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Intercropping Cocoa and Oil Palm

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In a feasibility study of intercropping cocoa and oil palm using various combinations of avenue planting, three intercropped treatments were tested against their respective monocrop controls. Early growth and yield performance of both cocoa and oil palm were encouraging. The most promising treatment appears to be the one with single row oil palm at 10m x 7m (143 palms per hectare interplanted with a single row of cocoa at 10m x 2.5m (400 trees per hectare).

The hedged planting of oil palm has not resulted in any depression of its yield. The yield of cocoa on the other hand corresponds almost proportionally to its respective planting density in the various treatments. A simple cost-benefit analysis based on conservative prices of the two commodities (ex-farm price of $1.50/kg raw cocoa bean; $333/t palm oil and $319/t kernel) indicates that monocropping of cocoa gives a better return than monoculture oil palm, but the returns can be comparable when the latter is suitably intercropped with cocoa. The trial has, however, entered only its seventh year. It is therefore not known whether this performance can be sustained in view of the possible increase in competition for light, nutrients and water as the trees grow older.

Intercropping of cocoa with coconut has been proven to be a highly profitable venture. The association between these two crops has been regarded as near ideal and the profitability difficult to match by other agriculture enterprise in the tropics (Leach, Shepherd & Turner, 1969; Blencowe, 1971). The acreage of coconut in Malaysia, however, has remained stagnant for the past decade, while the area under oil palm has expanded by leaps and bounds. The Federal Land Development Authority (FELDA) alone has developed to-date some 200 000 ha of oil palm holdings in West Malaysia.

The success of cocoa/coconut intercropping has stimulated similar interest in the combination of oil palm and cocoa. Early results of growing cocoa under oil palm have however, not been very encouraging (McCulloch, 1968), but the prospect of probable good economic returns has prompted FELDA to undertake a different approach in the investigation of the intercropping of the two crops.

MATERIALS AND METHODS

The trial is located at Tun Razak Agriculture Research Centre in Tekam, Pahang. It consists of the following treatments:

- Normal oil palm monoculture at 9m triangle spacing (143 palms per hectare).

- Double row oil palm at 25m/2 x 7m with five rows of cocoa in between at 25m/5 x 3m (114 palms per hectare + 667 cocoa per hectare).
- Single row oil palm at 10m x 7m plus single row cocoa at 10m x 2.5m (143 palms per hectare + 400 cocoa per hectare).
- Single row oil palm at 13m x 7m plus three rows cocoa at 13m/3 x 3m (110 palms per hectare + 761 cocoa per hectare).
- Normal cocoa monocrop at 3m x 3m square planting (1 111 cocoa per hectare).

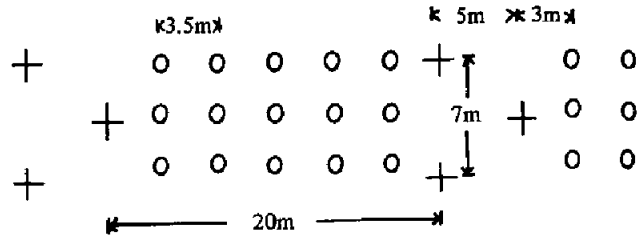
The actual planting patterns for the various intercropped treatments are given in *Figure 1.* The layout consists of a randomised block design with three replications. Each treatment occupies approximately 1 ha and has a guard space of 10m planted with *Gliricidia maculata* and cocoa. The plots are located on soils consisting mainly of a shale-derived mixture of Durian and Malacca series, with only patches of local alluvial and some negligible Munchong lateritic. A detailed soil survey of the area has been carried out. Topographically the land is gently undulating. The treatments and the replications are reasonably well distributed amongst the soil series and relief.

All the avenue palms were planted in the north-south direction to minimise self-shading and to maximise shading of the cocoa. Oil palm was planted in October 1970. Commercial DP seedlings from a neighbouring FELDA scheme nursery were used. Five-month-old hybrid cocoa seedlings were transplanted to the field one year later in August 1971. The seeds were supplied by the Department of Agriculture, Sabah. They were raised in a standard FELDA sprinkler irrigation nursery in 15 x 23 cm layflat black perforated polybags under an erected palm-frond shed. Planting was completed within seven days.

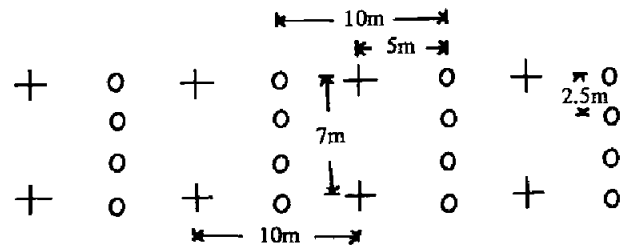
A combination of *Gliricidia* and *Parkia* was planted at the centre of the cocoa interrow at an approximate ratio of one shade to four cocoa trees. Bush cover, *Moghania macrophylla,* was also sown on both sides of the cocoa rows at approximately 4 kg/ha to provide some lateral shade and subsequent mulch. All the shade plants were established in late 1970, *i.e.*, one year before the planting of cocoa. Normal *Centrosema* and *Pueraria* creeping covers were established in the oil palm control plots.

In mid-1972, about one year after the establishment of cocoa, all *Moghania sp.* was eradicated. The slashed branches served as mulch for cocoa. Later, in late 1974, all the *Gliricidia* in the intercropped plots was cut down and poisoned in order to reduce the overhead shade. The *Gliricidia* shade in the cocoa control plots was pruned periodically to prevent excessive shade.

(a) Treatment 2



(b) Treatment 3



(c) Treatment 4

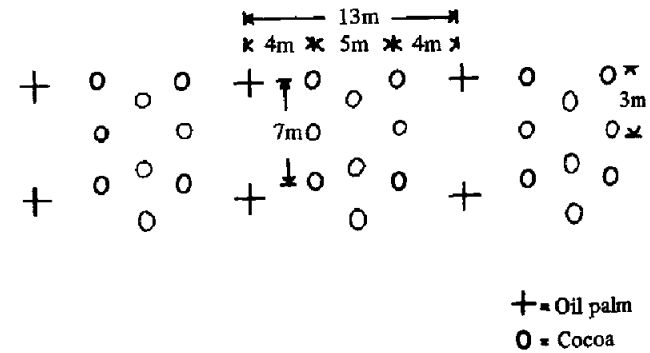


Figure 1. Planting pattern of cocoa and oil palm intercrop treatments

The oil palm received fertiliser at rates accorded to crops of similar age. The rates for mature palms were based on foliar analysis recommendations and increased from 7.7 kg/palm (NPKMg 6 : 5 : 16 : 2) in the third to 9.9 kg/palm (NPKMg 5 : 4 : 17½ : 3½) in the seventh year after planting.

Manuring of cocoa was carried out three times a year with 0.3 kg/tree/year (NPKMg 11 : 4 : 16 : 2) in the 1st to 0.9 kg/tree/year (NPKMg 10 : 6 : 12 : 1½), after the fifth year of planting.

Castration was done on oil palm in mid-1972. Harvesting of FFB and cocoa pods was started in March 1973 and yield recordings were made on a plot basis. For convenience, yield of cocoa was converted to kilogram dry bean equivalent (DBE) per hectare basis by taking thirty pods to 1 kg of dry bean.

Lateral root distribution studies of both oil palm and cocoa were made by using the auger method outlined by Chan (1976). The roots were sampled vertically to a depth of 30 cm. Samples were taken between two adjacent palms or cocoa trees in the case of the two monoculture control treatments, while for the intercropped treatments, sampling was carried out between a palm and the mid-cocoa tree. The core samples were taken linearly and laterally at 30 cm intervals. Three samplings were done per treatment for each replicate. The oil palm and the cocoa roots in each soil core were separated after washing. For convenience, total root weights only were considered. Their dry weights were determined by drying to constant weight in the laboratory oven.

RESULTS

Early growth

Growth of cocoa trees about eight months after transplanting was comparable amongst the various treatments as shown in *Table 1*. The overall planting casualty rate was 3.6%. More than half the trees transplanted had begun to jorquette at this stage. Though the growth of individual trees was variable amongst the treatments, the difference was not significant.

TABLE 1. CASUALTY AND GROWTH PARAMETERS OF COCOA SEVEN TO NINE MONTHS AFTER FIELD PLANTING

No.	*Treatment*	*Basal stem diameter (cm)*	*Plant height (m)*	*Jorquette (%)*	*Casualty (%)*
1.	Mono-oil palm control	–	–	–	–
2.	2 rows O.P. + 5 rows cocoa	2.17	1.18	69	2.0
3.	1 row O.P. + 1 row cocoa	2.38	1.20	72	4.5
4.	1 row O.P. + 3 rows cocoa	2.15	1.14	57	5.1
5.	Mono-cocoa control	2.14	1.13	59	2.8
	Mean	2.21	1.16	65	3.6
	S.E.	± 0.10	± 0.06		

TABLE 2. YIELD OF OIL PALM FFB

No.	Treatment	Palm density (no./ha)	Oil palm FFB yield (t/ha) Mar-Dec 1973	1974	1975	1976	Jan-Jun 1977	Mean annual FFB yield (t/ha)	% over control yield	density
1.	Mono-oil palm control	143	2.68	7.05	21.22	17.59	9.19	13.33	100	100
2.	2 rows O.P. + 5 rows cocoa	114	2.62	6.85	18.99	11.80	7.41	11.01	82.6	80
3.	1 row O.P. + 1 row cocoa	143	3.31	10.71	24.45	18.61	11.59	15.86	119	100
4.	1 row O.P. + 3 rows cocoa	110	2.64	8.26	20.98	13.73	9.10	12.63	94.8	77
5.	Mono-cocoa control	–	–	–	–	–	–	–	–	–
Mean			2.81	8.22	21.41	15.43	9.32	13.21		
S.E.			± 0.20	± 0.20	± 1.03	± 1.64	± 0.75	± 1.29		

Yield

Yields of oil palm FFB amongst the various treatments were not significantly different in the first three years. A definite yield trend, however, persisted throughout the fifty-two months of the harvesting period (*Table 2*). Hedge-planted oil palm intercropped with single row cocoa (Treatment 3) consistently out-yielded the monoculture oil palm control, while those with multiple rows cocoa (Treatments 2 and 4) gave lower yield. The difference became significant only in the fourth year. The overall performance of Treatment 3 was better than that of the control by 19% though they had the same planting density.

Palms from the intercropped treatments yielded a higher number of bunches per palm. The difference was however not significant (*Table 3*). Examination of the bunch weight indicated that the double row oil palm treatment had a lower bunch weight while the two single row hedged planting intercrop treatments had a higher bunch weight than the monoculture oil palm control. Significant difference was observed only in the fifth year of harvesting (*Table 4*).

TABLE 3. INDIVIDUAL YIELD OF OIL PALM FFB

No.	Treatment	Bunches/palm Mar-Dec 1973	1974	1975	1976	Jan-Jun 1977	Mean annual bunches per palm
1.	Mono-oil palm control	6.1	10.7	13.5	12.9	6.2	11.4
2.	2 rows O.P. + 5 rows cocoa	7.9	12.3	15.9	12.6	7.1	12.9
3.	1 row O.P. + 1 row cocoa	7.6	15.3	15.2	14.1	7.5	13.8
4.	1 row O.P. + 3 rows cocoa	7.4	13.0	15.8	12.5	7.6	13.0
5.	Mono-cocoa control	–	–	–	–	–	–
Mean		7.3	12.8	15.1	13.0	7.1	
S.E.		± 0.5	± 1.2	± 0.8	± 0.6	± 0.5	

Difference in cocoa yield amongst the treatments was evident since the first year of harvesting, though this was not significant (*Table 5*). Except for the second year, the number of pods per individual tree for all the treatments was also not significantly different (*Table 6*). The yield from the various treatments corresponded fairly closely with their respective density of planting. Treatments 2 and 4 which have 60% and 68% tree stand respectively of the monoculture cocoa control yielded respectively an average of 62% and 66% of the control. Although Treatment 3, which has the lowest stand with only 36% of the control, yielded only 287 kg/ha DBE; this was equivalent to 45% of the control.

TABLE 4. MEAN OIL PALM BUNCH WEIGHT (KG)

No.	*Treatment*	*Mean bunch weight (kg/bunch)*					*Mean bunch weight*
		Mar-Dec 1973	*1974*	*1975*	*1976*	*Jan-Jun 1977*	
1.	Mono-oil palm control	3.10	4.65	11.05	9.62	10.44	7.77
2.	2 rows O.P. + 5 rows cocoa	3.01	5.03	10.84	8.55	9.42	7.37
3.	1 row O.P. + 1 row cocoa	3.12	4.99	11.57	9.59	11.16	8.09
4.	1 row O.P. + 3 rows cocoa	3.07	4.94	11.50	9.53	10.42	7.89
5.	Mono-cocoa control	–	–	–	–	–	–
Mean		3.08	4.90	11.24	9.32	10.36	
S.E.		± 0.05	± 0.09	± 0.26	± 0.58	± 0.19	

Pest and disease damage of the oil palm FFB was negligible. Pod losses from cocoa were, however, fairly substantial, averaging about 20% in each treatment. They were due mainly to rodent damage and brown pod rot. The rodents have apparently been diverted from oil palm to attacking cocoa pods, the latter being probably more palatable.

Root distribution

Results of the root distribution of oil palm and cocoa in the various treatments are presented in *Figures 2 (a)* and *2 (b)* respectively. Root distribution between the two monoculture cocoa trees in Treatment 5 is plotted in *Figure 2 (b)* along that of the two adjacent cocoa trees of the intercropped treatments for comparison.

The patterns of root distribution of the intercropped oil palm were similar to that of the control except that in Treatment 2 the quantity of roots appeared to be less. It can be noted that the root of the oil palm extended right into the inner cocoa interrows of the intercropped treatments. Trace amounts of oil palm roots were detected even some 10m away from the base of the palm in Treatment 2.

In cocoa, the lateral root distribution between adjacent cocoa trees in the intercropped treatments was also similar to that of the control, though the latter may have a slightly larger quantity of roots. The pattern and quantity of the cocoa lateral root distribution adjacent to the oil palm row were similar for all intercropped treatments.

TABLE 5. YIELD OF COCOA

No.	*Treatment*	*Cocoa density (no./ha)*	*Cocoa yield (kg/ha DBE)*					*Mean annual yield (kg/ha DBE)*	*% over control*	
			Mar-Dec 1973	*1974*	*1975*	*1976*	*Jan-Jun 1977*		*Yield*	*Density*
1.	Mono-oil palm control	–	–	–	–	–	–	–	–	–
2.	2 rows O.P. + 5 rows cocoa	667	86	420	439	506	257	394	62	60
3.	1 row O.P. + 1 row cocoa	400	114	365	299	359	114	287	45	36
4.	1 row O.P. + 3 rows cocoa	761	122	484	500	502	218	420	66	68
5.	Mono-cocoa control	1 111	180	625	744	871	303	633	100	100
Mean			126	480	496	560	223	434		
S.E.			± 24	± 62	± 76	± 37	± 19	± 55		

TABLE 6. INDIVIDUAL COCOA TREE YIELD (PODS)

No.	Treatment	No. of pods per tree					Mean total annual pods per tree
		Mar-Dec 1973	1974	1975	1976	Jan-Jun 1977	
1.	Mono-oil palm control	–	–	–	–	–	–
2.	2 rows O.P. + 5 rows cocoa	3.2	18.6	19.4	22.3	11.3	17.3
3.	1 row O.P. + 1 row cocoa	6.8	26.3	21.5	25.8	8.2	20.5
4.	1 row O.P. + 3 rows cocoa	4.1	19.5	20.1	20.3	8.8	16.8
5.	Mono-cocoa control	4.1	17.6	20.1	23.5	8.2	17.0
Mean		4.6	20.5	20.3	23.0	9.1	17.9
S.E.		±0.9	± 1.5	± 2.7	± 2.4	± 0.7	

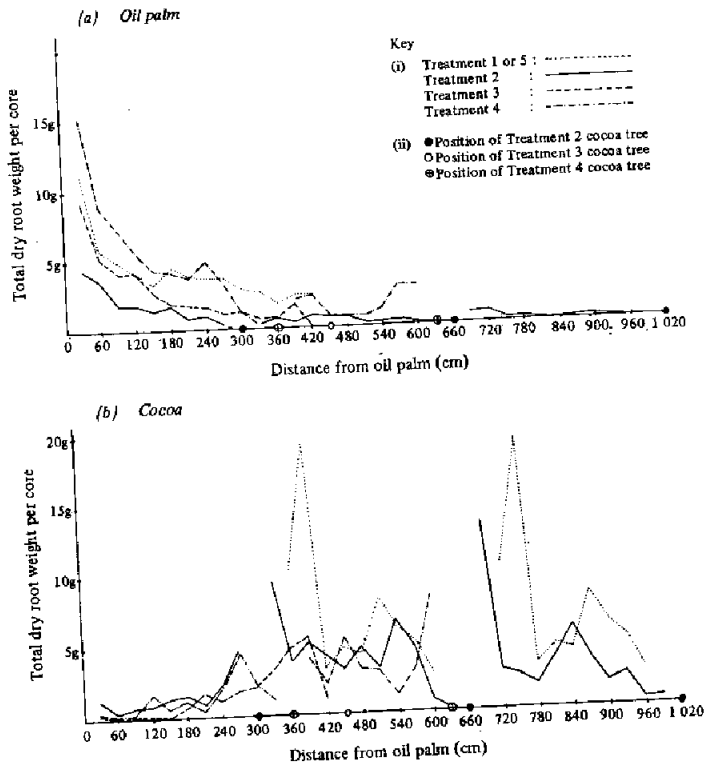


Figure 2. Lateral distribution of roots from oil palm to the mid-cocoa tree

DISCUSSION

As the age difference between oil palm and cocoa during transplanting was minimal, any overshading effect from oil palm would not be expected to be significant in the early stages. This was clearly manifested in the early growth and yield performance of cocoa.

The yield of cocoa in the control plot could be considered acceptable. Those from the intercropped treatments were quite reasonable in the first two years of harvesting. Subsequently, their yields seemed to stagnate at the second year level of 300–500 kg/ha DBE. Yield differences among the various cocoa treatments could be accounted at least partly due to the difference in their planting density, since the individual tree yield was almost similar.

In general, the oil palm FFB yield could also be regarded as reasonable, considering the poor Malacca/Durian soil on which the trial is located. Contrary to observations obtained in Nigeria (Hartley, 1969), the avenue spacing of intercropped oil palm treatments yielded almost as well as and some times even better than the control with the same, or nearly equal, density. In fact, taking the percentage over the control (*Table 2*), all the hedge-planted palms exceeded the proportion of their density with respect to the control in yield. This was probably due to the wider within-row spacing (7m) used in this trial as compared to that used in Nigeria (3.6m). Competition between palms was evident from the double row (5m apart) planting where, unlike the other two avenue planted treatments, the bunch weight was smaller than that of the control.

Although the root distribution study undertaken may not be complete or comprehensive, it nevertheless provides an indication of the relative root distribution in the upper surface region (30m) of the various treatments, where most of the cocoa (Smyth, 1966) and the oil palm feeder roots (Tinker, 1976) would generally be found. The extensive lateral distribution of oil palm roots in the intercropped treatments revealed that the intercropped oil palms have a bigger soil surface area and a larger quantity of nutrients and water for exploitation. The comparatively better yield of the intercropped oil palm with respect to their planting density, particularly for Treatments 3 and 4, is probably a reflection of such benefits derived from the cocoa planted in their interrows. The reduced quantity of oil palm roots in Treatment 2 could be caused by greater inter-palm competition arising from the closer double row planting.

The intercropped cocoa trees which are likely to benefit from any oil palm nutrients will be mainly those which are planted directly adjacent to the oil palm rows. The relatively lesser quantity of cocoa roots obtained adjacent to the oil palm region as compared to those between the two neighbouring cocoa trees implies that the distal or inner cocoa trees in the intercropped treatments have not extended any significant quantity of their roots into these regions. They are, therefore, unlikely to benefit

significantly from nutrients of oil palm. But the proximity of the cocoa adjacent to the oil palm rows in Treatment 2 (at 3m) and Treatment 4 (at 4m) may have resulted in greater shade effect and therefore offset any benefits derived from nutrients applied to the oil palm. It is well known that in general, shaded cocoa exhibits poor response to increased fertiliser application (Murray, 1966; Asomaning, 1972). On the other hand, the cocoa in the distal or inner rows of the intercropped treatments (Treatments 2 and 4) will encounter competition from oil palm for both nutrients and water. However, in Treatment 3, where the cocoa trees are planted further away from the oil palm (at 5m) there would be a reduced shading effect. Also, the oil palm and the cocoa are mutually benefiting from the dual fertiliser applications. This probably accounts for the constantly superior yield of Treatment 3.

Since individual cocoa tree yield is almost similar amongst the various treatments, increasing the density of cocoa may perhaps help to boost its yield return from the intercrop treatments. But the idea may not be too viable as it would entail planting cocoa closer to each other or to oil palm. This is likely to bring about greater competition, over-shading and even antagonistic effect with regard to the utilisation of fertiliser between cocoa or oil palm. Another possibility is to orient the hedge-palm rows in the east-west instead of the present north-south direction. It is not known, however, whether such orientation can significantly alleviate any yield constraint that may exist for cocoa at the expense of, perhaps, the yield of oil palm.

A simple cost benefit analysis is attempted (*Table 7*). The operating and production cost of cocoa for the various treatments is taken as proportional to their respective planting densities. The cost for monoculture cocoa in the inland region of Peninsular Malaysia has been estimated at about $1 000/ha and in the case of oil palm, estimate of production costs is at about $1 424/ha. Only yields from the third year onwards were used for the cost analysis as they would have been more indicative of the subsequent mature yield.

The analysis results show that monocrop cocoa control gives a higher percentage profit. However, the net revenues from all the intercropped treatments are higher when compared to the monocrop oil palm control, especially those from the single avenue palm row treatments. Amongst the latter, Treatment 3, with its hedge-planted oil palm row plus single row cocoa, appears to be the most favourable. The return of this treatment is approaching that of the monocrop cocoa control in terms of percentage profit. One added advantage for intercropping is, of course, the derivation of income from the diversified commodities, providing a safeguard against any price fluctuation.

TABLE 7. COST AND REVENUE OF COCOA/OIL PALM INTERCROPPING

Treatment	Density (no./ha)		Mean annual yield		Cost ($)		Total cost ($)	Revenue ($)		Total revenue ($)	Net revenue ($)	Profit (%)
	cocoa	oil palm	cocoa (kg/ha)	oil palm (t/ha)	cocoa	oil palm		cocoa	oil palm			
1	–	143	–	19.2	–	1 424	1 424	–	1 524	1 524	100	7.0
2	667	114	480.8	15.3	600	1 212	1 812	721	1 214	1 935	123	6.8
3	400	143	308.8	21.9	360	1 571	1 931	463	1 738	2 201	270	14.0
4	761	110	488.0	17.5	685	1 293	1 978	732	1 389	2 121	143	11.1
5	1 111	–	767.2	–	1 000	–	1 000	1 151	–	1 151	151	15.1

Note: (1) Cocoa revenue is based on ex-farm price of $1.50/kg dry bean, derived from twenty years (1957–1976) average London spot price of £382.05/t (Gill & Duffus, Cocoa Market Reports 1977) less 10% freight charges and other trade discount; and an exchange rate of $4.36 to £1.

(2) Oil palm revenue is based on that used by Paterson (1969) and Khera (1976): with an assumed oil extraction rate of 20% and ex-farm price of $333/t, while kernel at 4% FFB and ex-farm price of $319/t.

(3) Yields of oil palm and cocoa are based on mean of 1975/77 production.

CONCLUSION

Early results indicate that with suitable hedge-planting of oil palm, intercropping of cocoa is feasible. A simple cost analysis shows that it can give a higher return than the monocrop oil palm control but is lower than the monocrop cocoa control. The individual yield of the intercropped oil palm in all treatments has exceeded that of the control while their plot yields were almost as good as and in one case (Treatment 3) even better than the monocrop control. This can be attributed to the additional nutrients derived from the intercropped cocoa area. On the other hand, the cocoa in the intercropped treatments could hardly benefit from the intercropping except for Treatment 3. This can be attributed to close oil palm shade and the unavailability of the oil palm nutrients to the distal intercropped cocoa rows. Nevertheless, the individual yield of the intercropped cocoa was comparable to or even better than (in the case of Treatment 3) their monocrop control.

Suitable hedge planting of oil palm has apparently reduced the overall shading effect of oil palm under the normal planting distance. At the moment however, it is too early to know whether this yield trend will be maintained, since the palms have been only seven years in the field. Further overshading of cocoa and competition may occur as the palms grow older and taller. This may subsequently suppress the individual performance of the cocoa interplanted under the palms. Also, the competition between hedge-planted palms may become significant.

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