Preliminary comparative analysis of cocoa yield under three treatments in combination with oil-palm in Nigeria

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SUMMARY

The study investigates the pattern of cocoa yield when cocoa is grown in combination with oil palm in specific layout patterns. The experimental design is randomized block design of six blocks and three treatments each containing cocoa and oil palm. The three treatments were Control, Avenue planting and the Hollow square arrangement. Equal size area of land was used for cocoa in each plot. The experiment was started at Cocoa Research Institute of Nigeria, at the old Gambari Experiment Station in 1965 in collaboration with the Nigerian Institute for Oil-Palm Research. The data in pods and dry weight beans per plot analysed covered the period from 1968/69 to 1978/79. The method used was the analysis of covariance. The adjusted mean yield of each treatment for the Control, Avenue and Hollow square arrangements was in the proportion 1.000 : 1.183 : 3.515 respectively. There were significant differences among the treatments, with the Hollow square arrangement > Avenue > Control at $P < 0.05$.

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RÉSUMÉ

ADENIKINJU, S. A., AFOLAMI, C. A. & AJOBO, O.: *Analyse comparative préliminaire de rendement du cacao cultivé en association avec le palmier en trois combinaisons de traitements au Nigeria.* Cet étude porte sur le rendement de cacao cultivé en association avec le palmier dans des écartements specifiques. L'espérience de type random block design de six blocs et trois traitements de semis consistant du contrôle, de l'Avenue et du carré a été fait. Une superficie égale de parcelle a été utilisée. L'étude a été commencé à l' Institut de Recherche en Cacao au Nigeria, à l'ancienne centre de recherche à Gambari en 1965, avec la collaboration de l'Institute de Recherche en Palmier au Nigeria. Les données sur la cosse et le poids sec du cacao par parcelle analysés couvrent la periode de 1968/69 à 1978/79. La méthode d' analyse statistique utilisée était l' analyse de covariance. Les moyens corrigés de chaque traitement pour le controle, l' Avenue et le carré étaient dans la proportion 1.000:1.183:3.515, respectivement. Il y avaient des différences significatives entre les traitements, dans l'ordre suivant : le carré > l'avenue > le contrôle à $P < 0.05$.

Introduction

Since the initiation of the cocoa-oil palm experiment at the old Gambari Experiment Station in 1965, some results have been published (Adenikinju, 1980; Onwubuya, Iremiren & Kolade, 1981). A review of the available literature on mix-cropping of cocoa with other crops like the oil palm, rubber, coffee and coconut in the tropics has been carried out (Afolami & Ajobo, 1983; Hunter & Camacho, 1961; Kolade, 1986; Onwubuya, Iremiren & Kolade, 1981; Poncin, 1958; Sparnaaij, 1987). The benefits from inter-cropping or mix-cropping include insurance against complete crop failure through diversification, keeping the farmer busy all the time and allowing better use of his time, improving land use efficiency and the income accruing to the farmer. The last is due to the mutual benefits to all crops from such mix-cropping and the increase in profit per unit area of land.

Cocoa cultivation as a sole crop has been found

over the years not to be in the best interest of the farmer since it is a cash crop that cannot meet his food requirements and does not make any contribution to the local diet unlike the oil palm. The interval between harvesting of the cocoa pods and the actual sale of the processed dry beans is relatively long and outside the farmer's control unlike what applies to palm fruits, which can be quickly processed and sold or consumed within a short time. Palm production generally stretches over a longer part of the year than cocoa, thus providing the farmer with some income most of the time, apart from keeping him busy. In addition, while the farmer can process fresh cocoa beans only into one intermediate product, i.e. the dry cocoa beans for sale, he can on the other hand process the palm fruits, kernel, palm bunch residue and palm fronds into a number of finished products for immediate use or for sale.

The advantage of mix-cropping cocoa with oil palm is, therefore, to increase the efficient utilization of the arable land by increasing the total output from both crops and ultimately the income accruing to the farmer. The objective of this report is to compare the yields from cocoa cultivated with oil palm in specific layouts in Nigeria.

Materials and methods

The experiment was started in 1965 and located at the Gambari Experiment Station (GES) of the Cocoa Research Institute of Nigeria (CRIN). The cocoa cultivar used was F_3 Amazon, the oil palm was 18-month old first and third grade E.W.G. palm seedlings. The experimental design was randomized block design of six blocks and three treatments. Each block was divided into three equal plots 0.4 ha each. The three treatments described in an earlier report (Afolami & Ajobo, 1983) consisted of the Control: pure stands of cocoa and oil palm containing 81 palms and 1995 cocoa stands per hectare; Avenue planting: one line in three of palms omitted and the space planted with cocoa resulting in 81 palms and 1688 cocoa stands, and the Hollow square treatment: created by omitting one palm out of each square of nine palms planted with cocoa, producing 99 palms and 1600 cocoa stands per hectare (Fig. 1).

Cocoa was planted at a spacing of 1.55 m × 1.55

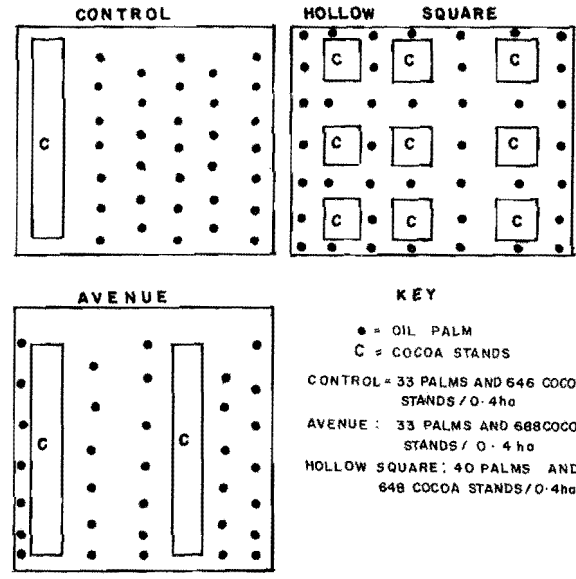

Fig. 1. Arrangement of cocoa (c) and oil palm (•) in the control, Avenue and Hollow square treatment.

m the same time as the oil palm which was planted at 9 m × 9 m. Three cassava at 3.1 m × 3.1 m was used to shade the cocoa while banana at 3.1m × 3.1m was planted as wind break along the north-south boundaries.

The data for the annual potential cocoa yield between 1968/79 reported earlier (Kolade, 1986; Onwubuya, Iremiren & Kolade, 1981), were used for this study. Potential yield here is the coverted pod count at the conversion rate of 26 pods equivalent to 1 kg dry beans.

The data were analysed using analysis of covariance with the dependent variable being the number of pods per plot per annum while the independent variables (nominal variables) were the treat-

ments and blocks; the covariates were the age of the tree and the population of the plant per plot. Since cocoa yield depends on the age of the population, this method allowed for the adjustment of the yield for age and population effects before looking into the effects of treatments on yield. It also increased the precision in testing whether any yield differences exist among the treatments. Potential yields of dry beans were also analysed statistically.

Results

The mean yield for each treatment: Control, Avenue and Hollow square when adjusted for the effects of the covariates (given by the sum of the grand mean and the corresponding value in the column of yield adjusted for covariates) are 699, 828 and 2318 pods per plot per annum respectively. These are in the proportion 1.000 : 1.183 : 3.315. The Hollow square method of growing cocoa in combination with oil-palm, therefore, gives the best yield followed by the Avenue method and the Control.

Actual number of pods harvested per plot during the same period 1968-1979 also confirmed the superiority of the Hollow square arrangement over the other two types of arrangements (Table 3).

TABLE 1

Analysis of Covariance for Potential Cocoa Yield under Three Treatments with Oil Palm

Source of variation	*Sum of squares*	*DF*	*Mean square*	*F*	*Significance of F*
Covariates	277621920	2	13810960	10.273	0.001
Tree age	18800624	1	18800624	13.985	0.001
Tree population	8821303	1	8821303	6.562	0.001
Main effect	104842736	2	52421360	38.994	0.001
Treatment	104842736	2	52421360	38.994	0.001
Explained	132464656	4	33116160	24.634	0.001
Residual	259457008	193	1344336		
Total	391921664	197	1984450		

Covariate	Beta
Tree age	97.444
Tree population	3.955

The initial analysis of covariance in which the total variance in yield of potential pods was partitioned among the covariates - the age and population of trees per plot, and the factors - treatments and blocks, showed significant effect on yield for all the variables ($P = 0.01$), except for the blocks. The model was, therefore, re-estimated, allowing the sum of squares for the blocks to be pooled together with the residual. Table 1 shows that the model is good as indicated by the significance of the explained variance of the total. The highly significant value of the F-ratio for treatment (P-0.001) implies that differences exist among the treatment categories. Thus, the multiple classification analysis table was constructed to find the magnitude of differences among the category means in the treatment (Table 2).

TABLE 2

Multiple Classification Analysis for Potential Cocoa Yield under the Three Treatments

Grand mean= 1281.65 Variable + Category	*N*	*Unadjusted deviation ETA*	*Adjusted for independents + BETA*
Treatment:			
Control	66	-566.73	-582.34
Avenue	66	-407.21	-454.05
Hollow	66	973.94	1036.39
		0.49	0.52

TABLE 3

Mean cocoa Yield in Pods per Plot, Dry Bean Weight (kg/plot) and Value in Naira (N, 1968-1979

Treatment	*Pods*	*Bean weight*	*Value (N)*
Control	8,023	308.58	493.72
Avenue	10,540	405.39	648.63
Hollow square	24,549	944.17	1,510.67

TABLE 4

Mean Pod Number per Plot in Selected Years during the Period 1968-1979

Year	*Treatments*		
	Control	*Avenue*	*Hollow square*
1970	224	449	777
1973	1614	1549	2555
1976	479	574	3693
1979	563	750	2225

Although the differences between the actual yields were not as dramatic as those between the adjusted yields, these differences between the Hollow square treatment and the other two treatments were all the same statistically significant ($P=0.05$). The cocoa yield differences, however, varied from year to year but the benefits were in favour of the Hollow square arrangement over the period reported (Table 4). The compounding effect of tree age and the population (i.e. the covariates) on the main treatments was responsible for this situation, a fact that necessitated the analysis of the covariates as stated earlier.

Using the Nigerian producer price of 1986, Table 3 shows that cocoa yield from the Hollow square arrangement gave an increase of 205.9 and 132.9 per cent in revenue over the Control and Avenue treatments respectively.

It is surprising to find that the yield of cocoa per annum on a given size of land on cocoa is more when the F_3 Amazon cocoa is grown in patterns that combine cocoa with the oil-palm than when the same land size is solely devoted to cocoa. As regards the better performance of Hollow square treatment over Avenue, this may be due to the shading effect of oil palm trees on cocoa as more cocoa trees are shaded by the oil palm in the Avenue treatment thus creating keen competition between them for light. The observed improved yields of cocoa agree generally with those reported for Malaysia (Hartley, 1977), where cocoa is commercially grown under oil palm and coconut palm. As postulated earlier for cocoa-oil palm mixcropping (Egbe & Adenikinju, 1991), the synergistic or mutually beneficial effects of the two crops could explain the enhanced cocoa yield. This could have resulted from the absence of any adverse competition between the inextensive fibrous roots of the oil palm and the more extensive superficial feeding roots of the cocoa. Moreso as each crop was allocated relatively adequate spacing. The 'hedge row' effect of the oil palm on the 'surrounded' cocoa due to the ameliorating effects on wind and insulation could have contributed to the observed benefits attributed to cocoa in the Hollow square arrangement (Fig. 2).

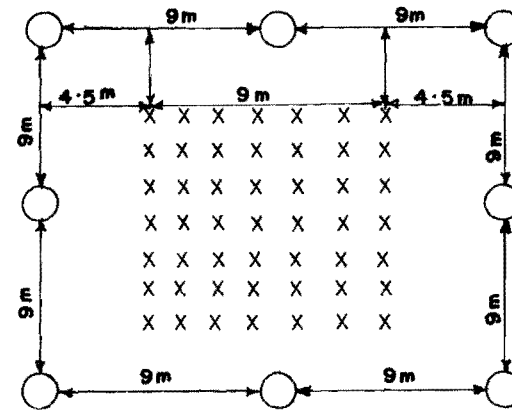

Fig. 2. Relative position of cocoa (X) and oil palm (O) in the Hollow square arrangement.

One big factor that is assumed in this analysis is the uniformity of pods among treatments, thus using pod count for yield. This assumption may not hold as not all pods are equal. Since the

marketable product, the dry bean weight is a function of the pod size and pod number, the proportion of the yields may not strictly be as obtained if yields is measured by dry bean weight. However, given that the superiority of mean yield of Hollow square treatment over the others in this preliminary analysis is not marginal, a similar order may be preserved. Before the experiment is terminated, data on the effect of the treatments on pod size distribution and other parameters likely to be affected will be collected to throw more light on this aspect.

The 1986 Nigerian Cocoa Board's producer price was used to calculate the revenue from yield of beans only for the sake of comparison. However, it is expected that the grower will increase his income as the producer price increases and moreso from the Hollow square arrangement for the mixed cultivation of F_3 Amazon cocoa and the oil palm in the Oyo State and adjacent areas constituting that ecological zone. The grower is expected to realize the significant benefits in revenue annually from both cocoa and oil palm when combined for the Hollow square arrangement, even in years not covered by this report when cocoa returns alone may not be in favour of this treatment.

Conclusion

The Hollow square treatment of growing cocoa with oil palm was found superior in cocoa pod production to the other treatments of Avenue and Control. However, since all pods are not of equal size, the dry bean weight, which is the ultimate marketable product, may not give the same adjusted yield proportion of 1.000 : 1.183 : 3.315 for Control, Avenue and Hollow square treatments respectively. But given that the yield differences using pod count are not marginal, the order of the treatments' performance is likely to be preserved if yield is measured by dry bean weight. The mixcropping of F_3 Amazon cocoa and the oil palm using the Hollow square arrangement appears to be a viable proposition for the ecological zone comprising Oyo State and the adjacent areas.

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