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EVALUATION OF COCOA (*THEOBROMA CACAO* L.) HYBRIDS*

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An experiment on evaluation of 17 cocoa hybrids was conducted at CPCRI Regional Station, Vittal in 1984-85. The data on stabilized bean yield over six years from 1991 to 1996 indicated that the progenies belonging to hybrid combination I-56 x II-67 had performed better with regard to their yield potential and gained maximum yield increment over the check. Among the growth parameters, collar girth and weight of pruned biomass were found to influence the bean yield.

INTRODUCTION

Cocoa (*Theobroma cacao* L.) is gaining importance in the national economy and this has necessitated the identification of superior genotypes with high yield potential (Bhat *et al.*, 1990). A number of cocoa lines and hybrids have been evaluated at different centers; the main thrust being the development of high yielding and locally adaptable varieties with standard bean characters (Nair *et al.*, 1996). While evolving the better lines of cocoa, certain important criteria like high yield potential and low canopy volume are considered to safeguard the compatibility with main crop like areca and coconut. Many hybrids have been evolved by crossing the compatible parental lines with high yield potential. Certain hybrids have shown greater values of heterosis and higher percentage of gain in bean yield over the regular check which are known to perform better locally. An attempt was made to correlate the growth characters over the bean yield using principal component analysis for deciding the contributing factors.

MATERIALS AND METHODS

At CPCRI Regional station Vittal an experiment involving 17 hybrid combinations was initiated under a progeny row trial with seven parental lines and an elite line, I-56 as a check. In total the 25 treatments were replicated thrice in a completely randomized block design. The experiment was started during 1984-85 with eight plants per plot, planted at a spacing of 2.7 x 5.4 m. While making crosses, I-14 has been used only as female parent, IV-20 and NC 42/94 have been used as only male parents and the remaining four lines have been used both as male and female parents in the compatible combinations. Only one year data on growth parameters have been

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involved in interpreting the pooled analysis of six years yield data. Observations were made on the growth and yield parameters like collar girth, plant height, height at jorquetting, canopy volume and number of pods and their weight.

The present set of data on dry bean yield, per plant basis have been derived by pooling six years annual data. A sample from five pods of each hybrid progenies were collected and the pod value were studied by working out the bean weight after fermentation on dry weight basis. The number of pods necessary for realizing one kilogram of dry beans was used for computation and the values were utilized to derive the dry bean yield. Gain in the bean yield of each progeny had also been worked out and expressed in terms of per cent. Heterosis, the hybrid vigor of each F_1 combination was worked out by employing the formula, [((F_1 value - MP value) x 100)/MP value], where MP value is [(F_1 value of male and female parents)/2]. Actual canopy size of the plant was derived by adopting the formula, [(22/7 x r 2 x h)/3] where, r = radius of the canopy and h = canopy height with an assumption that the canopy resembled a cone in shape (Thomas and Balasimha, 1992) and the same was expressed in terms of cubic meter. The canopy radius had been computed by averaging the canopy spread over east to west and north to south directions.

Table 1. Bean yield increment and heterosis values of hybrids

Hybrid/parent	Bean yield (kg/plant)	Per cent increase	Heterosis
Hybrids			
I-14 x NC 42/94	1.389	65.0	32.5
I-14 x IV 20	1.331	59.2	31.1
I-14 x I-56	1.465	72.6	33.5
I - 14 x III - 35	1.137	39.8	7.5
I-14 x III - 105	1.069	33.0	-5.0
I-56 x NC 42/94	0.996	25.7	3.7
I-56 x IV - 20	1.358	61.9	46.4
I-56 x II-67	1.481	74.2	39.6
I-56 x III- 35	1.418	67.9	46.3
I-56 x III - 105	0.968	22.9	-6.7
II-67 x NC 42/94	0.977	23.8	-3.7
II-67 x IV - 20	0.991	25.2	1.2
III-35 x NC 42/94	1.096	35.7	19.0
III-35 x IV - 20	1.391	65.2	56.6
III-105 x NC42/94	1.368	62.9	38.4
III-105 x IV - 20	1.204	46.5	26.0
III-105 x I-56	0.903	16.4	-5.5
Parents			
I - 14	1.185	44.6	
I - 56	1.009	27.0	
II - 67	1.113	37.4	
III - 35	0.930	19.1	
III - 105	1.065	32.6	
IV - 20	0.846	10.7	
NC 42/94	0.912	17.3	
Check : I - 56	0.739		
C.D at P=0.05:	0.263		
CV (%)	35.32		

RESULTS AND DISCUSSION

Hybrids showed significant differences with regard to their bean yield. All the hybrid progenies gave an annual yield of more than 1.002 kg per plant, significantly higher than that of check, I-56. The progenies of I-56 x II-67 hybrid gave the maximum bean yield showing their superiority over the others followed by I-14 x I-56 and I-56 x III-35 (Table 1). Progeny, I-56 x II-67 showed an heterosis value of 39.6 per cent while four hybrids expressed negative heterosis (Table 1).

Hybrid progenies showed marked differences among themselves and from the check plants only with respect to stem girth and weight of pruned biomass (Table 2). Plant height, canopy height and canopy volume did not differ much among the hybrids. Among the progenies, I-14 x I-56 exhibited maximum collar girth and produced more biomass.

Principal component analysis of the data revealed the major two components which together accounted for more than 82 per cent of

Table 2. Growth characters of hybrid progenies

Hybrid / parent	Plant height (m)	Stem girth (cm)	Canopy height (m)	Canopy volume (m^3)	Weight of pruned biomass (kg)
I-14 x NC 42/94	4.61	42.44	2.58	7.519	11.85
I-14 x IV 20	4.29	47.77	2.76	3.325	14.93
I-14 x I-56	4.77	42.77	2.96	2.870	21.73
I - 14 x III - 35	4.66	45.33	2.60	2.788	14.22
I-14 x III - 105	4.38	46.88	2.78	5.161	19.61
I-56 x NC 42/94	4.04	41.66	2.66	3.308	9.64
I-56 x IV - 20	4.51	47.99	2.89	6.148	13.23
I-56 x II-67	4.56	50.66	3.27	7.743	19.01
I-56 x III-35	4.44	46.66	2.74	1.435	15.07
I-56 x III - 105	4.22	39.33	2.67	2.258	12.62
II-67 x NC 42/94	4.42	39.55	2.53	3.580	11.19
II-67 x IV - 20	4.46	43.11	2.88	4.419	10.08
III-35 x NC 42/94	4.44	46.22	3.15	4.807	21.67
III-35 x IV - 20	4.34	45.11	2.81	5.062	11.04
III-105 x NC 42/94	4.35	47.72	3.16	4.052	19.33
III-105 x IV - 20	4.41	45.22	2.70	6.112	13.09
III-105 x I-56	3.94	46.78	2.34	5.462	18.22
I - 14	4.38	50.11	2.76	3.845	13.28
I - 56	4.18	41.66	2.64	6.485	14.39
II - 67	3.99	39.44	2.53	3.226	12.77
III - 35	4.15	38.22	2.66	3.624	8.67
III - 105	4.47	45.66	2.34	3.006	7.71
IV - 20	4.19	32.78	2.48	2.694	5.22
NC 42/94	4.39	44.55	2.94	4.297	7.47
I - 56	4.11	41.55	2.29	3.998	8.00
CD at P=0.05:	NS	8.67	NS	NS	2.49
CV (%)	9.4	11.99	16.15	81.44	11.34

variance found in the total observations. The loading of these principal components had revealed the major contributions by the stem girth and weight of pruned biomass in the first component and solely by the canopy volume in the second component. These three variables accounted for the major variances among the data (Table 3).

A strong and positive correlation was observed between bean yield and stem girth; the major contributor towards the establishment and production of crop (Table 4). Stem girth had a significant positive relationship with the plant's overall height. The canopy height also had strong positive relationship with the stem girth of the plant indicating that the vigour and total plant maturity are decided by the stem girth at the collar region. Correlation between different characters were found significantly positive in Forastero cocoa and similar results had already been reported by Balasimha (1988). Stem girth at collar region is regarded as the major repository of starch reserve (Balasimha and Nair, 1989). Mobilization of stored stem starch for flushing and pod load has been depicted from previous studies conducted by Thomas and Balasimha (1992). Hence there is a strong relationship between stem girth and bean yield.

Though pruning level was uniform for all the treatments, there had been significant

Table 3. Principal component analysis of growth characteristics on bean yield

a) Principal component scores

	Latent roots	percent variance	Cumulative Variance
PRIN 1	3148.221	46.218	46.218
PRIN 2	2496.94	36.657	82.875
PRIN 3	1137.77	16.703	99.578
PRIN 4	18.351	0.269	99.848
PRIN 5	6.53	0.096	99.944
PRIN 6	3.864	0.057	100.000

b) Latent vectors in descending order

Variable	PRIN 1	PRIN 2
Stem girth	0.857	- 0.187
Weight of pruned biomass	0.476	- 0.064
Canopy volume	0.195	0.980
Canopy height	0.029	- 0.004
Plant height	0.019	- 0.003
Bean yield	0.017	- 0.006

variations in the weight of prunings indicating the differential flushing behaviour of hybrids. The weight of pruned materials can be taken as a measure of biomass since it is a linear proportion of the total biomass. Equally there had been an indication of negative impact of canopy volume on bean yield. Similar results were obtained from previous studies (Balasimha, 1988) where increased canopy area had increased bean yield only during the early age of the plants and not during the stabilized phase. Previous studies had indicated a negative correlation between vegetative flushing and pod yield indicating that more of the energy is diverted towards flushing than towards pod production.

The hybrid, I-56 x II-67 had thicker stem with moderate canopy volume and produced moderate biomass. The foliage had better spread over the canopy area with increased canopy height, paving the way for better infiltrated light interception. This could have resulted in higher amount of net photosynthesis, ultimately realizing higher bean yield. However, there had been negative correlation between canopy volume and bean yield pointing to a scope for further computation of yield potential of cocoa progenies in relation to the canopy volume rather than their *per se* potential yield. This is a relevant point because the crop occupies the inter spaces in areca and coconut gardens. Hence genotypes with maximum bean yield potential and with minimum canopy volume may be evolved in the future breeding programmes that are suitable for inter cropping system. There is also a contemporary way to adopt the canopy volume restriction through pruning to fit in the mixed cropping system and to realize the expected bean yield.

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Table 4. Correlation coefficients of growth characters and bean yield

Parameter	Plant height	Stem girth	Canopy height	Canopy volume	Pruned biomass	Bean yield
Plant height	1.000					
Stem girth	0.312**	1.000				
Canopy height	0.684**	0.400**	1.000			
Canopy volume	0.019	0.033	0.042	1.000		
Pruned biomass	0.16	0.405**	0.308**	0.050	1.000	
Bean yield	0.062	0.320**	0.057	-0.039	0.277*	1.000

Table 'r' value at n-2 = 73; df = 0.296 and 0.228 one and five per cent probability

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