CORRELATION STUDIES IN COCOA (*Theobroma cacao* L.)

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Abstract

Correlation studies were made between yield and growth characters in Forastero variety of cocoa (*Theobroma cacao* L.). Individual plant data on 660 cocoa plants collected from a progeny trial of the Cadbury-KAU Co-operative Cocoa Research Project, Vellanikkara, for 12 years formed the basis for the study. Significant correlations were obtained between the girth from the first to fifth year after planting and precocity, which in turn had significant correlation with total yield. Height from seedling to pruning stage had significant influence on yield as indicated by the correlations. It is emerged from the study that for exploiting the yield potential of cocoa, the plant should attain an optimum height in the initial stage, should maintain a minimum girth at different stages of growth and should have a minimum precocity.

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Introduction

Cocoa (*Theobroma cacao L.*) belongs to the family Malvaceae. Cocoa is mainly grown in Kerala, Andhra Pradesh, Karnataka and Tamilnadu. Kerala accounts for about 60 per cent of the area and production of cocoa in the country. The country's annual cocoa demand is considered to be around 18,000 tonnes and is growing around 15 percent annually. Cocoa exhibits high variability with respect to yield and related characters like girth and height, even among clones which are genetically similar and supposed to be uniform (Cherian, 1993). Yield potential of a cocoa tree is influenced by its growth characters and early yield. Hence, the information on the association of yield with these characters is of great importance. Significant correlations were reported between yield and growth characters of cocoa at different ages after planting (Longworth and Freeman 1963, Atanda 1972, Glendinning 1966 and Francies 1998). This article provides a detailed account of the correlation between yield and growth characters at different stages of plant growth and strategy for cocoa breeders is proposed.

Key words: Correlation, early yield, growth characters, precocity, yield stabilization.

Materials and Methods

The individual plant data on growth and yield characters of 660 cocoa plants from a progeny trial of Cadbury-KAU Co-operative Cocoa Research Project at Vellanikkara, Thrissur District, were collected for the study. A summary of the data collected are depicted in Table 1. The cocoa plants came to bearing in second year after planting. Precocity (P) is a measure of early yield in cocoa, and was estimated as:

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$$P = \sum_{i=2}^{5} Y_i$$

Total yield of a plant up to 13 years after planting was estimated as Total Yield Y = where Y_i is the $\sum_{i=2}^{13} Y_i$ yield in the i^{th} year after planting.

Results and Discussion

Correlation between girth measurements (G_0, G_1,...,G_{12}) and annual yield (Y_2, Y_3, ...Y_{12}) as well as total yield Y is presented in Table 2. Significant correlation was observed between girth in a particular year and yield in the same year as well as subsequent four to five years (lead influence). The girth of seedling (G_0) had high significant correlation with the yield during the first five years (Y_2 to Y_6). However, its correlation with total yield Y was found to be non significant. Girth in the first year after planting (G_1) had high significant correlation with yield in the second to sixth year after planting (Y_2, Y_3, Y_4, Y_5 and Y_6). The highest correlation (0.593) was with yield in the immediately succeeding year (Y_2). G_1 had high significant correlation with total yield Y also (0.18). Correlations between girth in the second year after planting (G_2) and annual yield during second to sixth year after planting (Y_2, Y3, Y_4, Y_5 and Y_6) were highly significant. G_2 also had high significant correlation of 0.256 with the total yield Y. Girth in the fourth year after planting (G_4) had significant correlation with yield in the same year (Y_4) and also up to eighth year after planting (Y_8). G4 had significant correlation with total yield Y also (0.319).

Girth in the third year after planting (G_3) had significant correlation with yield in the same year (Y_3) and yield during the subsequent three years (Y_4, Y_5 and Y_6). The correlation between G_3 and total yield Y was also highly significant (0.303). It could also be observed that the correlations between girth in the fifth year after planting (G_5) and yield from fifth to ninth year after planting (Y_5, Y_6, Y_7, Y_8 and Y_9) were highly significant. The correlation between G_5 and total yield Y was also significant (0.396). The yield of cocoa got stabilized in the sixth year after plating. Girth in the year of yield stabilization (G_6) had significant correlation with Y_6, Y_7, ... Y_{13}. High significant correlation was observed between G_6 and total yield Y also (0.431). Similarly, girths in the 7th to 12th year after planting except G_{11} had significant correlation with yield in the same year and all subsequent years. G_7 to G_{12} had high significant correlation with total yield.

Thus, it could be inferred that the girth of cocoa plant during a year had significant correlation not only with its yield during the same year, but lead relations existed with subsequent years also. Generally, the correlations were high in the current and the immediate succeeding year and thereafter its magnitude got progressively reduced. It could be safely concluded that the total yield of a cocoa plant for 12 years is influenced by girth of the plant at all stages of its growth. Similar observations were made by Longworth and Freeman (1963) and Atanda (1972). Thus girth is a determining factor of yield of cocoa.

The correlations between height (H_0, H_1 and H_2) and girth (G_0, G_1,...,G_{12}) are given in Table-3. It could be noted that height and girth of cocoa plants were highly correlated. High significant correlation was observed between seedling height (H_0) and girth up to eighth year after planting (G_0 to G_8). Correlations between H_0 and girths G_9 to G_{12} were non significant. H_1 had significant correlation with girths up to seven year after planting (G_0 to G_7). H_2 had significant correlation with girths in all years from G_0 to G_{12}. Significant positive correlation between plant height and girth in cocoa was reported by Bhat *et al.*(2000). This shows the close association between heights in the early years after planting and girths in the different stages of growth of cocoa. Height in the year just before pruning (H_2) was found to have more influence on girth.

To know the influence of plant height in the early years on yield, the correlation between plant height and annual yield from Y_2 to Y_{13} as well as

total yield (Y) was estimated and is presented in Table 4. It may be noted that the seedling height (Ho) had high significant correlation with yield in the first five years viz., Y_2, Y_3, Y_4, Y_5 and Y_6. H_1 had significant correlation with yield in the subsequent three years, viz., Y_2, Y_3 and Y_4. However, H_0 and H_1 had no significant correlation with the total yield (Y). H_2 had high significant correlation with yield in the same year (Y_2) and subsequent four years (Y_3, Y_4, Y_5 and Y_6) as well as with total yield Y. This indicates that height of the plant in the early years of plant growth influences yield in the subsequent years. Also, the height before pruning (H_2) has influence on the total yield for the 12 years. Thus, it emerges that girth and height have significant influence on the yield of cocoa.

Precocity being a measure of early yield of a cocoa plant, it is of immense use for a cocoa breeder to know the extent of association of precocity with other characters. The correlations provided in Table 5 show that girth from the first to fifth year after planting had high significant correlation with precocity (P). Seedling height H_o as well as heights in the first and second YAP (H_1 and H_2) had high significant correlation with P. High significant correlation was also observed between precocity and total yield Y. (Atanda, 1972) also reported influence of precocity on the yield potential of cocoa. This information is of very much practical importance in improving yield of cocoa.

Conclusion

In cocoa, height is controlled by pruning up to 150-200 cm and further growth is reflected in the girth of the plant. It is emerged from the present study that height of a cocoa plant up to pruning stage has significant influence on yield. Total yield during the economic life period of a cocoa plant (reckoned as 12 years) is influenced by girth of the plant at all stages of its growth. This information suggests that the plant should attain an optimum height in the early years and should maintain a minimum girth at different stages of growth. Influence of precocity of total yield suggests that a plant should attain a minimum precocity to maximize its yield. Maintenance of data on height, girth and precocity of each plant will help to identify low yielding plants during early years itself. Thus the study has significant relevance in cocoa breeding and management. It recommends the need for selection of genetically superior stocks and its scientific cultivation so that the plants attain optimum girth, height and precocity thereby higher yield realizations.

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Table 1: Particulars of data

Character	Period of observation	No. of years	Notations
Girth	From 1989-90 to 2001-02	13	G_i, i=0 to 12
Height	From 1989-90 to 1991-92	3	H_i, i=0 to 2
Pod yield	From 1991-92 to 2002-03	12	Y_i, i=2 to 13

Table 2 : Correlation between girth and yield

	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y
G_0	.249**	.348**	.249**	.121**	.138**	-0.06	0.03	-0.114	-0.16	-0.089	-0.071	-0.09	0.045
G_1	.593**	.490**	.352**	.236**	.191**	-0.088	.232**	-0.118	-0.142	-0.108	-0.046	-0.026	.18**
G_2	.423**	.622**	.481**	.366**	.241**	-0.003	.202**	-0.08	-0.154	-0.067	-0.047	-0.047	.256**
G_3		.521**	.486**	.412**	.260**	0.044	.192**	-0.043	-0.077	-0.031	-0.034	-0.03	.303**
G_4			.348**	.389**	.277**	.111**	.174**	0.021	-0.002	0.015	-0.001	0.012	.319**
G_5				.367**	.345**	.225**	.194**	.127**	.079*	.087*	0.053	0.063	.396**
G_6					.342**	.272**	.224**	.164**	.147**	.134**	.097*	.107**	.431**
G_7						.292**	.212**	.170**	.162**	.155**	.103**	.123**	.408**
G_8							.225**	.192**	.197**	.160**	.117**	.146**	.387**
G_9								.256**	.309**	.261**	.179**	.190**	.408**
G_{10}									.306**	.227**	.134**	171**	.377**
G_{11}										0.065	-0.002	0.026	.111**
G_{12}											.178**	.179**	.337**

** Significant at 1 % level

* Significant at 5% level

Table 3: Correlation between girth and height

	G_0	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9	G_{10}	G_{11}	G_{12}
F_0	.543**	.537**	.525**	.438**	.312**	.212**	.179**	.142**	.104**	0.05	0.07	0.05	0.04
F_1	.310**	.313**	.342**	.305**	.224**	.154**	.129**	.104**	0.07	L0.02	0.03	0.03	0.01
F_2	.479**	.623**	.745**	.701**	.573**	.467**	.410**	.337**	.287**	.168**	.170**	.145**	.131**

Table 4: Correlation between height and yield

	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}	Y_{13}	Y
Ho	.272**	.308**	.224**	.127**	.105**	-0.01	.081*	-0.11	-0.16	-0.07	-0.06	-0.08	0.063
H,	.159**	.187**	.152**	0.075	0.076	-0.03	0.043	-0.01	-0.07	-0.01	-0.03	-0.01	0.075
H_2	.243**	.492**	.386**	.341**	.232**	0.028	.098*	-0.02	-0.15	-0.07	-0.1	-0.09	.197**

Table 5: Correlation between precocity and growth parameters and total yield

	Go	G,	G_2	G_3	G_4	G_5	Ho	H,	H_2	Y
p	0.05	.181**	.255**	.298**	.130**	.418**	.312**	.213**	.560**	.397**

** Significant at 1% level * Significant at 5% level