Research Article
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Evaluation of cocoa (*Theobroma cacao* L.) genotypes for pod and bean characters

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Abstract

Performance of cocoa genotypes was studied for pod and bean characters at Pollachi, Coimbatore district. Based on the continuous evaluation, ten plus trees were identified as best performers. To study the stability of these genotypes, the pod and bean characters were evaluated during 2017-2018. Five uniformly ripened pods were collected from each genotype for the assessment of pod and bean characters. Cocoa genotypes used for the evaluation were TNAUCC 1-10. These genotypes differed from each other. Data were collected for number of flowers per tree, number of pods per tree, pod weight, pod set percentage, number of beans per pod, dry bean weight per pod, single dry bean weight and estimated dry bean yield per tree. The coefficient of variation in these genotypes differed from 5.7 per cent to 17.8 per cent. Number of pods per tree and pod set percentage was found to be high in TNAUCC 2. Pod weight, single dry bean weight, dry bean weight per pod and estimated dry bean yield per tree was maximum in TNAUCC 5. Number of pods per tree showed significant and positive correlation with pod weight, single dry bean weight and estimated dry bean yield per tree. Single dry bean weight had significant and positive correlation with dry bean weight per pod and estimated dry bean yield per tree. Hence, the cocoa genotypes TNAUCC 5 and TNAUCC 2 can be further exploited for crop improvement program.

Keywords: Bean weight, cocoa, correlation, genotypes, pod set, yield performance

Introduction

Cocoa (*Theobroma cacao* L.) has its origin in the hot, humid region of Amazon valley in South America (Wood and Lass, 2001; Bartley, 2005). It is mainly cultivated for its seeds known as beans which are commercially used in chocolate and beverage industries. The genus *Theobroma* has 22 species. Among these, *T. cacao* is cultivated in large areas in Bolivia, Cameroon, Côte d'Ivoire, Ecuador, Ghana, Nigeria, Indonesia and India. The domesticated *T. cacao* has a wide diversity in plant morphology and the three cocoa types *viz*., Criollo, Forastero and Trinitario were mainly classified based on their morphology especially the pod and bean characters (Wood and Lass, 1985). Commercial cultivation of this crop in India started in the early 1960's and at present Forastero is being cultivated predominantly.

In India, cocoa is being cultivated in the states of Kerala, Karnataka, Andhra Pradesh and Tamil Nadu in an area of 78,000 ha with total production of 16,050 MT. Tamil Nadu ranks first with an area of 29,969 ha. Andhra Pradesh ranks first in production (8085 MT) and Kerala rank first in productivity (785 kg ha^{-1}). In Tamil Nadu, the production is 1733 MT and productivity is 320 kg ha^{-1} as against the national average productivity of 475 kg ha^{-1} (DCCD, 2018). One of the reasons attributed for cocoa production and productivity in Tamil Nadu is adoption of high yielding varieties or genotypes. Evaluation of cocoa genotypes for pod and bean characters is the prerequisite to identify high yielding genotypes.

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Selection and improvement of high yielding cultivars was possible by utilizing the genetic diversity within the plant species (Arzani, 2008). Identification and evaluation of high yielding superior cocoa genotypes increases the genetic base of the crop and these identified plus trees can be utilized for further breeding program to meet the demand of cocoa beans throughout the world. The main aim of the study was to evaluate the yield performance of cocoa genotypes and their correlation with yield contributing characters to select a best performing genotype for Coimbatore district.

Materials and methods

Ten cocoa genotypes were selected based on their yield performance at farmer's field in Pollachi, Coimbatore district. Cocoa plants of 20 years old grown as an intercrop in the coconut ecosystem were evaluated for their yield performance. The cocoa plants were introduced in between the two rows of coconut with a plant spacing of 3 m.

Cocoa genotypes used for this study were TNAUCC 1, 10. Morphological traits *viz*., number of flowers tree^{-1}, number of pods tree^{-1}, pod weight, pod set percentage, number of beans per pod, dry bean weight pod^{-1}, estimated dry bean yield tree^{-1} and single dry bean weight were recorded and analyzed. Pods were harvested at full maturity stage 4 to 5 months after flowering.

$$\text{Pod set (\%)} = \frac{\text{No. of pods harvested + cherelle wilted pods + rodents and pod rot affected pods}}{\text{Total no. of flowers tree}^{-1}} \times 100$$

Correlation between the morphological characters was studied using the statistical software SPSS (Nei, 1978).

Results and discussion

Pod and bean characters

The 10 selected plus trees of cocoa showed significant difference for all the observed traits. Data on number of flowers tree^{-1}, number of pods tree^{-1}, pod set per cent, pod weight, number of beans pod^{-1}, single dry bean weight, dry bean weight pod^{-1} and estimated dry bean yield tree^{-1} were recorded. The results are presented in the Table 1. Wide variability within the genetic resources is mainly used as a source material and these materials provide the basis for the selection of suitable parents and further utilization in the breeding program (Vodouhe *et al*., 2007). Coefficient of variation is mainly used to observe the range of variation available in the genotypes (Apshara and Nair, 2011).

Variation in number of flowers tree^{-1} ranged from 4595.6 to 7082.8. Number of flowers was observed to be minimum in TNAUCC 6 and maximum in TNAUCC 9. Number of pods tree^{-1} showed variation ranging from minimum of 55 in TNAUCC 2 to maximum of 70 in TNAUCC 6.

Percentage of pod set in all genotypes was recorded and TNAUCC 2 recorded the highest pod set percentage of 3.4, while it was observed to be low in TNAUCC 9 (2.1). The mean pod set per cent was 2.7. Pod weight of all ten genotypes showed variation from 403.0 g to 534.7 g. Coefficient of variation for pod weight was 11.3 per cent. TNAUCC 5 showed maximum pod weight and TNAUCC 4 showed minimum pod weight. Number of beans pod^{-1} recorded significant variation with maximum number of beans in TNAUCC 6 (43.7) and minimum in TNAUCC 3 (36.2). Coefficient of variation and mean number of beans pod^{-1} were 5.7 and 38.7, respectively.

Single dry bean weight was calculated and it ranged from 0.85 g to 1.05 g in TNAUCC 6 and TNAUCC 5, respectively. Cocoa genotypes with bean weight more than 1 g are characterized as superior (Monteiro *et al*., 2009). Coefficient of variation for the single dry bean weight was 5.7 per cent. Selection of cocoa genotypes based on the higher dry bean weight will enhance the production of quality cocoa beans. Pods with higher weight have the equal value for the selection of cocoa genotypes as like that of higher bean weight (Adewale *et al*., 2013). Variation in dried bean weight is considered to be the direct and significant method for the selection of cocoa genotypes (Oyedokun *et al*., 2011).

Level of variability for dry bean weight per pod ranged from 32.2 g to 42.4 g in TNAUCC 3 and TNAUCC 5, respectively. Coefficient of variation

and the mean dry bean weight pod^{-1} was 7.6 per cent and 36.6 g, respectively. Estimated dry bean yield tree^{-1} showed variability among the ten plus trees with TNAUCC 5 recording the highest and TNAUCC 3, the lowest. The mean value and coefficient of variation was 2293.4 g and 13.3 per cent, respectively. Size and number of beans are significantly controlled at genetic level and also other factors like pod size and ratio between the number of potentially developed beans in a single pod of cocoa (Glendinning, 1963).

Beans are the economic part of cocoa. Size of bean is the important yield contributing component of cocoa (Soria, 1978). Broad level of genetic variation is observed in genetic resources of cocoa and these resources are being utilized as raw material for breeding and identification of improved new varieties for the achievement of sustainability in cocoa production (Laliberte *et al*., 2012). Higher pod set was obtained by planting of more number of divergent parents in the same field (Sajeevkumar *et al*., 2017).

Correlation between yield contributing characters

The data on correlation coefficient of pod and bean characters were measured and presented in Table 2. Pod set per cent recorded highly significant and positive correlation with number of pods tree^{-1}, pod weight, dry bean weight tree^{-1} and estimated dry bean yield tree^{-1}. Number of pods tree^{-1} was significantly and positively correlated with pod weight, single dry bean weight and estimated dry bean yield tree^{-1}. Pod weight had significant and positive correlation with single dry bean weight and estimated dry bean yield tree^{-1}. Single dry bean weight was positively correlated with dry bean weight pod^{-1} and estimated dry bean yield tree^{-1}.

Table 1. Pod and bean characters of cocoa plus trees

Accessions	No. of flowers tree^{-1}	No. of pods tree^{-1}	Pod set (%)	Pod weight (g)	No. of beans pod^{-1}	Single dry bean weight (g)	Dry bean weight pod^{-1} (g)	Estimated dry bean yield tree^{-1} (g)
TNAU CC 1	4597.8	63.0	3.1	521.7	38.3	0.95	36.4	2292.3
TNAU CC 2	5572.3	70.0	3.4	501.3	39.7	1.00	39.7	2779.0
TNAU CC 3	6514.9	61.0	2.3	442.3	36.2	0.89	32.2	1965.3
TNAU CC 4	5904.5	62.0	2.2	403.0	36.8	0.97	35.7	2211.8
TNAU CC 5	5248.2	68.0	3.3	534.7	40.5	1.05	42.4	2885.3
TNAU CC 6	4595.6	55.0	2.5	408.7	43.7	0.85	37.3	2051.4
TNAU CC 7	6487.7	57.0	2.3	411.3	37.3	0.96	35.8	2041.2
TNAU CC 8	5345.8	64.0	2.5	416.0	38.2	0.93	35.7	2281.5
TNAU CC 9	7082.8	63.0	2.1	438.7	37.0	0.94	34.6	2182.4
TNAU CC 10	5615.4	62.0	2.7	413.0	39.4	0.92	36.2	2244.3
Mean	**5696.5**	**62.5**	**2.7**	**449.1**	**38.7**	**0.95**	**36.6**	**2293.4**
CV (%)	**14.4**	**7.1**	**17.8**	**11.3**	**5.7**	**5.70**	**7.6**	**13.3**

Table 2. Correlation analysis of pod and bean characters of cocoa plus trees

	No. of flowers tree^{-1}	Pod set	No. of pods tree^{-1}	Pod weight	No. of beans pod^{-1}	Single dry bean weight	Dry bean weight pod^{-1}	Estimated dry bean yield tree^{-1}
No. of flowers tree^{-1}	1							
Pod set	-0.603	1						
No. of pods tree^{-1}	-0.036	0.675*	1					
Pod weight	-0.335	0.836**	0.693*	1				
No. of beans pod^{-1}	-0.717*	0.451	-0.110	0.139	1			
Single dry bean weight	0.043	0.564	0.754*	0.638*	-0.148	1		
Dry bean weight pod^{-1}	-0.502	0.795**	0.530	0.620	0.618	0.685*	1	
Estimated dry bean yield tree^{-1}	-0.307	0.842**	0.866**	0.752*	0.299	0.825**	0.883*	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

Dry bean weight per pod was significantly and positively correlated with estimated dry bean yield tree^{-1}. Number of flowers tree^{-1} had significant and negative correlation with number of beans pod^{-1}. Similar correlation results were obtained by Karthikkumar (2013).

Conclusion

TNAUCC 5 exhibited higher mean value for pod weight, single dry bean weight, dry bean weight pod^{-1} and estimated dry bean yield tree^{-1}. TNAUCC 2 showed maximum mean number of pods tree^{-1} and pod set per cent. Hence, TNAUCC 5 and TNAUCC 2 can be further exploited for crop improvement of cocoa.

Pod set per cent recorded highly significant and positive correlation with number of pods tree^{-1}, pod weight, dry bean weight tree^{-1} and estimated dry bean yield tree^{-1}. Number of pods per tree was significantly and positively correlated with pod weight, single dry bean weight and estimated dry bean yield tree^{-1}. Single dry bean weight was positively correlated with dry bean weight per pod and estimated dry bean yield tree^{-1}.

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