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AN APPRAISAL OF MIXED CROPPING TRIAL ON ARECANUT AND COCOA *

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ABSTRACT

While evaluating mixed cropping trials with two or more crops it is essential to give due importance to performance of different crops in a system and also the performance of system as a whole.

In bivariate analysis of data on arecanut-cocoa mixed crop trial in which spacing-cum-manurial treatments were imposed, it was found that yield per plant was higher when arecanut was spaced at 2.7m × 2.7m and cocoa at 5.4m × 5.4m. However, when both the crops were planted at a spacing of 2.7m × 2.7m, eventhough there was a decrease in yield of individual plants, yield per unit area was significantly higher due to higher population density. The economic evaluation based on gross returns also highlights the efficacy of 2.7m × 2.7m spacing for both the crops with average gross returns to the tune of Rs. 82,830 per hectare.

INTRODUCTION

Increased production and efficient use of resources can best be achieved through mixed cropping systems. Shama Bhat and Bavappa (1972) outlined how cocoa can effectively be grown in combination with either coconut or arecanut palms to increase the returns per unit area. In such mixed cropping trials, testing the response of crops to treatments imposed is difficult when two or more crops are involved.

There are complex interactions that occur in intercropping, depending on various combinations of the effect of plant species, plant density and spacing, planting patterns, canopy types, root systems, differential demands on environmental factors at different growth stages and so on (Trenbath, 1976). There are various functions such as Relative Crowding Coefficient, Competition Index, Aggressivity, Reciprocity, Land Equivalent Ratio, Land Utilization, Gross Returns, Net Returns, Diversity Index, Multiple Cropping Index, Harvest Diversity Index, Simultaneous Cropping Index, Cultivated Land Utilization Index and Crop Intensity Index (IRRI 1974; IITA 1975; Trenbath, 1976; Francis 1978; Meneyey, 1978) which expresses competitive abilities of components and or yield advantages for a given crop model. Each

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of these methodologies have advantage of their own in testing predefined objective but none of these can be used satisfactorily for assessing the efficacy of a given cropping model with due consideration to individual crop performance and that too when perennial crops are involved. This is because in perennial crop mixture

(a) the growth pattern and yield of each crops are highly interdependent;

(b) the extent of competition and other interactions among the crops vary substantially as the year advances and

(c) the prices of each crop will be fluctuating over years

Such an insight of assessing individual crop performance in addition to testing the efficacy of the given crop model can best be made by bivariate/multivariate analysis after eliminating the interdependency among the crops.

In the present study, data from arecanut–cocoa mixed cropping experiment was used. Apart from economic evaluation of different spacings based on gross returns per hectare, a bivariate analysis (Pearce and Gilliver, 1977) has been attempted in order to evaluate the treatment effects. This method has following advantages *viz.*,

(a) it brings out the extent of interdependency existing between two crops

(b) it considers both the crop yields as two variates instead of combining the two yields as one index and

(c) it assesses the performance of treatments for the mixed cropping system as a whole

MATERIALS AND METHODS

At CPCRI Regional Station, Vittal, a trial on arecanut–cocoa mixed crop involving six spacings and two manurial doses laid out in a 6 × 2 asymmetrical confounded factorial design with four replications is in progress. For economic evaluation gross returns for each of the plot was calculated and extrapolated to per hectare returns. Usual two factor confounded design analysis was carried out to assess the performance of various treatments for each of the individual years from 1982 to 1985 and averaged data. For bivariate analysis yield data for each of the individual years and averaged data on (i) weight of arecanuts/palm (x_1), weight of cocoa pods/tree (x_2), as one set of bivariates and (ii) weight of arecanuts/ha (x_1), weight of cocoa pods/ha (x_2) as another set of bivariates has been considered. The interdependency of these bivariates was eliminated by transforming the variables as detailed below:

If in the bivariate analysis of variance table (BANOVA) E_{11}, E_{22}, E_{12} denote the error mean sum of squares and sum of products, and

$$r = E_{12} / \sqrt{(E_{11}E_{22})}$$

is the correlation between x_1 and x_2, then the transformed variates y_1, y_2 which have unit error variance and zero error covariance are given by

$$y_1 = x_1 / \sqrt{E_{11}}$$

$$y_2 = [x_2 - E_{12}\, x_1 / E_{11}] / \sqrt{[E_{22} - E_{12}^2 / E_{11}]}$$

In order to test any hypothesis such as H_0 : Treatment means do not differ significantly, if after transforming to new variates T_{11}, T_{22}, T_{12} denote the treatment mean sum of squares and sum of products, e and t denotes the error and treatment degrees of freedom respectively, further if

$$\text{Bivariate } F = [(1-\Lambda)(e-1)] / \Lambda t$$

$$\text{where } \Lambda = e^2 / [(T_{11} + e)(T_{22} + e) - T_{12}^2]$$

then, the hypothesis H_0 can either be accepted or rejected depending on whether Bivariate F is less than or greater than F [2t, 2 (e–1)] at desired level of significance.

Since the new variates y_1 and y_2 are independent, a graphical representation of treatment means, taking y_1 on X–axis, y_2 on Y–axis was made to display the varying effect of the treatments. Here the variates are uncorrelated and have the same variance; hence displacement in one direction is equally important and similar to displacement in any other direction. For the mean obtained based on n plots, a circle of radius $1/\sqrt{n}$ drawn around the treatment point shows the standard error similar to limits around a mean showing standard error for univariate case.

RESULTS AND DISCUSSION

The Bartlett's test for testing homogeneity of variances among the four year's data revealed insignificant differences for all the parameters studied namely gross returns/ha, yields of areca and cocoa per plant and per hectare (calculated χ^2 values being 2.56. 1.34, 2.78, 1.56 and 3.12 respectively which are less than $\chi^2_{3;\ 0.05}$) Hence all the results and discussion that follow are for the averaged data of four years.

The results of the univariate analysis (columns 3, 4, 6, 7 and 9 of Table I) reveals significant difference between spacings for weight of cocoa pods for both per plant yield and per hectare yield. In the case of weight of arecanuts, the significant difference was noticed only for per hectare yield. Even for gross returns/ha the spacing treatment has shown significant effect. The manurial treatments did not show influence on any of the crops. From this analysis, although it is possible to make inference on the treatment effects for each of the crop separately, the effect of the treatment on the mixed crop model cannot be made with certainity, due to possible interdependency of variables considered.

The bivariate analysis (Table I) reveals that the correlation coefficient between two variables *viz.*, weight of arecanuts and weight of cocoa pods is –0.18 in the case of per plant yield and –0.26 in the case of per hectare yield indicating the interdependency of the two variables considered in the study. This clearly suggests the use

Table I. *Bivariate and univariate analysis of variance table*

Source	d f	Mean sum of squares & sum of products						Gross Returns
		(i) per plant yields			(ii) per hectare yields			
		x_1^2	x_2^2	x_1x_2	x_1^2	x_2^2	$x_1x_2^2$	
Blocks	7	67.62 (16.65)	121.18 (11.65)	77.56 (12.69)	53.07 (12.52)	87.66 (15.10)	56.70 (13.54)	3681.6
Spacings	5	2.61 (0.65)	113.80** (7.42)	4.12 (0.63)	62.35** (7.84)	54.82** (11.00)	–5.56 (1.24)	1676.9**
Manures	1	4.54 (1.11)	0.04 (0.02)	–0.40 (0.13)	0.03 (0.46)	3.18 (0.07)	0.30 (0.16)	96.5
(SxM)[1]	5	5.69 (1.40)	0.74 (0.89)	0.24 (0.29)	6.97 (1.08)	7.61 (1.23)	0.78 (0.17)	249.9
Error	29	4.06 (1.00)	16.25 1.00	–1.43 (0.00)	6.14 (1.00)	7.00 (1.00)	–1.72 (0.00)	200.1
		E_{11}	E_{22}	E_{12}	E_{11}	E_{22}	E_{12}	
r			–0.18		..	–0.26		

** – Significant at 1 % level; 1 – unadjusted interaction effect
x_1 – weight of arecanuts; x_2 – weight of cocoa pods;
Figures in parenthesis are transformed values

of bivariate analysis for drawing inferences on the treatment effect on mixed crop model. The bivariate analysis for the transformed data obtaining bivariate F for the spacing treatments alone for both per plant yield and per hectare yield revealed significant difference between spacing treatments. The mean yield in respect of various spacings for both original and transformed data are given in Table II. Inferences such as determining which spacing combination is better for each of the crop separately, can be made more accurately by considering the mean values for the transformed data, as the interdependency was eliminated in this case. However, in the present study, inference made from both original and transformed data coincides, since the significant differences observed were substantially high in magnitude.

The inference on treatment effect on the mixed crop can best be made with the graphical representation of the treatment means. The task here is more simple, as only two crops are dealt here The mean values for the transformed data (which involve some mathematical functions of yield components) are graphed (Figs 1 and 2) taking y_1 on X–axis and y_2 on Y–axis for both per plant yield and per hectare

Table II. *Mean yield in respect of various spacings*

	Spacing		Yield / plant (kg.)		Yield / ha ('000 kg)		Gross Returns/ha ('000 Rs.)
	Areca	Cocoa	Areca	Cocoa	Areca	Cocoa	
S_1	2.7 × 2.7 m	2.7 × 2.7 m	7.48 (3.71)	10.55 (3.32)	10.26 (3.88)	14.46 (7.10)	82.83
S_2	2.7 × 2.7 m	2.7 × 5.4 m	7.44 (3.69)	17.00 (4.94)	10.20 (3.86)	11.66 (5.93)	76.51
S_3	2.7 × 2.7 m	5.4 × 5.4 m	7.59 (3.76)	22.14 (6.25)	10.40 (3.93)	7.60 (4.25)	70.87
S_4	3.9 × 3.9 m	3.9 × 3.9 m	6.70 (3.33)	15.66 (4.54)	4.40 (1.66)	10.29 (4.76)	44.39
S_5	3.3 × 3.3 m	3.3 × 3.3 m	6.16 (3.06)	15.17 (4.37)	5.66 (2.14)	14.32 (6.57)	55.21
S_6	1.8 × 5.4 m	3.6 × 5.4 m	7.40 (3.68)	17.61 (5.10)	7.62 (2.88)	9.05 (4.57)	58.41

Figures in parenthesis are mean values for transformed data

yield. It is evident from the Fig. 1 that in the case of per plant yields, the spacing s_3 (arecanut spaced at 2.7m x 2. 7m and cocoa at 5. 4m x 5. 4m) significantly outyields over the rest of the spacings and the closest spacing s_1 (both arecanut and cocoa spaced at 2. 7m x 2. 7m) had deleterious effect. Whereas, for per hectare yields (Fig. 2) the spacing s_1 significantly outyields which is closely followed by spacing s_2 (arecanut spaced at 2.7m x 2. 7m and cocoa at 2. 7m x 5. 4m) and then s_5 (both arecanut and cocoa planted at 3.3m x 3.3m quincunx method of planting). This clearly brings out the fact that when both the crops were planted at a spacing of 2. 7m x 2. 7m there was a decrease in yield of individual plants but yield per unit area was significantly higher due to higher population density. This spacing combination and the next best spacing s_2 gives higher returns in terms of yield per unit area for each of the crops, thereby safeguarding substantial monetary return even in the case of unfavourable price fall in either one of the crop. As detailed above, evaluation of the model was possible by eliminating the interdependency of the variables used, by bivariate analysis whereas such conclusions are difficult to arrive at based on univariate analysis where individual crop performance alone can be ascertained. Therefore in assessing cropping models involving two or more crops it is desirable to employ bivariate or multivariate technique for arriving at dependable conclusions.

The economic evaluation too has highlighted the efficacy of s_1 spacing (2. 7m x 2. 7m spacing for both the

Fig. 1. Means of spacing treatments on transformed scale (per plant yield)

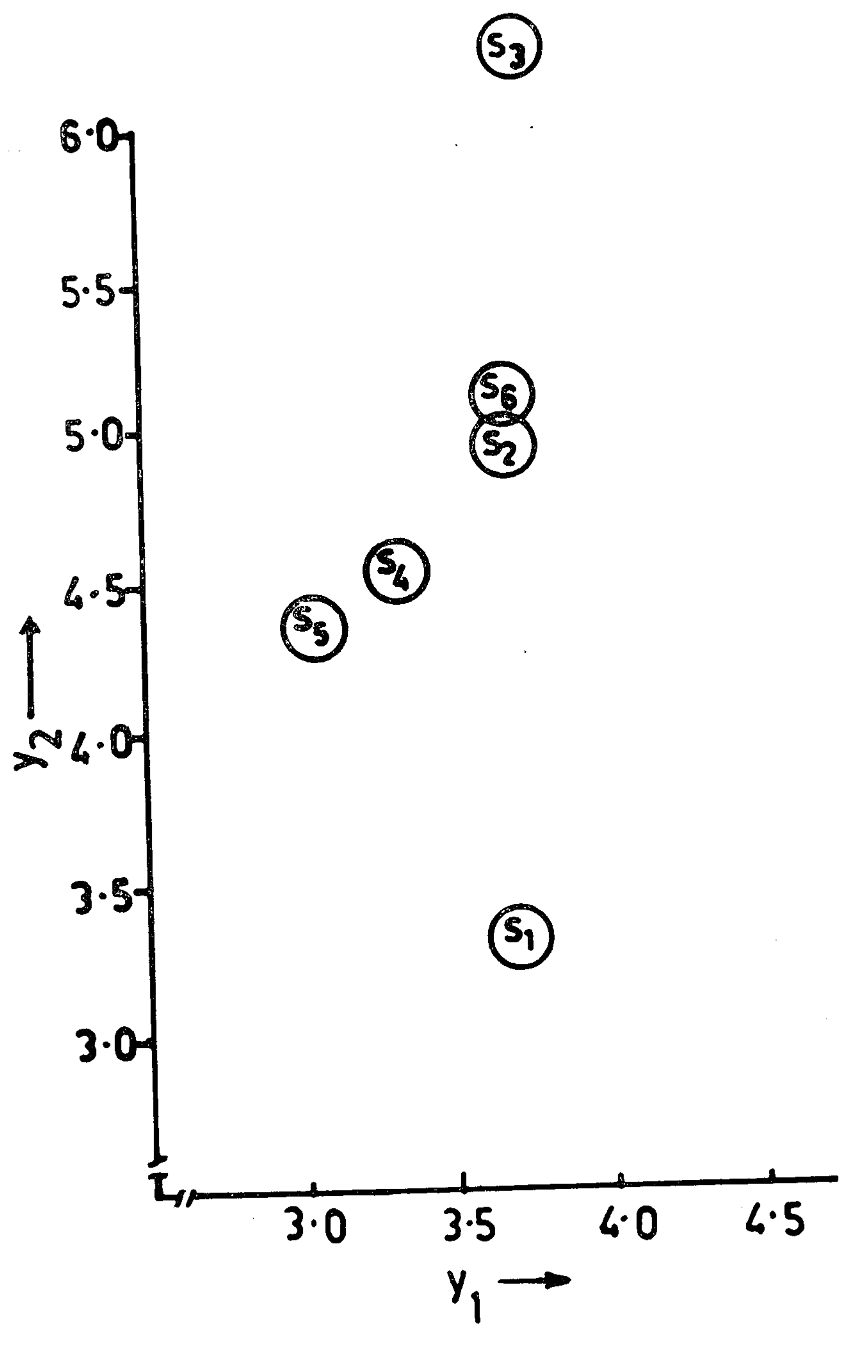
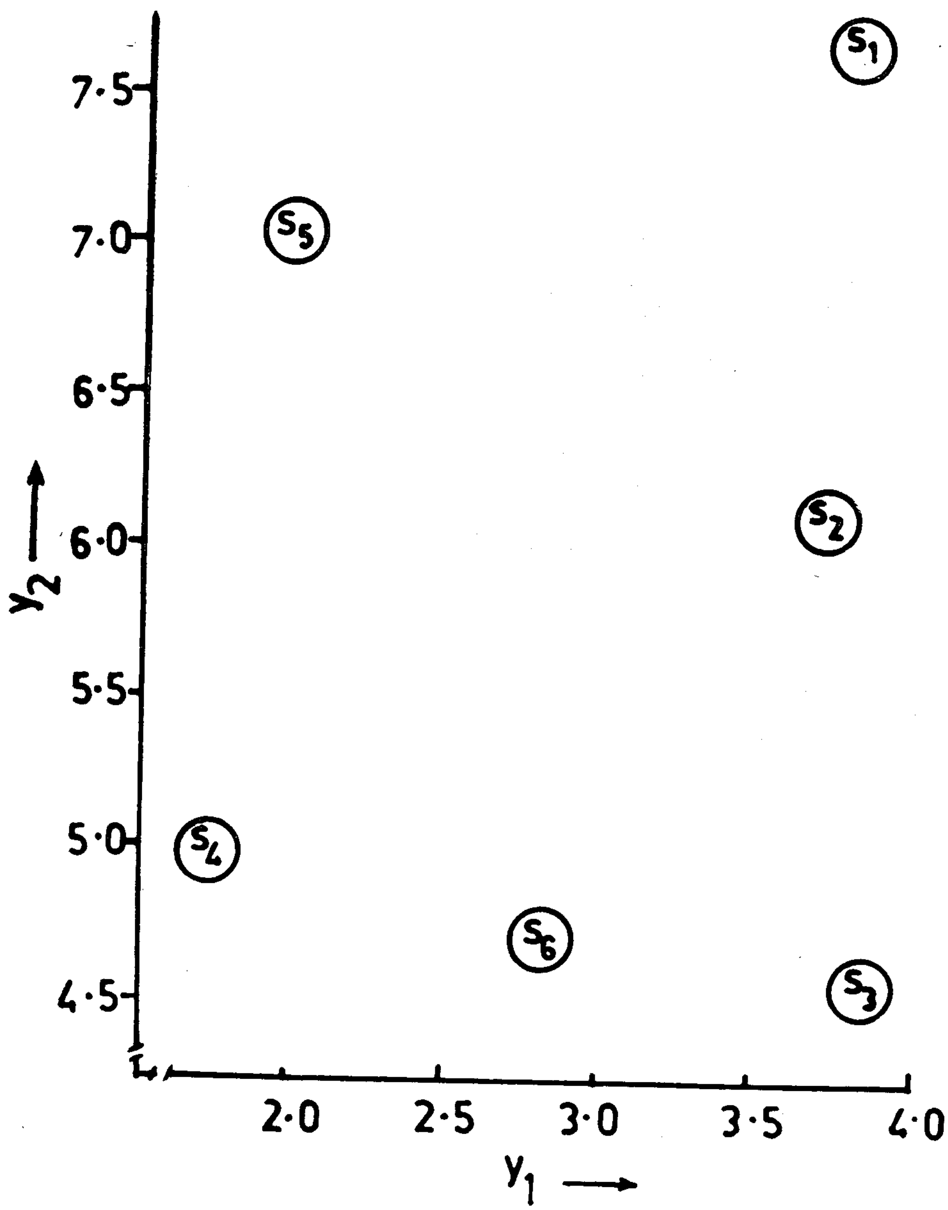


Fig. 2. Means of spacing treatments on transformed scale (per ha. yield)



plants) yielding Rs. 82,830/ha which significantly outyields over s_4, s_5, and s_6 spacings. In fact any increase in spacing from the recommended spacing for the arecanut *viz.*, 2. 7m x 2. 7m gives significantly poorer returns as the major portion (nearly 2/3 rd) of returns is realised from this crop.

From the analyis it is evident that cocoa can effectively be grown in the areca gardens in recommended spacing with cocoa trees spaced at 2. 7m x 2. 7m and if the cost of cultivation of cocoa is found to be high, the next best spacing *viz.*, cocoa spaced at 2. 7 x 5. 4m may be preferable for realising good returns.

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