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## Growth and yield performance of cocoa (*Theobroma cacao* L.) varieties under Tamil Nadu condition

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**Abstract**

Seven improved varieties of cocoa (CCRP 1, CCRP 2, CCRP 3, CCRP 4, CCRP 5, CCRP 6, CCRP 7) were planted during 2010 at Coconut Research Station, Aliyar Nagar, Coimbatore, Tamil Nadu and their performance were evaluated for growth, yield and quality characters during 2016. The results indicated that there was significant difference among the varieties and CCRP 3 recorded the highest plant height (3.52 m), stem girth (25.01 cm) and total phenol (80.1 mg equivalent for pyrocatechol per gram) whereas CCRP 5 registered the highest number flowers per cushion (7.12), number of flower cushions per tree (79.29), No. of pods harvested per tree (28.14), pod weight (502.19 g) and single dry bean weight (1.02 g). With respect to quality parameters CCRP 5 recorded the highest fat content of 52.5 percent and total carbohydrate content of 24.6 percent.

**Keywords:** Cocoa, varieties, fat content, quality

**Introduction**

Cocoa (*Theobroma cacao* L.) is a preferentially allogamous, Neotropica tree species of the family Malvaceae (Alverson *et al.*, 1999) [4]. *Theobroma* originated in the tropical rainforest of equatorial America, the most important of these being at the foot of the Andes on the upper reaches of the Amazon river (Mossu, 1992) [16]. Cocoa bean, the product of commerce is used for the extraction of cocoa butter which forms the principle ingredient in manufacturing of chocolate.

Breeding work has been initiated at Kerala Agricultural University since 1979 resulted in the release of seven improved clonal varieties of Forastero type *viz.*, CCRP 1, CCRP 2, CCRP 3, CCRP 4, CCRP 5, CCRP 6 and CCRP 7 (Prasannakumari *et al.*, 2009) [9]. These improved varieties are suitable for cultivation in different cocoa growing tracts of Kerala and also in the other warm tropical areas of India. There is no information available on its performance in Tamil Nadu where the crop is intercropped with coconut and the prevailing climate is hot tropical. This warrants breeding and development of cocoa varieties which are suitable for tropical hot climatic conditions. As development of new varieties is a long term process, the immediate step is the evaluation of already released clones / hybrids to assess their suitability to Tamil Nadu conditions. Considering all these challenges of cocoa cultivation, growth and yield performance of cocoa varieties (*Theobroma cacao* L.) under Tamil Nadu condition was undertaken.

**Material and methods**

The present investigation was carried out during July to December, 2016 at Coconut Research Station, Aliyar Nagar, Coimbatore which is the traditional cocoa growing area in Tamil Nadu lying between 10° 29' N and 76° 58' E at an altitude of 288 m above MSL. The released varieties from Kerala Agricultural University *viz.*, CCRP 1, CCRP 2, CCRP 3, CCRP 4, CCRP 5, CCRP 6 and CCRP 7 were used for this experiment. Grafted plants of these varieties have been planted at the spacing of 3 m between 2 rows of coconut under randomized block design with three replications and age of the tree is six years. Five trees each of these clones were considered as individual replication and observed for their growth parameters. Individual pod characters were measured from five pods of each clone harvested during the peak season of August to December. Processed, fermented and dried beans were observed for bean characteristics. Fat content in the bean was estimated by petroleum ether extraction method using soxhlet apparatus and expressed in percentage. Biochemical parameters like total Carbohydrate and total phenol were estimated using Anthrone Method and Folin-Ciocalteu

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reagent method. The data collected in respect of various parameters of growth yield attributes were analysed statistically as described by Panse and Sukhatme (1985) [18].

The package of practices recommended by Tamil Nadu Agricultural University were followed. Pruning was regularly done in the identified trees wherein excess chupons arising from the main stem and fan shoots were removed before and after each monsoon. All the cocoa plants were flood irrigated during the study period.

## Result and discussion

### Tree morphology

In cocoa, tree height and stem girth are the good indication of the plant vigour. It has got a direct relationship with bearing, as cocoa is a cauliflorous plant. In the present study, clonal difference existed for plant height and stem girth. Among the clones, CCRP 3 registered maximum plant height and stem girth of 3.52 m and 25.01 cm respectively which was on par with CCRP 5, which recorded the plant height and stem girth of 3.50 m and 24.97 cm respectively. The number of fan branches per tree ranged from two to four. The differences in the plant height and tree girth of cocoa trees were due to the multi various factors such as environmental factors, soil moisture, availability of nutrients and genetic factor of the tree. Similar differences in the plant height and stem girth of clones and hybrids have been reported by Elain Apshara *et al.* (2009) [6], Aikpokpodion *et al.* (2011) [3] and Thondaiman *et al.* (2013) [20].

### Flower characters

Cauliflorous flowering is observed in cocoa and it flowers throughout the year but peak season of flowering is during

January to June. The mean flower number per cushion and number of flower cushion per tree showed significant differences among the CCRP varieties. CCRP 5 recorded the higher number of flowers/ cushion and number of flower cushions/tree of 7.12 and 79.29 followed by CCRP 3(6.18 and 74.12) respectively. Flowering in cocoa is controlled by multi- various factors such as environmental factors, soil moisture, availability of nutrients and genetic factor of the tree. Environmental factors like temperature, light intensity and rainfall positively affected the production of flower cushion and production of open flowers. However, rainfall had the greater influence on phenological cycle of the cocoa plant (Adjaloo *et al.*, 2012) [1].

### Yield parameters

Yield is the main selection criterion (Eskes and Lauaud, 2001) [9] for any crop. The number of pods per tree in a year is the prime factor determining the yield in cocoa. In cocoa, yield is determined by yield contributing characters such as number of pods per tree, dry bean yield per tree and pod value (Thondaiman *et al.*, 2013) [20]. The number of pods harvested per tree showed significant variability among the cocoa clones CCRP 1 to 7 (Table.1). Among the different clones, CCRP 3 registered the highest number of pods per tree (28.14) followed by CCRP 5 (26.45) whereas, the clone CCRP 7 recorded the lowest number of pods per tree (22.95). In respect to pod weight, the results showed that the pod weight was significantly different among the cocoa clones, higher pod weight was observed in CCRP 5 (502.19 g) followed by CCRP 3 (460.18 g). These characters are influenced both by genetic as well as environmental factors which include soil moisture and nutrient status.

**Table 1:** Performance of CCRP cocoa clones for morphological and reproductive traits

Identified cocoa clones	Plant height (m)	Stem girth (cm)	Fan Branches	No of flowers /cushion	No. of flower cushions/tree	No. of pods harvested /tree	Pod weight (g)	Numbers of beans/pod	Single dry bean weight (g)
CCRP 1	3.34	24.15	3.0	5.21	65.21	24.19	426.16	38.41	0.85
CCRP 2	3.41	24.53	4.0	5.15	69.54	25.61	451.64	41.2	0.86
CCRP 3	3.52	25.01	3.0	6.18	74.12	28.14	460.18	42.18	0.98
CCRP 4	3.14	24.01	3.0	5.99	66.18	25.94	420.85	37.29	0.89
CCRP 5	3.50	24.97	4.0	7.12	79.29	26.45	502.19	43.81	1.02
CCRP 6	3.24	23.74	3.0	5.50	60.16	24.26	420.01	36.94	0.81
CCRP 7	3.09	22.19	4.0	5.00	58.64	22.95	399.45	34.18	0.83
Mean	3.32	24.09	3.43	5.74	67.59	25.36	440.06	39.14	0.89
SE(d)	0.0906	0.6548	0.096	0.1634	1.8724	0.6916	12.1197	1.0704	0.0248
CD (P=0.05)	0.1974	1.4268	0.212	0.3560	4.0797	1.5070	26.4067	2.3323	0.0539

Dried beans are the prime economic produce of cocoa. The number of beans decides the total weight of beans per pod. It is essential to select cocoa genotypes with more number of beans per pod so as to utilize the clones either in crop improvement for commercial plantations. Among the different varieties studied, CCRP 5 registered the highest number of beans per pod (48.31). Enriquez and Soria (1968) [8] classified the beans as small (< 0.99g), medium (1-1.5g) and large (>1.6g) on dry weight basis. Significant differences were recorded among the varieties for single dry bean weight with a range from 0.81 g to 1.02 g. CCRP 5 recorded the highest single dry bean weight (1.02 g). Bean, being the economic part of cocoa, focus on genotypes with higher bean weight will enhance production of cocoa (Oyedokun *et al.*, 2011) [18].

### Quality parameters

Cocoa butter is the major commercial product extracted from beans of cocoa. However, most cocoa breeding programmes have considered total bean yield per plant and disease resistance as the major selection criteria. In cocoa, the quality of beans is determined by two main parameters viz., fat and polyphenols. In the current study on evaluating the performance CCRP varieties (Fig.1), CCRP 5 registered the highest fat content of cocoa beans. Similar results of variability in performance for fat content by cocoa clones, accessions, hybrids has been reported by Adomako and Adu-Ampomah, (2003) [2]; Assemat *et al.* (2005) [5]; Elain Apshara *et al.* (2009) [6]; Lambert *et al.* (2009) [13] and Monteiro *et al.* (2011) [15].

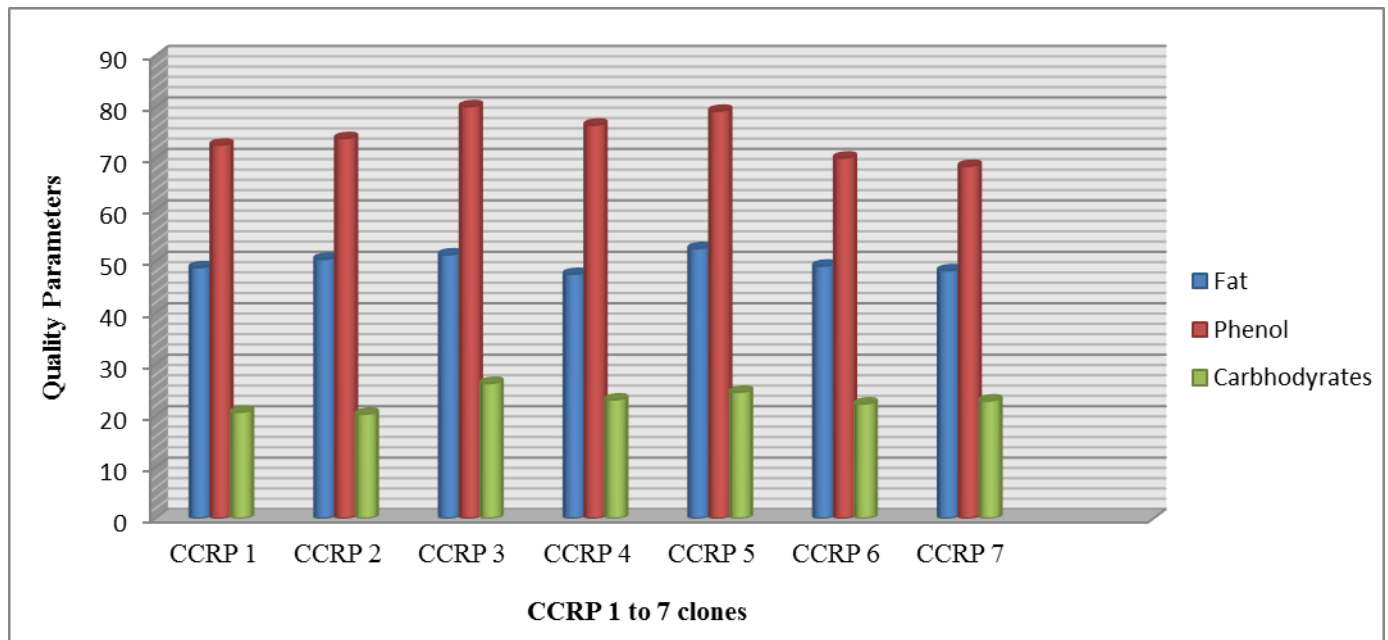


Fig 1: Performance of CCRP cocoa clones for quality parameters.

Phenolic compounds present in the cocoa beans contribute to the quality of raw cocoa, which serves as the basis of all chocolate products (Karthikkumar, 2014) <sup>[14]</sup>. The polyphenol content showed considerable variation among the CCRP clones. In the present study, poly phenol content ranged from 68.5 to 80.1 mg equivalent for pyrocatechol per gram. The present results were similar to the findings of Griffiths (1960) <sup>[11]</sup>, Jonfia-Essien *et al.* (2008) <sup>[12]</sup>, Elwers *et al.* (2009) <sup>[7]</sup>, Thondaiman (2013) <sup>[20]</sup> and Karthikkumar (2014) <sup>[14]</sup> in cocoa.

The total carbohydrate content in cocoa beans varied among CCRP varieties. In present study, it ranged from 20.6 to 24.41 percent and the highest total carbohydrates content was recorded by CCRP 5. The maximum value of total carbohydrate content exhibited by the clones may be due to their efficiency in partitioning of assimilates and thus could be selected for further crop improvement programme (Karthikkumar, 2014) <sup>[14]</sup>. Similar result of variability in carbohydrate content was reported by Fapohunda and Afolayan (2012) <sup>[10]</sup> in cocoa.

### Conclusion

From the growth and yield parameters assessed in the cocoa varieties, CCRP 5 and CCRP 3 were identified as potential varieties. These selected cocoa varieties can be used for commercial cultivation. However, further evaluation trials in multiple locations are required to confirm the growth performance and yield sustainability in cocoa.

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