Short Scientific Report
doi:10.19071/jpc.2015.v43.i3.2860
Journal of Plantation Crops, 2015, 43(3): 240-244

Growth and yield performance of Trinidad cocoa (*Theobroma cacao* L.) collections in Karnataka

S. Elain Apshara

ICAR - Central Plantation Crops Research Institute, Regional Station, Vittal-574 243, Karnataka, India

(Manuscript Received:19-05-2015, Revised:10-06-2015, Accepted:13-08-2015)

Keywords: Clones, cocoa, dry beans, pod yield, Trinitario

Cocoa is an important industrial and beverage crop of the world, famous for its produce, the beans, which are the only source for chocolates. Various genotypes contribute to the economic cultivation of cocoa in the major producing countries of south and central America, Africa and Asia. In India, selective collections from Malaysia and Nigeria constituted the old plantations and later many introductions were made from Amazon, Ghana, Peru and Trinidad. Cocoa is classified into three basic types Criollo, Forastero and a natural hybrid between these two, the Trinitario (Wood and Lass, 1955) which is said to have evolved from Trinidad. These clones comprise mixed characteristics and are well adapted to different growing zones. It is estimated that around 90 per cent of the world's current cocoa population is comprised of Forasteros and Trinitarios (Eskes and Lanaud, 2001). In Ivory Coast, which stands first in cocoa production, hybrids between upper Amazon Forastero and Trinitario clones are very popular due to their vigour, precocity, productivity and bean quality (Tahi *et al*., 2012). The major cocoa producers of Asian region, Malaysia and Indonesia are also widely cultivating Trinitarios for their quantitative and qualitative parameters (Amores *et al*., 2009; Anita-Sari and Agung, 2013). With this background, en effort was made to assess the Trinidad collections conserved by ICAR-CPCRI for its cropping efficiency in arecanut garden and to identify potential clones to be utilised in area expansion programs.

Thirteen Trinidad or true Trinitario collections were planted during 1995 and conserved at ICAR-CPCRI, Regional Station, Vittal, Karnataka at a spacing 2.7 m x 5.4 m under 2.7 m x 2.7 m spaced arecanut garden. Five trees each of these clones were considered as individual replication and observed for their growth parameters at the age of nineteen years. The annual pod yield was compiled for six years, from fourteenth to nineteenth year of bearing. Individual pod characters were measured from five pods of each clone harvested during the main season of June to August. Processed, fermented and dried beans were observed for bean characteristics in 100 beans from each clone. Fat content in the bean was estimated by petroleum ether extraction method using Soxhlet apparatus and expressed in percentage. Data were analysed using MSTAT program.

Among the Trinidad collections studied, significant difference was observed for all the growth characters. Plant height ranged from 3.2 to 4.6 m and vigour with respect to girth of stem ranged from 34.2 to 53.4 cm. Canopy of the trees spread to an area of 15.0 to 22.5 m^2 with 6.2 to 12.4 branches (Table 1) among the clones. The height at first branching, number of branches and canopy area were maintained with systematic annual pruning to make cocoa compatible and manageable in the intercropping system under arecanut and to enhance the pod production as suggested by Thomas and Balasimha (1992).

The average pod yield (six harvests per year) was compiled from fourteen to nineteen year old tress and observed for stable and high yielders.

*Corresponding Author: elain_apshara@yahoo.co.in

Table 1. Growth performance of Trinidad cocoa collections

Clones	Total height (m)	Girth (cm)	HAFB (m)	EW (m)	NS (m)	Branches (no.)	Canopy area (m^2)
VTLC 345	3.2	41.8	1.1	3.4	3.6	7.6	15.0
VTLC 346	4.2	53.0	0.9	3.8	3.5	8.8	21.4
VTLC 347	3.8	47.0	1.3	3.5	3.2	8.0	16.4
VTLC 348	3.8	34.2	0.9	3.1	2.8	6.0	15.1
VTLC 349	3.9	45.6	1.2	3.7	3.7	7.0	19.6
VTLC 350	4.6	44.8	1.4	3.7	3.9	8.4	21.8
VTLC 351	3.4	39.4	0.8	4.3	4.1	10.2	22.5
VTLC 352	4.6	50.8	1.6	3.9	3.9	8.2	21.8
VTLC 353	4.3	51.2	1.3	3.8	3.6	9.0	20.4
VTLC 354	4.2	44.6	1.2	3.7	3.8	10.8	22.1
VTLC 355	4.1	48.4	1.2	3.7	3.2	6.2	19.1
VTLC 356	4.3	44.2	1.2	3.7	3.7	8.8	21.3
VTLC 357	4.6	43.4	1.7	4.3	3.8	12.4	22.4
CV (%)	15.3	26.0	43.3	19.5	18.3	37.6	29.5
SE	0.7	12.0	0.5	0.7	0.7	3.2	5.9
CD (5%)	1.7	33.3	1.5	2.0	1.8	8.9	16.3

HAFB: Height at first branching, EW: East West, NS: North South

Table 2. Pod yield performance of Trinidad cocoa collections

Clones	Years (age from 14-19 years)						Mean
	2009	2010	2011	2012	2013	2014	
VTLC 345	41.6	56.4	38.4	84.0	65.4	55.4	56.9
VTLC 346	30.4	31.0	32.0	32.4	45.2	37.4	34.7
VTLC 347	32.4	32.2	35.2	50.4	55.2	63.4	44.8
VTLC 348	29.4	32.2	37.2	48.0	47.4	43.4	39.6
VTLC 349	30.4	28.2	27.2	52.4	64.2	51.4	42.3
VTLC 350	25.8	30.2	45.2	66.2	63.4	69.6	50.1
VTLC 351	41.4	56.4	66.0	76.0	67.4	72.6	63.3
VTLC 352	37.4	42.0	38.0	48.0	56.6	43.0	44.2
VTLC 353	53.0	36.8	34.4	41.8	53.0	43.0	43.7
VTLC 354	18.0	19.8	25.4	51.4	50.8	46.0	35.2
VTLC 355	22.0	27.8	35.4	63.4	62.8	54.0	44.2
VTLC 356	17.4	15.0	29.6	70.0	57.6	62.4	42.0
VTLC 357	36.0	36.8	38.0	71.2	76.2	62.0	53.4
CV (%)	16.2	18.3	18.0	11.9	14.5	14.1	-
SE	5.2	6.3	6.7	6.9	8.5	7.6	-
CD (5%)	14.4	17.4	18.5	19.2	23.7	21.2	-

Annual pod yield showed significant difference among the collections (Table 2) throughout the growth period. In the fourteenth year of bearing, the yield ranged from 17.4 to 53 pods tree^{-1} year^{-1}, whereas at the age of nineteen years, it ranged from 37.4 to 72.6 pods. The mean healthy pod yield over six years ranged from a lowest of 34.7 in VTLC-136 to a highest of 63.3 per tree in VTLC-141.

Table 3. Pod characteristics of Trinidad cocoa collections

Clones	Pod weight (g)	Pod length (cm)	Pod breadth (cm)	Husk:bean ratio	Ridge (cm)	Furrow (cm)	Bean no.
VTLC 345	382	16.8	7.8	2.9	1.2	0.9	44.2
VTLC 346	294	14.2	7.1	2.2	1.0	0.8	40.4
VTLC 347	376	17.0	7.5	2.7	1.1	0.9	43.8
VTLC 348	476	16.2	8.0	1.9	0.9	0.8	52.8
VTLC 349	360	16.0	7.5	2.3	1.0	0.7	42.2
VTLC 350	353	14.1	6.5	1.8	0.9	0.7	42.2
VTLC 351	458	18.1	8.6	3.5	1.3	1.1	42.6
VTLC 352	354	13.8	8.1	4.3	1.3	1.0	35.2
VTLC 353	326	12.7	7.8	2.4	1.1	0.9	40.6
VTLC 354	292	14.1	7.2	2.4	1.2	0.7	39.2
VTLC 355	368	18.6	7.2	3.1	1.2	0.9	35.8
VTLC 356	304	14.2	7.6	2.4	1.2	0.7	44.2
VTLC 357	350	14.9	7.2	1.9	0.9	0.8	42.6
CV (%)	15.80	7.01	5.98	35.30	11.30	19.40	14.80
SE	57.20	1.08	0.45	0.95	0.13	0.16	6.15
CD (5%)	158.9	3.00	1.25	2.64	0.36	0.44	17.10

Table 4. Bean traits of Trinidad cocoa collections

Clones	Wet bean wt (g)	Dry bean wt (g)	Wet to Dry	SBW (g)	DBY (kg)	Shell (%)	Nib recovery (%)	Fat (%)
VTLC 345	100	41.6	2.4	1.20	3.0	13.1	86	53.2
VTLC 346	94	43.2	2.2	0.92	1.3	16.7	83	50.3
VTLC 347	102	41.2	2.5	0.94	1.9	18.2	82	48.4
VTLC 348	168	52.3	3.2	0.99	1.9	14.3	85	49.6
VTLC 349	110	35.5	3.1	0.94	1.7	15.5	84	47.6
VTLC 350	102	48.1	2.1	1.00	2.1	13.7	86	50.1
VTLC 351	110	48.1	2.3	1.13	3.1	15.3	84	51.2
VTLC 352	62	28.1	2.2	0.93	1.2	16.4	83	48.6
VTLC 353	94	42.7	2.2	0.98	1.8	16.1	84	49.5
VTLC 354	88	35.3	2.5	0.90	1.3	18.5	81	48.2
VTLC 355	90	31.8	2.8	0.97	1.4	17.1	82	50.2
VTLC 356	92	39.8	2.3	0.90	1.6	17.5	83	47.8
VTLC 357	118	43.5	2.7	1.02	2.3	15.6	84	50.6

SBW- singly dry bean weight, DBY- dry bean yield

With more than 50 pods tree^{-1} year^{-1}, the clones VTLC-351, VTLC-345, VTLC-357 and VTLC-350 were the promising yielders identified in the arecanut based intercropping system.

Pod characteristics of cocoa collections are tabulated in Table 3. VTLC-144 produced small pods and VTLC-144 had bigger pods, as measured by length and breadth and shape of pods for description of clones (Turnbull and Eskes, 2010).

Table 5. Selected Trinidad clones and their desirable traits

	Vigour (cm)	Canopy area (m^2)	Pod no. $tree^{-1}$	Beans (no. pod^{-1})	Dry wt. (g $bean^{-1}$)	Dry bean yield (kg $tree^{-1}$)	Shell (%)	Recovery (%)	Fat (%)
VTLC-351	39.5	22.5	63.3	42.6	1.1	3.1	15.3	85	51.2
VTLC-345	41.8	15.0	56.9	44.2	1.2	3.0	13.1	87	53.2
VTLC-357	43.4	22.4	53.4	42.6	1.0	2.3	15.6	84	50.6
VTLC-350	44.8	21.8	50.1	42.2	1.0	2.1	13.7	86	50.1

It is considered optimal to have 350 g pod weight to ensure pod filling with >35 beans as a selection criteria for mother trees (Vikraman Nair *et al*., 2000). The husk:bean ratio ranged from 1.8 to 4.3 and an optimal husk:bean ratio of 3 is considered advantageous for more bean recovery. The ridge and furrow thickness of clones ranged from 0.9 to 1.3 and 0.7 to 1.1 respectively. Though less than one centimetre, husk thickness is being used as selection criteria, 1 cm and above is considered as advantageous in preventing spread of pod rot to beans and damage by boring insects, if the average bean number is 35 and above. Among the pod characters, number of beans per pod contributed much to the economic yield of the crop which ranged from 35.2 to 52.8. Interestingly, all the Trinidad collections irrespective of their pod sizes had the average bean number of 35 which is common in Trinitarios (Wood and Lass, 1955; Anita-Sari and Agung, 2013).

Other bean traits showed a positive estimate of wet:bean ratio in the range of 2.1 to 3.2 among the clones (Table 4). The high bean index of single dry bean weight of 1 gram and above was obtained in four clones, VTLC-135, VTLC-141, VTLC-147 and VTLC-140 in the order of 1.20, 1.13, 1.02 and 1.00 g, respectively. Trinidad Selected Hybrids (TSH), which have low pod index, large beans and good disease resistance with optimal management (Maharaj *et al.,* 2009; Maharaj, 2012), were the main component of cocoa economy of Trinidad and Tobago. The Trinidad collections studied also exhibited comparatively larger bean size of 0.9 to 1.2 g. Dry bean yield was further compiled with the mean pod number per tree, bean number per pod and single dry bean weight which showed a range of 1.2 to 3.1 kg $tree^{-1}$. Processing value regard to shelling percentage, nib recovery and fat contents were also assessed for their industrial suitability. Based on the overall performance and important characteristics, potential clones were selected from this trial and listed in Table 5, along with their desirable traits.

From the growth and yield parameters assessed over years in the Trinidad collections, VTLC-351, VTLC-345, VTLC-357 and VTLC-350 were identified as high and potential yielders with 3.1, 3.0, 2.3 and 2.1 kg dry bean yield per tree, respectively. These clones exhibited optimal vigour and canopy area in the intercropping system under arecanut. With single bean weight of more than 1 gram, 13-15 per cent shelling, 84-87 per cent nib recovery and >50 per cent fat, these true Trinitarios were found to be suitable for chocolate industry. These selected cocoa clones can be used for commercial cultivation. However, further evaluation trials under coconut canopy and in multiple locations are required to confirm the growth performance and yield sustainability in cocoa.

References

Amores, F., Pena, G., Calderon, D., Agama, J., Suarez, C., Motamayor, J., Schnell, R., Quiroz, J., Loor, G. and Tarqui, O. 2009. Research to identify and develop high yielding fine and flavour cocoa clones in Ecuador. In*: Proceedings of 16th International Cocoa Research Conference, Bali, Indonesia*. pp. 81-92.

Anita-Sari I. and Agung, W.S. 2013. Selection and exploration of fine flavour cocoa in Indonesia. In: *Proceedings of Malaysian International Cocoa Conference (MICC), Malaysia*. pp. 18-22.

Eskes, A.B. and Lanaud, C. 2001. Cocoa. In: *Tropical Plant Breeding* (Eds). Charrier, Jacquot M., Hamon S. and Nicolas D. Science Publishers Inc., USA and CIRAD, France. pp. 78-105.

Maharaj, K., Maharaj, P., Bekele, F.L., Ramnath, D., Bidaisee, G.G., Bekele, I., Persad, C., Gennings, K. and Sankar, R.

2009. Trinidad selected hybrids: An investigation of the phenotypic and agro-economic traits of selected varieties. In*: Proceedings of 16th International Cocoa Research Conference (ICRC), Bali, Indonesia*. pp. 63-72.

Maharaj, K. 2012. Cacao breeding and planting material situation in Trinidad and Tobago and some of the other Caribbean islands. In: *Abstracts of INGENIC Workshop*, *Bali, Indonesia*, p. 7.

Tahi, G.M., Ph. Lachenaud, J.A.K.N., Goran, P.N. Désiré, I.B. Kébé, D. Paulin, K.F., Cilas, C., Guessan, N. and Eskes, A.B. 2012. The current status of selected cacao material and future approaches to the development of cocoa varieties in Côte d'Ivoire. In: *Abstracts of INGENIC Workshop Bali, Indonesia*, p. 9.

Thomas, G. and Balasimha, D. 1992. Canopy architecture, photosynthesis and yield of cocoa. *Coffee, Cocoa and Tea* **36**(2): 103-108.

Vikraman Nair, R., Mallika, V.K., Prasannakumari Amma, S., Koshy Abraham and Balasubramanian, P.P. 2000. *Cocoa Cultivation: Science and Techniques*. Directorate of Cashewnut and Cocoa Development (DCCD), Cochin. 82 p.

Wood, G.A.R. and Lass, R.A. 1955. *Cocoa*. Longman Group Limited, Longman house, England. 620 p.