# AN ECONOMIC EVALUATION OF A CROPPING SYSTEM : THE CASE OF COCOA GROWN IN COMBINATION WITH OIL-PALM

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## INTRODUCTION

Pod loss in cocoa production is of such an economic importance that any innovation which increases yield has to consider this advantage along with the pod loss before the justification of the innovation. Pod loss could arise from pods being infected by the fungi *Phytophthora palmivora* which results in black pod, or damaged by rodents. The economic significance of cocoa black pod disease has prompted research into ways of controlling the disease (5). Methods of control that have been achieved include chemical control (16, 7, 9); breeding for resistance (14, 11), as well as breeding for varieties that will bear the bulk of the crop outside the main epiphytotics (18, 10). As regard control of rodents, very little has been done and this may be because the loss is considered insignificant.

In Nigeria, estimates of pod loss due to black pod was put at between 15,000 and 30,000 tons of dry cocoa beans annually (8). Also, it is reported that black pod may destroy up to 74 % of yield in Nigeria (16) and 90-95 % in the Cameroons (17), while in Ghana, it accounts for a mean annual loss of 19 % (4), and in some areas, all the crop may be lost (3). In a survey of rodents damage to mature pods at Gambari Experimental Station (GES), Nigeria, it was found that damaged pods could be as high as 19 % of total pod production (6), while the corresponding figure of 2.3 % was given as national loss in Ghana (15).

Cocoa grown with oil-palm has been reported to yield more cocoa pods per land unit than sole cropping (2). It has also been reported that wild alternative host plants of cocoa virus, a cocoa disease, exist and that they belong to the plant Kingdom orders of Tiliales and Malvales of which *Cola cordifolia*, a forest tree crop like oil-palm, is one (13). Likewise, nutritional host of mealybugs (vectors of cocoa swollen shoot virus) has been reported (1). The system of growing cocoa with oil-palm, though advantageous in terms of yield, raises the question of pest and disease build up. This paper examines the system with regards to black pod and rodent damages.

## MATERIALS AND METHODS

The experiment was located at GES, Ibadan, in 1965. The cocoa variety planted was $F_3$ Amazon cocoa while the oil-palm was first and third grade EWS planted with ball of earth. The experimental design is a randomised block design of six blocks and three treatments. Each block was divided into three equal plots which had the three treatments randomly allocated within the block. The three treatments are : i) Pure stands of oil-palm and cocoa with cocoa at initial spacing of 1.524 meters square, shaded by cassava trees at 3.048 meters square spacing and oil-palm at 9.3 meters spacing. ii) Avenue planting : One line of palms out of three is omitted and cocoa is planted in the wide interline. Cocoa was also planted initially at the spacing of 1.524 meters square, while the oil-palm was planted at 9.3 meters square spacing. iii) Hollow squares in which palms were planted at 9.3 meters square spacing, alternate palms in alternate lines being omitted and cocoa used to fill the square so formed

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at 1.524 meters square spacing. Figure 1 gives the field lay-out of the three treatments. The area of land under cocoa in each plot in the blocks is equal, this being 1 338.000 square meters. The spacing of cocoa trees was later increased to 1.524 meters × 3.048 meters, by reducing the plant population per plot. Normal maintenance cultural operations were carried out on the plots.

The annual potential cocoa yield record per plot (in number of pods) which was distributed into healthy pods, black pods and damaged pods were taken and used for this analysis. The record covered the period 1968/69 to 1978/79. The data were analysed using analysis of covariance, the factor being treatments while covariates are year of harvest and tree population per plot. This method of analysis was necessary because cocoa yield depends on year of harvest and plant population. It is therefore important to adjust the yield for year of harvest and plant population effects before looking into what effect treatments have on yield in the various classes of pods. The yields for the various treatments under each of the pod classes of healthy, black and damaged pods were compared separately using multiple classification analysis.

The model used was :

$$Y_{ij} = \&_0 + \&_1 D_1 + \&_2 D_2 + B_1 X_1 + B_2 X_2 + e_{ij}$$

where :

$Y_{ij}$ is the pod yield in the jth year under ith plot.

$\&_0$ is the mean annual pod production per plot for the base treatment.

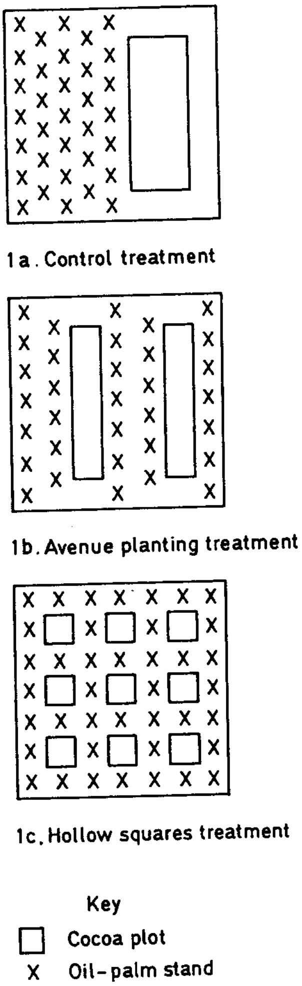
$\&_1$ and $\&_2$ are deviations of the mean of the other treatments from the base treatment.

$D_1$ and $D_2$ are dummy variables for the treatments, $X_1$ and $X_2$ are covariates, year of harvest and tree population per plot.

$e_{ij}$ is the random disturbance.

From the multiple classification tables I, II, III, the mean annual pod yield for the various treatments, which is the addition of the grand mean and corresponding adjusted covariate deviation, was calculated for each class of the pods i.e. healthy,

Fig. 1. — Field lay-out of the three treatments




black and damaged pods. It was observed that the differences between adjusted and non-adjusted deviations were relatively low. However, the adjusted deviations are used in our analysis because of the reason given earlier for the choice of the model. Later, the percentage of the total mean number of pods produced under each treatment was calculated for the various classes of the pods (i.e. healthy, black, and damaged).

TABLE I

Multiple classification analysis of damaged pods by treatments, year of harvest and tree population per plot, GES

| Variable + Category | N | Unadjusted deviation | θ | Adjusted for covariates deviation | β |
|---|---|---|---|---|---|
| Treatment | | | | | |
| Control | 66 | -99.34 | | -97.60 | |
| Avenue | 66 | -57.75 | 0.53 | -64.53 | 0.56 |
| Hollow | 66 | 153.10 | | 162.14 | |

Multiple R squared = 0.354

Multiple R = 0.594

Grand Mean = 182.83

Where N is the number of observations under each class ; θ is the proportion of variation in $Y_{ij}$, explained by the factor i.e. the treatments ; β is the proportion of variation in $Y_{ij}$ explained by the factor adjusted for covariates.

TABLE II

Multiple classification analysis of black pods by treatments, year of harvest and tree population per plot, GES

| Variable + Category | N | Unadjusted deviation | Θ | Adjusted for covariates deviation | β |
|---|---|---|---|---|---|
| Treatment | | | | | |
| Control | 66 | -64.20 | | -65.86 | |
| Avenue | 66 | -43.39 | | -48.39 | |
| Hollow | 66 | 107.59 | 0.41 | 114.26 | 0.44 |

Multiple R squared = 0.313

Multiple R = 0.559

Grand Mean = 115.15

TABLE III

Multiple classification analysis of healthy pods by treatments, year of harvest and tree population per plot, GES

| Variable + Category | N | Unadjusted deviation | Θ | Adjusted for covariates deviation | β |
|---|---|---|---|---|---|
| Treatment | | | | | |
| Control | 66 | -406.43 | | -418.23 | |
| Avenue | 66 | -304.74 | | -340.14 | |
| Hollow | 66 | 711.17 | 0.46 | 758.37 | 0.49 |

Multiple R squared = 0.294

Multiple R = 0.542

Grand Mean = 983.10

# RESULTS AND DISCUSSION

The result of the analysis of covariance showed that the covariates have positive coefficients and are significant at most at 5 % level of probability for all the pod classes. This implies that annual pod production per plot increases with the year of harvest and tree population per plot for the three pod classes (damaged, black and healthy pods) under the time period considered. Likewise, the main effect-treatments, and the model fitness were significant at 1 % level of probability for all pod classes.

Since our interest lies mainly in the yields of each treatment under the various pod classes, the multiple classification analysis was done and the results were tabulated. Tables I, II and III give the multiple classification analysis for damaged pods, black pods and healthy pods respectively. The explanatory variables for the annual yield explained 35, 31 and 29 % of total yield variation for the respective classes of damaged, black and healthy pods. These, though low, were found to be significant at 1 % level of probability. It would not have any serious implication for our objective since our interest is not in prediction.

Tables I, II and III give the multiple classification analysis for damaged pods, black pods and healthy pods respectively.

From table I, the mean annual numbers of pods, in the class « damaged pods » are 85.23, 118.30 and 344.97 for the respective control, avenue and hollow squares treatments. The proportions of damaged pods for the treatments are 1.000 : 1.434 : 3.215 for control, avenue and hollow squares. The values of the mean yield deviation of the treatments from the grand mean are shown on the tables.

From table II, the mean annual numbers of pods in the class « black pods » are 49.29, 66.76 and 229.41 for control, avenue and hollow squares treatments respectively. The proportions of black pods for the treatments are 1.000, 1.354, 4.654 for control, avenue and hollow squares.

Similarly from table III, the mean annual numbers of pods in the class « healthy pods » are 564.85, 642.96 and 1 741.47 for control, avenue and hollow squares treatments respectively. The proportions of healthy pods for the treatments are 1.00 : 1.138 : 3.083 for control, avenue and hollow squares respectively.

The mean annual numbers of damaged and black pods are larger in the treatments that combine growing cocoa with oil-palm, especially in the hollow squares treatment. If decision were to be based on the absolute values of the mean number of damaged pods and black pods, one would say growing cocoa in combination with oil-palm results in more damaged and black pods which are even more than threefold in hollow squares treatment, thus cocoa should not be grown in combination with oil-palm. However, in table III which shows the mean annual number of healthy pods among the treatments, the mean annual yield for treatments which combine cocoa with oil-palm is larger. The hollow squares treatment yields more than threefold healthy pods in the control. We therefore examined the pod distribution by class among treatments (percentage of the annual number of pods). The result is shown in table IV.

TABLE IV

Percentage annual mean pod distribution-pod class by treatments

| Treatment | Class | | | |
|---|---|---|---|---|
| | Damaged pod | Black pod | Healthy pod | Total |
| Control | 12.188 | 7.048 | 80.772 | 100.008 |
| Avenue | 14.294 | 8.067 | 77.689 | 100.050 |
| Hollow | 14.882 | 9.897 | 75.127 | 99.906 |

It is recalled that it has been reported that in Nigeria, as the yield per plot increases so does black pod incidence (15). Furthermore, it has been shown in Nigeria that the number of black pods per tree varies directly with the number of total pods per tree (7, 16).

The damaged pods for control, avenue and hollow squares treatments are respectively 12.188, 14.294 and 14.882 % of total pods. The black pods as percentage of total pods are 7.048, 8.067 and 9.897 respectively for control, avenue and hollow squares treatments while this percentage is 80.772, 77.687 and 75.127 respectively for the healthy pods. The values for various treatments in each class are not different from one another. This means that damaged pods and black pods incidence tends to increase with the number of total pods which supports the finding of Hislop and Park (1962) on black pod.

The comparison of the pod yields of the various treatments among the pod classes, surprisingly showed the hollow squares treatment to be superior, followed by avenue planting while control is the least. The reason that can be advanced for this performance is in the canopy effect. In the hollow squares and avenue treatments, the palms served as shade tree for cocoa at the early stage with better shade effect produced under hollow squares treatment. They later protected the soil from excessive heating when they towered over cocoa. However, the surprise in the result obtained stems from the shade effect that the palms have on cocoa, in manufacturing its food since it requires sunlight. The humid micro climate provided by the treatments in combination with oil-palm could explain why more pods with black pod were found under these treatments. The worst performance of the control treatment could stem from the competition between cocoa and the cassava shade tree used in the early years. This could have inpaired cocoa tree growth vigour and thus pod production capability.

On the input side, the establishment and maintenance costs can safely be regarded as same under the different treatments as the area of land under the three treatments is the same. Records on input use were not disaggregated by treatment. Maintenance operations were done at the same frequence. Harvesting however took longer time in the treatments in which cocoa is planted in combination with oil-palm because of the greater yield of cocoa pods.

# CONCLUSION

Though in absolute term, damaged and black pods yields of cocoa tend to be greater when cocoa is grown in combination with oil-palm than sole, this is not a sufficient reason to discourage growing cocoa and oil-palm in combination. Such a result is obtained because total cocoa yield is generally higher on plots in which cocoa is combined with oil-palm and consequently results in a larger number of damaged and black pods. The higher healthy pods yield that results when cocoa is grown in combination with oil-palm compensates more than the pod loss. Furthermore, the fact that there is no difference in the relative percentage annual mean pod number distribution among the pod categories, coupled with equal input use among treatments, confirms that farmers may gain more by combining growing cocoa with oil-palm especially if the layout is in the form of hollow squares.

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AFOLAMI (C. A.), AJOBO (O.). — **Evaluation économique d'un système de culture : le cas du cacaoyer cultivé en association avec le palmier à huile.** *Café Cacao Thé* (Paris), vol. XXVII, n° 2, avril-juin 1983, p. 121-126, 1 fig., 4 tabl., 18 réf.

L'étude a été menée dans le but de savoir si la perte en cabosses consécutive aux maladies et aux attaques des déprédateurs annule le gain de l'accroissement du rendement en cabosses résultant du système de culture.

Le dispositif expérimental est celui de blocs pris au hasard avec six blocs et trois traitements. Chaque bloc a été divisé en trois parcelles égales et les trois traitements ont été appliqués au hasard au sein du bloc. Les traitements sont : (1) peuplements purs ou témoin ; (2) plantation en files ; (3) plantation par remplacement des manquants en carré. Les rendements annuels en cacao, qui ont été répartis en cabosses saines, cabosses atteintes par la pourriture brune et cabosses endommagées et qui correspondent aux rendements de la période allant de 1968/1969 à 1978/1979, ont été utilisés pour l'analyse.

Les résultats ont montré que le nombre absolu de cabosses endommagées et atteintes par la pourriture brune est plus élevé sur les cacaoyers cultivés en association avec le palmier à huile, mais que l'accroissement du rendement en cabosses saines dans ce système de culture compense largement la perte de cabosses par maladies et déprédateurs.

AFOLAMI (C. A.), AJOBO (O.). — **An economic evaluation of a cropping system : the case of cocoa grown in combination with oil-palm.** *Café Cacao Thé* (Paris), vol. XXVII, n° 2, avril-juin 1983, p. 121-126, 1 fig., 4 tabl., 18 réf.

The study examines whether pod loss due to pests and diseases when cocoa is grown in combination with oil-palm sacrifices the gain of an increased pod yield that arose from the cropping system.

The experimental design is a randomised block design of six blocks and three treatments. Each block was divided into three equal plots which had the three treatments randomly allocated within the block. The treatments are : i) pure stands or control ; ii) avenue planting ; and iii) hollow squares planting. The annual cocoa yield which was distributed into healthy pods, black pods and damaged pods, taken for the period 1968/1969 to 1978/1979 were used for analysis.

The result showed that absolute number of damaged and black pods was greater on cocoa grown in combination with oil-palm, but the gain in increased yield of healthy pods in the cropping system more than off-set the pod loss due to pests and diseases.

AFOLAMI (C. A.), AJOBO (O.). — **Wirtschaftliche Bewertung eines Kultur-systems : gemeinsamer Anbau von Kakaobäumen und Ölpalmen.** *Café Cacao Thé* (Paris), vol. XXVII, n° 2, avril-juin 1983, p. 121-126, 1 fig., 4 tabl., 18 réf.

Zweck dieser Untersuchung war festzustellen, ob der Verlust an Kakaobohnen infolge Krankheit und Angriff durch Schädlinge die Erhöhung des Kakaobohnenertrags aufgrund des Kultursystems zunichte macht.

Die Versuchsanordnung bestand aus zufällig ausgewählten Blöcken, mit je 6 Blöcken und drei Behandlungen. Diese Blöcke wurden jeweils in drei gleich grosse Parzellen aufgeteilt und die drei Behandlungstypen wurden innerhalb des jeweiligen Blocks angewendet. Hierbei handelte es sich um : (1) Reine Bepflanzungen oder Vergleichsgruppen ; (2) Reihenbepflanzung ; (3) Auffüllung der Fehlenden im Quadrat. Für die Versuchsauswertung wurde der Jahresertrag an Kakaobohnen von 1968/69-1978/79 verwendet, aufgeteilt jeweils in gesunde, vom Braunrost befallenene bzw. beschädigte Bohnen.

Das Ergebnis zeigte, dass die absolute Anzahl der beschädigten, bzw. vom Braunrost befallenen Früchte bei den gemeinsam mit Ölpalmen kultivierten Kakaobäumen höher liegt, dass dieser Verlust jedoch durch den Ertrag an gesunden Kakaobohnen in diesem Kultursystem im Vergleich zu den durch Krankheit und Schädlingen verlorengegangenen Kakaobohnen bei weitem ausgeglichen wird.

AFOLAMI (C. A.), AJOBO (O.). — **Evaluación económica de una sistema de cultivo : el caso del cacao cultivado en combinación con la palma de aceite.** *Café Cacao Thé* (Paris), vol. XXVII, n° 2, avril-juin 1982, p. 121-126, 1 fig., 4 tabl., 18 réf.

Este estudio se ha emprendido con objeto de saber si la pérdida en cuanto a mazorcas, consecuencia de las enfermedades y de los ataques de los depredadores, anula los beneficios del incremento del rendimiento de mazorcas que resultan del sistema de cultivo.

El dispositivo experimental corresponde a aquél de bloques tomados según las leyes del azar con seis bloques y tres tratamientos. Cada bloque se ha dividido en tres parcelas equivalentes y se han aplicado los tres tratamientos también según las leyes del azar en el interior del bloque. Los tratamientos son : (1) poblaciones puras o testigo ; (2) plantación en hileras ; (3) plantación por sustitución de los elementos faltantes en cuadrado. Se han utilizado para el análisis los rendimientos anuales en cacao, que se han repartido en mazorcas sanas, mazorcas alcanzadas por la podredumbre parda y mazorcas dañadas y que corresponden a los rendimientos del periodo que va de 1968/69 a 1978/79.

Los resultados han permitido demostrar que el número absoluto de mazorcas dañadas y alcanzadas por la podredumbre parda es más elevado en los árboles del cacao cultivados en combinación con la palma de aceite, pero que el aumento del rendimiento en cuanto a mazorcas sanas en este sistema de cultivo compensa ampliamente la pérdida de mazorcas por enfermedades y efectos de los depredadores.