INFLUENCE OF DIFFERENT DENSITIES OF COCOA AND OIL PALM ON YIELD PERFORMANCES OF COCOA[1]/

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Resumen

La presente investigación enfocó tres sistemas especiales de cultivo mixtos o intercalados de cacao y palma de aceite bloques segregados de los dos cultivos (X), filas alternativas las de los dos (Y); y el arreglo del "cuadro hueco" (Z) Entre los tres arreglos especiales, no se notaron diferencias significativas en los promedios de establecimiento, crecimiento y desarrollo de las plántulas de cacao Al principio, tampoco se notaron diferencias significativas en los promedios de rendimiento Sin embargo, conforme avanzado el tiempo, se observó que el arreglo Z rindió bastante más que el X y el Y (Z:X = 3:1, Z:Y = 5:1)

Aunque el rendimiento del cacao en los tres arreglos mixtos es relativamente más bajo que el de cacao sólo, se compensa por el efecto sinérgico del rendimiento conjunto de la palma de aceite y el cacao

Las infestaciones de Phytophthora *y los daños al cacao causados por mamíferos mostraron frecuencias parecidas en los tres arreglos espaciales En resumen, se recomienda a los agricultores que quieren mezclar la siembra de cacao con la de la palma de aceite utilizar el arreglo Z, el "cuadro hueco"*

Introduction

Mixed cropping has gained popularity in Nigerian peasant agriculture. It involves planting one basic crop and two or more supplementary "catch" crops (1) Agronomists have observed the tendency for peasant farmers to overcrop their land and to combine incompatible crops, and therefore they discourage mixed cropping.

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However, it still being encouraged in more organised forms The main crop is often planted with wider spacing, and the gaps can be used for other crops (8). In Zaire and Malaysia, for example, productive stands of cocoa established under oil and coconut palms have given promising yields (8). Experiments with mixed cropping in Sumatra, involving cocoa and coconut, revealed that mean girth of cocoa increased from 34 4 cm to 36.7 cm in the single hedge and 33 9 cm to 34 1 cm in double hedge planting (2). In an experiment conducted by the Institute National pour l'Etude Agronomique du Cacao (INEAC), various densities of oil palm interplanted with coffee were compared with either palm or coffee alone An interesting result of this experiment was that the yield of oil palms at the normal density of 60 palms per ha combined with 858 coffee stands per ha was about 8 percent higher than the yield at the same density, but without coffee (13).

Mixed cropping offers both benefits and drawbacks. The benefits include: it serves as an insurance against crop failures, keeps the farmer busy and improves both land use efficiency and the incomeearning capacity of the farmers (1). The major drawback is that yields are usually below expectations The crops compete for light, water, and nutrients, resulting in a compromise between the different needs of the mixed crops (9, 13)

The present study considers the combination of cocoa and oil palm in various plant densities It then makes recommendations to farmers interested in combining these crops

Methods

The experiments were located in Nigeria at the Gambari Experimental Station (GES) in Oyo State, the Onishere Farm Settlement in Ondo State and Ikom in Cross River State. These places represent three different ecological zones

GES is stituated in the transition zone between the forest and the derived savannah regions of Nigeria,

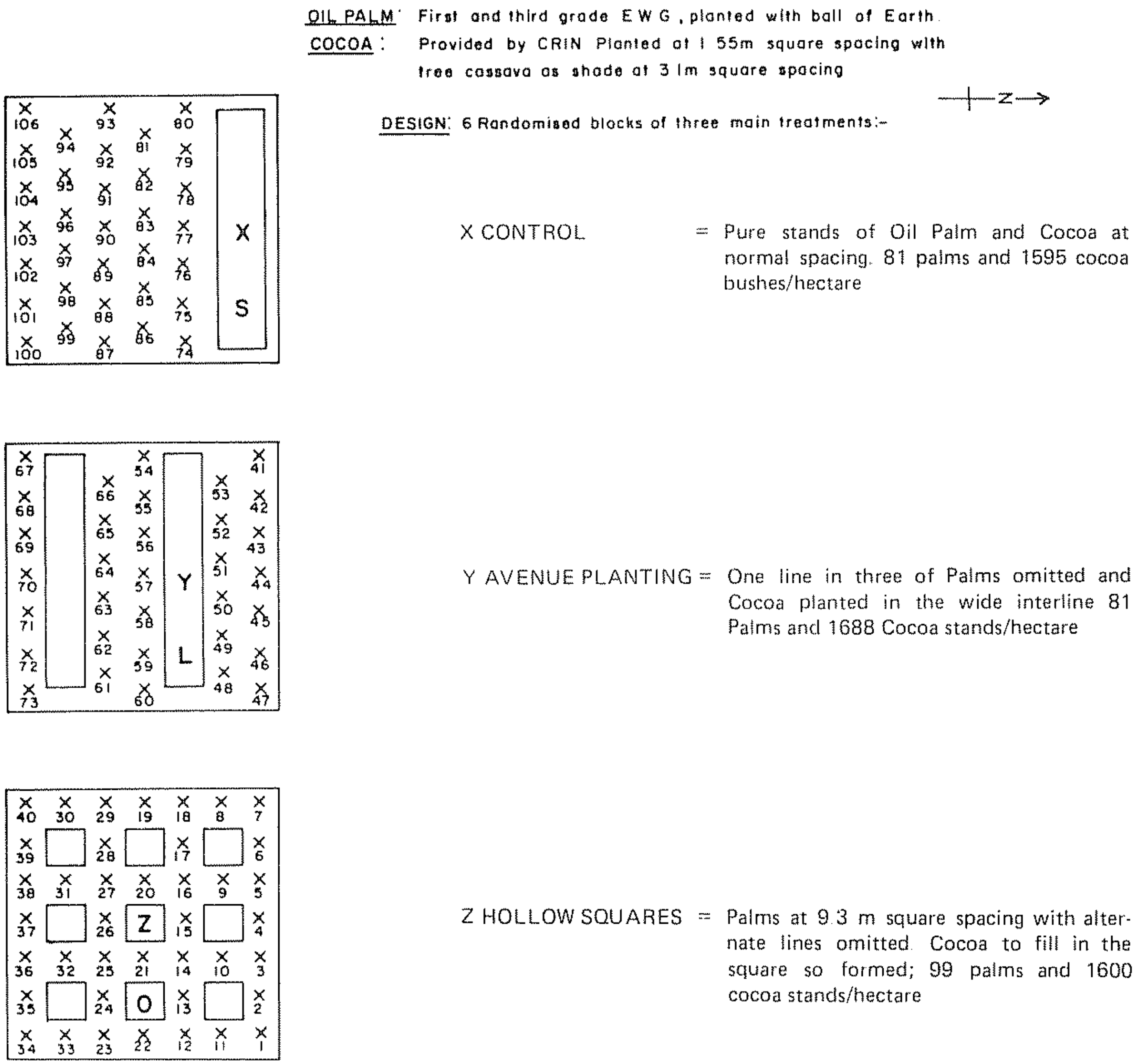

Fig 1 Expt 205-1 Mixed cropping experiment (Gambari experimental station) Experiment 205-2 Melanococca hybrid planting planted (1965)

where the annual rainfall is 1 168-1 270 mm and the severe dry season lasts from October to March. The soil type is the Iwo, Olorunda, Oba, Iregun and Apomu series (15)

Onishere is located in the forest zone, with heavy annual rainfall ranging from 2 320-2 540 mm. The soil type is the Calabar fasc (15).

Ikom is also in the forest zone. Annual rainfall (3 000 mm) is heavier than in Onishere, the dry season is less marked, and the annual water deficit is lower, about 150 mm.

A randomised block design was used for the experiment, with three spacing arrangement replicated six times at GES, seven at Ikom and eight at Onishere. Details of the treatments are as follows:

X Pure stands of oil palm and cocoa side by side and with a spacing of 9.1 m triangular for oil palm and 1.6 m square for cocoa (control). The densities for oil palm and cocoa were 83 and 1 595 trees per ha.

Y One line in three of palms was omitted and cocoa planted in the ensuing wide interlines (avenue planting). There were 83 palms and 1 688 cocoa trees per ha.

Z Palms were planted in a 9.1 m square with alternate palms in alternate rows ommitted. Cocoa was planted in the squares so formed (hollow square planting) There was 100 and 1 600 oil palm and cocoa trees per ha respectively.

The plot size was 0.4 ha shared between oil palm and cocoa in all the treatments (Fig. 1). Eighteen month-old Extension Work oil palm seedlings (dura x pisifera) and six month-old F_3 Amazon cocoa seedlings were used for the experiment. These were planted in 1964 at Onishere and 5 at GES and Ikom. However, due to fire outbreak at Onishere and the effect of the Nigerian Civil War at Ikom, the cocoa stands were replanted in 1970 in these two places. Cocoa in all the treatments was thinned to half the above density at four to five years after planting to maintain the recommended spacing of 2.7 x 2.7 m. The cassava was planted at 3.1 x 3.1 m to serve as nurse-shade for cocoa. Banana was planted along the north-south boundaries to serve as a wind break. Necessary care was taken to avoid the shading of palms by either the tree cassava or the banana. Vacant stands of cocoa and oil palm were supplied during the establishment stage.

General maintenance was regularly carried out in all the plots. Records were kept for yields of dry cocoa bean, black pod disease, infested pods and oil palm FFB weight. Yield of dry cocoa beans per ha was obtained on the basis of 26 pods to one kg dry cocoa (10).

Results

Growth and development of cocoa

When the three-year records for the Onishere Farm settlement (1964-67) were compared with those of the Gambari Experimental Station (GES 1965-1968), there were marked differences (Table 1). Survival and the canopy scores, for example, were better at Onishere than at GES. The cocoa at GES jorquetted earlier and had thicker stems than that at Onishere. The site differences in growth and development of cocoa seedlings could only have been due to the disparity between locations, i.e. soil and climatic factors. Onishere offers better agroclimatological conditions for the growth of cocoa than GES (7). Differences among treatments were not observed. The growth records for the Ikom location are not available because the civil war taking place in that part of the country prevented data collection.

Pod yield

Total annual yields for the three locations (GES, Onishere and Ikom) are shown in Fig. 2. The GES yield data for 11 years (1968-79) revealed consistent high pod production in the hollow square planting (Z), followed closely by yields from avenue planting

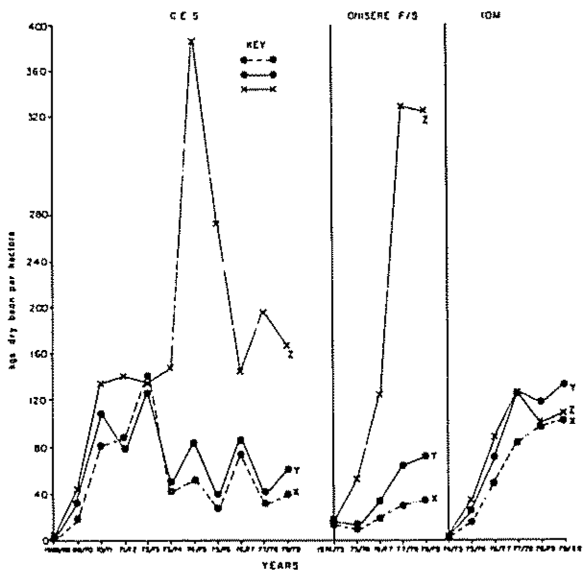

Fig. 2 Potential yield in kg dry bean per hectare (26 pods = 1 kg dry bean).

Table 1. Three-year growth/development performance record of cocoa seedlings at Onishere (1964-1967) and Gambari Experimental Station (1965-1968) in the CRIN-NIFOR Mixed Cropping Trial.

Growth/Development Parameters	Hollow Planting (Z)		Avenue Planting (Y)		Control Planting (X)	
	Gambari	Onishere	Gambari	Onishere	Gambari	Onishere
Number planted	3 736	5 184	4 113	5 472	3 825	5 168
Survival (percent)	58 70	96 51	61 59	97.75	68 65	98 12
Mean Canopy Score	3 77	4 00	3 92	9 97	4 03	4 09
Mean Height (cm)	121 14	109 80	124 42	120 09	120 34	124 91
Mean Stem Diameter	9 57	7 00	9 32	7 92	8 31	7 95
Jorquettes (percent)	79 25	22 59	51 86	29 37	55 89	30 07

Table 2. F-Ratios from results of analysis of potential pod yield.

Source of Variations	Gambari Experimental Station (GES)	Onishere CRIN Substation	Ikom CRIN Substation
	F-Ratios	F-Ratios	F-Ratios
Main Plots:			
Between Blocks (B)	2 60NS	3 02*	1 33NS
Between Variates (V)	16 40***	91 34***	4 76*
Sub Plots:			
Between Years (Y)	49 37***	159 01***	369 76***
VY Interaction	3 01***	12 99***	3 24**
BY Interaction	2 05**	6 54***	–

NS Not Significant
* Significant at 5% level
** Significant at 1% level
*** Significant at 0 1%

(Y). This same trend was observed for Onishere and Ikom with 5-year yield data. Yields were sharply differentiated between treatments Z and X and Z and Y.

Differences in yield are expressed in the following mean ratios: Z:X is 3:1 while Z:Y is 5:1 (Fig. 2). Analysis of variance of the yield data showed a nonsignificant (NS) yield difference between blocks at GES and Ikom and a low value of significance at P = 0 01 for GES and Onishere and at P = 0.05 for Ikom (Fig. 2, Table 2). In other words, the effect of treatment on yield was highly significant, as observed at GES and Onishere.

The yields of different treatments were found to increase steadily as the years progressed (Fig. 2). The increase in yield with years is highly significant at P = 0 01 (Table 2), with positive correlation coefficients of r = 0.30, 0 98, and 0 98 for GES, Onishere and Ikom respectively

Black pod incidence

The results as shown in Fig. 3 revealed a nonsignificant difference in the incidence of black pod disease in cocoa planted under oil palm at GES and Ikom. However, differences in black pod incidence among treatments at Onishere (Fig. 3) were significant at P = 0.05 (Table 4). Black pod incidence was partially or completely absent during the initial stages of pod bearing. This trend was observed in all three locations (GES, Onishere and Ikom). No black pod was recorded for GES in 1968-69 or Onishere in 1974-78, and very few pockets of black pod were recorded for Ikom (Fig. 3). Subsequently, black pod incidence increased with higher numbers of pods as the trees attained economic maturity.

Pod damage

The quantity of pods damaged by mammals such as squirrels, rats, and rabbits is shown in Fig. 4. The damage seems to be higher in the Z treatments at GES and Onishere when compared with treatments X and Y. However, damaged pods expressed as a percentage of healthy pods show no differences among treatments (Fig. 5). Ikom recorded fewer damaged pods than GES and Onishere (Figs. 4, 5).

Discussion

Our results confirmed the normal growth and development of cocoa under oil palm, in line with reports of previous authors, who reported successful establishment of cocoa under mature coconut (2) and oil palm (8). However, reported girth differences between single and double hedges of cocoa bushes under coconut (2) are at variance with our results. This disparity might reflect differences in methods and the crops involved as well as different environments.

The yield increases over time in all the treatments bore out our expectations as the pod-bearing capacity of the trees increased with maturity. However, the observed low correlation coefficient (r = 0.30) for GES might be an indication of the fact that the soil is poorer than those of Onishere and Ikom (7). Moreover, the experiment in GES is located in a marginal rocky area.

The yield levels in cocoa planted under oil palm as reported here are better than those of cocoa alone. There were also reports of similar yield increases in cocoa planted under the shade of either oil palm or coconut (2, 8, 14). One of the causes of better yields of cocoa under the shade of palms could have been better growth conditions. It has been established (3, 15) that cocoa without fertilizer performs better under shade (30 – 60 percent of full light). In other words, cocoa without shade definitely needs fertilizer supplements for better yields. Yield levels of cocoa without shade have been improved considerably by the application of fertilizer (3, 15). In this study, the check (X) was without shade after the initial nurse-shade of tree cassava was removed, and no fertilizer was applied. This might have accounted for the low

Table 3. F-Ratios from results of analysis of healthy pods (HP).

Source of Variations	Gambari Experimental Station (GES)	Onishere CRIN Substation	Ikom CRIN Substation
	F-Ratios	F-Ratios	F-Ratios
Main Plots:			
Between Blocks (B)	2.69 NS	3.76*	1.37 NS
Between Variates (V)	11.22**	73.76***	5.14*
Sub Plots:			
Between Years (Y)	576.36***	52.23	284.40***
VY Interaction	0.02 NS	7.49***	2.47*
BY Interaction	4.48***	2.58**	–

NS Not Significant
* Significant at 5% level
** Significant at 1% level
*** Significant at 0.1%

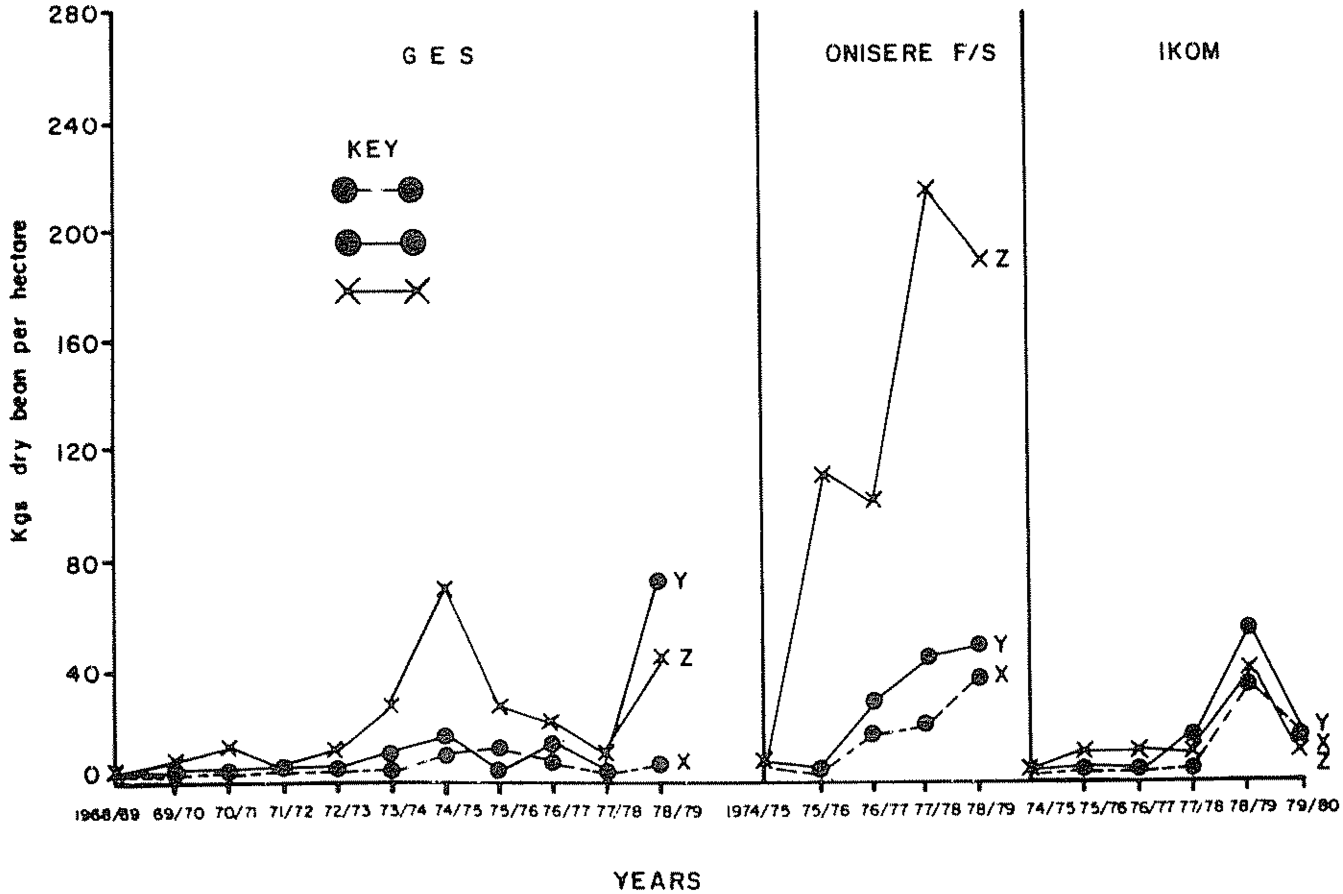

Fig. 3 Losses to black pod in kg per hectare (26 pods = 1 kg dry bean)

Table 4. F-Ratios from results of analysis of percentage incidence of black pod disease.

Source of Variations	Gambari Experimental Station (GES)	Onishere CRIN Substation	Ikom CRIN Substation
	F-Ratios	F.Ratios	F-Ratios
Main Plots:			
Between Blocks (B)	2 75 NS	0 69 NS	0.40 NS
Between Variates (V)	3 17 NS	4 62*	0 99 NS
Sub Plots:			
Between Years	15 93***	125 04***	36 94***
VY Interaction	0 28 NS	7.12***	2 47*
BY Interaction	–	–	–
BVY Interaction	–	–	–

NS Not Significant
* Significant at 5% level
** Significant at 1% level
*** Significant at 0.1% level (highly Significant)

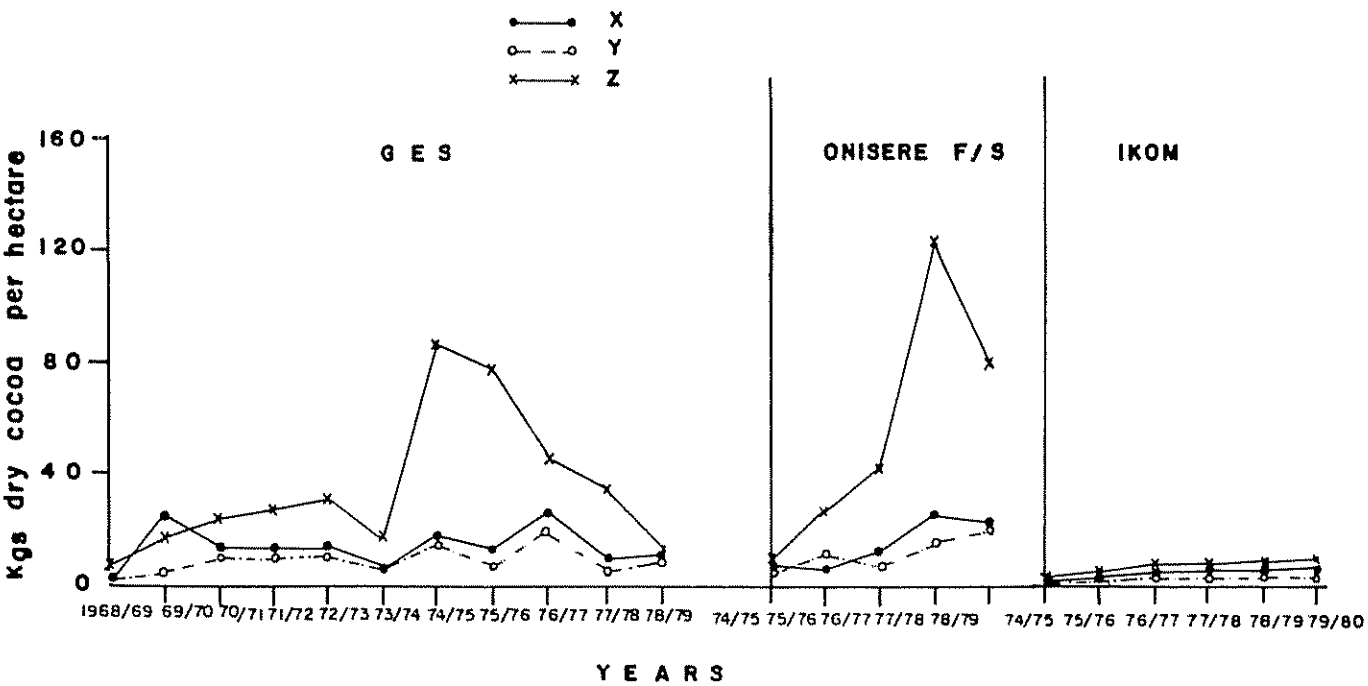

Fig 4 Pod damage by mammals in kg dry cocoa per hectare (26 pods = 1 kg dry bean).

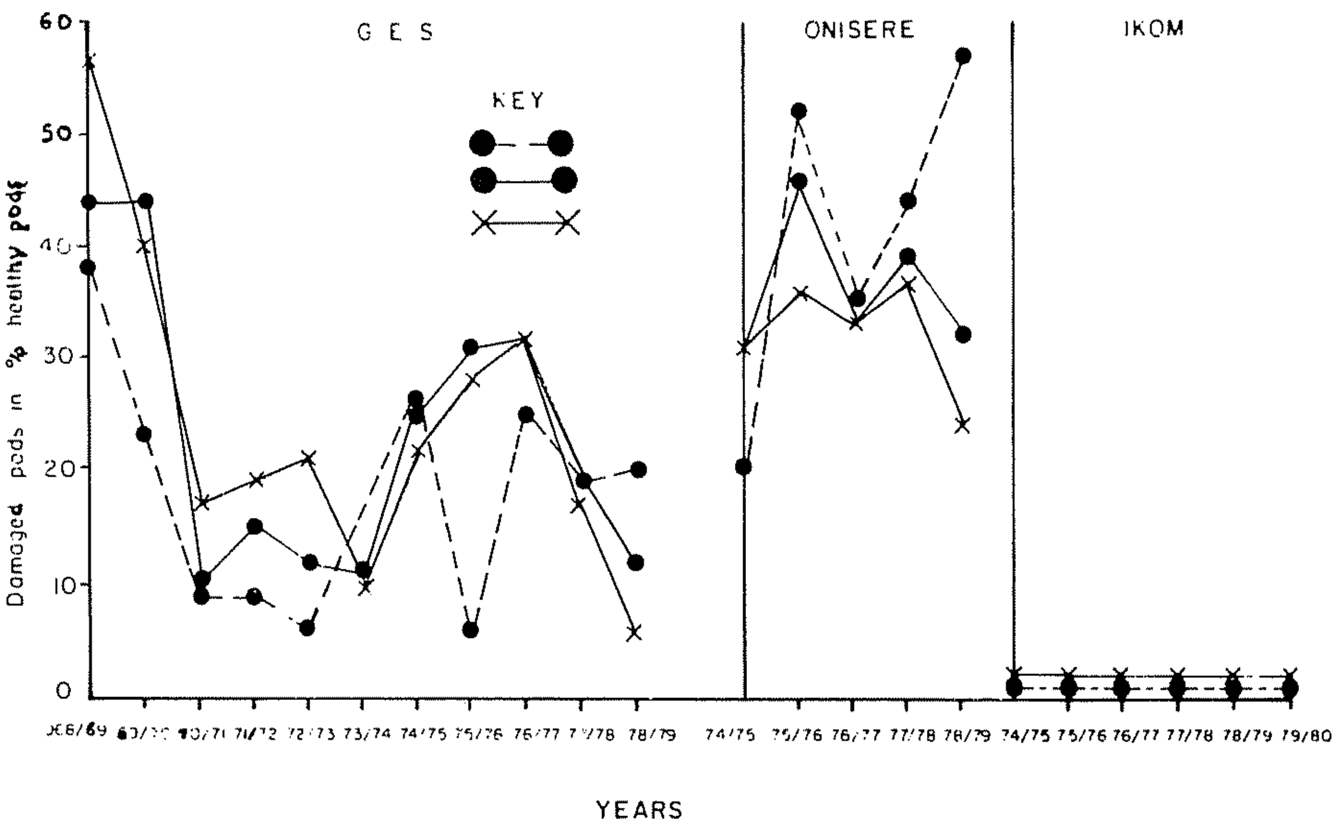

Fig 5. Pod damage by mammals in percent of healthy pods.

yields in the check compared with cocoa in treatments Y and Z, where cocoa was under oil palm shade.

The yield levels in all the treatments are generally low, averaging 160-180 kg of dry cocoa per ha in treatment Z, and far less in treatments X and Y. The yield trends, however, indicated that the optimum level has not been reached due to competition between crops for light, soil water, and nutrients (9, 13).

Although the yield levels of oil palm have not been made available, it is hoped that oil palm also stands to benefit from its combination with cocoa. Sparnaaij (13) has reported an increase in yield of up to 8 percent for oil palm under-planted with coffee.

Similarly, the yield from oil palm, in the present study, would surely compensate the farmer for the low yield level in cocoa. Overall, the synergistic results of yields from the two crops are expected to be higher than either cocoa or oil palm planted alone.

The partial or complete absence of black pod incidence during the initial stages of pod bearing as reported here confirms the views of Okaisabor (11). *Phytophthora*-infected pods which are left to rot away in trees and on the ground enhance future incidence of pod rot in the cocoa plantation. Obviously, the subsequent increase in pod rot as the trees advanced in age was due to the accumulation of pod rot inoculum in the soil and on the trees of the plantation. This has been the basis of the age-long recommendation that cocoa farmers rid their plantations of infested pods regularly. Djiekpor and Amefia (6) recommended that *Phytophthora*-infested pods should be collected from 47 to 50 times a year. On each occasion, infested pods should be buried outside the plantation.

One would have expected significant differences in black pod incidence in cocoa plots under oil palm because of the low temperature and high humidity conditions created in the canopy as a result of the oil palm. According to some authors (4, 5, 11, 12, 15), these two conditions influence the development of black pod disease. Black pod incidence in this study was observed to be higher in cocoa under oil palm, but the differences between treatments were not significant at GES and Ikom. This could be due to the regular pruning of palm fronds during harvesting of bunches. However, Onishere recorded significance at a low level of 5 percent. Apart from other factors at Onishere that might have motivated this result, the number of pods produced has also been implicated by Djiekpor (6) as one of the contributing factors influencing the appearance and spread of black pod disease. Our results in this respect confirm Djiekpor's (6) views.

The low mammal pod damage recorded for Ikom compared with GES and Onishere might be due to one or a combination of the following factors:

1) high maintenance level adopted in Ikom plots;

2) mammals' preference for fruits (including palm fruits) over cocoa pods;

3) the presence of only few of the species of mammals that prefer cocoa pods.

From the foregoing, the hollow square combination of cocoa and oil palm gave the best yield performance, with the cocoa suffering few adverse effects from the oil palm in terms of growth and development, yield, incidence of black pod disease and pod damage by mammals. The average yield of 160-180 kg of dry cocoa per ha recorded for the hollow square planting falls below the national average of 287 kg dry cocoa per ha (6). It is, however, assumed that the farmer would be compensated for the depression in cocoa yield by the oil palm produce (palm oil, kernel). On the basis of this study, the hollow square planting is recommended to farmers wishing to grow the two crops together.

Summary

Different ways of growing cocoa and oil palm together in a mixed cropping system were studied, giving consideration to three different densities of cocoa and oil palm: sole blocks of cocoa and oil palm (X), alternate strips of the two crops (Y), and the hollow square arrangement (Z). No significant differences were found within treatments in the rates of establishment, growth, and development of cocoa seedlings. Initially, no significant differences in yield between treatments were observed. Thereafter, remarkable differences were noticed when treatment Z outyielded treatments X and Y with mean ratios of 3:1 for Z:X and 5:1 for Z:Y. The observed depression in yield of cocoa is offset by the synergistic yield effect of the two crops. Infestations of *Phytophthora* and pod damage by mammals were similar in all spatial treatments. The hollow square planting (Z) is recommended to farmers wishing to underplant oil palm with cocoa.

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