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Performance of selected clones of Nigerian cocoa*

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Abstract

Eight selected Nigerian clones were subjected to yield evaluation along with seedling as well as clonal progenies of Jarangan Red Axil - a proven clone from Malaysia as check in a randomized block design at the Regional Station Vittal since 1985. The clone NC 45/53 had the highest yield (0.930-1.726 kg) over the six stabilised cropping years followed by NC 38/119 (0.904-1.394 kg). The majority of variations observed in all the 17 parameters studied could be explained through the two principal components that indicated two important characters viz. pod number and canopy volume contributing to the maximum variation in the data. Correlation studies have indicated strong and positive correlation between stem girth and canopy volume, while pod value of all the tested clones of the accessions collected from Nigeria and Malaysian Landas Estate were negatively correlated with 1000 seed weight. The stability in the yield potential of NC 45 53 and NC 38 119 could be confirmed by lower CV values coupled with higher yield range observed. Though NC 38 clone showed the best stability index with least CV value (21.32%), NC 45 had an added advantage of being self-compatible. These observations indicated that the above mentioned two clones are the better performing clones with a stable and higher bean yield.

Key words : Nigerian cocoa clones, Principal component analysis, Growth parameters

Introduction

Cocoa has been a suitable mixed crop in coconut and arecanut gardens (Bhat and Bavappa, 1972). Presently, it is being cultivated in an area of about 14,618 ha with an annual production of 7837 metric tonnes of dry beans. The states of Kerala, Andhra Pradesh and Karnataka share the major area under this crop and its production. The present gap between the projected demand and the domestic supply indicates the vast potential of cocoa left untapped in India (John, 1995). This can be achieved either by increasing the area under cocoa cultivation in areca / coconut cropping systems, or by enhancing the productivity of the crop itself. There has been a continuous effort in introducing different germplasm through many agencies and select good lines with high yielding potential along with other desired quality parameters. Preliminary selections made over the years at this Institute have resulted in many good yielders from Malaysian and Nigerian collections. All these have been subjected to their progeny evaluation trials. The objective of this paper is to identify the best performing clones among the selected eight Nigerian clones from these progeny trials.

Materials and Methods

Eight Nigerian cocoa clones with desired qualities were tested under a progeny trial laid out in a randomized block design with three replications, and clonal and seedling progenies of I-14 as checks for comparison, since 1985, at CPCRI Regional Station, Vittal. All the Nigerian clones have been propagated through soft wood wedge grafting. Dry bean yield of each clone has been worked out for six years after they attained yield stabilization. i.e. from their sixth cropping year onwards until 1996-97 and the same have been subjected to ANOVA separately and on pooled basis as well. Growth parameters like stem girth at collar region, plant height at first branching, total height of the plant, number of branches per plant, canopy height and the canopy volume

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have been measured and expressed in respective units. Height was recorded at first jorquetting. Data related to these parameters have been subjected to ANOVA and have been utilized in measuring their degree of contribution to the productivity of each clone. The data have been subjected to principal component analysis and multiple regression analysis. Stabilized bean yield over the six years has been subjected to stability analysis indicated by combinations of coefficients of variations, standard deviation, and the range for stable yield. All the eight Nigerian clones and the Jarangan Red Axil clones were selfed and tested for their compatibility reactions (Table 1) taking twenty flowers in each of these clones at a time and pollinating them with the pollen of the same plant. An attempt is made to select the best Nigerian clone among the tested eight lines - in comparison with the clonal progenies of Jarangan Red Axil - a line selected from Malaysian accessions using the parameters like bean yield and stability indices.

Table 1. Observations on pedigree and compatibility of clones

Nigerian clone	Pedigree	Self-Compatibility	Cross-Compatibility
NC 39/102	T 17/11	Incompatible	Compatible
NC 38/119	T 17/11	Incompatible	Compatible
NC 26/73	P6 X P4	Incompatible	Compatible
NC 29/63	P6 x P4	Incompatible	Compatible
NC 34/113	T 7/12	Compatible	Combatible
NC 40/116	P9 x P7	Incompatible	Compatible
NC 45/53	P10 x P1	Compatible	Compatible
NC 55/8	W5/15 (T63/881)	Incompatible	Compatible

Results and Discussions

There has been consistent performance by two Nigerian clones, viz., NC 45 and NC 38. There has not been much of a difference in the annual bean yield of these clones, except during 1995-96. There was a gradual increasing trend in the bean yield of all the lines involved in the trial upto 1994-95. The next cropping year saw a severe stress throughout the block and the decline in the yield has been to a significant extent. However, the clones started regaining their potential from the next cropping year onwards. NC 45/53 showed remarkable recovery compared to all other lines. The high yielding Malaysian check line also showed on par performance during the stress year but it exhibited a low recovering capacity (Table 2).

The NC 45 clones recorded the maximum consistent dry bean yield of 1.328 kg per plant (on pooled basis) followed by NC 38. The remaining clones have yielded less than the check plants. Three clones, viz., NC 39, NC 34 and NC 55 gave significantly lower yield than those of check plants while other three clones viz., NC 26, NC 29 and NC 40 could yield on par with that of check plants. Only NC 45 clone realized 27.20 per cent gain in the dry bean yield over the clones of check plants followed by NC 38 clones (9.30%). All others had a negative increment over check line with NC 55 clones realising the least yield increment (-27.60%).

The clones showed significant differences in the growth parameters viz., stem girth, total height, canopy height, number of branches and canopy volume. Maximum stem girth of 12.73 cm was recorded in the progenies of NC 40 while the minimum (9.16 cm) was observed in NC 55. High yielding clones had a wider stem girth, viz. NC 45 (11.86 m) and NC 38 (12.18 cm).

Table 2. Dry bean yield (kg/plant)

Nigerian clone	1991-92	92-93	93-94	94-95	95-96	96-97	Pooled	% gain over clonal check
NC 39/102	0.572	0.876	1.148	1.010	0.613	0.851	0.845	-21.10
NC 38/119	1.054	0.998	1.293	1.500	0.809	1.237	1.149	09.30
NC 26/73	0.950	1.033	1.271	1.515	0.544	0.923	1.040	-01.60
NC 29/63	0.971	1.037	1.225	1.182	0.644	1.299	1.060	00.40
NC 34/113	0.535	0.862	1.061	0.786	0.563	1.012	0.803	-25.30
NC 40/116	0.664	0.811	0.973	1.619	0.651	1.004	0.954	-10.20
NC 45/53	0.963	1.072	1.205	1.807	1.063	1.855	1.328	27.20
NC 55/8	0.452	1.048	1.39	0.615	0.479	0.949	0.780	-27.60
1-14 clone	0.671	1.298	1.258	1.194	0.716	1.203	1.056	--
1-14 seedlings	0.799	1.432	1.201	1.669	0.784	1.358	1.208	--
CV (%)	39.57	34.54	15.44	26.01	27.60	34.69	30.10	
SEM ±	0.174	0.209	0.105	0.194	0.109	0.234	0.07	
CD	NS	NS	NS	0.57	NS	NS	0.203	

Progenies did not differ with regard to the height at first branching. All of them started branching almost at a similar height with a range from 1.35 m to 1.65 m. However, NC 45 clones had a higher measurement in this respect. This branching at a higher point has resulted in more area on trunk for cushion development and also for more clearance for inter-cultivation practices - an added advantage from farmers' convenience point of view. Progenies differed with regard to their total height. NC 45 clones had a higher stature with total height of 4.16 m, while it ranged from 2.89 m (the least) recorded with NC 55 to 4.47 m (the maximum) noted with the NC 40 clones. Canopy height ranged from 1.52 m (NC 55) to 3.13 m (NC 40). The clones differed with respect to canopy volume also. The maximum canopy volume of 22.59 m^3 was observed with NC 40, while the minimum (4.12 m) was recorded with that of NC 55. NC 45 and NC 38 clones have moderate canopy volume of 12.86 m^3 and 11.78 m^3 respectively. The medium canopy volume with moderate to high range of canopy height influenced bean yield (Table 3). The clones, NC 45 and NC 38 had a stable bean production over six stabilized croppings. The former clone had a potential yield range of 0.930 - 1.726 kg dry beans per plant per annum, while the latter had a corresponding figure of 0.904-1.394 kg. The canopy volumes for the respective clones were 12.86 m^3 and 11.78 m^3. These two particular clones had CV values of 29.79 and 21.32 percent respectively (Table 4), indicating a better consistency in bearing higher bean yield over the years. It may be recalled here that a total of seventeen elite cocoa trees were selected from 288 trees of Malaysian origin taking into account their cumulative pod yield and a CV value of less than 40 percent (Bhat *et al.* 1990).

Table 3. Growth parameters of Nigerian clones

Nigerian clone No.	Stem diameter (cm)	HAFB (m)	Total height (m)	No. of branches	Canopy height (m)	Canopy volume (m^3)
NC 39/102	10.21	1.35	3.49	2.20	2.15	13.22
NC 38/119	12.18	1.43	3.77	2.00	2.35	11.78
NC 26/73	10.84	1.54	3.65	2.00	2.11	8.75
NC 29/63	10.61	1.36	3.40	2.00	2.04	8.34
NC 34/113	12.39	1.35	4.03	2.17	2.68	12.52
NC 40/116	12.73	1.65	4.47	2.10	3.13	22.59
NC 45/53	11.86	1.65	4.16	2.60	2.51	12.86
NC 55/8	9.16	1.38	2.89	2.00	1.52	4.12
1-14 clone	11.32	1.40	3.86	2.00	2.46	12.23
1-14 seedling	12.36	1.73	4.78	2.47	3.05	18.37
CV (%)	8.01	10.94	12.79	8.98	20.02	31.67
SEM ±	0.525	0.092	0.284	0.112	0.28	2.28
CD	1.56	NS	0.84	0.33	0.83	6.77

SI = Self-Incompatible, SC = Self-Compatible and HAFB = height at first branching

Table 4. Stability indices of Nigerian clones

Hybrid	Mean (a)	Standard deviation (b)	Coefficient of variation (CV%)	Range for the stable yield (kg/plant/annum) (a-b)	(a+b)
NC 39/102	0.845	0.223	26.39	0.622	1.068
NC 38/119	1.149	0.245	21.32	0.904	1.394
NC 36/73	1.040	0.331	31.83	0.709	1.371
NC 29/63	1.060	0.237	22.36	0.823	1.297
NC 34/113	0.803	0.221	27.52	0.582	1.024
NC 40/116	0.954	0.358	37.53	0.596	1.312
NC 45/53	1.328	0.398	29.97	0.930	1.726
NC 55/8	0.750	0.374	47.95	0.406	1.154
1-14 Clone (check)	1.056	0.284	26.95	0.772	1.340
1-14 Seedling (check)	1.208	0.356	28.18	0.852	1.564

High yielding clones had moderate canopy measurements compared to the low yielding ones. The stronger stems coupled with moderate canopy volume produce a better dry bean yield. This could be confirmed by looking at the correlation values among the canopy measurements and the bean attributes. A negative though not significant correlation coefficient (r=0.025) has been indicated between the canopy volume and the dry bean yield. Balasimha (1988) indicated similar results. Stem girth at collar region has been regarded as major repository of starch reserve (Balasimha and Nair, 1989). Thomas and Balasimha (1992) have depicted mobilization of stored stem starch for flushing and pod load from previous studies.

Correlation studies indicated a positive relationship between canopy volume and stem girth (r=0.665) and between stem girth and number of branches (r=0.4701). Previous works (Balasimha, 1988; Bhat *et al.*, 1988) have indicated similar results. There was a strong, significant negative correlation between pod value and 1000 seed weight (r=-0.701) indicating that higher the seed weight lower is the pod value (Table 5).

Table 5. Correlation values

Parameters	Pod value (1)	Canopy volume (2)	1000 seed wt. (3)	Dry bean wt./ fresh wt. (4)	Stem girth (5)	Number of branches (6)	Dry bean yield (7)
1.	1.000						
2.	0.029	1.000					
3.	-0.701	-0.142	1.000				
4.	-0.246	-0.020	0.204	1.000			
5.	0.022	0.665	-0.044	0.166	1.000		
6.	0.022	0.337	0.060	0.470	0.255	1.000	
7.	0.196	-0.025	-0.103	-0.021	0.020	0.112	1.000

Table 'r' value for error df (n-2) (p = 0.05) = 0.361 & (p = 0.01) = 0.463

Similarly, from the principal component analysis the main contributors towards the majority of variations observed in the data related to growth and yield attributes could be traced to pod number and canopy volume conversion factors. These parameters could explain 76.3 percent of the total variation and the correlation values among these parameters confirm the possible deciders among the parameters under study to project the clones as better performers (Table 5,6a and 6b).

Table 6 a. Principal components

Component	Latent roots	Percentage Variance	Cumulative Variance
Prin 1	5890.936	63.971	63.971
Prin 2	1136.525	12.342	76.313

Table 6b. Latent vectors in descending order

Characters	Principal component 1	Principal component 2
Pod number	0.992	0.019
Wt. loss in fermentation	0.075	0.026
Pod value	0.060	-0.029
Dry bean yield	0.033	0.001
Total height	0.005	0.004
Ht. at first branching	0.003	0.004
Number of branches	0.002	0.014
Canopy height	0.002	0.091
Stem girth at collar	0.002	-0.156
Bean fresh wt./pod wt.	0.002	0.231
Pod index	-0.000	0.000
Pod weight	-0.001	0.003
Bean size	-0.001	0.002
1000 seed wt.	-0.001	0.002
Dry bean / Wet bean	-0.003	0.063
Canopy volume	-0.014	0.943
Av. no. of beans / pod	0.069	0.100

Among the various pod and bean characters only pod value and the ratio of bean weight over pod weight had significant variations (Table 7.) Least pod value of 20.08 was found in NC 34/113, while the maximum pod value of 31.48 has been observed in the best line 45/53. Highest average single pod weight (0.481 kg), bean content (44.5) coupled with higher value for 1000 seed weight and conversion factor value made NC 34 clone to have the least pod value. However, NC 45 clone had the highest pooled dry bean yield over the years. Maximum single pod weight (0.481) was recorded in NC 34 while, it was least in NC 26.

Table 7. Pod and bean characters in the Nigerian clones

Treatment	Number of beans / pod	Single pod wt. (kg)	1000 seed wt (kg)	Bean wt. / pod wt ratio (%)	Dry bean/ wet bean (%)	Pod value
NC 39/102	41.8	0.374	0.928	24.3	43.44	26.03
NC 38/119	37.6	0.371	1.068	27.00	38.47	26.20
NC 26/73	40.3	0.307	0.889	28.9	40.26	28.18
NC 29/63	41.7	0.333	0.960	30.4	40.44	25.04
NC 34/113	44.5	0.481	1.121	24.6	42.22	20.08
NC 40/116	38.9	0.479	1.132	22.9	40.20	22.85
NC 45/53	38.9	0.479	1.132	22.9	40.20	22.85
NC 55/8	39.6	0.352	0.854	25.0	39.36	30.21
1-14 clones (check)	39.6	0.388	1.029	22.8	46.73	24.70
1-14 Seedlings (check)	42.3	0.393	0.920	26.6	37.76	26.03
CV (%)	9.15	13.51	12.15	9.3	8.6	10.92
SE M ±	2.13	0.029	0.045	0.014	2.035	1.64
CD	NS	0.88	NS	0.041	NS	4.89

Conclusion

Nigerian clone NC 45/53 outperformed other clones with a high degree of yield stability (CV% = 21.32) and maximum dry bean yield range (0.930-1.726 kg) followed by the clones of NC 38/119. The majority of variations observed in all the 17 parameters studied could be explained through the first two principal components that indicated two important characters viz., pod number and canopy volume that contributed to the maximum variations in the data. Correlation studies have indicated strong and positive correlation between stem girth and canopy volume, while pod value of each accession was negatively correlated with 1000 seed weight. The stability in bearing potential of NC 45/53 and NC 38/119 could be confirmed by looking through the parameters like lower CV values coupled with higher yield range observed with these particular clones. Though the clones NC 38/119 showed the best stability index with least CV value (21.32%), NC 45/53 had an additional quality of being self-compatible in addition to having the highest yield range of 0.930-1.726 kg per plant. The former clone has been self incompatible and cross compatible and thus needs some other compatible clones while planting in the main field while, the latter clone (NC 45) being self compatible can produce a crop in the garden with no pre-requisite presence of other clones in the vicinity. Hence, these two clones could be regarded as the elite clones with stable and higher bean yields.

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