative land area under sole crops, that is required to produce the incomes achieved in intercropping was extrapolated using the sole oil palm with pueraria cover crop as the basis of comparison.

CHAPTER FOUR

4.0: RESULTS

4.1: Features of oil palm based cropping systems in Ghana

4.1.1: Age distribution of oil palm farmers

Over 70% of oil palm farmers studied were aged between 30 and 60 years old (Table 4.1) . In the Western and Central regions, about 90% of the oil palm farmers were in this category. About 22% of the farmers were over 60 years Old. Farmers under 30 years rarely planted oil palm.

4.1.2. Level of education of farmer

Eighty-one percent of the respondents had some formal education (Table 4.2). Fifty percent of those interviewed had only primary school education, and only 3.5% went beyond Secondary School.

4.1.3. Composition of dependants

On the national scene, the mean age of dependants, above 18 years was highest and the least was recorded for those

below 10 years (Table 4.1). Over 40% of the dependants were above 18 years, except for Central region.

Table 4.1: Age of Farmers (%)

Region	Age of farmers (yr.)		
	< 30	30 - 60	> 60
Eastern	–	75	25
Aconite	-	80	20
Western	10	90	-
Central	-	88.9	11.1
B/Ahafo	-	62.5	37.5
Volta	-	60	40
Average	1.7	76.0	22.3

Table 4.2: Level of Formal Education(%)

Region	Level of education			
	No School	Primary school	Secondary school	Tertiary Level
Eastern	25	75	-	-
Ashanti	10	70	10	10
Western	20	40	40	-
Central	11.1	44.1	33.4	11.1
B/Ahafo	25	37.5	37.5	-
Volta	20	30	50	-
Average	18.8	49.5	28.5	3.5

Table 4.3: Composition of Dependants on Farm Revenue (%)

Region	Age of Dependants		
	< 10 yrs	10 - 18yrs	> 18 yrs
Eastern	25.8	25.8	48.4
Ashanti	22.9	35.5	41. 6
Western	26.5	30.6	42.9
Central	37.3	33. 6	29.1
Brong Ahafo	27.7	26.5	45. 6
Volta	16.7	38.9	44.4
National Average	26.2	31. 8	42.0

4.1.4: Income from oil palm produce

Table 4.4 shows the proportion of farm income from various oil palm produce. On the average, farmers generated about 38% of their income from sale of bunches. In the Volta region, however, palm oil generated the highest revenue of 32% followed by sale of 7 bunches (30.7%), kernel (16%), kernel oil (9.3%), palm wine (8%) and loose fruit (4%).

In the Western region about 55% of income from oil palm came from bunches and only 7% from palm oil. Between 22.7% and 54.9% of revenue was record from sale of bunches in the Eastern, Central, Western and Ashanti regions.

Table 4.4: Relative incomes from various oil palms Produce (%)

Region	Bunches	Fruits	Palm Oil	Kernel	Kernel Oil	Palm Wine
Eastern	22.7	25.0	22.7	9.0	9.0	4.5
Ashanti	34.4	31.2	23.6	-	-	-
Western	54.9	32.9	7.3	-	-	-
Central	41.3	21.2	21.7	-	9.3	-
Brong Ahafo	47.3	27.0	14.9	-	-	-
Volta	30.7	4.0	32.0	8.0	9.3	8.0
Mean	38.0	24.1	20.4	2.1	4.6	2.1

4.1.5: Income from food intercrops

Farm income from food intercrops is presented in Table 4.5. Maize, cassava and plantain in a declining order of importance are the major food crops used as intercrops in oil palms. They provide 32.0%, 30.5% and 16.1% of revenue to the farmer beside the oil palm produce.

The same trend is exhibited in the regions except in the Volta region where maize provided 5.8% more income than cassava.

Cocoyams, fruits, vegetables, yams and rice follow in declining order of importance as intercrops providing extra revenue to the farmers. Farmers indicated that consumption of these intercrops takes precedence over their sale for extra income.

Table 4.5: Relative Incomes from Food Intercrops (%)

Region	Maize	Cassava	Plantain	Cocoyam	Fruits	Vegetables	Yams	Rice
Eastern	32.6	32.6	11.6	7.0	9.2	7.0	-	-
Ashanti	29.3	26.0	23.6	7.3	3.3	8.9	1.6	-
Western	36.4	29.9	20.6	6.6	2 . 8	3.7	-	4.0
Central	32.0	27.1	17.3	3.3	10.2	1.0	5.1	3.7
B/Ahafo	28.0	27 .1	15 . 9	9.3	-	5.6	10.3	-
Volta	33.9	39.7	7.53	4.9	6.1	4.1	3.8	-
Mean	32.0	30.4	16.7	6.4	5.3	5.1	3.5	1.3

4.1.6: Agronomic practices of farmers

Categorisation of farmers according to some agronomic practices is shown in Tables 4.6. and 4.7. The practices of farmers seemed to change little from region to region. No respondent planted his palms at a wider spacing than the recommended 8.8-m triangular (148 plants hectare'^{1}). Over 70% of the farmers in the Volta region planted denser than the 148 palms hectare"^{1}. (Table 4.6)

In the Brong Ahafo region, 33.3% planted denser than 14 8 plants hectare"^{1}. Between 77.8% and 90% of farmers in the Eastern, Ashanti, Western and Central regions planted at 148 palms hectare^{-1}.

All farmers interviewed except some in the Brong Ahafo and Volta regions planted the improved material, 'Tenera'. About 58% of respondents in the Volta Region planted unimproved 'Dura' materials collected as volunteer plants from other plantations and or tendered the natural oil palm grove.

All farmers visited during the survey had weed problems. Most of their farms especially, the younger ones were infested With Chromolaena odorata.

The most common among the weed control measures adopted was hand weeding followed by slashing (Table 4.7).

Less than 10% of the farmers interviewed used herbicides and this was mostly used to control weeds in maize intercrops.

Table 4.6: Frequency of planting materials and planting density used by farmers. (%)

Region	Planting density (plants/hectare)		Planting material	
	148	>148	Tenera	Dura
Eastern	80	20	100	-
Ashanti	90	10	100	-
Western	90	10	100	-
Central	8	22.2	100	-
Brong Ahafo	66.7	33.3	80	20
Volta	27.3	72.7	41.7	58.3
Mean	72.0	28.0	87.0	13. 0

Table 4.7: Frequency (%) of weed control methods Adopted by farmers.

Region	Weed Control Method		
	Weeding	**Slashing**	**Herbicides**
Eastern	50	25	25
Ashanti	76.9	7.7	15.4
Western	100	—	—
Central	66.7	22.2	11.1
Brong Ahafo	67. 6	22.5	9.9
Volta	83.4	8.3	8.3
Mean	74.1	14.3	11.6

4.1.7: Duration of intercropping

The duration of intercropping food crops in oil palm is presented in (Table 4.8). In the Eastern, Ashanti, Western and Central regions, young palms were intercropped up to three years. Some farmers in the Central, Brong Ahafo and the Volta regions planted intercrops for six years.

Table 4.8: Distribution of farmers in terms of duration of intercropping Food crops. (%)

Region	Intercropping Duration	
	1-3 yrs.	4-6 yrs.
Eastern	100	–
Ashanti	100	-
Western	100	-
Central	90	10
Brong Ahafo	16.7	83.3
Volta	66.7	33.3
National Mean	78.9	21.1

4.2: Physiological and agronomic studies on oil palm based cropping systems.

4.2.1: Weather during the Period of experimentation at Kusi.

The temperature, rainfall, and water deficit in the years of experimentation followed the same trend as the long-term area means. Mean monthly temperatures fluctuated between 22.6°C and 31.1°C, and the yearly mean was between 26.3°c and 26.9°c (Table 4.9).

The mean annual rainfall of the area is 1512 mm and was distributed in a bimodal pattern. The major rains fell between March and June and followed by a short dry season in July to August. The minor rains were in September and October.

The major dry season started from November to March. Rainfall pattern from 1994 to 1997 seemed to follow same trend. The wettest year was 1995 with a total rainfall of 1768 mm while 1996 was the driest year with 1306 mm rainfall (Table 4.10) .

Monthly water deficits were recorded for January and February for 1994 through to 1996 and from January to

March in 1997. January to March is usually the driest period for the area (Table 4.11).

Comparatively, moisture retention of the soil during the period of experimentation was better than the average for the area.

Table 4.9: Mean Monthly Temperatures (°c) 1994 - 1997

Month	Area Mean	YEAR			
		1994	1995	1996	1997
January	28.2	25.5	26.1	26.3	26.9
February	26.9	27.8	27.8	27.8	27.9
March	27.8	27.2	26.7	27.7	28.0
April	27.5	27.7	27.7	27. 6	24.7
May	27.1	26. 6	27.2	27.1	26.4
June	26.2	26	31.1	26.0	26.2
July	22.6	24.9	25.3	25.5	25.1
August	24.9	25.0	25.4	26.1	25.2
September	25.8	25.4	26.1	27.5	26.6
October	26.3	26.5	26.5	26.5	27.4
November	26.8	26.9	26.9	27.1	26.9
December	26.1	25.9	25.9	26.5	26.7
Mean	26.4	26.3	26.9	26.7	26.5

Table 4.10: Monthly Amount of rainfall (mm) 1994 - 1997

Month	Area Mean	YEAR			
		1994	1995	1996	1997
January	22.5	91.6	24.4	8.4	8.6
February	40.5	8.9	9.9	36.1	30.5
March	135.9	128.1	153.6	224.2	45.7
April	167.8	211.2	285.0	89.1	238.7
May	214.6	199.3	247.3	201.3	150.3
June	211.3	164.9	252.4	213.4	314.6
July	119.7	81.5-	133.9	148.4	91.8
August	94.8	59.2	175.4	95.5	66.9
September	145.1	170.3	148.9	52.5	88.9
October	187.3	180.1	162.0	115.2	150.0
November	121.8	164.5	119.0	49.5	118.0
December	50.8	0.0	56.1	72.4	56.7
Total	1512.1	1459.6	1767.9	1306.0	1360.7

Table 4.11: Monthly water deficit (mm) 1994 - 1997

Month	Area Mean	YEAR			
		1994	1995	1996	1997
January	102.4	0.0	75.6	36.5	141.4
February	115.0	134.4	140.1	113.9	119.5
March	31.5	21.9	0.0	0.0	30.5
April	6.1	0.0	0.0	0.0	0.0
May	3.5	0.0	0.0	0.0	0.0
June	0.0	0.0	0.0	0.0	0.0
July	0.7	0.0	0.0	0.0	0.0
August	25.2	0.0	0.0	0.0	0.0
September	8.9	0.0	0.0	0.0	0.0
October	7.6	0.0	0.0	0.0	0.0
November	9.2	0.0	0.0	0.0	0.0
December	20.4	0.0	0.0	0.0	0.0
Total	330.5	136.3	215.7	150.4	291.4

4.2.2: The effect of intercropped food crops on growth, development and yield of oil palm.

4.2.2.1: Leaf area (LA) development

Table 4.12 shows oil palm leaf area as affected by-cropping systems. Significant differences in leaf area among the various intercropped systems occurred only at 18 and 36 months after plantin. Mean leaf area per palm at six months after planting was 4.65 m^2. This increased to 92.97 m^2 at thirty-six months after planting. Leaf area development was 95.3%, 124%, 88.3%, 33.4% and 80.4% at 12, 18, 24, 30 and 36 months after planting respectively. Highest increase in leaf area at 18 months after planting.

Leaf area was highest in the system with oil palm intercropped with maize in both major and minor season. The lowest LA development was for the system oil palm + maize + cassava (Table 4.12).

Table 4.12: Oil Palm Leaf area (m²) as affected by cropping systems

CROP COMBINATION [a]	Months after planting					
	6	12	18	24	30	36
Op + Pue	4 .75	9. 40	20.11	39. 90	52.71	92.14
OP + Ma + Ca	3.88	7.75	16. 05	33.10	45. 64	81.50
OP + Ma + PI	4.78	9.64	19. 98	38.92	52.21	94.12
OP + Ma + Ma	5.17	9.54	26.48	73.70	55.54	104.13
LSD (P=0. 05)	NS	NS	6.15	NS	NS	14.18
CV (%)	15.66	17.45	18.60	12.12	8.71	9.53

a: OP = Oil Palm; Ma = Maize; Ca = Cassava; PI = Plantain and Pue = Pueraria.

4 .2.2 .2: Leaf area index (LAI)

The LAI of the oil palm also varied with the cropping Systems (Table 4.13). The lowest LAI was recorded for Oil palm + maize + cassava treatment.

The trend of attainment of LAI was similar to that of LA Development.

Table 4.13: Leaf Area Index in relation to Cropping system.

CROP COMBINATION [a]	Months after planting (MAP)					
	6	12	18	24	30	36
Op + Pue	0.04	0. 08	0.17	0.32	0.43	0.77
OP + Ma + Ca	0. 03	0.06	0.13	0.27	0.38	0. 68
OP + Ma + PI	0.04	0.08	0.16	0.32	0.42	0.77
OP + Ma + Ma	0.05	0.08	0.21	0.36	0.46	0.85
LSD (P=0.05)[b]	NS	NS	0.05	NS	NS	0.10
CV (%)	22.36	14 .25	17.05	16.24	9.82	88.26

a: OP = Oil Palm; Pue = Pueraria; Ma = Maize;
Ca = Cassava and PI = Plantain
NS = Not significant

4.2.2.3: Rate of Leaf production

Leaf production per month was significantly ($P < 0.05$) affected by the cropping systems but only during the first six months(Table 4.14).

Oil palm cover cropped with pueraria and oil palm in association with maize + maize had higher rates of leaf production than oil palm with cassava or plantain (Table 4.14) .

Table 4 .14 : Leaf Production per month under various cropping systems

CROP COMBINATION [a]	Months after planting (MAP)					
	6	12	18	24	30	36
Op + Pue	1.5	2.0	2.5	3.2	3.9	5.0
OP + Ma + Ca	1.3	1.9	2.1	2.9	3.6	4.9
OP + Ma + PI	1.4	1.9	2.4	3.0	3.5	4.9
OP + Ma + Ma	1.5	2.2	2.9	3.5	3.8	5.1
LSD (P=0.05)	0.2	NS	NS	NS	NS	NS
CV (%)	18.0	25.1	20.1	15.7	13.6	10.04

a: Op = Oil palm; Pue = Pueraria; Ma = Maize; Ca = Cassava; PI = Plantain and NS = not significant.

4.2 .2 .4 :Frond dry weight

Table 4.15 shows frond dry weight (FDW) as affected by various cropping systems. The FDW of the oil palm was significantly affected by intercrop (PC0.05). Rate of increase in FDW was highest in oil palm + maize + maize treatment and lowest in oil palm + maize + cassava. Differences in FDW of oil palm grown in association with the various intercrops were significant (P < 0.05)at all the sampling times.

Table 4.15: Frond Dry weight (kg) accumulation in relation to cropping systems

CROP COMBINATION [a]	Months after planting					
	6	12	18	24	30	36
Op + Pue	0.41	0. 47	0.71	0.84	0. 98	1.02
OP + Ma + Ca	0.37	0.44	0.66	0.76	0.89	0. 92
OP + Ma + Ca	0.39	0.45	0.68	0.81	1.03	1.01
OP + Ma + Ma	0.38	0.48	0.72	0.84	1. 04	1.06
LSD (P=0.05)	0.031	0.02	0.02	0.027	0.026	0.03
CV (%)	12.9	11.0	7 .30	6.22	5.09	5.04

a: Op = Oil palm; Pue = Pueraria; Ma = Maize; Ca = Cassava; PI = Plantain and NS = not significant.

4.2.2.5: Inflorescence production of oil palm

Table 4.16 shows inflorescence production by oil palm from 1995 to 1997. In 1995, only male inflorescences were produced. Sole cropped oil palm and oil palm intercropped with maize + maize produced higher number of male flowers than the combinations with plantain and cassava.

In 1996, female flower production was significantly ($P < 0.05$) affected by the various cropping systems. Again, sole - cropped oil palm with pueraria cover crop and oil palm intercropped with maize + maize produced higher number of female flowers than the combinations with plantain and cassava.

The sex ratio ranged from 42% in oil palm with maize + cassava to 65% in oil palm intercropped with maize in both seasons in 1996. A similar trend in sex ratio was maintained in 1997 as in 1996.

Table 4.16: Number of inflorescence per plot and sex ratio under various intercropping systems

Crop Combination	Number of Male Inflorescence			Number of Female inflore.		[b]Sex Ratio (%)	
	1995	1996	1997	1996	1997	1996	1997
Op + Pue	34 .5	100	30	146.1	53.2	59.4	63.9
OP + Ma + Ca	7.9	125	39.3	87.4	45.0	42.3	53.3
OP + Ma + PI	9.0	92.5	38.2	100.7	55.0	52.1	59.0
OP + Ma + Ma	31.8	100.5	25.0	183.0	56.9	64.6	69.4
LSD (P=0.05)	NS	NS	NS	44.2	NS	NS	NS
CV (%)	71.0	23.4	26.5	20.4	27.3	14.9	15.12

a: Op = Oil Palm; Pue = Pueraria; Ma = Maize; Ca = cassava; PI = Plantain and NS = Not significant

b. No. of female infloresence/No. of male + female Inflorescences

4.2.2.6: Yield of the oil palm

In Table 4.17, the number of bunches per palm, single bunch weight and fresh fruit bunches per hectare are presented for the period August to December, 1996 and for the full year in 1997. Harvesting of fresh fruit

bunches (ffb) started in August 1996, some twenty-seven months after transplanting the oil palm seedlings to the field. Significant differences ($P < 0.05$) among the cropping systems were found for some yield parameters. Number of bunches produced per palm varied significantly ($P < 0.05$) among the intercrops for the five months in 1996 but differences were not significant for 1997.

The average of bunches produced per palm in 1996 was 2.4 for the oil palm + maize + maize treatment. This was about 70%, 74% and 20% higher than oil palm + maize + cassava, oil palm + maize + plantain and oil palm + pueraria respectively. A similar trend was obtained in 1997. There was very little variation in the average single bunch weight among the treatments. Thus the number of bunches produced per tree greatly influenced the yield of fresh fruit bunches.

Table 4.17: Effect of intercropping oil palm with food crops on yield of oil palm

Crop combination[a]	No. of bunches palm"[1]		Single bunch weight(kg)		Yield (T/ha)	
	1996	1997	1996	1997	1996	1997
Op + pue	1.9	7.5	2.9	2.1	1.2	2.35
Op + ma + ca	0.5	6.0	3.4	2.1	1.0	1.84
Op + ma + pi	0.6	8.8	2.8	2.1	1.2	2.75
Op + ma + ma	2.4	8.8	3.0	2.5	1.3	3.25
LSD (P=0.05)	0.96	NS	NS	NS	0.50	0.78
CV (%)	49.99	24.0	18.94	15. 69	25.81	62.6

a: Op = Oil Palm; Pue = Pueraria; Ma = Maize;

Ca = cassava; PI = Plantain and NS = Not significant

4.2.3: Effects of intercropping on nutrient dynamics, soil moisture retention and light interception by oil palm

4.2.3.1: Soil acidity(PH)

Soil pH changes under various oil palm - based cropping systems are shown in (Table 4.18). in 1995,the soil under oil palm + maize + cassava was significantly

higher in pH ($P < 0.05$) than the soil under other crop combinations.

In 1996 and 1997 however, it was the soil under oil palm + maize + plantain which had the lowest pH values. The differences were however not significant.

There were some increments in soil pH with years of about 0.25 to 0.50 units for oil palm undercropped with Pueraria phaseoloides. The oil palm intercropped with maize in both seasons, also recorded increment in soil pH by about 0.5 - 0.6 units. The combination with cassava had soil pH values either almost the same throughout the test period or decreased slightly.

Generally, soil pH values were very acidic and will require improvement by about 1 pH unit to provide favourable conditions for optimum nutrient uptake. Growing of pueraria as cover crop in oil palm improved slightly the pH and so is intercropping with maize by about 0.5 units.

Table 4.18: Effect of intercropping food crops in Oil Palm on dynamics of soil pH from 1994 to 1997.

CROP COMBINATION	1994	1995	1996	1997
0 - 15cm depth				
Oil palm + pueraria	4.6	4.5	5.0	4.7
Oil palm + maize + cassava	4.6	4.9	4.8	4.9
Oil palm + maize + plantain	4.6	4.4	4.3	4.4
Oil palm + maize + maize	4.6	4.5	5.1	5.0
LSD (P = 0.05)	NS	0.2	NS	NS
CV (%)		1.30	3.73	6.57
15 - 30cm depth				
Oil palm + pueraria	4.5	4.5	5.0	4.7
Oil palm + maize + cassava	4.5	4.8	4.5	4.8
Oil palm + maize + plantain	4.5	4.3	4.2	4.2
Oil palm + maize + maize	4.5	4.5	5.0	4.9
LSD (P = 0.05)	NS	NS	NS	NS
CV (%)		1.31	3.82	6.74

4.2.3.2: Soil organic matter

Table 4.19 shows organic matter content of soil under various crop combinations. Changes in organic matter content were not significantly different over the test period. Organic matter levels were generally moderate to high and ranged from 2 to 2.8% at 0-15 cm. These values decreased with soil depth.

Oil palm intercropped with plantain had a gradual reduction of soil organic matter content from 1995 to 1997 by about 27% at the depth of 0 - 1 5 cm. Reduction at the depth of 15 - 30 cm from 1995 to 1997 was 10% greater than at 0 - 15-cm depth. The use of pueraria improved the organic matter content of soil from 1995 to 1997 by about 14% at the 0 - 15 cm depth while over the same period a reduction of over 30% was recorded in the 15 - 30 cm depth. Oil palm intercropped with maize in the major season and maize in the minor season maintained almost the same level of organic matter content at the 0 - 15 cm depth from 1994 to 1997. At the 15 - 30 cm depth however there was a reduction of about 48% from 1994 to 1997.

Table 4.19: Effect of intercropping food crops in Oil Palm on dynamics of soil organic matter (%) at 0-15cm and 15-30cm depth from 1994 to 1997.

CROP COMBINATION	1994	1995	1996	1997
0 - 15cm depth				
Oil palm + Pueraria	2.6	2.3	2.6	2.8
Oil palm + maize + cassava	2.6	2.5	2.3	2.8
Oil palm + maize + plantain	2.6	2.7	2.6	2.1
Oil palm + maize + maize	2.6	2.2	2.9	2.6
LSD (P = 0.05)	NS	NS	NS	NS
CV (%)		7.02	8.67	17.28
15 30cm depth				
Oil palm + Pueraria	2.1	1.8	1.7	1.4
Oil palm + maize + cassava	2.1	2.1	1.7	1.3
Oil palm + maize + plantain	2.1	2.0	1.5	1.3
Oil palm + maize + maize	2.1	2.1	1.4	1.1
LSD (P = 0.05)	NS	NS	NS	NS
CV (%)		8.43	14.25	35.11

4.2.3.3: Total nitrogen

Total nitrogen values showed no significant differences among the means for thevarious cropping systems (Table 4.20). Values for the 0-15-cm depth were significantly higherthan values for 15-30 cm.

Generally, values were almost the same, decreasing or increasing slightly over the test period.

In 1995, the oil palm + maize + maize treatment had the least total N values of 0.16% in the 0-15 cm depth but by 1997, and along side the oil palm + maize + cassava, it had accumulated the most total nitrogen of **0.21%.**

In 1997, the treatment with plantain had the least nitrogen accumulation of 0.17%, which may be related to the relatively higher nutrient demand by the crop.

Table 4.20: Effect of intercropping food crops in Oil Palm on dynamics of total N (%)

CROP COMBINATION	1994	1995	1996	1997
0 - 15 cm depth				
Oil Palm + Puraria	0.21	0.19	0.21	0.19
Oil Palm + Maize + Cassava	0.21	0.19	0.19	0.21
Oil Palm + Maize + Plantain	0.20	0.20	0.21	0.17
Oil Palm + Maize + Maize	0.21	0.16	0.20	0.21
LSD 0.050	NS	NS	NS	NS
15 - 30cm dept: *l*				
oil Palm + Pueraria	0.13	0.15	0.14	0.11
Oil Palm + Maize + Cassava	0.13	0.15	0.14	0.10
Oil Palm + Maize + Plantain	0.13	0.16	0.12	0.10
Oil Palm + Maize + Maize	0.13	0.16	0.11	0. 09
LSD 0.050	NS	NS	NS	NS
CV (%)		6.33	16.55	15.4

4.2.3.4. Available phosphorus

Table 4.21 shows the available phosphorus levels as influenced by the various treatments. Available phosphous levels for the 0-15-cm soil depth were significantly ($P<0.05$) higher than for the 15 - 30 cm depths.

The latter were only about 30% of the former at the start of the studies in 1994.

The treatment with *Pueraria* had P levels reduced to levels below 10 mg P/kg soil by 1995. At the 0 - 15 cm depth oil palm + Pueraria had the lowest P values from 1995 - 1997. Except for the cassava intercrop for which the P levels improved moderately all others followed the same trend as the treatment with Pueraria. For oil palm + maize + plantain there was a consistent decline of P level from 1994 to 1997 at both soil depths.

Table 4.21: Effect of intercropping food crops in Oil Palm on dynamics of available Phosphorus (mg P kg"^{1} soil) from 1994 to 1997.

CROP COMBINATION	1994	1995	1996	1997
0 - 15cm depth				
Oil palm + Pueraria	23.7	4.8	2.4	2.6
Oil palm + maize + cassava	23.7	11.8	4.9	13.0
Oil palm + maize + plantain	23.7	10.1	5.8	2.3
Oil palm + maize + maize	23.7	7.7	9.3	4.9
LSD (P = 0.05)	NS	NS	NS	NS
CV (%)		53.2	14.2	33.3
15 - 30cm depth				
Oil palm + Pueraria	8.3	4.2	0.7	2.9
Oil palm + maize + cassava	8.3	5.6	1.7	6.3
Oil palm + maize + plantain	8.3	6.4	3.2	1.0
Oil palm + maize + maize	8.3	3.8	1.2	2.1
LSD (P = 0.05)	NS	NS	NS	NS
CV (%)		32 .3	46.3	49.5

4.2.3,5: Available potassium

There was an initial decrease in available K in 1995 followed by increases in subsequent years (Table 4.22). The highest amount of available potassium occurred in the treatment with Pueraria at 0 - 15 cm depth. Potassium level increased from 88.8 in 1995 to 209.6 mg K/kg soil in 1997. The other cropping systems followed same trend. The treatment with cassava had accumulated the lowest amount of available potassium of 132.1 mg Kg"^{1} soil by 1997.

Available potassium levels in the 15 - 30 cm depths were generally lower than at the 0 - 15-cm depth.

Table 4.22: Effect of intercropping food crops on dynamics of available Potassium (mg K kg"[1] Soil'[1])

CROP COMBINATION	[1994	| 1995	1996	1997
0 - 15cm depth				
Oil palm + Pueraria	107.7	88.8	146.4	209. 6
Oil palm + maize + cassava	107.7	85.1	87.9	132.1
Oil palm + maize + plantain	107.7	76.8	78.9	169.3
Oil palm + maize + maize	107.7	76.3	98.4	145.0
LSD (P=0.05)	NS	NS	NS	NS
CV (%)		18.82	6. 88	16.85
15 - 30cm depth				
Oil palm + Pueraria	86.8	62.0	67.9	133. 9
Oil palm + maize + cassava	86.8	77.5	65.1	104.3
Oil palm + maize + plantain	86.8	64.1	45.6	107.9
Oil palm + maize + maize	86.8	66.3	51.3	105.0
LSD (P=0.05)	NS	NS	NS	NS
CV (%)		32.32	12.31	18.68

4.2.3.6: Dynamics of oil palm nutrient up-take

The leaf nutrient contents using frond number 17 are presented in Table 4.23. None of the cropping systems significantly affected % N, P and K contents of the leaves.

Nitrogen content decreased with age of palm. Generally, the N content of the leaves above the critical level of 2.5% desired, up to 30 months after planting but dropped below critical levels for all treatments by 36 Months After Planting (MAP).

For P, the levels for oil palm + Pueraria and oil + maize + cassava were maintained above the critical level of 0.15 over 36 months.

Potassium leaf nutrient contents followed the same trend as nitrogen. The K levels in the leaves dropped below the deficiency threshold of 1.0 by 36 months after planting for all treatments

Cropping system did not significantly affect the leaf nutrient content of the oil palm.

Table 4.23: Effect of intercropping food crops in oil Palm on dynamics of available leaf Nitrogen, Phosphorus and Potassium

CROP COMBINATION	Months after planting				
	6	18	24	30	36
percentage leaf nitrogen					
Oil palm + Pueraria	3.0	3.1	2.7	3.0	2.3
Oil palm + maize + cassava	3.3	3.1	2.6	2.6	2.3
Oil palm + maize + plantain	3.2	3.2	2.7	2.8	2.0
Oil palm + maize + maize	3.2	3.1	2.5	3.0	2.4
LSD (p = 0.05)	NS	NS	NS	NS	NS
CV (%)	20.25	17.69	20.59	8.54	10.36
percentage leaf phosphorus					
Oil palm + Pueraria	0.35	0.29	0.32	0.31	0.26
Oil palm + maize + cassava	0.34	0.26	0.30	0.32	0.31
Oil palm + maize + plantain	0.34	0.31	0.33	0.32	0.15
Oil palm + maize + maize	0.33	0.31	0.31	0.32	0.16
LSD (p=0.05)	NS	NS	NS	NS	NS
CV (%)	10.69	7.79	8.84	9.78	9.43
percentage leaf potassium					
Oil Palm + Pueraria	1.7	1.7	1.8	0.9	0.9
Oil palm + maize + cassava	1.7	1.5	1.7	1.2	0.8
Oil palm + maize + plantain	1.9	1.7	1.8	1.5	0.9
Oil palm + maize + maize	1.7	2.0	1.8	1.1	0.8
LSD (p = 0.05)	NS	NS	NS	NS	NS
CV (%)	24.54	13.23	21.04	28.47	19.62

4.2.3.7: Soil moisture status

Percentage soil moisture status was not significantly-affected by the various cropping systems during the dry season

(Table 4.24) .

At both 0 - 30 cm and 30 -60 cm depth differences in moisture status among the treatments were not significant.

Generally, oil palm with the Pueraria cover crop retained more soil moisture than what pertained with the oil palm + food crop intercrops at 0 - 15 cm depth.

In the lower horizon, of 30 - 60 cm depth, oil palm + maize + Maize retained the highest amount of soil moisture.

Table 4.24: Percentage soil moisture of various Intercropped combinations during a dry Season.

Crop Combination[3]	Dec. 1994	Jan. 1995	Feb. 1995
0 - 30 cm depth			
Op + Pue	7.1	7. 65	5. 60
Op + Ma + Ca	7.7	5 .33	4.49
Op + Ma + PI	9.1	5.33	2.25
Op + Ma + Ma	11.4	5.81	2.75
LSD (P = 0.05) CV (%)	NS 20.20	NS 39.24	NS 40.09
30 - 60cm depth			
Oil palm + Pue	10.97	9.6	3. 68
Op + Ma + Ca	10. 94	6.70	3.26
Op + Ma + PI	11.68	7.73	3.60
Op + Ma + Ma	13.31	8.22	6.28
LSD (P = 0.05) CV (%)	NS 16.92	NS 16.72	NS 43.15

a: Op = oil palm; Pue = Pueraria; Ca = cassava;

PI = plantain and Ma = maize.

4.2.3.8: Light interception by oil palm

Table 4.25 shows daily light interception by the oil palm in various cropping systems. Light interception varied with intercrops. Differences among cropping systems were not significant before noon. Beyond mid - day, differences in light interception among intercrops were significant. Oil palm intercropped with cassava

intercepted the least percentage of light. Oil palm + maize + maize intercepted significantly higher percentage of light than all the others at P<0.05 level.

Table 4.25: Effect of intercropping food crops on percent Light Interception by the oil palm

CROP COMBINATION [a]	TIME OF DAY					
	10.30 am	11.30 am	12.30 pm	13.30 pm	14.30 pm	15.30 pm
Op + Pue	52.2	51.5	49.5	45.5	44.4	43.6
OP + Ma + Ca	46.6	44.0	42.0	39.1	34 .7	31.9
OP + Ma + PI	52.3	46.2	45.8	46.3	46.9	47 .0
OP + Ma + Ma	49.0	59.2	65.0	60.0	54.9	52.9
LSD (P=0.05)[b]	NS	NS	11.9	10.9	12.8	12.0
CV (%)	23.4	16.8	14.7	14.3	17 .7	17.1

a: Op = Oil Palm; Pue = Pueraria; Ma = maize; Ca = cassava; PI = plantain,
b: NS = not significant

4.2.4: The performance of the food crops intercropped with oil palm

4.2.4.1: Growth of maize in oil palm - maize intercrop systems

Plant height, leaf area and leaf production per plant of maize intercropped in oil palm produced from 1994 to 1996 is shown in Table 4.26.

There were no significant differences in the growth of sole and intercropped maize. Growth in 1995 was reduced by 24% for height, 31% for leaf area and 30% for leaf production relative to 1994 values.

In 1996 % reduction in growth were 32%, 32% and 28% for height, leaf area and leaf production respectively also relative to 1994.

Table 4.26: Growth of maize in oil palm based cropping Systems

o n o n 1_8 H-P (U ft p-O 3	Plant Height (can)			Leaf area(m^2)			Leaf production plant"[1]		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
Ma+Ca+Op	303.0	247 .3	188.1	1.70	1.24	1.25	12.4	8.6	8.2
Ma+Pl+Op	303.0	-	-	1.62	-	-	12.2	-	-
Ma+Ma+Op	312.0	253.8	220.5	2.14	1.30	1.29	12.9	8.6	9.2
Ma Sole	305.3	246.7	215. 9	2.07	1.29	1.29	12.2	8.7	9.7
Mean	308.5	249.3	208.2	1.9	1.3	1.3	12.4	8.6	9.0
LSD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	3.04	3.09	10.40	10.50	3. 98	2. 65	3.52	10.20	19.51

a: Ma = Maize, Ca = Cassava, PI = Plantain and Op = Oil palm; NS = not significant

4.2.4 .2 : Grain yield and components of grain yield in maize intercropping systems

The grain yields of major and minor season maize as influenced by cropping system are presented in Tables 4.27 and 4.28 respectively.

There were no significant differences among treatments ($P<0.05$) in respect of 1000 seed weight. For grain yield, treatments differed significantly only during the 1996 major season.

Mean yield for 1994 was 2.9 tons perhectare. This was reduced by 14% in 1995 and by more than 50% in 1996. Differences in yield were not significant inrespect of cropping system in 1994 and 1995. The yields of sole crop maize and maize + maize intercropped with oil palm were similar. The poorest maize yield was obtained in 1996 with the maize + cassava + oil palm mixture.

Yields of minor season maize was consistently lower than the major season maize. Sole and intercropped maize yields were not significantly different from 1994 to 1996.

Table 4.27: Major season maize yield as influenced by cropping system.

Crop combination[3]	1000 seed wt(g)			Grain yield T/ha)		
	1994	1995	1996	1994	1995	1996
Ma + Ca + Op	377.5	399	349.7	2.74	2.5	0. 91
Ma + PI + Op	353.0	-	-	2.86	-	-
Ma + Ma + Op	350.3	440	344.4	3.16	2.6	1.48
Ma Sole	365. 6	416	351. 6	2.76	2.4	1.49
Mean	361.5	418.3	348.6	2 . 9	2.5	1.3
LSD (P=0.05)	NS	NS	NS	NS	NS	0.38
CV (%)	8 .72	12.37	8.89	18.44	10. 64	16.82

a: Ma = Maize, Ca = Cassava, PI = Plantain and Op = Oil palm

NS: not significant

Table 4.28: Minor Season Maize Yield as influenced by Cropping Systems.

Crop combination	1000 seed wt(g)			Grain yield T/ha)		
	1994	1995	1996	1994	1995	1996
Ma (Sole)	258	194	152	0.54	0.48	0.48
Ma + Ma + Op	256	176	155	0.71	0. 65	0. 65
LSD (P=0.05)	NS	NS	NS	NS	NS	NS
CV (%)	3.94	7.60	11.68	18.44	10. 64	16.82

a: Ma = Maize, Ca = Cassava, PI = Plantain and Op = Oil palm, NS = not significant

4.2.4.3: Tuber yield of cassava in oil palm intercropping systems

Yield of sole cassava was consistently higher than that under intercropping in all the three years of study. The difference was however significant (PC0.05) only in the first year (Table 4.29).

Tuber yields declined with continuous cropping for both sole and intercropped cassava. The differences in tuber yield between the sole crop and intercropped cassava reduced from 8.5T/ha in 1995 to only 0.3T/ha in 1997.

Table 4.29: Tuber yield of sole and intercropped cassava

Crop combination®	Fresh tuber wt plant^{-1} (kg)			Fresh tuber yield (T/ha)		
	1995	1996	1997	1995	1996	1997
Ca + Ma + Op	1.22	1.6	1.3	10.3	9.8	8.1
Ca (Sole)	2.12	2.1	1.4	18.8	13.5	8.4
LSD (P=0.05)	NS	NS	NS	8.1	NS	NS
CV (%)	25.19	8.81	7.14	24.53	20.88	5.65

a: Ma = Maize, Ca = Cassava, PI = Plantain
and Op = Oil palm
NS = not Significant.

4.2.4.4: Growth of plantain intercropped with maize and oil palm.

Intercropping did not significantly affect growth of plantain. (Table 4.30). Plant heights, pseudostem girth, rate of leaf production and leaf area at flowering, were similar for sole plantain and plantain intercropped with maize and oil palm.

Table 4.30: The growth of sole and intercropped Plantain at Flowering.

CROP a COMBINATION	Height (cm)	Girth of Pseudostem (cm)	Leaf Production	Leaf area (m^2)
PI (Sole)	252.7	43.7	11.7	4.1
PI + Ma + Op	245.6	45 .2	11.4	3.8
LSD (P = 0.05)	Ns	Ns	Ns	Ns
CV (%)	7.76	8.05	13.96	44.35

a: PI = Plantain, Ma = Maize, and Op = Oil pam

4.2.4.5: Lodging damage in sole and intercropped plantain.

Table 4.31 shows lodging in plantain plants.

The damage was in the form of snapping, uprooting and stem breaking. Plantain whether planted solely or intercropped with maize and oil palm was not affected by wind damage until the plants started flowering in 1995. Intercropping seemed to have protected the plantain from wind damage as less damage was recorded. The differences between sole and the intercropped plantain were however not significant.

Table 4.31: Lodging Damage of Plantain by wind.

CROP COMBINATION*	Snapping (%)			Uprooting (%)			Breaking (%>		
	'94	'95	'96	'94	'95	'96	'94	'95	'96
PI + Ma + Op	0	0.3	0	0	0	3.0	0	4.2	0.8
PI	0	0.8	0	0	0.5	3.5	0	11.5	0.8
Mean	0	0.55	0	0	0.25	3.25	0	7.75	0.8
LDS(P= 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

a: PI = Plantain; Ma = Maize; Op = Oil palmand

PI = Plantain

4.2.4.6: Effect of intercropping on bunch yield of plantain

The number of bunches and bunch yield per hectare were similar for sole and intercropped plantain (Table 4.32).

There was 38% and 29% drop in the number of bunches produced for sole cropped plantain and intercropped plantain respectively in 1996 relative to 1995. In 1995 sole cropped plantain out yielded intercropped plantain by 238kg but dropped behind the intercropped in 1996 by 237kg.

Table 4.32: Yield of sole and intercropped plantainin oil palm.

Crop combination[3]	No of Bunches Ha^{-1}		Yield (Kg/Ha)	
	1995	1996	1995	1996
PI (Sole)	546	341	2438	1563
PI + Ma + Op	525	375	2200	1800
LSD (P=0.05)	NS	NS	NS	NS
CV (%)	2.75	0.8	3.42	1.73

a: PI = Plantain, Ma = Maize, and Op = Oil palm

NS = not significant

4.2.4.7: Performance of maize and cassava as influenced by spatial arrangement in oil palm.

Table 4.33 shows the yield of cassava at different radial distances from oil palm plant.

Cassava root tuber yield per plant was significantly ($P < 0.05$) higher, the closer the plant was to the oil palm in 1995. In the subsequent years however yields were higher the farther the plant was away from the oil palm. In 1997, the differences in yields among different distances from oil palm were significant ($P = 0.05$).

Maize yield was also significantly ($P < 0.05$) higher the farther the maize row was away from the oil palm.(Table 4.34). The differences in yield were however significant ($P=0.05$) only in 1994.

Table 4.33: Effect of spatial arrangement on intercropped cassava Yield

Distance from oil Palm row (m)	Fresh Tuber wt Plant^{-1} (kg)			Fresh Tuber Yield (T/ha)		
	1995	1996	1997	1995	1996	1997
0.0	1.45	1.40	1.35	11.53	9. 65	6.78
0.7	1.33	1.45	1.20	11.18	8.15	7.30
1.4	1.12	1.40	1.15	9. 65	8.50	7. 90
2.1	1.20	1.70	1.23	10.15	10.90	8.00
2.8	1.17	1.93	1.26	9.05	11.58	10. 60
LSD (P=0.05)	0.14	NS	NS	1.99	NS	2.0
CV (%)	7.59	18.78	23.94	12.62	24.80	16.38

Table 4.34: Effect of spatial arrangement on grain yield of intercropped maize.

Distance from oil Palm row (m)	Grain yield of maize (t. ha"^{1})		
	1994	1995	1996
0.0	2.50	2.12	0.92
0.7	2.59	2.18	1.02
1.4	2. 66	2.30	1.07
2.1	3.12	2.25	1.05
2.8	3.19	2.25	1.05
LSD (P=0.05)	0.42	NS	NS
CV (%)	18.04	40.86	75.43

4.2.5: The effect of intercropped food crops on weed succession and growth in oil palm

4.2.5.1: Influence of cropping system on weed species present

Weed species present under various cropping systems from 1994 to 1996 are shown in Table 4.34. Under oil palm + pueraria in 1994 there were eleven weed species comprising of five broad leaved types, two grasses, three sedges and a volunteer oil palm were identified. In 1995, the broad-leaved types had reduced to four while the sedges and volunteer oil palm were suppressed. In 1996, there were two new introductions to the grasses, *Rctboellia cochinchinensis* and *Panicum maximum.* While *Solanum* species were always present, *Chromolaena odorata* and *Lantana camara* were suppressed (Table 4.35).

Under oil palm + maize + cassava, there was not much change in the weed flora. As much as seven(7) weed species were always present. While broad leaved species were eliminated, there were two new introductions under the the grasses. Volunteer oil palm was also suppressed.

Weed infestation under oil palm + maize + plantain was similar to the cassava associations. Nine (9) weed species were always present. By 1996, only three(3) Weed species namely Astilia gigantia, Cida acuta and volunteer oil palm were suppressed. Under oil palm + maize + maize, in 1994, there were ten (10) weed species composed of five(5) broad leaved species, two(2) grasses, two(2) sedges and volunteer oil palm. The number of broad leaved species increased to six (6) in 1995 while the volunteer oil palm got eliminated. By 1996, the number of grasses upsurged to four(4) while the broad leaved species reduced to two(2). The two(2) sedges persisted.

Irrespective of the cropping system Cyperus rotundus and Paspalum species were always present. Three(3) weed species namely Agerantum conizoides, Peperonia species and Commelina species were also present under the intercropping treatments.

jo: wji.au *aeisuj.es* PRESENT UNDER VARIOUS CROPPING SYSTEMS

Year	CROP COMBINATION	LEAVES								SEDGES			OTHERS
		Agerantum conizoides	Pueraria phaseoloides	Solanum species	Chromolaena odorata L.	Lantana camara L.	Aspilia africana	Astilica gigantia	Cida accuta Burm	Cyperus rotundus L.	Paspalum speccies	Rotboelia cochinchinensis	Panicum capillare L.	Phyllanthus species	Commelina benghalengis L.	Peperonia species	Volunteer oil palm
1994	Op + pue	+	o	+	+	+	o	o	+	+	+	o	o	+	+	+	+
	Op + Ma + Ca	+	+	+	+	+	o	o	+	+	+	o	o	+	+	+	+
	Op + Ma + PI	+	+	+	+	+	o	o	+	+	+	o	o	+	+	+	+
	Op + Ma + Ma	+	+	o	+	+	o	o	+	+	+	o	o	o	+	+	+
1995	Op + Pue	o	o	+	+	+	o	+	o	+	+	o	o	o	o	+	o
	Op + Ma + Ca	+	+	+	+	o	o	+	o	+	+	o	o	o	o	+	o
	Op + Ma + PI	+	+	+	+	+	+	+	o	+	+	o	o	+	o	+	o
	Op + Ma + Ma	+	+	o	+	+	+	+	o	+	+	o	o	+	o	+	o
1996	Op + Pue	o	o	+	o	o	+	+	o	+	+	+	+	o	o	+	o
	Op + Ma + Ca	+	+	o	+	o	+	o	o	+	+	+	+	+	o	+	o
	Op + Ma + PI	+	+	+	+	o	+	o	o	+	+	+	+	+	o	+	o
	Op + Ma + Ma	+	o	o	o	o	+	o	o	+	+	+	+	o	o	+	o

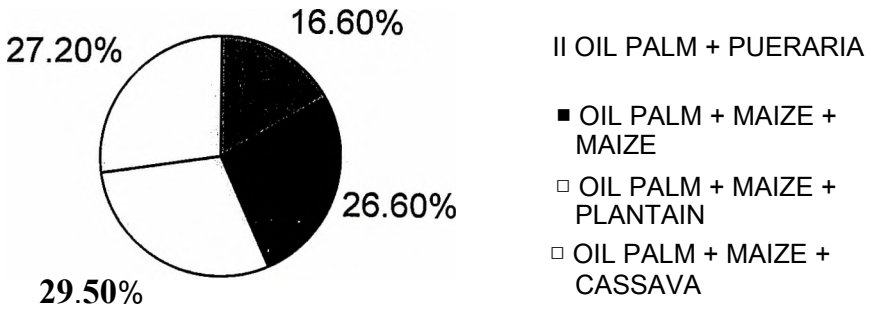
Presence; 0 Absence; Op= oil palm; Pue = Pueraria; Ma = Maize; ca= Cassava; Pl= Plantain

4.2.5.2: Weed suppression ability by the various cropping systems

Weed suppression ability by the cropping systems is summarized in Fig 6.5.1. The treatment with pueraria cover crop suppressed weeds most efficiently with only 16.7% weediness of the plots. This was followed by the treatment involving oil palm + maize + maize with 26.6%. The oil palm + maize + cassava treatment had 27.2% weediness while oil palm + maize + plantain least suppressed weeds with as much as 29.5% weediness.

The trend in decreasing magnitude of ability to suppress weeds was■oil palm + pueraria > oil palm + maize + maize > oil palm + maize + cassava > oil palm + maize + plantain.

Fig: 6.5.1: Relative weediness of the various cropping sys terns.



4.2.5.3: Effect of intercropping food crops in an oil palm on weed growth (g/m²)

Weed growth in the various plots for 1995 and 1996 is presented in Table 4.36. At the commencement of the growing season weed growth was not significantly affected by the cropping systems. However, during the growing season, both in 1995 and 1996, weed growth under oil palm + maize + plantain was significantly higher than for other oil palm associations.

Table 4.36: Effect of intercropping food crops and cover crops in oil palm on weed growth (dry weight) during the growing season of 1995 and 1996 (g/m²) .

rop Combination[3]	GROWING SEASON							
	1995				1996			
	Major		Minor		Major		Minor	
Op + Pue	184	26.3	89	69	41.1	45. 6	86	84.1
Op + Ma + ca	271	94.3	60	145	56. 8	85.9	93	150.5
Op + Ma + PI	222	151.4	114	203	74.2	112.69	149	160.7
Op + Ma + Ma	224	40.6	111	114	103	56.4	214	119.3
LSD(P=0.05)	NS	53.1	NS	86.3	NS	48.2	NS	68.2

a: Op = Oil palm; Pue = Pueraria; Ma = Maize; Ca = Cassava; PI = Plantain; NS = not significant

4.2.5.4: Relative contribution of weed species to the total biomass of weeds

The relative abundance of the weed types, namely broad - leaved species, grasses, sedges and volunteer oil palm is shown in Table 4.37.

In 1995, broad leaved weeds made up 60.8% of the total biomas. Percentage contribution of the grasses was 29%, the sedges was 8.9% while relative weediness of the volunteer oil palm on the plots was 1.3%.

In 1996, percentage contribution of the grasses rose to 39.2%. The percentage contributions of the broad leaves, the sedges and volunteer oil palm dropped by 9.2%, 36.4% and 66.7% respectively.

From 1995 to 1996, under sole oil palm with pueraria cover crop, and oil palm + maize + plantain, percentage broad leaves species dropped by 23.8% and 31.8% respectively. While under oil palm + maize + cassava and oil palm + maize + maize, contribution of the broad leaves increased by 8.6% and 36.6% respectively. Except under oil palm + maize + cassava for which percentage grasses of the biomas dropped by 8.3%, all other crop combinations upsurged of between 12.9 and 162.2%.

Percentage sedges and volunteer oil palm increased under oil palm + maize + plantain, but dropped under other crop combinations. Percentage volunteer oil palm dropped for all crop combinations except for OP+ MA + PL which remained same.

Table 4.37: Percentage contribution of weed species to the total biomass of weeds per plot for 1995 and 1996

Crop combinationa[3]	Broad Leaved Species		Grasses		Sedges		Volunteer oil palm	
	1995	1996	1995	1996	1995	1996	199E	1996
Op + Pue	14 .7	11.2	3.1	3.5	0.0	0.4	0.4	0.1
Op + Ma + Ca	11.6	12.6	14.5	13.3	2.5	1.5	0.4	0.1
Op + Ma + PI	23.3	15.9	4.5	11.8	1.5	1.6	0.1	0.1
Op + Ma + Ma	11.2	15 .3	6.9	10. 6	4.9	2.0	0.4	0.1
Total	60.8	55	29	39.2	8 . 9	5.4	1.3	0.4

a. OP = Oil Palm; Pue = Pueraria; Ma = Maize

Ca = Cassava and PI = Plantain

4.2.6: Agroeconomic analysis of intercropping food crops with oil palm.

4.2.6.1. Establishment costs

Table 4.38. shows the establishment cost per hectare for various cropping systems. Cost of establishing one hectare of sole oil palm with pueraria cover crop amounted to about c£1.3 million.

For treatments involving intercropping, there was an increase in the cost of establishment of between 6% to 21%. Some items considered under establishment costs were under-brushing, felling, and burning. Others were lining and pegging including cutting of pegs, cutting and fixing of wire collars, cost of planting and sowing, transportation of seedlings and materials to the farm, cost of planting materials and cost of rolls of wire collars (Appendix 31 and 32) .

Table 4.38: Establishment costs for various cropping systems (£' 000/ha) .

[a] Crop Combinations	Land Preparation	Planting Materials	Field Operation	Total costs
Op + Pue	310	926.8	70	1306
Op + Ma + Ca	310	946	134.2	1390.2
Op + Ma + PI	310	1128	152.2	1590.2
Op + Ma + Ma	310	946	134.2	1390.2

a. OP = Oil Palm; Pue = Pueraria; Ma = Maize

Ca = Cassava and PI = Plantain

4.2.6.2: Maintenance and harvesting costs

Maintenance and harvesting costs are shown in Table 4.39 Annual maintenance costs for oil palm with Pueraria cover crop was <=113.5 thousand cedis in 1994. This increased by about 3.5 fold in 1997. Total cost of maintenance over the period amounted to about <=1.2 million cedis. Cost of fertilisers accounted for about 47% of the maintenance costs while labour costs accounted for 53% of this total (Table 32 appendix).

The treatments involving food intercrops had 63.4 to 87.8 % higher maintenance costs than the one without.

Table 4.39: Maintenance and Harvesting Costs per Hectare (4'000) of oil palm and food crop Intercrops

Crop Combination [a]	Costs (<>'000)				
	1994	1995	1996	1997	Total
Op + Pue	113.5	357. 4	372. 4	383.9	1227.2
Op + Ma + Ca	391	622.4	637.4	492. 4	2143.2
Op + Ma + PI	391	607. 4	622.4	383.9	2004.7
Op + Ma + Ma	531	687.4	702.4	383. 9	2304.7

a. OP = Oil Palm; Pue = Pueraria; Ma = Maize
Ca = Cassava and PI = Plantain

4.2.6.3: Annual revenue from oil palm and food intercrops.

The harvested produce was sold at the selling prices shown in Table 4.40. Oil palm fresh fruit bunches were sold at <J150 kg'[1], maize at <:600 per kg"[1] while fresh cassava tubers and bunches of plantain went for <=300 and 1000 per kg'[1] respectively.

Annual revenue from the oil palm and the food intercrops is presented in Table 4.41. The intercropping treatments involving maize generated an average of 25% of the total income for the period for the first year.

Cassava and plantain generated some income after one year of cultivation. The sole oil palm with Pueraria brought in some income only in the third year and thereafter.

Table 4.40. Selling Prices of Oil Palm and Food Crops

Food item	**Price Kg** [1] (<>)	**Source**
1. Oil palm fresh fruit bunches	150	OPRI sales unit
2. Maize grains	600	Price survey around Kusi area
3. Fresh cassava tubers	300	
4 .Bunch of plantain	1000	

Table 4.41: Revenue from oil palm based Cropping systems.

CROP COMBINATION	Yield (Kg Ha^{-1})				Revenue (C'000)			
	1994	1995	1996	1997	1994	1995	1996	1997
Oil palm	-	-	1200	2350	-	-	180	352.5
Pueraria	-	-	-	-	-	-	-	-
Oil palm	-	-	993	1840	-	-	149	276.0
Maize	2740	2500	910	-	1644	1500	546	-
Cassava	-	10300	9800	8100	-	3090	2940	2430
Oil palm	-	-	1158	2750	-	-	173.7	412.5
Maize	2860	-	-	-	1716	-	-	-
Plantain	-	220	1800	-	-	220	1800	-
Oil palm	-	-	1280	3250	-	-	192	487.5
Maize	3160	2600	1480	-	1896	1560	888	-
Maize	710	650	650	-	426	390	390	-

4.2.6.4: Economic evaluation of the oil palm based cropping systems.

Table 4.42 shows the economic analysis for the various cropping systems. Sole oil palm with pueraria cover crop generated the least gross income of about 533 thousand cedis which was not enough to offset the production costs of 2533 thousand cedis.

As a result there was yet about 2 million cedis deficit by the end of 1997. The crop combinations involving cassava gave the highest net income of 6611.6 thousand cedis and return per cedi invested of 2.9. Next in order of declining economic returns were oil palm + maize + maize > oil palm + maize + plantain. Using sole oil palm with pueraria as basis for comparism, income equivalent ratio for oil palm + maize + cassava; oil palm + maize + maize and oil palm + maize + plantain are 19.1, 11.7 and 8.1 respectively.

Table 4.42: Economic evaluation of the oil palm based cropping systems

CROP COMBINATION[3]	GROSS INCOME (C'000)	TOTAL COST OF PRODUCTION (C'000)	NET INCOME AT THE END OF PERIOD (C'000)	RETURN PER CASH INVESTED	INCOME EQVT. RATIO
Op + pue	532.5	2533.2	-2000.7*	0.2	1
Op + Ma + Ca	10145	3533.4	6611.6	2.9	19.1
Op + Ma + PI	4322.2	3594.9	727.3	1.2	8.1
Op + Ma + Ma	6229.5	3694.9	2534.6	1.7	11.7

a: Op = oil palm; Pue = Pueraria cover crop; Ma = maize; Ca = cassava and PI = Plantain

+: deficit

CHAPTER FIVE

5. DISCUSSION

5.1 Overview of oil palm based cropping systems in Ghana

Most oil palm farmers in Ghana are at least 45 years old, which indicates that the Ghanaian oil palm farmers are ageing. There is therefore the need to attract younger farmers into the oil palm industry in order to sustain the industry.

The percentage of the farmers with tertiary education seemed negligible but it should be gladdening to note that this group is composed of university graduates, medical officers, army officers and other senior public servants. This is necessary because the more formally educated a farmer is, the easier it is for him to cope with improved technology. Perhaps, if more literates could join in the oil palm production, productivity is likely to increase because adoption rates for new and improved technologies would go up. Farming would also be seen more as a business rather than as a way of life.

Sale of bunches in the Eastern, Central, Western and Ashanti regions fetched the highest revenue to farmers. The large oil palm development estates such as the Ghana Oil Palm Development Corporation, Twifo Oil Palm Plantation, Benso Oil Palm Plantation and National Oil Palm Limited, which have mill facilities are located in these regions. These companies send their vehicles round with cash to purchase palm fruits, mostly bunches, from these small scale farmers. In these regions also, the mini palm oil mills concept seem to have replaced the large estates especially outside their operational zones.

In the Volta region, 'Zomi', a high quality palm oil product was the commonest product for sale. Few farmers would therefore put on sale oil palm bunches.

Generally, no farmer planted his oil palm at a wider spacing than the recommended 8.8 meters triangular against the background that all respondents practised intercropping and one would have thought that by wider spacing, more space could have been created for the intercrops. Probably because no farmer practised permanent intercropping, such wide spaces between the plants were therefore not needed. It appeared that the

technology of lining and pegging to obtain the standard 8.8 metre triangular has been successfully transferred to most farmers. Dense planting with more than 148 palms hectare^{-1} was practised in the Volta and Brong Ahafo regions. Climatic conditions in these two regions are below the optima and palm canopies scarcely close up as early as in the other regions. While this could explain denser planting in the Volta and Brong Ahafo regions than other regions, some farmers in the latter regions planted denser than the 148 palms per hectare to obtain more trees per unit area to sell to tappers for more cash returns when the palms mature.

The 'tenera' material planted by farmers is mostly from the Oil Palm Research Institute (OPRI) Kusi or from the development estates. Most farmers from the Volta region who planted volunteer materials claimed they did so for lack of access to OPRI improved planting materials. The Oil Palm Research Institute in collaboration with the Ministry of Food and Agriculture (MOFA) would have to find sale points for the farmers in the Volta region.

The responses in the survey also indicated that the Small-scale oil palm farmer in Ghana commonly intercrops Oil palm with maize, cassava and plantain especially during the first three years of planting.

According to respondents, intercropping food crops in the oil palm beyond the first six years led to the depression of the growth and yield of the food crops. By the sixth year the canopies of the palms would have closed, so the food crops are almost completely shaded. If farmers still want to permanently intercrop in the oil palm, there will be the need to investigate and find out the appropriate planting distance and/or arrangements of the oil palm for such a purpose.

Most of the non-users of herbicides were aware of chemical weed control but complained of high cost of such chemicals. May be some form of credit to these farmers could be worked out for the purchases of inputs. Presently the out-growers and small holders affiliated to the development estates enjoy these credit facilities which enchance their productivity.

5.2: Growth and yield of oil palm intercropped with food Crops

The results obtained indicated that intercropping oil palm with food crops generally had no adverse effect on the growth, development and yield of the oil palm.

This observation agrees with that of Sparnaaij (1957), Onwubuya and Eneh (1987) who reported on oil palm intercropped with food crops in Nigeria. Oil palm intercropped with maize + Cassava had the least leaf area, leaf area index, number of leaves produced and accumulation of frond dry weight. It also consistently had the least number of fruit bunches which was reflected in the yield per hectare.

Sole oil palm with pueraria cover crop seemed to perform better than oil palm intercropped with maize + plantain. The differences in growth and yield were however negligible. Oil palm growth, development and yield were apparently strongly influenced by its uptake and use of nutrients, water and intercepted light.

This is accounted for by Competition generated among the various crop combinations. Maize + maize associations and sole oil palm with Pueraria cover crop offered the least

competition for these resources and correspondingly recorded the highest oil palm growth and yields. Plantain associations followed these two crop combinations. The cassava associations posed the severest competition for light, water and nutrients. Accordingly, cassava depressed the growth and yield of the oil palm most. Onwubuya and Eneh (1987) and Ofo et at; (1988) attributed the depressions in growth and yield of the oil palm in their intercropping studies involving cassava, to shading effect.

Cassava might have reduced the yield of oil palm also because it has a longer growth concurrency with the oil palm. Growth and yield of the oil palm with plantain was better than with cassava, probably because plantain had a wider spacing in the oil palm and therefore better interception by oil palm.

5.3: The effect of intercropped food crops on nutrient dynamics, soil moisture retention and solar Interception by oil palm.

The difference between the sole oil palm with Pueraria Cover crop and the three oil palm - food crop intercrops with respect to the uptake and use of nutrients, water and intercepted light was not significant.

The soil pH values ranged between 4.2 and 5.0. Jacquemard (1998) observed that the oil palm can cope with such very acidic soils but is better adapted to soils with a pH close to neutral. The food crops, intercropped with the oil palm also tolerate acid pH values but not soils' with such very low pH levels. The optimum pH range for maize and cassava cultivation is 5.5 to 7.0 (Onwueme and Sinha, 1991); and 5.0 to 6.5 for plantain (Skinner, 1987). And so, to enhance optimun nutrient uptake and therefore good production of these crops, there is the need to use ameliorators such as dolomitic lime or magnesium sulphate to improve the soil pH by about one pH unit.

Values for organic matter and total nitrogen content of the soils under the plantain associations decreased

more than for any other crop association by 1997. For plantain nitrogen (N) , potassium (K) and magnessium (Mg) are the most important elements. Plantain requires not less than 8.4 Kg N, 4 6.0 Kg K and 1.57 Kg of Mg to produce a tonne of fruit (Skinner 1987) . This coupled with the heavy oil palm nutrient requirement would facilitate and or encourage a faster rate of organic matter decomposition and mineralization. This situation could have resulted in the lower organic matter and total nitrogen contents of the soils under the plantain associations, which were at the second Raton crop stage by 1997 and without any nutrient addition.

The plantain no doubt depleted the soil of its K and Mg which are exchangeable bases, a situation which could have caused the more acidic conditions under the plantain based system.

The general decrease in available P for all Treatments except the cassava treatment with continuous Cropping might be due to crop uptake or crop fixation. Cassava being a mycorrhizal *Sp.* plant (Sivaprasad, et al; 1989, and Habte and Byappanahalli, 1994), might have benefited from extended sources of phosphorus and which

could have accounted for the higher P values registered under the cassava associations.

Lower P levels could prevent the uptake and use of available potassium (Hartley 1988) . This and the fact that K was applied annually under the immature oil palm might have given rise to the general increase in available K as experienced from 1995 to 1997. Obigbosan (1978) ; Kang (1993) and Kapinga et *al*, (1995) showed that due to high extraction of K by Cassava, most soils become K deficient if cassava is grown continuously without adequate K applications. In this regard, Howeler (1996) suggested that if cassava is to be grown continuously on the same land it is important to apply annually about 80 - 120 Kg K_20 ha^{-1} in order to maintain soil fertility and sustain high yields which explains the lowest amount of available under the cassava associations in this trial without fertilization of the food crops.

Percentage soil moisture conserved within the month was partially influenced by the amount of the monthly rainfall and for that matter, monthly water deficit.

In February 1995, occurred the highest soil moisture deficit and correspondingly the lowest percentage of soil moisture.

The cropping systems also influenced the percentage soil moisture status. The least amount of soil moisture was conserved in the plantain and cassava treatments. Cassava has relatively sparse canopy and therefore might have transpired less water. But the sparse canopy could have also allowed greater evaporation from the soil surface or loss through the transpiration of weeds. Where weed control is not effective, weeds are likely to grow in the interspace losing water through transpiration (Natarajan and Willey, 1980). Plantain stem and leaves also store a lot of water, which can only be absorbed from the soil, thus reducing the soil water content.

The Pueraria cover crop provided continuous cover to the soil, which could have reduced evaporation loss. Besides, wasteful use of water by weeds, which the Pueraria cover crop suppressed, was eliminated. The only avenue through which water could be lost was through transpiration by the pueraria itself. Also, during the

dry season, most of the pueraria leaves senescence providing dry mulch cover for the soil that could have conserved some soil moisture. There was therefore limited evapotranspiration.

The ability of the cropping systems to conserve soil moisture might have influenced the differences in light intercepted. Higher percentage of light was intercepted in the morning when little water was transpired from the plant. The leaves irrespective of the cropping system were then turgid and were better displayed to intercept light.

However as the day advanced and with increased water loss through evapotranspiration, the oil palm leaves became flabby and therefore much more light was transmitted through them to the ground. For the treatment with Maize + maize under which the highest percentage of moisture was conserved, the oil palm leaves maintained some turgidity and therefore intercepted highest percentage of light. The cassava treatment with the least percentage soil moisture conserved also had the least percentage light intercepted.

5.4: Performance of food crops intercropped with oil palm

Up to the 36th months after transplanting oil palm to the field, the growth, development and yield of maize, cassava and plantain intercropped with the oil palm compared favourably with the growth, development and yields of these crops when solely cropped. This suggests that resources were probably adequate for intercropping food crops in the oil palm. More importantly, light transmission through the oil palm at this stage was adequate for the support of growth and yield of the intercrops. Maize yields however declined with continuous cropping. This could be due to depletion of soil nutrients, since the food crop and maize plots for that matter were not fertilized. However maize plots are traditionally, fertilised with 90-38-38 Kg of N,P and K ha'^{1} especially where the crop is cultivated continuously in each season (Ghana/Grains Development Project, 1991). Minor season maize yields were lower than the major season maize yields. The minor season rains during the study were lighter resulting in drought conditions. This could have affected the minor season maize yields. Maize

yield was somehow depressed by cassava and this could be due to the concurrence of the growth of maize and cassava with regards to competition for light, nutrients and water.

In the absence of competition for light in the first year, the rows of maize and cassava nearest to the planting rows of the oil palm having benefited from the fertiliser applied to the oil palm out-yielded the outer most rows. Later when competition for light was more intense, there was a reduction in the yields of the rows of maize and cassava closer to the oil palm planting row.

5.5: Effects of intercropped food crops on weed Succession and growth in oil palm

Oil palm with Pueraria cover crop and oil palm + maize + maize seemed to control weeds better than oil palm with cassava and plantain associations. Fewer weed types infested the sole oil palm with Pueraria and the oil palm + maize + maize association than did the oil palm + maize + cassava.and the oil palm + maize + plantain.

With continuous cropping, the grasses gradually-replaced the broad leaf weeds. Asamoah (1989) made similar observations of weeds succession pattern under the oil palm. The sole oil palm with Pueraria provided the best weed control because the Pueraria established fast enough to smother the weeds (Gray and Hew, 1968).

Percentage light interception by the oil palm + maize + maize association was highest. This was an indication of early ground cover provided by maize canopy formed. Shading might have therefore contributed to the control of the less shade tolerant weed types especially the broad leaf weeds under the maize + maize association with oil palm.

Cassava takes about three months after planting to establish adequate canopy. Plantain takes approximately five months after planting to establish enough ground cover. Until these canopies were formed, there were enough growth resources - light, water and nutrients to enhance the infestation by weeds. This is why cassava and plantain associations provided inadequate control of weeds.

5.6: Economics of intercropping food crops in oil palm for the small scale farmer

All the oil palm associations with foodcrop intercrops showed positive net revenue by the 3rd year. The sole oil palm with Pueraria cover crop however recorded some deficits. This has more than justified why farmers would not plant the Pueraria cover crop but would intercrop the oil palm with food crops. With his limited resources, the food derived from the intercropping systems provides for the immediate energy needs of his family. The excess is usually sold to generate income for other needs of the family (Sparnaaij, 1991; Benneh, 1987). If the small scale farmers decision is solely influenced by what crop brings in maximum revenue to sustain his family until his palms mature, then farmers would opt for the cassava associations with the oil palm which has a cost benefit ratio of 2.9 the most attractive (Palaniappan, 1985) . But the farmer takes a number of other factors into consideration some of, which are not measurable. The spread of the harvest offered to the farmer in the absence of effective processing and storage facilities (Webster and Wilson, 1966; de Wilde, 1967) and

other benefits assigned to intercropping as has been documented (Norman, 1974 and Onochie 1977) . The maize + maize and maize + plantain associations with oil palm are also economically profitable over the sole oil palm with pueraria.

CHAPTER SIX

6.0: CONCLUSIONS

The responses in the survey of the Oil Palm Cultivation in Ghana indicated that irrespective of regions, the small-scale farmers practiced intercropping with various food crops in the first four years of establishment. Maize, Cassava and Plantain were the main crops, which provided additional incomes to farmers during the period of establishment.

The studies established that maize + maize associations enhanced the growth and yield of the oil palm, as did the Pueraria cover crop. Maize plus plantain and Maize + Cassava associations however depressed them.

Cassava reduced the yield of the oil palm probably because it has a longer growth concurrency with the oil palm. Cassava was a severer competitor for light, water and nutrients than any other crop association with the oil palm.

Growth and yield of the oil palm with plantain was better than with cassava probably because plantain had a wider spacing in the oil palm and therefore light transmission through plantain was adequate.

The yields of food crops were higher the farther they were from the oil palm.

Oil palm with Pueraria cover crop and oil palm + maize + maize suppressed weeds better than the other associations.

The economic analysis revealed that intercropping oil palm with food crops during the establishment stage was more profitable than cover cropping with Pueraria. Cassava associations with the oil palm was the most profitable option.

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APPENDICES

Table 1: Mean squares for leaf area per plant at 6 to 36 months after planting (map).

Source of Variation	df	6	12	18	24	30	36
Rep	3	1.35	16.57	95.39	198.88	322.09	983.15
Treatment	3	1.19	3.18	74.62	76.62	70.23	344.23
Residual	9	0.53	2.51	14.77	31.62	20.15	78.57

Table 2: Mean squares for leaf area index at six - monthly intervals from 6 to 36 months after planting (map).

Source of Variation	df	6	12	18	24	30	36
Rep	3	0.00009	0.00125	0.00608	0.01398	0.01808	0.05969
Treatment	3	0.00012	0.00018	0.00461	0.00487	0.00412	0.01937
Residual	9	0.00008	0.00013	0.00084	0.00207	0.00170	0.00405

Table 3: Anova for rate of leaf production.

Source of Variation	d.f.	S.S.	M.S.	F-Value	Pr>F
Rep	3	1.43013	0.47671	7.52	
Treatment	3	1.88455	0.62818	9.91	**<.001**
Date	5	127.86287	25.57257	403.37	**<.001**
Treatment/Date	15	0.60140	0.04009	0. 63	0.838
Residual	69	4.37440	0.06340		

Table 4: Anova for frond dry weight.

Source of Variation	d.f.	S.S.	M.S.	F-Value	Pr>F
Rep	3	0.230083	0.076694	30.20	
Treatment	3	0.87142	0.029047	11.44	**<.001**
Date	5	5.382725	1.076545	423.94	<.365
Treatment/Date	15	0.042233	0.002816	1.11	0.365
Residual	69	0.175217	0.002539	0.002539	

Table 5: Mean squares for single bunch weight from 1996 to 1997.

Source of Variation	df.	Year 1996	1997
Rep.	3	0.5500	7.607
Treatment	3	3.5025	6.845
Residual	9	0.3624	3.505

Table 6: Mean squares for single bunch weight from 1996 TO 1997.

Source of Variation	df.	Year 1996	1997
Rep.	3	0.2782	0.0349
Treatment	3	0.2498	0.1432
Residual	9	0.3227	0.1191

Table 7: Mean squares for oil palm yield from 1996 to1997.

Source of Variation	df.	Year 1996	1997
Rep.	3	0.15980	1.3347
Treatment	3	0.67982	1.3769
Residual	9	0.09591	0.2363

Table 8: Mean squares for soil aciddity (p^h) from 1995 to 1997

Source of Variation	df.	Year 1995	1996	1997
Rep.	3	0.02252	1.26333	0.31549
Treatment	3	0.38164	1.12844	0.69954
Residual	9	0.02836	0.51252	0.39160

Table 9: Mean squares for organic matter from 1995 to 1997.

Source of Variation	df.	Year 1995	1996	1997
Rep.	3	1.99854	1.56499	4.90904
Treatment	3	0.16332	0.04315	0.25429
Residual	9	0.22072	0.20397	0.80248

Table 8: Mean squares for soil aciddity (p^h) from 1995 to 1997.

Source of Variation	df.	Year 1995	1996	1997
Rep.	3	0.02252	1.26333	0.31549
Treatment	3	0.38164	1.12844	0.69954
Residual	9	0.02836	0.51252	0.39160

Table 10: Mean squares for total nitrogen from 1995 to 1997.

Source of Variation	df.	Year 1995	1996	1997
Rep.	**3**	0.01452	0.00952	0.00058
Treatment	3	0.00031	0.00030	0.02632
Residual	9	0.000152	0.00179	0.00190

Table 11: Mean squares for soil available phosphorus from 1995 to 1997.

Source of Variation	df.	Year 1995	1996	1997
Rep.	3	86.48	3.57	53.49
Treatment	3	32.04	20.97	86.03
Residual	9	20.99	10.13	58.10

Table 12: Mean squares for available potossium from 1995 to 1997.

Source of		Year		
Variation	df.	1995	1996	1997
Rep.	3	1185.59	2071.49	
Treatment	3	68.72	2907.52	
Residual	9	293.72	800.43	

Table 13: Mean squares for leaf nitrogen at 6 to 36 months after planting (map).

Source of		Months after planting				
Variation	df.	6	18	24	30	36
Rep.	3	0.2636	0.2169	0.3936	0.0335	0.0538
Treatment	3	0.0769	0.0077	0.0375	0.1890	0.0976
Residual	9	0.4197	0.3007	0.3090	0.0614	0.0568

Table 14: Mean squares for leaf phosphorus at 6 to 36 months after planting (map).

Source of		Months after planting				
Variation	df.	6	18	24	30	36
Rep.	3	0.00096	0.00111	0.00114	0.00076	0.00104
Treatment	3	0.00036	0.00169	0.00058	0.00099	0.00081
Residual	9	0.00132	0.00051	0.00080	0.00098	0.00043

Table 15: Mean squares for leaf potassium at 6 to 36 months after planting (map).

Source of		**Months after planting**				
Variation	df.	6	18	24	30	36
Rep.	3	0.3023	0.11333	0.0473	0.4573	0.32229
Treatment	3	0.0440	0.15833	0.0206	0.2490	0.02562
Residual	9	0.1951	0.05056	0.1434	0.1167	0.03118

Table 16: Mean squares for soil moisture at 0 -30cm depth for the period dec. 1994 to feb. 1995.

Source of Variation	df.	Sampling periods 24/12/94	07/01/95	16/02/95
Rep.	3	4.51	39.04	52.22
Treatment	3	4.85	93.18	11.16
Residual	9	3.16	56.37	22.85

Table 17: Mean squares for soil moisture at 0 -30cm depth for the period dec. 1994 to feb. 1995.

Source of Variation	df.	Sampling periods 24/12/94	07/01/95	16/02/95
Rep.	3	6.06	3.31	85.87
Treatment	3	5.90	12.08	19.90
Residual	9	3.94	18.17	33.28

Table 18: Mean squares for light interception by the oil palm from 10.30hours to 15.30 hours.

Source of		Sampling times					
Variation	df.	10.30	11.30	12.30	13.30	14.30	15.30hrs
Rep.	3	541.2	369.9	209.4	107.8	33.4	27.3
Treatment	3	30. 6	183.8	73.8	309.4	278.1	313.9
Residual	9	137.4	70.0	55.5	46.4	64.1	56.0

Table 19: Mean squares for maize intercropped with oil palm from 1994 to 1996.

Source of		Year		
Variation	df.	**1994**	**1995**	**1996**
Rep.	3	181.41	131.76	1439.1
Treatment	3	106.21	62.47	2099.5
Residual	9	86.23	59.20	468.8

Table 20: Mean squares for leaf area of maize intercropped with oil palm from 1994 to 1996.

Source of		Year		
Variation	df.	**1994**	**1995**	**1996**
Rep.	3	0.00893	0.00196	0.00443
Treatment	3	0.31561	0.00051	0.00245
Residual	9	0.03894	0.00260	0.00115

Table 21: Mean squares for leaf production of maize intercropped with oil palm from 1994 to 1996.

Source of		Year		
Variation	df.	**1994**	**1995**	**1996**
Rep.	3	0.5542	0.3000	0.842
Treatment	3	0.4075	0.0158	**2 . 000**
Residual	9	0.1903	0.7692	3.083

TABLE 22: mean squares for major season maize yield from 1994 to 1996.

Source of		1000 Seed wt			Grain yield		
Variation	df.	1994	1995	1996	1994	1995	1996
Rep.	3	951.0	514.0	2644.3	0.5139	2.1936	0.3328
Treatment	3	626.7	2086.0	56.2	0.1513	0.0314	0.4382
Residual	9	994.3	2677.0	958.2	0.2819	0.0708	0.0471

Table 23: Mean squares for minor seasonn maize yield from 1994 to 1996.

Source of		1000 Seed wt			Grain yield		
Variation	df.	1994	1995	1996	1994	1995	1996
Rep.	3	4076.0	872.7	761.0	0.09334	0.13628	0.160
Treatment	3	3.0	708.8	1005.8	0.05314	0.05831	0.060
Residual	9	102.5	197.6	321.5	0.03098	0.05458	0.051

Table 24: Mean squares for cassava yield and yield components from 1994 to 1996.

Source of		Fresh tuber wt plant^{-1}			Cassava yield		
Variation	df.	1994	1995	1996	1994	1995	1996
Rep.	3	0.175	0.025	0.083	19.71	6.26	10.47
Treatment	1	1.620	0.451	0.020	143.65	28.50	0.18
Residual	3	0.177	0.028	0.010	12.83	5.97	0.22

Table 25: Mean squares for growth of plantain at flowering stage.

Source of		Growth Parameters			
Variation	df.	Height	Girth	Leaf Prodn.	Leaf Area
Rep.	3	1639.6	46.60	4.707	7.187
Treatment	1	127.4	5.78	0.196	0.289
Residual	3	373.6	12.83	2.623	3.147

Table 26: Mean squares for plantain yield and yield components per hectare for 1995 and 1996.

Source of Variation	df.	Bunch Number		Bunch Weight	
		1995	**1996**	**1995**	**1996**
Rep.	3	34.7	73.167	1998.0	1655.1
Treatment	1	4.2	10.667	542.0	532.0
Residual	3	216.7	8.167	6297.0	850.5

Table 27: Mean squares for cassava yield and yield components as influenced by spatial arrangement for 1995 - 1997.

Source of Variation	df.	Fresh tuber wt plant^{-1}			Fresh tuber yield H"		
		1994	**1995**	**1996**	**1994**	**1995**	**1996**
Rep.	3	0.043	0.162	0.244	15.35	52.94	22.79
Treatment	**1**	0.069	0.215	0.038	4.27	8.79	8.695
Residual	3	0.009	0.088	0.062	1.66	5.86	1.77

Table 28: Mean squares for major season maize yield as influencedd by spatial arrangement from 1994 to 1996.

Source of		YEAR		
Variation	df.	**1994**	**1995**	**1996**
Rep.	3	1.027	1.245	0.689
Treatment	4	1.227	0.120	0.044
Residual	12	0.257	0.823	0.592

Table 29: Mean squares for weed growth in an oil palm intercropping system at 11 to 31 months after planting (map).

Source of		Month after planting							
Variation	df.	11	13	17	19	23	25	29	31
Rep.	3	3399	2603	6659	2909	227	1397	1098	129C
Treatment	3	5018	12964	2516	12541	3237	5287	14234	4710
Residual	9	13003	1101	2127	2912	1123	908	5230	1291

Table 30: Establishment cost of 1 hectare ofoil palm.

ITEM	Mandays Ha^{-1}	Quantities/ Units required	Unit costs	Cost Ha^{-1}
1. Land Preparation:				
a) Under brushing	12		5000.00 +	60,000.00
b} Felling	18		do -	90,000.00
c) Chopping down crown	15		do -	75,000.00
d! Cutting fire belts, burning, heaping and 2nd burning	9		do -	45,000.00
2 Lining and Pegging Including cutting of pegs	8		- " do -	40,000.00
3.Cutting and fixing of wire collars.	4		- - do -	20,000.00
1. Planting/sowing:			-	
a) oil palm seedlings	3			
b) Pueraria seeds	3		do — do —	15,000.00 15,000.00
2. Cost of Planting materials				
a) Oil palm DXP seedlings		148	3.500 00	518,000.00
b) Pueraria seeds		6. 5kg	3,200.00	20,800.00
3. Transportation of seedlings to farm(with 5km radius)			20,000.00	20,000.00
4 . Rolls of wire collars		4	97,000.00	388,000.00
5. Total				1,306,000

Table 31: Establishment costs of 1 hectare food Crops.

Item	Mandays Ha"[1]	Qty. Required	Unit Cost	Total cost Ha"[1]
1. LAND PREPARATION		—		
a) Under brushing	12	-	5000	60,000
b) Felling	18		- do -	70,000
c) Chipping down crown		-		
d) Cutting of fire belts, burning, heaping and	15		- do -	75,000
2nd burning	9		- do -	45,000
Sub-Total	54	-		270,000
2. PLANTING MATERIAL				
a) Seed Maize	-	10kg	2000	20,000
b) Cassava Sticks	-	10 bundles	2000	20,000
c) Plantain suckers	-	1100	200	220,000
3. PLANTING/SOWING				
a) Maize Seeds	8	-	5000	40,000.00
b) Cassava Sticks	8	-	do -	40,000.00
c) Plantain suckers	8		do -	40,000.00

Table 32: Maintenance and harvesting cost of oil palm and food crops ha^{-1}.

	1994	1995	1996	1997	Total Over the Period
A. OIL PALM					
1. LABOUR REQUIREMENT(md)					
Ring Weeding	5	20	20	20	65
Interrow Weeding	5	20	20	20	65
Filling Vacancies	–	0.2	0.2	0.2	0. 6
Fertilizer application	1	2	2	2	7
Harvesting			3	6	9
SUB-TOTAL	11	42.2	45.2	48.2	146.6
2. FERTILIZER REQUIREMENT (kg)					
Ammonium Sulphate	29.6	74	74	74	251.6
Single Suger Phosphate	29.6	74	74	74	251.6
Nutriate of Potash	29.6	74	74	74	251.6
Magnesium Sulphate	-	-	-	-	222
SUB-TOTAL	88.8	222	222	444	976.8
B. FOOD CROPS					
1. LABOUR REQUIREMENT(md)					
(a) WEEDING				-	
Maize	37.5	50	50		137.5
Cassava	37.5	50	50	12.5	150
Plantain	37.5	50	50	-	135.5
(b) Harvesting					
Maize	10	10	10	-	30
Cassava	-	15	15	15	45
Plantain		12	12	–	24
n Dehusking of Maize	10	10	10		30
(d) Shelling of Maize	8	8	8		24

• md - mandays