Short scientific report *Journal of Plantation Crops, 2011, 39 (1): 153-156*

Genetic analysis in Cocoa (*Theobroma cacao* L.) collections obtained from Nigeria

(Manuscript Received: 20-12-10, Revised: 24-02-11, Accepted: 08-04-11)

Keywords: Cocoa, genetic variability, heritability, genetic advance

Cocoa is an important plantation crop grown for its dry beans, which is the economic part used in chocolate preparation. The productivity of cocoa in India is only 535 kg/ ha which is very low compared to that of other producing countries. Genetic progress to overcome production constraints can be obtained through adequate application of proven breeding techniques as well as by additional evaluation of germplasm (Bertus Eskes, 2000). Parameters of genotypic and phenotypic coefficients of variation (GCV and PCV) are useful in detecting the amount of variability present in the available genotypes. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection. Crop improvement depends upon the magnitude of genetic variability and extent to which the desirable characters are heritable. Very little efforts has been made to the genetic studies in cocoa, hence the present investigation was undertaken to assess the nature of available variability and association of yield with its contributing traits and to identify the desirable genotypes.

The materials of the present investigation comprised of 44 accessions of cocoa collected from Nigeria, maintained in the germplasm conservatory of the Central Plantation Crops Research Institute (CPCRI), Regional Station (RS), Vittal, Karnataka. These were planted during 1998 at a distance of 2.7 m x 5.4 m in arecanut gardens spaced at 2.7 m x 2.7 m with eight trees per clone. Clones were used as planting material and all the cultural practices including need based plant protection measures were followed as per the recommendations of CPCRI.

Seventeen observations with regard to growth, yield and quality characters were taken in these collections and compared. Growth characters such as plant height (m), girth (cm), height at first branching (m), north south and east west spreads (m), canopy volume (m^3) and prunings weight (kg) were observed and compiled here from the sixth year data. Yield parameters like no.of pods per tree per year (mean of 8 years data), single pod weight (g), length (cm) and breadth (cm) of pod, furrow thickness (cm), bean no. per pod, single dry bean weight (g), dry bean yield per tree per year (kg) and quality aspect in percentage of fat content (%) and shelling (%) were taken in ten years old trees and analysed. The phenotypic and genotypic coefficients of variation (PCV and GCV) (Tahir and Gupta, 2000), broad sense heritability (H^2) (Singh and Choudhary, 1985) and genetic advance (GA) (Singh and Narayanan, 1993) were computed by adopting standard statistical procedures (Panse and Sukhatme, 1978) using GENRES software program.

The mean, range and phenotypic and genotypic coefficients of variation with respect to growth, yield and quality attributes of cocoa are presented in Table 1. Analysis of variance showed that the forty four accessions differed significantly for all the seventeen characters showing difference between them at genotypic level. Wide range of genetic variability was observed for the clones studied. The pod weight had the maximum range of performance (242.00- 735.16) in the clones NC-38 and NC-39 with a mean value of 455.97 followed by fat content (37.10- 55.25) in NC-34 and NC-63 with a mean value of 47.77 % and no.of beans (26.34- 49.66) in NC-15 and NC-52 with an average of 41.14. The minimum range of performance (0.25- 2.52) in NC-12 and NC-23 with a mean of 1.25 kg was observed for dry bean yield per tree per year, thus indicating the involvement of lower number of alleles in the control of this character and minimal influence of environmental factors. Differential variability of vegetative, reproductive and fruit characters and their potential in breeding have been reported by earlier workers in cocoa (Lachenaud *et al*., 2000), coconut (Ratnambal *et al*., 1995, 2000), coffee (Nikhila *et al*., 2002; Raghu *et al*., 2003) and medicinal plants (Misra

Table 1. Estimates of genetic parameters in cocoa

Characters	Range	Mean	GV	PV	GCV	PCV	H^2	GA (%)
Plant height (m)	1.31-4.24	2.52	0.31	0.696	22.09	33.08	44.58	30.39
Girth (cm)	10.13-36.25	21.94	25.26	50.54	22.91	32.41	49.97	33.36
HAFB (m)	0.42-1.10	0.68	0.010	0.094	14.65	44.81	10.69	9.87
North South spread (m)	0.88-3.16	2.18	0.259	0.626	23.38	36.31	41.47	31.02
East West spread (m)	0.80-3.17	2.25	0.245	0.606	22.02	34.64	40.40	28.83
Canopy volume (m^3)	1.06-20.40	7.90	15.13	16.16	49.23	50.88	93.62	98.10
Prunes weight (kg)	1.25-8.25	4.19	2.72	8.206	39.35	68.32	33.17	46.69
Pod weight (g)	242.0-735.16	455.97	13831.36	14609.14	25.79	26.51	94.68	51.70
Pod length (cm)	13.31-24.28	19.46	9.78	10.23	16.07	16.43	95.69	32.39
Pod breadth (cm)	6.66-13.01	10.05	2.93	3.32	17.03	18.14	88.18	32.95
Furrow (cm)	0.57-1.45	0.93	0.044	0.051	22.43	24.19	85.96	42.84
Bean No.	26.34-49.66	41.14	22.20	26.26	11.45	12.46	84.55	21.70
SBW (g)	0.71-1.28	0.98	0.021	0.024	14.83	15.73	88.93	28.82
DBY (kg)	0.25-2.52	1.25	0.368	0.379	48.38	49.12	97.01	98.17
Fat content (%)	37.10-55.25	47.77	27.28	28.79	10.93	11.23	94.75	21.92
Shelling (%)	10.23-21.38	15.73	8.82	9.203	18.88	19.28	95.83	38.07
Pod no.	8.03-61.92	30.84	116.36	276.85	34.98	53.96	42.03	46.72

HAFB- Height at first branching, SBW- Single dry bean weight, DBY- Dry bean yield

GV- Genotypic Variance, PV- Phenotypic Variance, GCV- Genotypic Coefficient of Variation, PCV- Phenotypic Coefficient of Variation, H^2- Heritability, GA- Genetic Advance

et al., 1998). Yield is a very variable character in cocoa and made up of several components of quantitative nature and specific combination of alleles of genes enable the plant to exhibit maximum favourable characters (Homey Cheriyan *et al*., 1996). However, the absolute variability in different characters cannot be the criteria for deciding as to which character is showing the highest degree of variability. The total variability can be partitioned into heritable and non-heritable components with the help of genetic parameters like phenotypic and genotypic coefficient of variation, heritability and genetic advance. Heritable variation can be effectively studied in conjunction with genetic advance.

The selection applied to the cocoa trees has been primarily based on the phenotype. If the heritability estimates are high, the selection was achieved based on the individual and if low based on means of families. Because in cocoa repeated measurements of a given character are being taken in the same individual, the generations are overlapping and the data are frequently unbalanced. Therefore, the selection can be made based on predicted breeding values and through variance components estimation (Luis Antonio *et al*., 2000). To assess additive and genotypic effects, narrow and broad sense heritability and repeatability estimates of a trait of interest are necessary.

In the present study, the estimates for GCV and PCV indicated that there is an ample scope for the improvement of cocoa. In our study, the PCV was slightly higher than GCV in all the cases, showing the non-involvement of environment to some extent in the expression of characters. Low values of PCV and GCV were recorded for characters like fat content and bean no., this indicates that the varieties do not exhibit much variation among themselves with respect to these characters. Narrow difference between PCV and GCV values were noticed for all the characters studied. Genetic improvement in the performance of these characters is very much desirable, as the improved lines would not be affected by environmental expressivity and thus productivity is predictable. The GCV which gives a picture of the extent of variability in the population ranged from 10.93 for fat content to 49.23 for canopy volume. The GCV estimates were considerably high (>30 %) for characters such as prunes weight, dry bean yield and pod yield, whereas it was moderate for plant height, girth, canopy spread, pod weight and furrow thickness, indicating better scope of improvement through selection. In such a situation, selection can be effective on the basis of the phenotypic alone with equal probability of success. A similar trend has been reported in many vegetable and field crops.

With the help of GCV alone, it is not possible to determine the amount of variation that is heritable. Very high heritability estimate values were recorded for all the characters. Heritability of the characters ranged from 10.69 to 97.01 %. The highest heritability value of 97.01 % was observed for dry bean yield and high values were recorded for many characters such as shelling percentage (95.83 %), pod length (95.69 %), fat content (94.75 %), pod weight (94.68 %) and canopy volume (93.62 %)

showing that these characters are influenced by environment to a very low extent. The minimum estimate of heritability was observed for height at first branching (10.69 %) indicating the influence of environmental factors. Heritability which determines the accuracy with which a genotype can be relied for its phenotypic performance was high for all the characters under study except height at first branching. Similar studies have been undertaken in coconut (Ratnambal *et al*., 1995).

High heritability accompanied by high genetic advance was more useful than heritability alone and considerable improvement could be made in these characters by predicting the results and selecting the best genotypes. Heritable variation can be found out with greater degree of accuracy when heritability is taken into consideration along with genetic advance. Hence, both heritability and genetic advance were determined to get a clear picture of the scope of improvement in various characters through selection.

The genetic advance in the present study ranged from 9.87 to 98.17 % of mean (genetic gain). Genetic advance was found to be the maximum for dry bean yield (98.17 %) followed by canopy volume (98.10 %). Genetic advance in percent of mean was low in case of height at first branching (9.87 %). High heritability value accompanied with high genetic gain for canopy volume (93.62 and 98.10) and dry bean yield (97.01 and 98.17) indicated additive type gene action. Simple selection therefore could be effective for the improvement of these traits. High heritability estimates along with low genetic gain was probably due to non-additive type of gene action and direct selection for these characters will be less effective (Panse and Sukhatme, 1978). It is clear from the table that traits like canopy volume, dry bean yield possessing high GCV, heritability and genetic gain could be effectively used in selection, as it has been suggested that characters with high heritability coupled with high genetic gain would respond to selection better than those with high heritability and low genetic gain.

High heritability with high genetic advance was reported for many horticultural crops. Moderate heritability along with low genetic advance was shown by few more characters like pod breadth, furrow thickness, number of beans per pod and single bean weight. This indicates that these characters are mostly in control of non additive genes and selection of these characters will be less effective. The current study envisaged that selection of superior genotypes in cocoa can be based on characters like dry bean yield and canopy volume. It was also proved earlier that there was a direct relation between canopy spread to no. of pods per plant and bean yield (Nair *et al*., 1990).

Thus, computation of PCV, GCV, heritability and genetic advance of characters provided an idea of the extent of environmental impact, estimates of inheritance of characters that can be expected from parent to progeny which is very essential in identifying superior genotypes and plant types for horticultural purposes. Hence, selection of superior genotypes for higher performance for the traits of high heritability with high genetic advance would be possible for the characters in the studied material. Among the 44 accessions studied, the accession NC-37 was found to possess desirable traits like medium canopy volume with high yield. The accessions NC- 23, NC-57, NC-45 and NC-63 exhibited high canopy volumes. The dry bean yield per tree per year was the highest in NC-23 followed by NC-26, NC-37, NC-52 and NC-25 (Table 2). The studies revealed that the conserved Nigerian cocoa clones in India could be useful in breeding programmes owing to the wide variability observed for heritable traits. Hence, there is a need to explore the cocoa germplasm for their possible use in improving the productivity and sustainability of the crop.

Table. 2. Selected clones with desirable characteristics

Clone	Canopy volume (m^3)	Pod (no./ tree/year)	Bean (no./pod)	Single bean weight (g)	Dry bean yield (kg/ tree/year)	Shelling (%)	Fat (%)
NC-37	11.81	61.9	42.7	1.03	2.45	10.9	51.0
NC-23	20.40	53.3	42.3	1.12	2.53	11.5	51.3
NC-26	12.26	49.4	43.0	1.17	2.48	13.1	53.2
NC-50	9.74	48.4	43.3	1.00	1.45	12.7	50.6
NC-20	11.34	45.1	43.0	1.00	1.93	11.2	54.5
NC-51	9.11	44.2	43.3	1.00	1.83	13.9	50.1
NC-27	3.39	43.9	43.7	1.07	2.06	12.5	51.6
NC-25	9.69	43.1	40.3	1.24	2.16	13.1	53.2
NC-52	12.24	40.7	49.7	1.11	2.25	12.7	51.6

References

Bertus Eskes. 2000. Collaborative activities on cocoa germplasm utilization and conservation supported by the CFC/ ICCO/ IPGRI project. pp. 23- 29. In: *Proceedings of 13th International cocoa research conference. Volume I*, Kota Kinabalu, Sabah, Malaysia 9-14 October 2000.

Homey Cheriyan, Vijayakumar, N.K. and Vikraman Nair, R. 1996. Evaluation of variability in crosses and their parent populations of cocoa. *J. Plantn. Crops* **24**(1): 43- 49.

Lachenaud, P.H., Oliver,G. and Letourmy, P.H. 2000. Agronomic assessment of wild cocoa trees from the camopi and tanpok basins (French Guiana). pp. 169- 173. In: *Proceedings of 13th International cocoa research conference volume I*, Kota Kinabalu, Sabah, Malaysia 9-14 October 2000.

Luis Antonio Dos Santos Dias and Marcos Deon Vilela De Resende. 2000. Estimation of genetic parameters and prediction of breeding values by mixed model in the cocoa improvement. pp. 189- 194. In: *Proceedings of 13th International cocoa research conference. Volume I*, Kota Kinabalu, Sabah, Malaysia 9-14 October 2000.

Misra, H.D., Sharma, J.R., Lal, R.K. and Sharma, S. 1998. Genetic variability and path coefficient analysis in Ashwagandha (*Withania somnifera*). *Journal of Medicinal and Aromatic Plant Sciences* **20**: 753- 756.

Nair, R.V., Appaiah, G.N. and Nampoothiri, K.U.K. 1990. Variability in some exotic accessions of cocoa in India. *Indian Cocoa Arecanut and Spices Journal* **14**(2): 49-51.

Nikhila, K.D., Reddy, A.G.S., Sureshkumar, V.B. and Mohanan, K.V. 2002. Consequences of sibmating in C x R (*Coffea congensis* x *Coffea canephora*) coffee. pp. 83-87. In: *PLACROSYM XV.*, Indian Society for Plantation Crops, Kasaragod.

Panse, V.G. and Sukhatme, P.V. 1978. *Statistical methods for agricultural workers*. 75 pp. ICAR, New Delhi.

Raghu, A.V., Mohanan, K.V., Reddy, A.G.S. and Sureshkumar, V.B. 2003. Variability in a sibmated progeny of C x R coffee. *Indian J. Agric. Res*. **37**(2): 110- 114.

Ratnambal,M.J., Nair, M.K., Muralidharan,K., Kumaran, P.M., Bhaskara Rao, E.V.V. and Pillai, R.V. 1995. *Coconut Descriptors Part I*. 197 pp. Central Plantation Crops Research Institute, Kasaragod, India.

Ratnambal,M.J., Niral, V., Krishnan, M. and Ravi Kumar, N. 2000. *Coconut Descriptors Part II.* CD-ROM. Central Plantation Crops Research Institute, Kasaragod, India.

Singh, R.K. and Choudhary, B.D. 1985. *Biometrical methods in quantitative genetic analysis*. Kalyani Publishers, New Delhi, India.

Singh, P. and Narayanan, S.S. 1993. *Biometrical techniques in Plant Breeding.* Kalyani Publishers, New Delhi, India.

Tahir, H. and Gupta, S.K. 2000. Statistical techniques. pp. 344- 384. In: *Plant breeding: Theory and Techniques*. (Eds.) Gupta, S. K. Agrobios, India.

CPCRI, Regional Station, Vittal, Karnataka - 574 243.

S. Elain Apshara,
R.V. Nair