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Cacao-coconut intercropping in Ghana: agronomic and economic perspectives

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Abstract

In Ghana, shade for cacao (*Theobroma cacao* L.) is becoming a critical issue because of extensive deforestation. Unlike in some other cacao-growing countries, cacao is not grown under the shade of coconut (*Cocos nucifera*) in Ghana. An experiment to compare the merits of four cacao-coconut intercropping systems with the traditional cultivation of cacao under *Gliricidia sepium* shade was undertaken at the Cocoa Research Institute of Ghana. Cacao seedling girth was not affected when intercropped with coconut but was significantly ($P = 0.01$) reduced when intercropped with *G. sepium*. High density cacao facilitated better early canopy formation. Yield of cacao spaced at 2.5 m triangular (1739 plants ha^{-1}) with coconut at 9.8 m triangular (105 plants ha^{-1}) was significantly higher ($P = 0.05$) than from the other treatments during 1993/94 to 1995/96. There were no major disease problems associated with intercropping cacao with coconuts. Widely spaced coconuts intercropped with cacao spaced at 3 m × 3 m showed better flowering and gave higher coconut yields, but cacao spaced at 2.5 m triangular under coconuts spaced at 9.8 m triangular was more profitable than the other treatments. Moisture stress was the greatest in cacao system with *G. sepium* shade and this could be responsible for the low yield of cacao in that treatment. It is suggested that properly arranged high density cacao under widely spaced coconuts can be a profitable intercrop system for adoption by cacao farmers in Ghana.

Introduction

In Ghana, cacao (*Theobroma cacao* L.) is traditionally planted under thinned forest tree shade (Wood 1985). In cases where the shade tree species are of economic value, their exploitation for timber destroys the cacao farms through logging activities and inadequate shade. Shade is also provided by fruit trees like oil palm (*Elaeis guineensis*), avocado (*Persea americana*), coconut (*Cocos nucifera*) and citrus (*Citrus sinensis*) interspersed in the farm (Alvim 1988 Oladokun 1990). The profitability of cacao shaded with *Cola nitida* has been discussed by Oladokun and Egbe (1990). Benneh (1987) noted that the practice of perennial tree crop intercropping is an attempt to spread the financial risk in cacao farming.

In Indonesia and Malaysia, cacao is sometimes planted under coconut trees (Daswir et al. 1988 Abbas and Dja'far 1989). Mixed cropping systems of coconuts with cacao, rubber (*Hevea brasilensis*), mango (*Mangifera indica*), cashew (*Anacardium occidentale*), breadfruit (*Artocarpus communis*) and citrus are also commonly practised in several countries (Purseglove 1976). Fagon and Topper (1988) found in Jamaica that closely planted cacao under coconuts yielded more cacao than when widely spaced. Daswir et al. (1988) reported that cacao intercropped with coconut was less profitable than with *Leucaena glauca* in Indonesia. In Kerala State, India, coconut intercropped with double rows of cacao has been reported to be more profitable than that intercropped with a single row (Nair 1979 Bastine et al. 1986). According to Mathes (1986), the relative return to a cacao-coconut intercropping was second highest compared to coconut alone, coconut and coffee (*Coffea robusta*) and coconut and black pepper (*Piper ni-*

grum). Depending on the location and associated environmental factors, coconut yields range between 2500 to 7600 nuts ha^{-1} from plant densities ranging between 140 to 200 palms ha^{-1} (Purseglove 1976). In the Ivory Coast, the optimal planting density for the West African Tall was reported to be between 143 to 160 trees ha^{-1} (Coomans 1974 De-Taffin et al. 1992).

Some agronomic benefits of coconut intercropping are better land and solar radiation utilization, better retention of soil moisture, improved soil fertility and checking of erosion in wet and slopping areas (Nair 1979 Liyanage 1985).

In Ghana, cacao is not commonly cultivated under coconut shade. Most often, coconuts found in a cacao plantation indicate where hamlets have been overtaken by cacao farms, but where sole coconuts are cultivated in the Central and Western Regions of Ghana, a spacing of 8.5m triangular is commonly used (F. Ofori, pers. comm., 1998). Shade for cacao cultivation is becoming critical because of the large-scale deforestation in the cacao growing areas (Salleh 1997), hence this trial was set up to investigate the merits in the use of coconut as shade for cacao. The trial also attempts to compare the benefits of different spatial arrangements of cacao and coconut as an intercrop system.

Materials and methods

The trial was conducted at the Cocoa Research Institute of Ghana, Tafo (06°15′ S, 00°25′ E). The soils at the site are deep gravely-clay loams or Rhodic Ferralsols (FAO/UNESCO 1999) with a pH of 5.5 and 40 to 50% base saturation. Prior to 1982, the plot was used for an Amazon cacao x shade x fertilizer trial. The land was then left fallow for five years. *Terminalia ivorensis* trees in the plot were clear-felled and the stumps were poisoned with Garlon 2 (Triclopyr) to prevent regeneration. The configurations and planting densities, constituting the experimental treatments illustrated in (Figure 1) were:

1. Cacao spaced at 3 m × 3 m and intercropped with *Gliricidia sepium* spaced at 12.0 m × 6.0 m as control (T1). The *G. sepium* was eventually thinned to 12.0 m × 12.0 m five years after planting.
2. Cacao spaced at 2.5 m triangular with coconut at 8.8 m triangular spacing (T2).
3. Cacao spaced at 3 m × 3 m with coconut at 9.1 m triangular (T3).
4. Cacao spaced at 2.5 m triangular with coconut at 9.8 m triangular (T4).
5. Cacao spaced at 3 m × 3 m with coconut at 12.2 m × 10.7 m (T5).

As illustrated in (Figure 1), the cacao rows in T4 were arranged at 2.5 m away from the coconut trees whilst in T2 the cacao was not uniformly spaced away from the coconuts, thus giving different cacao plant densities as indicated below.

The densities of the various components in the treatments on a hectare basis can be found in (Table 1):

Certified high yielding ″seed″ of tall coconuts were acquired from the University of Ghana Agricultural Research Station, Kade in 1986. The nuts were pre-germinated by regular watering in the nursery and were subsequently potted off into large black polythene bags of size 30 cm × 45 cm holding about 15 kg of soil. The coconut seedlings were kept for one year under the shade of *G. sepium* (about 60% sunlight) in the nursery until they attained approximately 1 m central frond height at the time of transplanting. The coconut seedlings and *G. sepium* cuttings of approximately 1.5 m length were planted at the requisite spacings in June/July, 1987. Plantain (*Musa sapientum*) suckers were intercropped in the entire plot at 3 m × 3 m to provide temporary shade (about 50% incident sunshine) for the cacao seedlings in July 1988. The shade trees and plantains were maintained by regular weeding and removal of climbers.

In June/July 1989, six-month-old hybrid cacao (Upper Amazon x Amelonado) seedlings were transplanted into the field at the required spacings. Basal chupons (suckers) on the cacao were pruned twice a year, and insect pests were controlled by spraying with the recommended chemicals. Manual weed control was undertaken as and when necessary and the plantain was eliminated as the cacao canopy closed. Data were gathered on growth, development and yield of cacao and phenology of coconut. The growth parameters studied on cacao were stem girth measured at 15 cm from the ground with calipers and seedling height measured from the ground. The growth rate of the cacao seedlings was obtained as the difference between the absolute values of two consecutive years. The cacao plant canopy closure was obtained by estimating the area shaded by the crown of the tree within the rows and extracting the average per plot basis. The proportion of cacao seedlings in the core

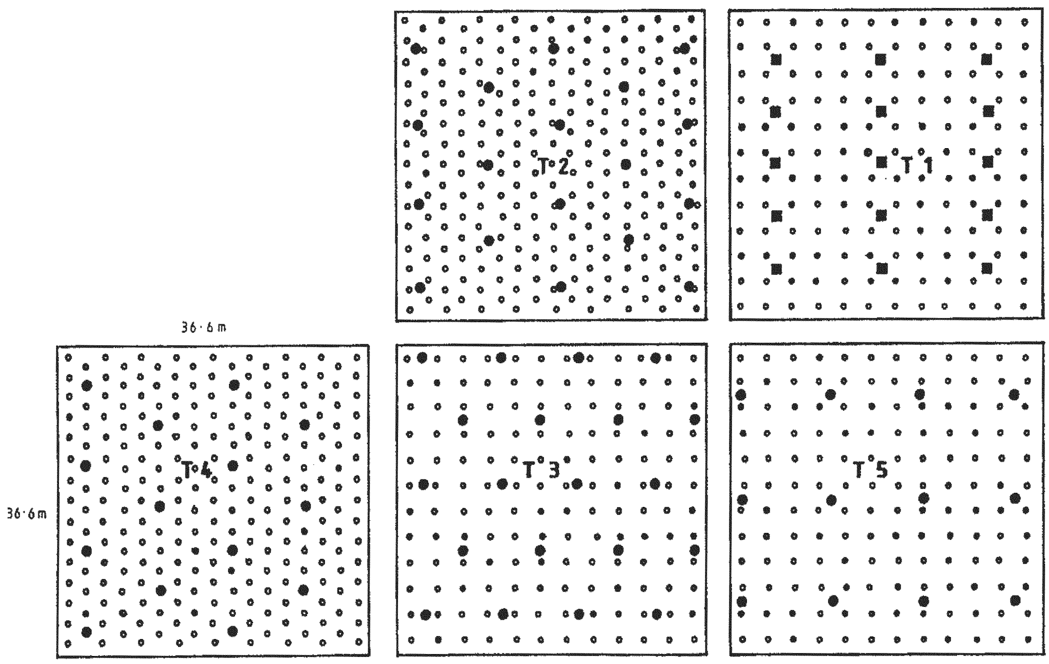

Figure 1. **Legend:**
T1 – Cacao (●) at 3 m × 3 m, *G. sepuim* (■) at 12.0 m × 12.0 m;
T2 –Cacao (●) at 2.5 m triangular coconut (○) at 8.8 m triangular;
T3 – Cacao (●) at 3 m × 3 m; coconut (○) at 9.1 m triangular;
T4 – Cacao (●) at 2.5 m triangular, coconut (○) at 9.8 m triangular;
T5 – Cacao (●) at 3 m – 3 m, coconut (○) at 12.2 m – 10.7 m.
Spatial arrangement of the components in the cacao-coconut intercropping trial at CRIG, Tafo, Ghana.

Table 1. Treatment.

	Treatment				
	1	2	3	4	5
Cacao	1074	1829	1074	1739	1074
	(1111)	(1844)	(1111)	(1844)	(1111)
Coconut	–	134	149	105	90
	–	(170)	(150)	(115)	(90)
G. sepium	67	–	–	–	–
	(70)	–	–	–	–
Plantain for shade	1111	1111	1111	1111	1111

Figures in parentheses represent the expected densities.

of a plot that produced flowers was recorded three years after planting and transformed into percentages. Because of the high incidence of theft from the young coconut palms, nut yields were estimated by using immature fruits with approximately 5 cm diameter. Soil moisture content was measured bi-monthly for 18 months, using the gravimetric method from two replications per treatment at 15 cm, 30 cm and 45 cm soil depth.

Results

Growth studies

The treatment effect on stem development of one-year-old cacao was statistically significant at $P \leqslant 0.001$. Cacao seedlings in T1 showed the least girth increment; but no differences were observed in that of cacao seedlings intercropped with coconuts. Cacao plant height in T1 was significantly shorter ($P = 0.05$) than from the other treatments. Taller seedlings were however produced in T4 plots than in T2 and T3 (Table 2). At two years after planting, the treatment effect on percentage flowering of cacao was not significant. Up to about 50% canopy closure was attained at the end of the third year in all the treatments. In T2 and T4 plots, significantly ($P = 0.05$) higher canopy closure (81% and 86% respectively) was observed than in T5 (65%) in year four (Table 2).

Table 2. Rate of growth, flowering and canopy closure in cacao under various intercropping treatments at CRIG, Tafo, Ghana.

	1989–1990		1991	1992	1993
	Girth increment (mm)	Height increment (mm)	% flowering	% canopy closure	
T1	1.0	18.2	12.5	58	75
T2	12.2	59.3	14.6	65	81
T3	10.1	62.3	10.4	57	75
T4	12.6	80.2	18.8	68	86
T5	11.5	69.3	16.7	48	65
SED (12 df)	1.7	15.5	–	–	6.3
C.V. %	24.8	37.8	–	–	11.6

T1 = Cacao (3 m × 3 m spacing) intercropped with *Gliricidia sepium* (initially at 12.0 m × 6.0 m spacing, thinned to 12.0 m × 12.0 m after 5 years); number of cacao plants per ha = 1074.
T2 = Cacao and coconuts at triangular configurations; cacao 2.5 m and coconut 8.8 m spacing; number of plants/ha – cacao 1829 and coconut 134.
T3 = Cacao 3 m × 3 m; coconut 9.1 m triangular; number of plants/ha – cacao 1074, coconut 149.
T4 = Cacao and coconuts at triangular configurations; cacao at 2.5 m and coconut 9.8 m spacing; number of plants/ha – cacao 1739 and coconuts 105.
T5 = Cacao (3 m × 3 m spacing) intercropped with coconut at 12.2 m × 10.7 m; number of plants/ha – cacao 1074 and coconut 90.

Table 3. Yield of cacao under various intercropping treatments at CRIG, Tafo, Ghana.

Treatment[a]	Crop years Dry beans (kg ha^{-1})							
	1991/92	1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	Cumulative yield
T1	29.6	126.2	613.8	807.3	810.1	426.5	223.5	3037.0
T2	53.2	233.4	943.0	1240.8	1179.5	678.3	648.9	4977.1
T3	20.4	207.7	1167.6	1601.4	1828.5	1161.3	615.1	6602.0
T4	48.9	397.8	1770.8	2337.5	2353.0	1325.1	622.1	8855.2
T5	19.4	197.8	1299.3	1447.7	1768.2	1099.4	636.8	6468.6
Sig. level	ns	ns	*	**	*	ns	ns	
SED (12 df)	–	–	323.2	289.0	394.8	–	–	
CV %	–	–	39.4	27.5	35.2	–	–	

* Significant $P \leqslant 0.05$; ** Significant $P \leqslant 0.01$. [a]See Table 2 for treatment configurations.

Crop yields

Cacao

Treatment effect on the yield of cacao beans was statistically significant only in 1993/94, 194/95 and 195/96 (Table 3).

The highest yields of 1771 kg ha $^{-1}$ and 2337 kg ha $^{-1}$ were recorded in the T4 plots in 1993/94 and 1994/95 respectively. The lowest yields obtained for the same periods were 614 kg ha $^{-1}$ and 807 kg ha $^{-1}$ respectively in treatment T1. The differences in yield between T3, T5 and T2 were not statistically (P = 0.05) significant. In 1995/96, the yield in T4 plot was significantly higher (P = 0.05) than that in T2 and T1 plots. Differences in mean yield between T3, T4 and T5 were not significant. The yield of cacao declined in 1996/97 and 1997/98 and no significant differences between treatments were observed. The cumulative cacao bean yield over seven years was greatest in T4 (8.9 t ha $^{-1}$) followed by that in T3, T5 and T2 with 6.6, 6.5 and 5.0 t ha $^{-1}$ respectively whilst the least yield of 3.0 t ha $^{-1}$ was recorded in treatment T1.

Pod losses due to black pod rot caused by *Phytopthora palmivora* and cherelle wilt (a physiological defect) were quite high (15% and 48% respectively) in proportion to the healthy pods produced in 1991/92 (Table 4). However pod losses were low in subsequent years, except in 1996/97 when a significantly ($P \leqslant 0.01$) high pod rot ranging between 12–15% occurred in T1 and T2. The high pod rot (31%) in T1 compared to the other treatments in 1997/98 was statistically non-significant.

Table 4. Pod losses from cacao plants under varying intercropping treatments at CRIG, Tafo, Ghana.

	Crop years													
	1991/92		1992/93		1993/94		1994/95		1995/96		1996/97		1997/98	
Treatment[a]	%BP+	%IR++	%BP+	%IR++	%BP+	%IR++	%BP+	%IR++	%BP+	%IR++	%BP+	%IR++	%BP+	%IR++
T1	6.2	65.6	16.2	12.3	5.5	7.2	5.2	3.8	6.2	10.9	14.8	20.6	31.3	15.7
	(14.4)	(54.1)	(23.7)	(20.5)	(13.6)	(15.6)	(13.2)	(11.2)	(14.4)	(19.3)	(22.5)	(26.9)	(33.9)	(23.2)
T2	16.5	37.1	14.2	10.3	8.0	14.8	5.2	6.2	6.1	12.2	11.8	14.8	19.7	14.9
	(24.0)	(37.5)	(22.1)	(18.7)	(16.4)	(22.6)	(13.2)	(14.4)	(14.3)	(20.4)	(20.1)	(22.6)	(26.3)	(22.7)
T3	30.2	38.6	11.2	13.1	6.4	12.1	4.8	5.3	5.5	6.0	8.2	16.0	21.7	16.0
	(33.3)	(38.4)	(19.5)	(21.2)	(14.6)	(20.4)	(12.7)	(13.3)	(13.5)	(14.2)	(16.6)	(23.5)	(27.1)	(23.6)
T4	15.4	47.1	15.1	19.0	9.4	12.8	2.8	4.2	7.4	5.9	6.8	14.1	19.0	17.9
	(23.1)	(43.3)	(22.9)	(25.8)	(17.8)	(20.9)	(9.6)	(11.8)	(15.8)	(14.1)	(15.1)	(22.1)	(25.8)	(25.0)
T5	6.3	50.8	10.5	13.3	4.4	9.1	2.2	4.8	5.1	5.5	9.6	12.5	15.3	19.1
	(14.5)	(45.5)	(18.9)	(21.4)	(12.1)	(17.6)	(8.5)	(12.7)	(13.1)	(13.6)	(18.0)	(20.7)	(23.0)	(25.9)
Sig. level	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	**	ns	ns	ns
SED (12 df)	–	–	–	–	–	–	–	–	–	–	(1.8)	–	–	–
–	–	–	–	–	–	–	–	–	–	(13.9)	–	–	–	

+ BP – Percent ballpod rot; ++ IR – Percent cherelle wilt; () – Figures in parentheses represent angular transformed data; ** – Significant P $\leqslant$ 0.0; ns – Not significant at $P = 0.05$. [a]See Table 2 for treatment configurations.

Coconuts

Although a higher proportion of the coconuts flowered earlier from treatments T3 and T5, differences in percentage flowering, percent of bearing coconuts and nut production from the different treatments were not significant (Table 5). Cumulative nut production was however highest from T3 (4095 nuts ha^{-1}) followed by T5 (3176 nuts ha^{-1}). The lowest nut yield of 2730 nuts ha^{-1} was recorded from treatment T4.

Intercrop performance

T4 gave the highest revenue followed by T3, T5, T2 and T1 (Table 6). The revenue trend followed the yield pattern obtained from the cacao (Table 3) with very small contributions ranging from 0.5% to 17% from the coconuts.

Soil moisture

During the dry season, soil moisture content was significantly greater in treatments with coconuts than in those intercropped with *G. sepium*. Soil moisture contents were not significantly different within treatments intercropped with coconuts.

Discussion

Intercropping cacao with coconut is practised on a small scale in Sri Lanka(Liyanage 1985), and in Northeast Brazil (Alvim and Nair 1986). According to Liyanage (1985), it helps to spread the risk of tree crop farming for the smallholder farmer as an agroforestry land use system but it may not be necessarily economically (Oladokun 1990 Brierley 1987). In both Nigeria and Ghana, tree crop intercropping systems have been practised for generations without a serious look at the biological and economic advantages (Ekanade and Ebge 1990 Oladokun 1990 Benneh 1987). One reason for the failure to recognise the contributions of the components in the system was that some of the components occurred haphazardly and sometimes very sparingly. By standardising the spatial arrangements of the cacao and coconuts in the present investigations, it was possible to determine the best combination that can be recommended to farmers.

According to Glendining (1960), the most sensitive measure of cacao growth is the girth rather than the height increments. This was supported by this trial in which girth increments in the cacao were not significantly different between the treatments intercropped with coconuts; but these showed superior growth than when intercropped with *G. sepium*. Height increments varied between T4 and the other treatments but according to Glendining (1960), this

Table 5. Performance of coconuts intercropped with cacao at CRIG, Tafo, Ghana.

Treatment[a]	% flowering coconut 1992/93	1993/94	1994/95	1995/96	1996/97	1997/98	% yielding coconut trees 1993/94	1994/95	1995/96	1996/97	1997/98
T1	–	–	–	–	–	–	–	–	–	–	–
T2	6.3	26.3	36.0	56.3	61.3	65.0	3.8 (1.0)	15.0	30.0	47.5	51.3
	(12.4)+	(29.9)	(41.3)	(48.6)	(51.7)	(54.0)		(22.1)	(33.0)	(43.5)	(45.7)
T3	17.5	40.0	53.0	61.3	68.8	71.3	13.8	30.0	37.5	44.7	51.3
	(23.9)+	(38.2)	(46.4)	(51.8)	(59.9)	(58.2)	(21.1)	(31.8)	(37.0)	(41.9)	(45.7)
T4	3.6 (7.7)+	37.5	50.0	60.7	69.7	71.4	8.9 (14.9)	20.0	32.1	44.7	51.3
		(36.9)	(45.0)	(51.2)	(56.7)	(57.8)		(25.9)	(34.8)	(41.9)	(47.1)
T5	3.6 (7.7)+	45.8	58.0	70.7	75.0	75.0	14.6	25.0	43.8	56.3	60.4
		(42.5)	(49.8)	(57.8)	(60.9)	(60.8)	(19.2)	(28.9)	(41.3)	(48.6)	(51.1)
Sig. level	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

	No. of coconut fruits per ha[b] 1993/94	1994/95	1995/96	1996/97	1997/98	Cumulative coconut yield per ha
T1	–	–	–	–	–	
T2	136	157	579	1001	1022	2895
	(11.7)++	(12.5)	(24.1)	(31.6)	(31.9)	
T3	254	441	1106	1403	891	4095
	(15.9)++	(21.0)	(33.2)	(37.4)	(29.8)	
T4	60	150	454	570	1496	2730
	(7.7)++	(12.2)	(21.3)	(23.9)	(38.7)	
T5	108	177	671	1088	1132	3176
	(10.4)++	(13.3)	(25.9)	(32.9)	(33.6)	
Sig. level	ns	ns	ns	ns	ns	

– Figures in parentheses represent angular (+) and square root (++) transformed data; ns – not significant at $P = 0.05$. [a]See Table 2 for treatment configurations. [b]Potential yield of coconuts with fruit size above 5 cm width.

Table 6. Economic returns[1] of the cacao-coconut intercrop system at CRIG, Tafo, Ghana.

	1991/92 Cacao	cocoanut	1992/93 Cacao	cocoanut	1993/94 Cacao	cocoanut	1994/95 Cacao	cocoanut	1995/96 Cacao	cocoanut	1996/97 Cacao	cocoanut	1997/98 Cacao	cocoanut	Cumulative
T1	7.6	–	38.9	–	429.6	–	678.1	–	972.1	–	767.7	–	502.9	–	3397.0
T2	13.7	–	71.9	–	660.1	13.6	1042.3	15.7	1415.4	86.9	1220.9	200.2	1460.0	204.4	6405.1
						(2.0)		(1.5)		(5.8)		(14.1)		(12.3)	
T3	5.3	–	64.0	–	817.3	25.4	1345.2	44.1	2194.2	106.9	2090.3	280.6	1384.0	178.2	8594.5
						(3.0)		(3.2)		(4.6)		(11.8)		(11.4)	
T4	12.6	–	121.6	–	1239.6	6.0	1963.5	15.0	2823.6	68.1	2385.2	114.0	1399.7	299.2	10448.1
						(0.5)		(0.8)		(2.4)		(4.6)		(17.6)	
T5	5.0	–	60.9	–	909.5	10.8	1216.1	17.2	2121.8	100.7	1978.9	217.6	1432.8	226.4	8298.2
						(1.2)		(1.3)		(4.5)		(9.9)		(13.6)	
	0.258+	–	0.308	–	0.700	0.100++	0.840	0.100	1.200	0.150	1.800	0.200	2.250	0.200	

+ – Unit price of kg dry cocoa beans (Source: COCOBOD); ++ – Tafo market price for milk coconut fruit; () Figures in parentheses represent proportion of revenue derived from coconut fruits. [1] In units of 1000 cells. [2] See Table 2 for treatment configurations.

may not be a useful measure of seedling performance. The better canopy closure in T2 and T4 compared to the other treatments at year four could have been due to the higher density of cacao in these two treatments. However over a period of seven years, cacao yields from the cacao-coconut intercrop system were 54% to 193% higher than when intercropped with *G. sepium*.

Among the cacao-coconut intercrop systems, planting cacao at 2.5 m triangular with coconut at 9.8 m triangular (T4) gave the greatest cumulative cacao yield (8.85 t ha $^{-1}$) over seven years. In 1993/94 to 1995/96, the yield of cacao in this plot was significantly higher than in the other treatments. Cacao was planted at the same spacing in both T2 and T4, but the densities of cacao and coconut were greater in T2 (1829 and 134 trees ha^{-1} respectively) than that in T4 (1739 and 105 trees ha^{-1} respectively) because of their different spatial arrangements. Thus the higher yield in T4 could be due to the combination of better spatially arranged high density cacao (Bastine et al. 1986) under widely spaced coconuts. This probably allowed for adequate solar radiation to pass through the canopy to the lower strata of cacao in the T4 plot than in the T2 plot (Liyanage 1985). Interestingly, Amoah et al. (1995) have recorded similar significantly higher yields of cacao planted under widely spaced (10.1 m) than under closely spaced (8.8 m) oil palms and explained this in terms of better illumination under the former than the latter. On the other hand, the low cumulative yield of cacao in plot T5, with widest spaced coconut trees, was due to its low planting density of 1074 plants ha^{-1} as compared to 1739 plants ha^{-1} in plot T4 (Fagon and Topper 1988 Osei-Bonsu et al. 1996). The decline in the yield of cacao for two consecutive years probably represented a loss in soil fertility of an area that had previously carried cacao for twenty years and had only been fallowed for five years. It may therefore be necessary to apply fertilizers to restore soil fertility. Soil moisture was lower in T1 especially during the dry season, than in the other treatments. This is consistent with the observation by Liyanage (1985) that coconuts helped to conserve soil moisture. It is also possible that competition for moisture by the intercropped *G. sepium*, which flower and produce flushes in the dry season (November to March), exacerbated the low moisture content. This increased moisture stress could have resulted in the low yields obtained from T1. On the other hand, the soil in T2 also showed marginal low moisture contents (water stress) during the same period and this together with the poor illumination for the cacao could be responsible for the low cacao yields recorded in this treatment. It may therefore be necessary to evaluate the performance of different spatially arranged high densities of cacao under widely spaced coconuts at different locations to arrive at specific recommendations for the country.

The high incidence of black pod rot and cherelle wilt in the cacao crop in 1991/92 was due to the relatively low yield of cacao at the initial bearing stage that distorted the proportions extracted. However, the slight increase in cacao crop losses over the years may indicate a greater level of competitive stress from the maturing coconuts thus resulting in more cherelle and pod defects.

Coconuts intercropped with cacao at 2.5 m triangular (T2 and T4) did not perform well in this experiment. Coconuts intercropped with cacao at the spacing of 3 m × 3 m in plots T3 and T5 however yielded 4095 and 3176 nuts ha^{-1} respectively. It is worth observing that over the years there was higher flowering and podding from plots T3 and T5 than from plots T2 and T4. This could have been due to the competition exerted on the coconuts by the higher densities of cacao in plots T2 and T4. Also important was the fact that the coconuts were still juvenile when this study was conducted. Light availability on the plantation floor vis-à-vis shading from the cacao change as the coconuts grow taller and this could play a role in the yields obtained from the coconuts (Nair 1979). Thus, as more coconut trees mature and come into bearing, higher coconut yields would be expected from the favourable environments created for the coconuts (Purseglove 1976). On the other hand, with the possible decline in soil fertility in the experimental area, higher losses of cacao pods from cherelle wilt and black pod may likely occur in the cacao planted at high densities in plots T2 and T4.

Contrary to Daswir et al. (1988) intercropping cacao with coconuts was more profitable than intercropping with *G. sepium*, primarily due to the absence of additional income from the *G. sepium* in this trial. The cost-benefit analysis also showed that T4 was approximately 34% more profitable than from T3 that gave the greatest coconut yield (4095 nuts ha^{-1}). This was because the revenue contribution from the coconuts averaged only 1.6 percent of the total revenue in 1993/94 to 1994/95, 4.3% in 1995/96, 10.1% in 1996/97 and 14.0% in 1997/98. The proportion of revenue contribution from the coconuts is likely to increase with time as the coconut trees mature and attain their optimum yield potentials. In the long-term, this will enhance the attractiveness of the cacao-coconut system to farmers. The practice of intercropping cacao with coconuts as shade trees is thus proposed to be both economically and biologically more attractive than intercropping with *G. sepium* in Ghana.

Conclusion

Intercropping cacao with coconuts is environmentally and economically more beneficial than intercropping with *G. sepium*. Soil moisture retention was better in the cacao-coconut intercrop systems than in the cacao – *G. sepium* system. Widely spaced coconuts probably allowed for better illumination and consequently gave better yield of the cacao intercrop. It is proposed that high density planting of cacao in an appropriate spatial arrangement with widely spaced coconuts will bring the best economic returns.

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