

INCOME INTENSIFICATION STRATEGY: DETERMINATION OF THE OPTIMUM TIME TO UNDER-PLANT OIL PALM WITH COCOA

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ABSTRACT

Cocoa was inter-cropped with oil palm of three different palm ages to determine the best time to under plant cocoa in oil palm. The experiment was conducted from 1994 to 2004 at the Oil Palm Research Institute, Kusi. Oil palm at three different ages; 2, 4 and 6 years after planting were under-planted with mixed cocoa hybrids. These were compared with sole oil palm and sole cocoa. The treatments were arranged in a randomized complete block design and replicated three times. Growth and yield of oil palm under-cropped with cocoa after 4 years compared favorably with sole oil palm. The income equivalent ratio defined as the land area under sole oil palm that is required to produce the incomes achieved in inter-cropping, were 1.08, 1.25, 1.02, 1, 0.31 for 2 years oil palm with cocoa, 4 years oil palm with cocoa, 6 years oil palm with cocoa, sole oil palm and sole cocoa respectively. Results of this study suggest that maximum returns from the land is achieved when 4 years old oil palm is under-planted with cocoa followed by 2 years and 6 years old oil palm respectively. Such intercropping gave higher returns from the land than either sole oil palm or cocoa plots.

INTRODUCTION

The importance of the cocoa (*Theobroma cacao*) industry to the economy of Ghana cannot be over emphasized. The cocoa sector employs over 800,000 smallholder farm families for whom cocoa contributes about 70-100% of their annual household incomes (COCOBOD 1998). In 2001, cocoa accounted for 22.6% of total foreign exchange earnings of Ghana's exports (ISSER 2002).

Oil Palm (*Elaeis guineensis*) is the second most important cash crop in Ghana cultivated by both large and small-scale farmers. It is estimated that about 636,000 households are involved in its cultivation nationwide generating some 87.5 billion cedis annually (Anonymous 1990).

Traditionally, both cocoa and oil palm farmers in Ghana establish their farms with food crops into which the cocoa or oil palm seedlings are planted (Benneh 1987). Osei-Bonsu et al. (1998)

found that the practice of intercropping food crops with cocoa enhances growth and precocity of the cocoa.

Although widely practiced in tropical regions, intercropping has previously been considered to be an under-developed agricultural practice. In spite of the emphasis of research on monocropping, intercropping remains widespread and in many situations represents a more efficient use of natural resources (Fordham 1983). Mixed cropping can serve as an insurance against crop failure, makes more efficient use of labour and improves both land use efficiency and the income earning capacity of the farmer. The main demerits of mixed-cropping are that yields from the individual crops are usually below yields from monocultures owing to inherent competition for light, water and nutrients, and farm maintenance operations may be difficult to mechanize.

One interesting characteristic of cocoa-oil palm inter-cropping is that the labour calendars for these crops do not interfere with each other. Thus in Ghana, whilst the peak yield and high labour requirements for oil palm occur between February and July, that for cocoa is from September to March.

Earlier works by other researchers (Egbe and Adenikinju 1990, Oladokun 1988 and Kolade 1986) have documented the agro and socio-economic benefits of cocoa-tree crop systems. Amoah et al. (1995) studied the feasibility of underplanting oil palm with cocoa and found optimum cocoa growth and yield when planted under oil palm spaced at 10.5 m triangular rather than the usual 8.7 m triangular.

Whereas, oil palm has been cultivated without shade due to its high light requirement (Hartley, 1988), cocoa requires shade for its cultivation (Wood 1985). The economic life span of both crops is between 25 – 30 years and hence at the time of felling the oil palm, the cocoa could be grubbed out and the two crops replanted. Currently, information on oil palm – cocoa associa-

tion from early stages of their life-cycle, which is vital for determining the best time to plant cocoa under oil palm is lacking.

The objective of this study was therefore to assess the age compatibility of oil palm – cocoa association and to identify the critical age of oil palm stands to under plant cocoa in order to maximize income.

MATERIALS AND METHODS

Site

The experiment was set up at the Oil Palm Research Institute, Kusi (06.00 N, 001.45 W) known to be climatically suitable for both cocoa and oil palm cultivation. The soils of the experimental field were derived from forest ochrosols occurring on a gently sloping topography. The soils of the Nzema series occurred in the upper to middle slope and colluvial soils of the Kokofu series on the lower parts (Asiamah and Senayah 1991).

Experimental design and treatments

The experiment was in a randomized complete block design with 5 treatments in 3 replications. 12-months-old (tenera) oil palm seedlings were transplanted to the field in April 1994. Planting was done at a spacing of 10.5m triangular giving a plant population of 105 trees per hectare. Each plot measured 0.12 ha and had 12 palms.

Three age groups of oil palm-cocoa associations were imposed by under planting the oil palm with cocoa when the oil palms were 2, 4 or 6 years old. Six-month-old recommended mixed hybrid cocoa seedling were planted at a spacing of 3 m x 3m under the oil palm of the various ages. Two control treatments consisting of sole oil palm stands (sole oil palm) and sole cocoa stands were planted at 3 m x 3 m.

Cultural practices

Weeds control was carried out three times a year by slashing with cutlass. Fertilizer was applied to oil palm once in a year in September/October. Nitrogen was applied at 42 g in the form of urea,

phosphorus at 48 g as triple super phosphate and potassium at 250 g per tree as muriate of potash, as recommended (Anonymous 1988). There was no deliberate attempt to fertilize the cocoa. As a routine management practice basal chupon as well as climbers and dead branches were periodically removed from the cocoa. The skirt of the cocoa canopy was raised as and when necessary by pruning the lower branches to enhance better ventilation and to facilitate easy movement of labour for farm operations.

Data collection

Growth parameters of oil palm measured were leaf area development, leaf area index, fronds production rate, fronds dry weight and height. The peak harvesting season for oil palm was between February and July each year. Yield components of oil palm measured were number of bunches produced/palm/yr, single bunch weight and oil palm yield (tons/ha). Harvesting of cocoa was done at monthly intervals from September to January and data was collected on weight of dry cocoa beans.

Economic analysis

Net returns for the various crop combinations were estimated by deducting all cost incurred from the revenue derived.

The cost-benefit ratio, which is the return per cash invested, was calculated by relating the gross income to total cost of production or cash invested. This was obtained from the formula:

$$CBR = \frac{GR}{TCC}$$

Where CBR is the Cost-Benefit Ratio, GR is the Gross Return, and TCC is the Total Cost of Cultivation.

The Income Equivalent Ratio (IER), which is the relative land area under sole crop that is required to produce the incomes achieved in intercropping was used to compare productivity of the various crop age combinations in relation to oil

palm monoculture. IER was calculated using the procedure of Mead and Willey (1980).

$$IER = \frac{P_{oil\ palm} + P_{cocoa}}{M_{oil\ palm}}$$

Where:

$P_{oil\ palm}$ = intercropping yields of oil palm

P_{cocoa} = intercropping yields of cocoa

$M_{oil\ palm}$ = monoculture yield of oil palm

The cost of inputs and operations were noted and revenue obtained from the various associations was calculated based on the prevailing market prices.

RESULTS

Effect of under-cropping oil palm with cocoa on growth and development of oil palm

Under-planting oil palm with cocoa had no significant ($P < 0.05$) effect on leaf area development in the oil palm. Even though, oil palm under-planted with cocoa at 2 years after planting developed slightly lower leaf area than the other crop combinations (Fig 1). Leaf area development was fairly uniform from 1998 to 2004 with a marginal expansion of 21% - 25% during the period. Peak leaf area of 7-7.8 m² was attained in last year of the study.

The effect of the different oil palm – cocoa age association on LAI is shown in Fig 2. Under-planting oil palm with cocoa at different palm ages had no clear effect on LAI. Even though lower LAI values were observed in 2 years old oil palm-cocoa intercrop. The oil palms attained a peak LAI of 1.6-1.8 in 2003 (9 years after planting).

Oil palm frond production rate and frond dry weight were not significantly ($P < 0.05$) affected by the cropping system. Frond production rate remained fairly constant whereas frond dry weight increased appreciably by 32%-40% during the 7 years period. Lower frond weight was frequently observed in oil palms underplanted with cocoa at 2 years old (Fig 3 and 4).

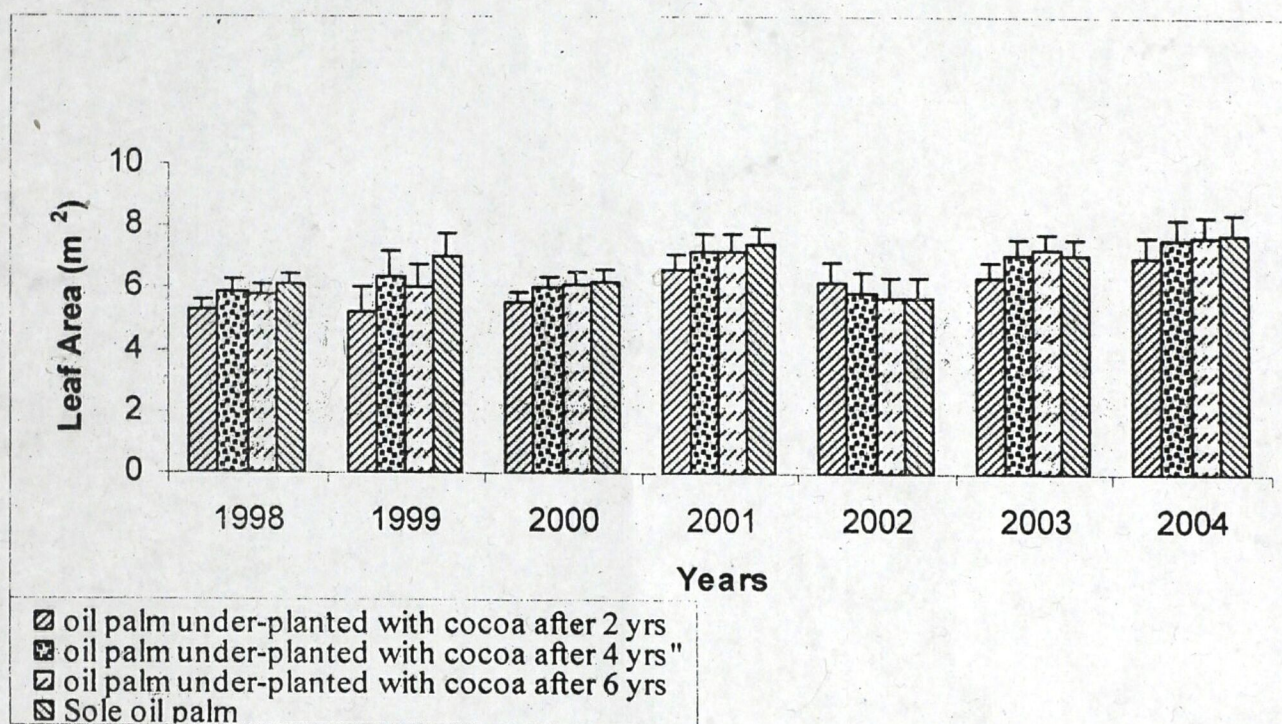


Fig. 1: Effect of under-cropping cocoa in Oil palm on LA development of oil palm)

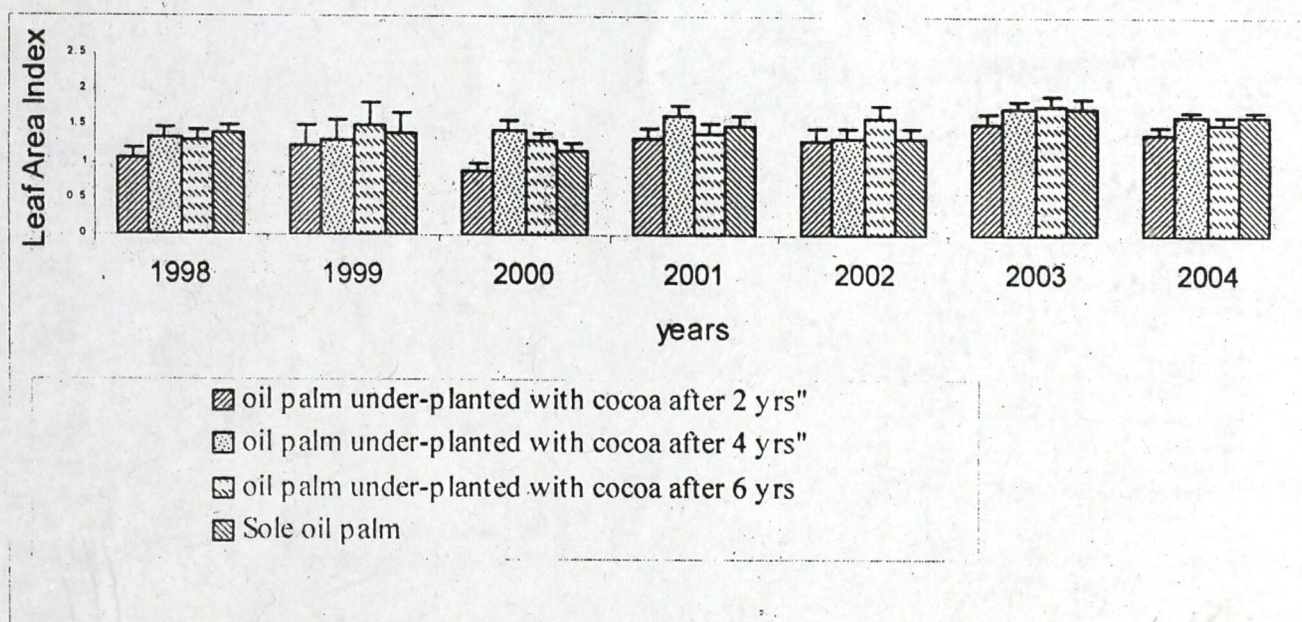


Fig. 2: Effect of time of under-planting oil palm with cocoa on LAI of oil palm

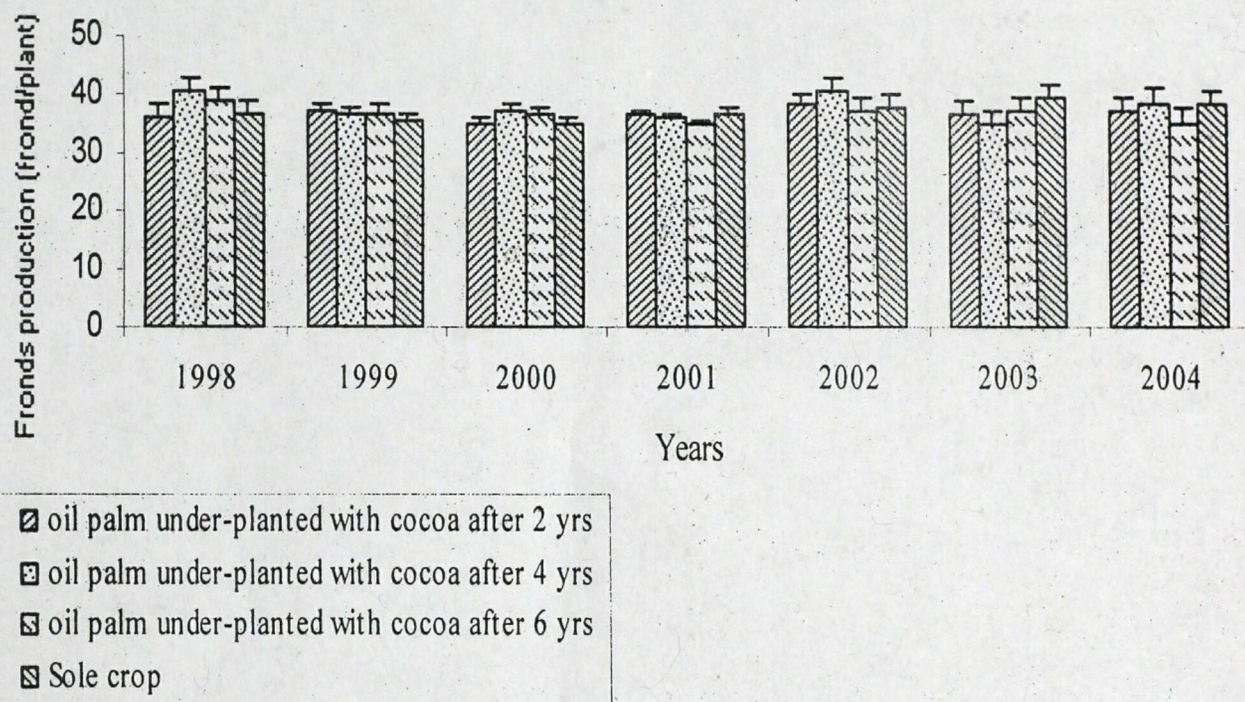


Figure 3: Effect of time of under-cropping oil palm with cocoa on fronds production

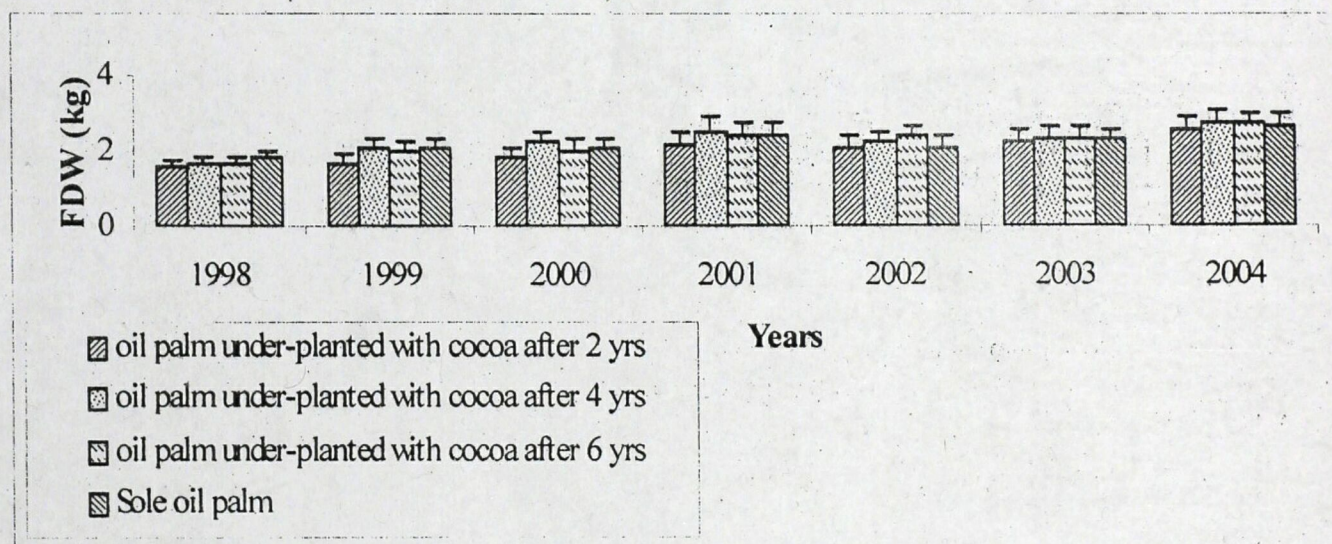


Figure 4: Effect of time of under-planting oil palm with cocoa on FDW of oil palm (kg)

In 1998, the highest plant height was observed in sole oil palm stands. Oil palms under-planted with cocoa at 4 years old were moderately taller than oil palms under planted with cocoa at 2 or 6 years after planting. These differences in height were however not significant ($P < 0.05$). This pattern of oil palm height increment were apparent and was mirrored in the subsequent years with some 61% - 66% increase in shoot elongation by 2004 (Fig 5).

Effect of under-cropping oil palm with cocoa on yield of oil palm

The oil palm - cocoa age associations had no significant ($P < 0.05$) effect on the number and weight of oil palm bunches produced.

The number of bunches produced by oil palm per ha annually, was highest in 1998 and declined gradually till the end of the study. Generally, however oil palm under-planted with cocoa at 4 years produced more but non significant number of bunches than the other crop combinations (Fig 6).

Single bunch weight increased steadily from (6.2 - 7.8 kg) in 1997 to (14.9 - 16.3 kg) in 2004. Oil palm under-planted with cocoa at 4 year after planting produced the heaviest bunches up to 2001. Thereafter, it became second to those under planted with cocoa when oil palms were 6 years old, (Fig 7).

The yield of the oil palm defined as the product of the number of bunches and weight of bunches per ha from 1997 to 2004 is shown in Fig 8. The oil palm yields in the monoculture were significantly ($P < 0.05$) higher than those inter-cropped with cocoa during the first year of harvest. Oil palm under-planted with cocoa at 4 years after planting produced yields comparable to that of the sole oil palm from 1999 to 2002. During the last two years of the study, oil palm yields obtained from palm under-planted with cocoa at 4 years after planting were significantly higher than the other crop combinations (Fig 8). The

average oil palm yields (FFB) produced by the crop combinations over the 7 years period were 7.1 ton/ha, 8.6 ton/ha, 7.0 ton/ha and 8.9 ton/ha per annum for oil palm under-planted with cocoa at 2, 4 and 6 years after planting respectively.

Effect of under-cropping oil palm with cocoa on the yield of cocoa

Cocoa yield as measured by the dry weight of cocoa beans per ha depended on the time of planting the cocoa under the oil palm. During the first two years of yield assessment only the sole crop and those under-planted 2 years after the oil palm establishment were considered since the other options were in the vegetative phase of their growth. By the last 3 years of the study, when all the crop combinations were producing pods, the average yield of cocoa under-planted in 4 years old oil palm was slightly higher than the other treatments (Fig 9). The average cocoa annual yield (dry beans) produced by the crop combinations during this period were 244 kg/ha, 252 kg/ha, 216 kg/ha and 245kg/ha under-planted in oil palm at 2, 4 and 6 years respectively after planting the oil palm.

Economic assessment of the productivity of the various crop combination

The economic indices used to assess the productivity of the various crop combinations are shown in Table 1.

In general, all the inter-cropping combinations were profitable as no loss on investment was incurred. Under planting cocoa in 2, 4 and 6 years old oil palms earned 27%, 46% and 10% more net income than oil palm monoculture. Cocoa monoculture appeared to be the least productive option generating 89% less net income than oil palm monoculture and consequently, yielded the lowest income equivalent and cost benefit ratios of 0.31 and 1.4 respectively.

DISCUSSION

The results of the study indicated that leaf area, development leaf area index, front dry weight

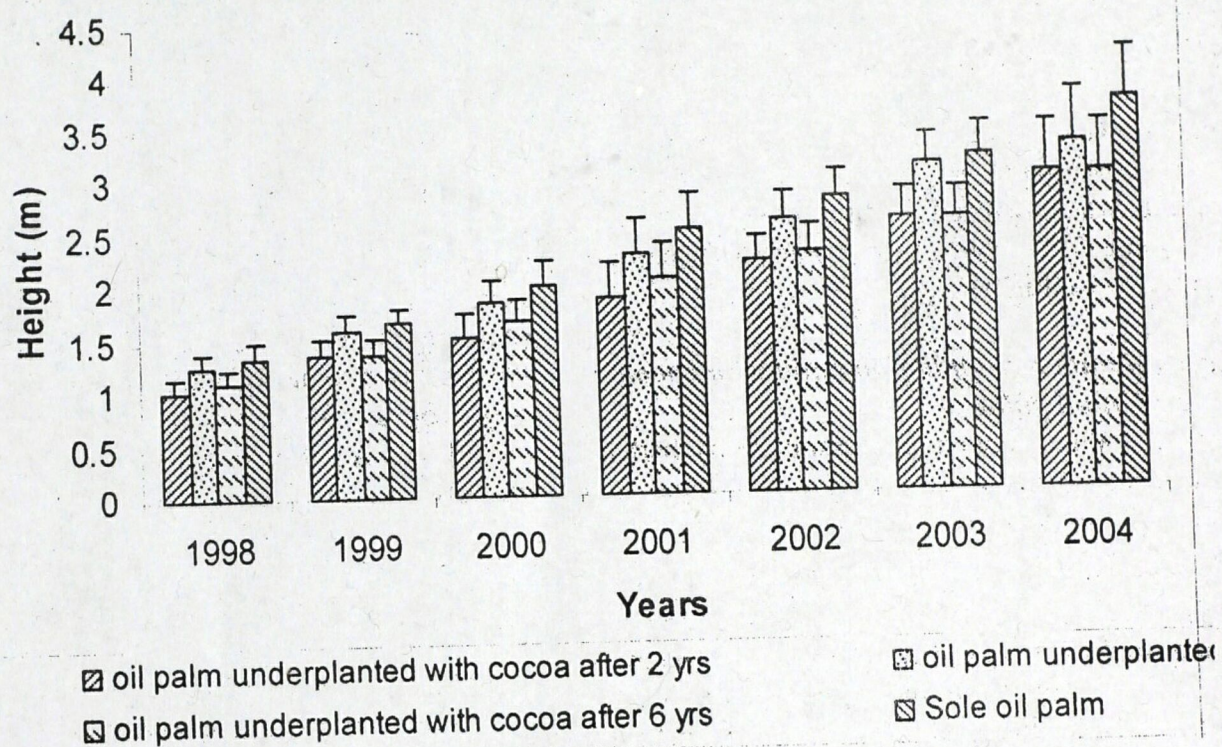


Figure 5: Effect of time of underplanting oil palm with cocoa on height of oil palm(m)

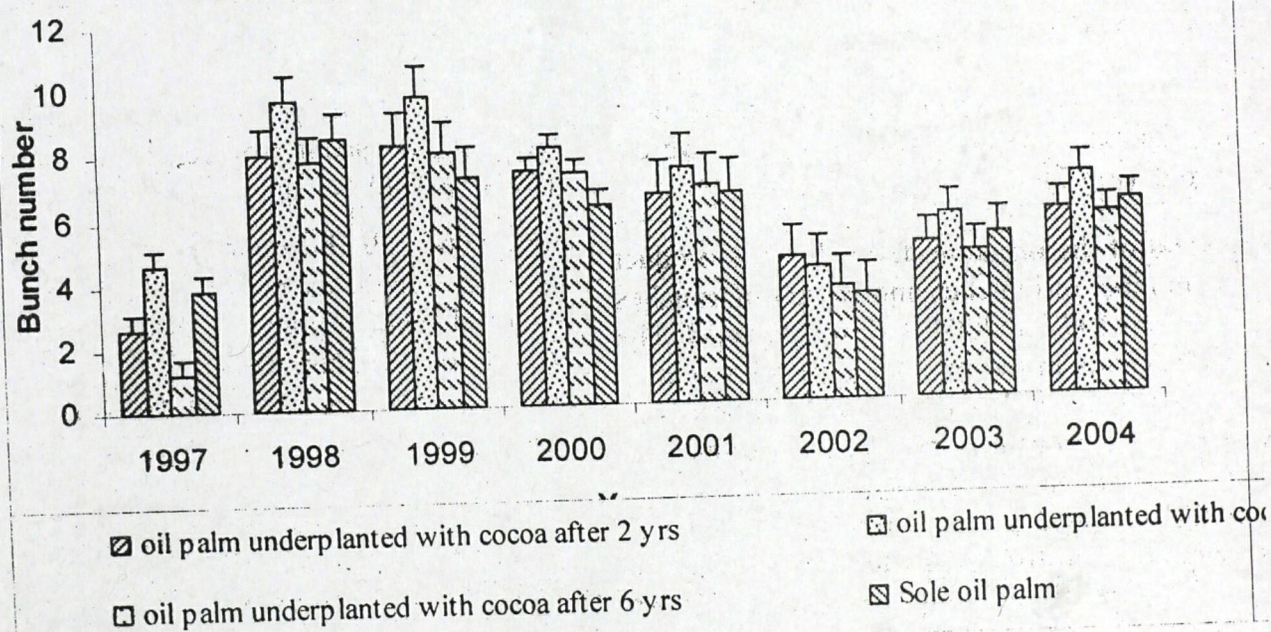


Figure 6: Effect of time of underplanting oil palm with cocoa on oil palm bunch numbers

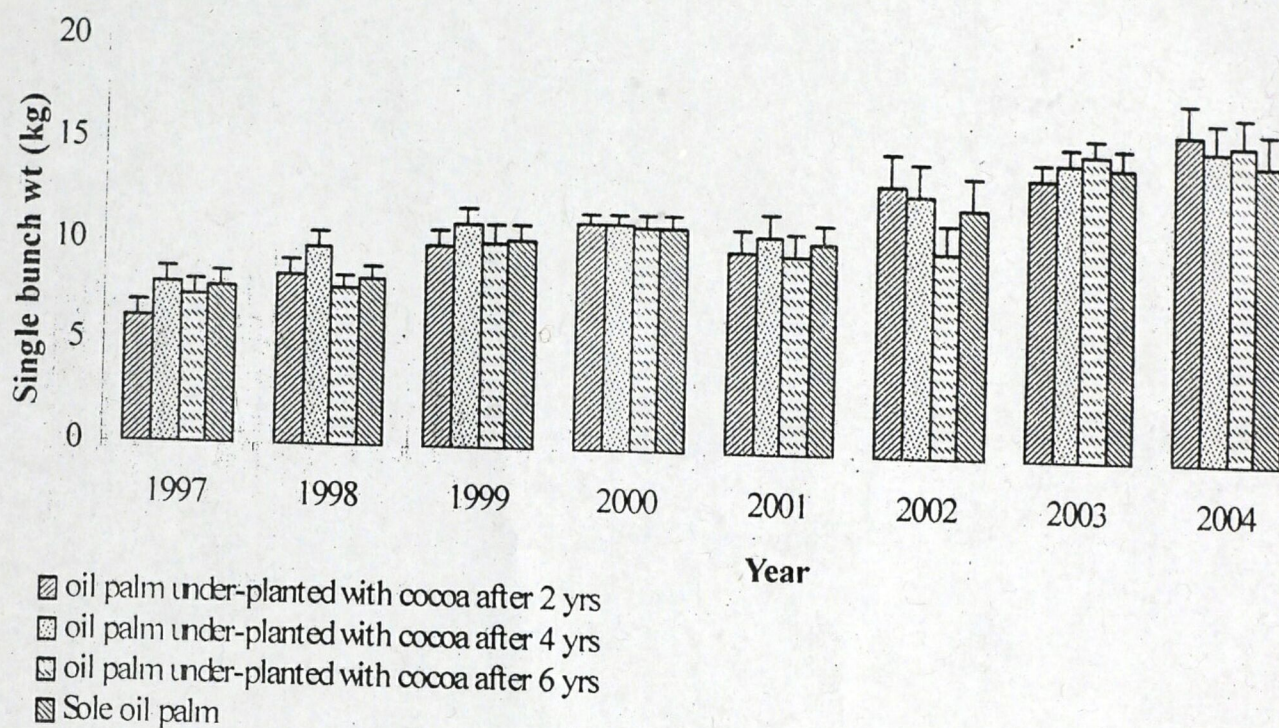


Figure 7: Effect of time of under-planting oil palm with cocoa on oil palm single bunch weight(kg)

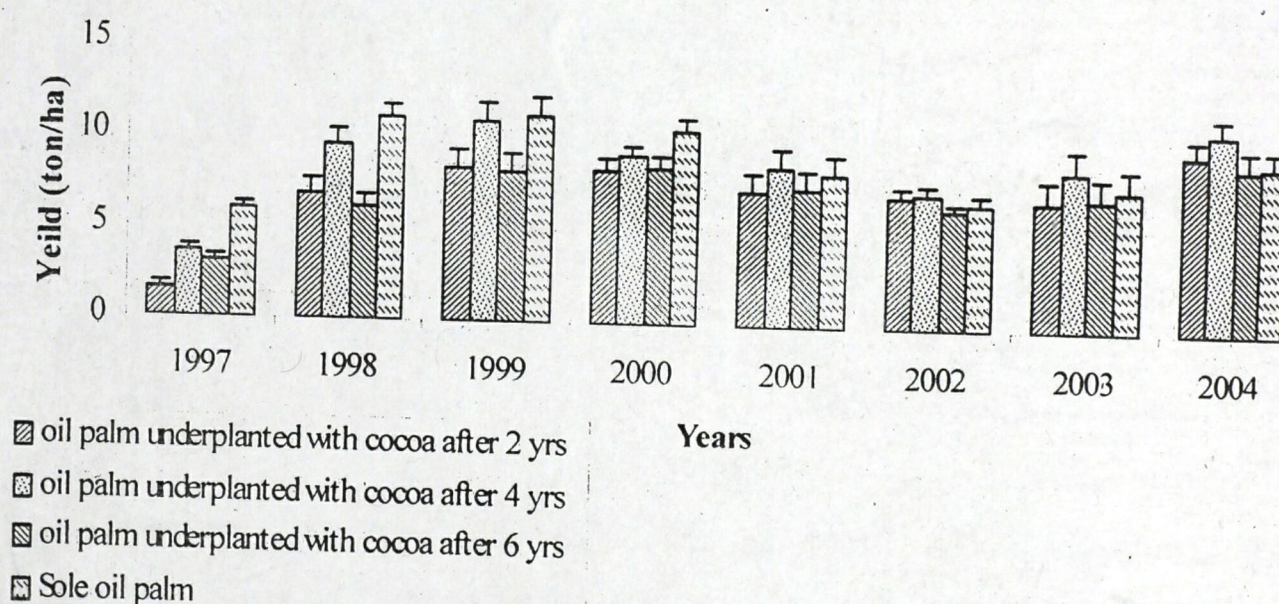


Figure 8: Effect of time of intergration of cocoa under oil palm on oil palm yield (ton/ha)

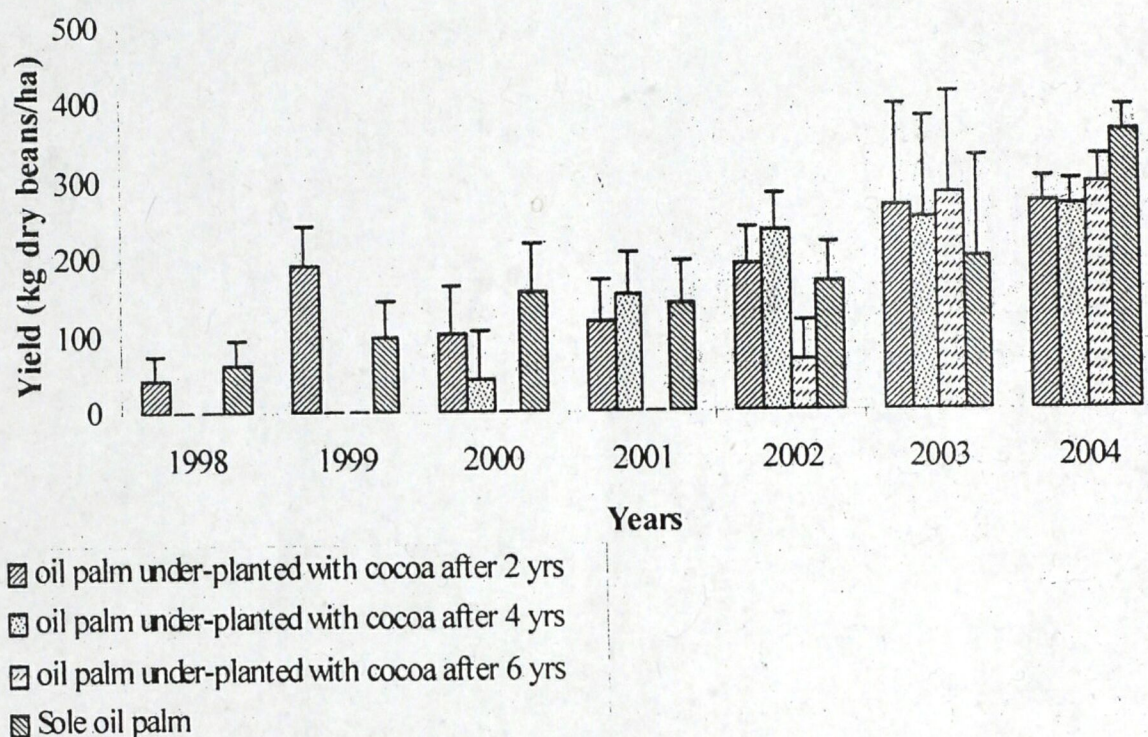


Figure 9: Effect of under-planting oil palm with Cocoa on the cocoa yield 9kg/ha)

Table 1: Economic evaluation of oil palm - cocoa Inter-cropping system

Crop combination	Total Production Cost(¢000)	Gross Income (¢000)	Net Income (¢000)	Income Equivalent Ratio	Return on Cash Invested
Oil palm(2 yrs) + Cocoa	4,750	27,678	22,928	1.08	5.8
Oil palm (4 yrs)+ Cocoa	5,350	31,837	26,487	1.25	6.0
Oil palm (6 yrs)+ Cocoa	5,950	25,924	19,974	1.02	4.4
Sole Cocoa	5,870	7,954	2,084	0.31	1.4
Sole Oil palm	7,390	25,514	18,124	1.00	3.5

and plant height were generally lower when 2 years old oil palm was inter-cropped with cocoa. Active competition for water and nutrients during the vegetative phase of the interacting crops may account for the poor growth rate observed in the 2 years oil palm – cocoa association. Woods (1985) asserted that the restricted fibrous roots of oil palm and the extensive superficial feeding roots of cocoa reduced mutual competition in oil palm-cocoa intercrop. On the contrary, inter-cropping juvenile oil palm (under 3 years) with cocoa tends to encourage early competition as both plants rely on the upper horizons of the soil for their nutrient and water supply. The observation that oil palm inter-cropped with cocoa when the oil palms were 4 or 6 years old exhibited growth comparable to the sole oil palm was affirmed by Vanderwegen's (1952) recommendation that cocoa should be intercropped with oil palm when palms are about 2 m high (5-8 years old).

Among the growth parameters monitored, frond production rate and trunk height depicted contrasting but interesting attributes of oil palm growth. While frond production rate remained fairly constant (Fig. 3) suggesting that the palms were in the reproductive phase of their growth and that more photosynthates were partitioned into bunch formation, trunk height increased steadily (Fig. 5) confirming to the Jacquemard (1998) observation that apical growth of oil palm is indeterminate.

The observed lower yields of oil palm inter-cropped with cocoa during the initial fruiting years could be partly attributed to competition for resources during the bunch filling period. Irrespective of the crop combination, oil palm yields varied from year to year in an irregular manner (Fig 8). According to Shepherd et al. (1977) climatic and physiological factors are the major contributors to the observed irregular fluctuations in yield of oil palm and not its association with cocoa. On the contrary, Amoah et al. (1995) in a long-term study found a clear depression in yield of oil palm as the trees advanced in

years. The discrepancy in these results may be attributed to the age of the palm trees used in the study in relation to their economic life span. In the study carried out by Amoah et al (1995) yield assessment was undertaken when palm trees were in the terminal phase of their economic life span (16 – 22 years old) whereas yield assessment in the present study was carried out when palm trees were in the initial phase of their economic life span (3 – 10 years old).

Undoubtedly, the 4 years old oil palm – cocoa association showed superior performance over the other age associations and produced a mean yield of 8.6 ton/ha per annum FFB which was similar to the 8.9 ton/ha per annum FFB obtained from the sole oil palm cultivation. These yield values were not different from the average yield (8.5 ton/ha per annum FFB) obtainable during the initial phase of the economic life span of oil palm under the Ghanaian conditions (Anonymous 1988). Since the yield of 4 years old oil palm – cocoa association was almost equal to the yield obtained from the sole oil palm, the additional yield from cocoa could be taken as 'bonus' and may translate into more income in the farmer's coffers.

Irrespective of the time cocoa was under-planted in the oil palm, yields of cocoa produced by the various crop combination were not significantly ($P < 0.05$) different by the last two years of the study (Fig 9). During the last three years of the study, the 4 years old oil palm – cocoa association affirmed its superiority by producing the highest average cocoa yield of 252 kg/ha dry beans. In relation to the average national yield of cocoa (280 kg/ha) as reported by Adomako (1990) the cocoa yields obtained in this study were moderately low. However, since no deliberate attempt was made to fertilize the cocoa trees, the observed lower yields of cocoa may be partly due to inadequate supply of nutrients during the fruiting period. Also the overhead shade from the oil palm was probably high for cocoa as the recommended shade for cocoa is 15-18 forest trees/ha. (Wood, 1998).

Economic appraisal of the crop combinations found the inter-cropping combinations to be more profitable than sole cropping of oil palm or cocoa. The enhanced productivity of the inter-cropping system conforms to the famous assertion by several authors that inter-cropping offers a more efficient means of using growth resources (Wiley 1979, Fordham 1983 and Clark and Myers 1994). Compared to the other crop combinations, 4 years old oil palm – cocoa association was the most productive option and generated the highest net income of 26.5 million cedis. The income equivalent ratio as an economic index for assessing the productivity of these cropping systems revealed that in oil palm monoculture, 25% more land area would be required to generate the income earned from the 4 years old oil palm – cocoa association where as only 0.085% and 0.02% additional land would be sufficient to generate the incomes accrued from 2 years old oil palm – cocoa association and 6 years old oil palm – cocoa association respectively.

Clearly, the most appropriate time to plant cocoa under oil palm is when the palm trees planted at a spacing of 10.5 m triangular are 4 years old.

CONCLUSION

The agronomic and economic indices evaluated favored 4 years oil palm – cocoa inter-planting. Given the input and output quantities and prices, it is agronomically and economically sound to under-plant oil palm with cocoa when oil palm trees are 4 years old.

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