International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 634-636

Received: 14-07-2018
Accepted: 18-08-2018

S Sumitha
Ph.D. Scholar, Department of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu, India

S Balakrishnan
Departments of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu, India

N Shoba
Departments of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu, India

M Kumar
Department of Cotton, TNAU, Coimbatore, Tamil Nadu, India

P Jeyakumar
Department Crop Physiology, TNAU, Coimbatore, Tamil Nadu, India

V Jegadeeswari
Departments of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu, India

Correspondence
S Sumitha
Ph.D. Scholar, Department of Spices and Plantation Crops, HC & RI, TNAU, Coimbatore, Tamil Nadu, India

Performance of identified cocoa clones for morphological and yield traits during initial growth phase

S Sumitha, S Balakrishnan, N Shoba, M Kumar, P Jeyakumar and V Jegadeeswari

Abstract
Performance of identified cocoa clones (TNAU CC 1 to 9) was studied for morphological and yield characters at Coconut Research Station, Aliyar Nagar. As the seedling progenies show wider genetic variability, to maintain true to type, grafted plants were used. Data collected for plant height, stem girth, number of flowers per tree, number of pods per tree, pod weight, dry bean weight per pod and single dry bean weight revealed that the nine identified cocoa clones showed significant variation. Among the clones, TNAU CC 5 recorded the highest plant height (164.5 cm), stem girth (15.16 cm), flower number per cushion (6.32), number of flower cushions per tree (65.2), No. pods harvested per tree (13.40) and pod weight (396.03 g).

Keywords: clones, grafted plants, cocoa, bean weight

Introduction
Cocoa (*Theobroma cacao* L.) is a preferentially allogamous tropical woody species formerly in the Sterculiaceae family (Cuatrecasas, 1964) [9] and reclassified in the Malvaceae family (Alverson *et al.*, 1999) [3] which originates from the tropical rainforests of the America. Cocoa is grown almost exclusively within 10°N and 10°S of the equator; predominantly grown in the tropical areas of Central and South America, Asia and Africa (Marita *et al.*, 2001) [19] where, the climate is warm and humid and thus suitable for growing (Hartemink and Donald, 2005) [14].

It is considered as one of the most important perennial with global annual production exceeding 4 million tons. Around 80–90% of global cocoa production comes from smallholder farms, with 5–6 million cocoa farmers worldwide (WCF, 2014) [26]. Estimated yield at Ghana is around 400 kg/ha (Aneani and Ofori-Frimpong, 2013) [4] while potential yield was reported to be 5000 kg/ha under rainfed conditions (Zuidema *et al.*, 2005) [27].

In India, cocoa was introduced in the early part of 20th century *i.e.*, 1798 (Ratnam, 1961) [20] and now it has become one of the important commercial horticulture crops. (Prasannakumari *et al.*, 2009) [21]. Cocoa cultivation is largely confined to southern states, *viz.*, Kerala, Karnataka, Tamil Nadu and Andhra Pradesh in an area of 78000 ha with total production of 16,050 MT. Tamil Nadu ranks first with an area of 26,969 ha whereas Andhra Pradesh ranks first in production. The average productivity of cocoa in India is 475 Kg/ha. (DCCD, 2017) [10].

The spreading cultivation of cocoa in India has necessitated the production of large number of high yielding hybrids and clonal materials with pest and disease resistance suited to different agro-climatic conditions. Evaluation of the germplasm for yield and quality under humid tropics helped in identifying elite materials which acclimatized to Indian conditions. Entries screened for yield and quality were planted in polyclonal seed gardens and the hybrid combinations were also developed and being evaluated. The pods from best performing cocoa trees were supplied to the farmers for area expansion programme.

The foremost necessity to get sustainable and profitable yield in this perennial crop is through supply of good planting materials from high yielding and quality mother plants as cocoa is a highly cross pollinated crop and the seedling progenies are not expected to breed true. Selection and improvement of high yielding cultivars was obtained through genetic diversity within the plant species (Arzani, 2008) [5]. 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 is to evaluate the performance of cocoa genotypes for yield at field conditions.

Materials and methods

A total of nine high yielding clones identified (TNAU CC 1 to TNAU CC 9) (Karthikumar, 2014) [17] and multiplied through soft wood grafting (Janani, 2014) [16]. They were planted at Coconut Research Station, Aliyar Nagar, Pollachi taluk which is the traditional cocoa growing area in Coimbatore district. As the seedling progenies show wider genetic variability, in order to maintain true to type, asexual or vegetative propagation (clonal propagation) is followed. It also ensures multiplication of identified high yielding clones in large quantities and exhibit early bearing nature. Grafted plants of nine high yielding clones (TNAUCC 1 to TNAUCC 9) were planted in the main field for clonal evaluation. The experiment was laid out in Randomized Block design with three replications. One row of cocoa was planted at a spacing of 2.7 m in between two rows of coconut spaced at 7.5 m x 7.5 m. 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.

Results and Discussion

The morphological characters of pods and beans pertaining to yield traits were recorded during July to December, 2016 and the results obtained are presented in table 1. In the present study, the identified clones (TNAU 1 to TNAU 9) exhibited significant differences for plant height and stem girth. Among the nine clones, TNAU CC 5 recorded the highest plant height (164.5 cm) and stem girth of 15.16 cm. Further, a tree with good tree girth, more number of fan branches and tree spread reflect the vigour of the trees indirectly favouring higher yield.

The mean flower number per cushion and number of cushions per tree showed significant differences among the nine identified clones of cocoa. The highest value for flower number per cushion (6.32) and number of flower cushions per tree (65.2) were recorded by TNAU CC 5. Flowering in cocoa is also influenced by genetic characters and each genotype is a heterogenous population hence exhibited differences in their performance. Pruning is an important practice to ensure proper ventilation within the crown and penetration of sunlight to stimulate cocoa flowering and fruit setting (USDA, 2007) [24].

The number of pods harvested per tree per year varied among the TNAU CC series (Table 1). The maximum number of pods harvested per tree was recorded in TNAU CC 5 (13.40) followed by TNAU CC 4 (12.60). While the minimum number of pods per tree was recorded in TNAU CC 9 (8.20). Pod production was low during the initial years. Later on, it increased every year. For studying the yield of cocoa per tree, Bartley (1970) [7] proposed to initiate selection of potentially high yielding cocoa tress on or after eighth year of planting, since with young trees, fruitification begins approximately at the fourth year. Pods are produced throughout the year, but the main harvest usually begins at the end of the wet season and may extend for 3 month.

The highest pod weight was recorded by TNAUCC 5 (396.03 g). Selection of genotypes with heavier pods means a selection of genotypes with higher bean weight (Adewale *et al.,* 2013)(1). Pod weight of more than 350 g to ensure pod filling with > 35 beans is the ideal selection criteria for yield improvement (Vikraman Nair *et al.,* 2000) [25]. Pod weight had significant (P<0.01) and positive correlation with pod length and pod girth Adewale *et al.,* 2013 [1] and Sobowale *et al.,* 2015 [25].

The economic part of this crop is the beans. In the present study, dry bean weight of single bean was observed from 0.82 g to 0.99 g respectively. Enriquez and Soria (1968) [13] observed that the dry bean weight of single bean varies from 0.5 g to 2.5g. Maharaj *et al.,* (2011) [18] reported dry bean weight in the range of 0.74 g to 1.49 g. Thondaiman *et al.,* (2013) [23] reported 0.59 g to 1.72 g. Similar variation in bean number per pod by entries in hybrid and clonal evaluation trials as well as on farm and germplasm evaluation had been reported earlier by Adomako and Adu-Ampomah (2003) [2], Iwaro *et al*. (2003) [15], Assemat *et al*. (2005) [5], Bekele *et al*. (2006) [8], Elain Apshara *et al.* (2009) [12] and Efombagn *et al.* (2009) [11].

Table 1. Performance of Identified cocoa clones (TNAU CC 1 to 10) for morphological and yield traits

Identified cocoa clones	Plant height (cm)	Stem girth (cm)	Fan Branches	No of flowers /cushion	No. of flower cushions/tree	No. of pods harvested /tree	Pod weight (g)	Single dry bean weight (g)	Dry bean yield per pod (g)
TNAU CC 1	154.2	14.56	2.67	5.25	52.4	10.90	354.20	0.89	29.19
TNAU CC 2	158.9	13.98	3.00	5.33	58.1	10.50	349.12	0.84	29.06
TNAU CC 3	154.2	14.27	2.33	5.40	56.1	11.90	336.14	0.93	29.75
TNAU CC 4	160.8	14.85	3.00	5.50	58.9	12.60	351.63	0.80	25.68
TNAU CC 5	164.5	15.16	3.67	6.32	65.2	13.40	396.03	0.97	35.99
TNAU CC 6	156.2	15.06	3.33	5.00	61.2	11.20	360.89	0.85	32.92
TNAU CC 7	152.8	14.37	2.67	5.50	49.5	10.60	364.08	0.89	31.15
TNAU CC 8	155.3	13.85	2.00	5.00	50.4	9.50	315.91	0.81	23.81
TNAU CC 9	158.4	13.52	3.00	4.90	45.9	8.20	320.64	0.84	28.14
Mean	157.25	14.40	2.85	5.35	55.30	10.97	349.84	0.86	29.52
SE(d)	3.94	0.36	0.45	0.13	1.43	0.29	9.02	0.02	0.77
CD (P=0.05)	NS	0.77	NS	0.29	3.03	0.62	19.12	0.04	1.64

Conclusion

Evaluation of the nine identified cocoa clones (TNAU CC 1to 9) propagated through soft wood grafting in this present study revealed that all the growth traits such as tree characters, flowers characters, pods and beans traits showed significant variation among the clones at three years after planting. This is preliminary evaluation study conducted at initial years of establishment. Hence, continuous evaluation in the future years will be required to select best performing cocoa clones suitable for Tamil Nadu conditions.

Acknowledgement
The first author is highly grateful to Department of Spices and Plantation Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore for providing the financial support and necessary facilities for conducting the experiments.

References

1. Adomako B, Adu-Ampomah Y. Bean characteristics of progenies of upper Amazon cacao in Ghana. Tropical journal of Agriculture. (Trinidad). 2003; 80:41-47.
2. Adewale DB, Adeigbe OO, Adepoju OO, Muyiwa AA. Descriptive and discriminatory significance of pod phenotypic traits for diversity analysis of cocoa genotypes. Journal Plant Breeding Genetics. 2013; 1(3):131-137
3. Aneani F, Ofori-Frimpong K. An analysis of yield gap and some factors of cocoa (*Theobroma cacao)* yields in Ghana. Sustainable Agriculture Research. 2013; 2:117-127
4. Alverson WS, Whitlock BA, Nyffeler R, Bayer C, Baum DA. Phylogeny of the core Malvales: Evidence from ndhF sequence data. American Journal Botany. 1999; 86:1474-1486.
5. Arzani A. Improving salinity tolerance in crop plants: a biotechnological view. In Vitro Cell Development of Biology and Plant. 2008; 44:373-383.
6. Assemat S, Ph. Lachenaud, Ribeyre F, Davrieux F, Pradon JL, Cros E. Bean quality traits and sensory evaluation of wild Guianan cocoa populations (*Theobroma cacao* L.). Genetic Resources and Crop Evolution. 2005; 52(7):911-917.
7. Bartley BGD. Yield variation in the early productive years in trials with cacao (*Theobroma cacao L*.) Euphytica. 1970; 19:199-206.
8. Bekele F, Bekele LI, Butler DR, Bidaisee GG. Patterns of morphological variation in a sample of cacao (*Theobroma cacao* L.) germplasm from the International Cocoa Genebank, Trinidad. Genetic Resources and Crop Evolution. 2006; 53:933–948.
9. Cuatrecasas J. Cacao and its allies: a taxonomic revision of the genus Theobroma. Bulletin of the United States National Museum. Smithsonian Institution Press, Washington. 1964; 35:379-614.
10. DCCD. (Directorate of cashewnut and cocoa Development). Area production and productivity of cocoa in India, 2017.
11. Efombagn MIB, Sounigo O, Nyasse S, Manzanares-Dauleux M, Eskes AB. Phenotypic variation of cacao (*Theobroma cacao* L.) on farms and in the gene bank in Cameroon. Journal of Plant Breeding and Crop Science. 2009; 1(6): 258-264.
12. Elain Apshara S, Bhat VR, Ananda KS, Nair RV, Suma D. Evaluation and identification of high yielding trees in Nigerian cocoa germplasm. Journal of Plantation Crops. 2009; 37(2):111-116.
13. Enriquez G, Soria JV. The variability of certain bean characteristics of cacao (*Theobroma cacao* L.). Euphytica. 1968; 17:114-120.
14. Hartemink AE, Donald LS. Nutrient stocks, nutrient cycling, and soil changes in cocoa ecosystems: A Review, Advances in Agronomy. 2005; 86:227-253
15. Iwaro AD, Bekele FL, Butler DR. Evaluation and utilisation of cacao (*Theobroma cacao* L.) germplasm at the International Cocoa Genebank, Trinidad. Euphytica. 2003; 130:207-221.
16. Janani P. Studies on certain aspects of crop improvement in cocoa (*Theobroma cacao* L.) Ph.D. (Hort.) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore, 2014.
17. Karthikkumar RB. Performance evaluation and adaptability behaviour of plus trees of cocoa (*Theobroma cacao* L.). Ph.D. (Hort.) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore, 2014.
18. Maharaj KP, Maharaj F, Bekele D, Ramnath GG, Bidaisee I, Bekele C, Presad K, *et al*. Trinidad selected hybrids: an investigation of the phenotypic and agro-economic traits of 20 selected cacao cultivars. Tropical. Agriculture. (Trinidad). 2011; 88(4):175-185.
19. Marita JM, Nienhuis J, Pires JL, Aitken WM. Analysis of genetic diversity in *Theobroma cacao* with emphasis on witches' broom disease resistance. Crop Science. 2001; 41:1305-1316.
20. Ratnam R. Introduction of criollo cacao into Madars state. South Indian Horticulture. 1961; 9:24-29
21. Prasannakumari Amma, S, Nair RV, EK Lalithabai, V.K. Malika, J.S. Minimol and Koshy Abraham. Cocoa in India. Kerala Agricultural University, India. 2009; 72.
22. Sobowale OI, Akinyele BO, Odeiyi AC, Adewale DB, Muyiwa AA. Heterosis and heritability estimates of some yield traits in eight hybrids of cocoa (*Theobroma cacao*). Journal of Advance Biology and Biotechnology. 2016; 6(1):1-8.
23. Thondaiman V, Rajamani K, Senthil N, Shoba N, Joel AJ. Variability studies and identification of high yielding plus trees of cocoa (*Theobroma cacao* L.) in Tamil Nadu. African Journal of Agricultural Research. 2013; 8(26):3444-3453.
24. USDA. Global research on cocoa-woking with and for farmers. Gro – cocoa. 2007; 11:1-8
25. Vikraman Nair R, Mallika VK, Amma Prasannakumari S, Koshy Abraham, Balasubramanian PP. Cocoa Cultivation: Science and Technology. Directorate of Cashewnut and Cocoa Development (DCCD), Cochin. 2000; 82.
26. WCF. Cocoa Market Update, 2014. http://www.worldcocoafoundation.org/wp-content/uploads/Cocoa-Market-Update-as-of-4-1-2014.pdf.
27. Zuidema PA, Leffelaar PA, Gerritsma W, Mommer L, Anten NPR. A physiological application production model for cocoa (*Theobroma cacao*): model presentation, validation and application. Agricultural System. 2005; 84:195-225.