High Yielding Cocoa Varieties of the Central Plantation Crops Research Institute, India

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Introduction

The cocoa breeding programme of the Central Plantation Crops Research Institute (CPCRI) encompasses germplasm collection, evaluation, selection and hybridization. The hybridization activities were conducted from 1983 onwards to develop high-yielding varieties with specific characters. The hybrids were established in four progeny trials to assess their performance. One clonal trial was conducted with the objective of developing high-yielding clones. The major objectives of these programmes were to develop superior hybrids and clones with distinct evidence of heterosis and medium canopy size that can easily be accommodated in arecanut and coconut gardens. These activities resulted in the identification of two hybrids; I-56 x II-67 and ICS 6 x SCA 6, and a clone, NC- 45/ 53, that have high yields, an early bearing habit, medium canopy size and superior bean qualities.

1. I-56 x II-67

This hybrid variety is a product of a progeny trial conducted with seventeen hybrids (seedling progenies) along with their parents (seven clones) and a control progeny (open-pollinated I-56 seedlings) (Table 1). This trial was laid out during 1984-85 in a randomized complete block design replicated thrice with a plot size of eight plants at a spacing of 2.7 m x 5.4 m under arecanut shade at CPCRI, Regional Station, Vittal, Karnataka.

Growth and yield were recorded from the second year of planting, and conclusions were drawn from six years of pooled data and also from the annual performance of the hybrids. Seven superior hybrids were identified with dry bean yields in excess of 1.3 kg. The hybrid, I-56 x II-67, produced the highest dry bean yield of 1.48 kg/plant/year compared to all other hybrids and parents. The parents involved in this cross were originally obtained from Landas Estate, Malaysia in 1968. This hybrid showed a heterosis value of 39.6 percent above the mid-parent value and a genetic gain of 74.2 per cent yield over that of the control progeny, which produced only 0.74 kg/tree/year. The beans of I-56 x II-67 weighed 1.00 g (dry weight) and had a pod index value of 23.8. This hybrid also showed vigorous growth with a girth of 50.7 cm 12 years after planting. Detailed descriptions of morphological, pod, bean and quality characters are presented in Table 3.

2. ICS 6 x SCA 6

A set of nine bi-parental crosses ("F_1" hybrids), along with "F_2 progenies" of four Malaysian hybrids imported from Malaysia in 1968, and a control (F_2 progeny of PA 7 x NA 33) were planted at two sites during 1986-87 (Table 2). These hybrids were established under arecanut (at Vittal) with a spacing of 2.7 m x 5.4 m and under coconut (at Kasaragod) in a randomized block design (RBD) with three replications and eight plants/plot with a spacing of 5.4 m x 5.4 m in a quincunx system. Pod and bean values were recorded for all the treatments over a period of five years. Eight trees were identified as high yielders and have been planted in a comparative yield trial. With regard to the average performance of all the progenies, the ICS 6 x SCA 6 hybrid has shown superiority in almost all of the five years of observation, with a yield of 1.15 kg dry beans per plant per annum, and with a canopy of 10m^3 at the age of 10 years after planting. The range for the adult tree production over the two environments for individual progeny trees of this cross is 0.54 to 1.76 kg/tree/year.

3. NC-45/ 53

Eight high-yielding trees of Nigerian origin (NC-102, NC-119, NC-73, NC-63, NC-13, NC-116, NC-53 and NC-8) that were derived from seeds obtained from Nigeria during 1974, were selected during 1985, multiplied clonally (by side-grafting) and used in a clonal trial. This experiment was laid out in a RBD along with two checks represented by the I-14 open-pollinated seedling progeny and I-14 clone. Thirty-six clones of each of the 10 treatments were planted during 1985 in three replicated blocks in a quincunx system comprising of 12 plants (plot size) with a spacing of 5.4 m x 5.4 m.

Annual growth and yield parameters were assessed after stabilization of yield *i.e.* after six years of planting. Based on the pooled data and the yield stability indices over 6 years (1991-1997), the clone NC-45/53 was selected. This clone had the highest yield per plant per annum (0.93 -1.73 kg) with a lower value for coefficient of variation for individual tree yield. NC-45/53 has an additional quality of being self-compatible, and had an average dry bean yield of 1.33 kg, with 10m^3 canopy, in 5 rounds of harvest at the age of 10 years. Nine other superior Nigerian clones with a yield potential of >90-pods/tree/year were also identified in this trial.

4. Conclusions and Perspectives

The two hybrids (I-56 x II-67 and ICS 6 x SCA 6) and the clone NC-45/53 have been selected and found to be suitable for arecanut gardens of coastal Karnataka and coconut gardens of Kerala. They are under investigation to determine their adaptation in other areas such as the Tamil Nadu and Andhra states of south India and north-eastern India, respectively. They have been selected under the following conditions: lateritic to loamy soil with pH of approximately 5 to 6 and with good drainage, temperature range of 26-38°C, minimum precipitation of 1000 mm with a protective irrigation supplement for 5-6 months. They come into bearing in the 2nd year after transplanting, if clones are used, and 3 years

Table 1: Parents and progenies involved in the trails

1No.	Hybrids	No.	Hybrids	No.	Parents
1	I-14 x NC-42/94	10	I-56 x III-105	18	I-14 (Jerangau Red Axil)
2	I-14 x IV-20	11	II-67 x NC-42/94	19	I-56 (PA 7 x NA 32)
3	I-14 x I-56	12	II-67 x IV-20	20	II-67 (Landas-364*)
4	I-14 x III-35	13	III-35 x NC-42/94	21	III-35 (Amelonado x NA 33)
5	I-14 x II-105	14	III-35 x IV-20	22	III-105 (Amelonado x PA 7)
6	I-56 x NC-42/94	15	III-105x NC-42/94	23	IV-20 (Landas-357)
7	I-56 x IV-20	16	III-105 x IV-20	24	NC-42/94 (T86/2)
8	I-56 x II-67	17	III- 105 x I-56	25	I- 56 check
9	I-56 x III-35				

Table 2: Progenies involved in the trial

No.	Hybrid	No.	Hybrid
1	ICS 1 x SCA 6	8	NA 31 x ICS 6
2	ICS 1 x SCA 12	9	ICS 89 x SCA 6
3	NA 31 x ICS 1	10	PA 7 x NA 32 (F_2)
4	ICS 6 x SCA 6	11	Amelonado x PA 7 (F_2)
5	ICS 6 x SCA 12	12	Amelonado x NA 32 (F_2)
6	ICS 6 x NA 33	13	Amelonado x NA 33 (F_2)
7	IMC 67 x ICS 6	14	PA 7 x NA 33 (F_2 selfed, control)

after planting in the case of the hybrids. The selections respond well to the recommended cultural practices.

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Table 3: Characteristics of hybrids I-56 x II-67 and ICS 6 x SCA 6 (12 years after planting)

Hybrid	I-56 x II-67	ICS 6 x SCA 6
Variety name	Vittal Cocoa Hybrid – 1 (VTLCH 1)	Vittal Cocoa Hybrid - 2 (VTLCH 2)
Breeding method	Introduction, evaluation and selection of hybrid progenies or clones, followed by hybridization between selected genotypes, evaluation and selection.	Introduction, evaluation and selection of introduced clones, followed by hybridization, evaluation and selection.
Pedigree	I-56 = a PA 7 x NA 32 progeny tree II-67 = Landas 364 clone	ICS 6 = Imperial College Selection 6 SCA 6 = Scavina 6
Source of material	Landas Estate, Malaysia. Parental clones were originally introduced from Landas estate, Malaysia and utilized in the hybridization programme	Kew Gardens, England via Lalbaugh Garden, Bangalore
Compatibility	Self-Incompatible and cross-compatible with other trees of the same variety	Self-Incompatible and cross-compatible with other trees of the same variety
Dry bean yield	1.48 kg/ tree/ year	1.15 kg/ tree/ year
Special features	Heavy bearer and vigorous	Early and heavy bearer, tolerant to black pod disease (BPD)
Plant habit	Erect	Intermediate
Girth (cm)	50.7	42.0
Height at first branching (m)	1.29	1.43
Height of canopy (m)	4.56	4.00
Canopy volume (m^3)	16.82	13.60
Leaf traits	Base - Obtuse Apex - Short acuminate Petiole - Non-pulvinated Colour of young leaf - Intermediate	Base - Obtuse Apex - Short acuminate Petiole - Pulvinated Colour of young leaf - Pale purple
Pods/ tree/ per year	46.93	70.0
Pod	Weight - 300 g, length - 16.7 cm, breadth- 8.7 cm	Weight - 260 g, length - 14.6 cm, breadth - 10 cm
Fruit	Shape - Obovate Basal constriction - Nil Apex - Mammilate Surface - Intermediate to smooth Ridge and furrow prominence - Slight Hardness - Hard	Obovate Slight Mammilate Intermediate to slight rugose Slight Hard
Husk thickness	At ridge 1.0 cm, at furrow 0.8 cm	At ridge 1.06 cm, at furrow 0.8 cm
Colour pattern	Green (immature), Yellow (ripe)	Green (immature), Yellow (ripe)
Number of beans/ pod	42.0	35.0
Bean weight (dry)	1.00 g	1.10 g
Fat content	53.6%	53.6%
Shell (testa) percentage	13.0%	10.9%

Table 4: Characteristics of the NC-45/ 53 clone (12 years after planting)

Name	Vittal Cocoa Clone – 1 (VTLCC-1)	**Petiole colour of young leaf**	Purple and pulvinated
Breeding method	Introduction - Evaluation - Selection - Evaluation – Selection ("ortet selection")	**Fruit shape**	Obovate
Source	Nigeria	**Basal constriction**	Slight
Pedigree	P-10 x P-1 (unknown selections)	**Apex form**	Mammilate
Compatibility	Self-compatible	**Pod surface**	Intermediate to smooth
Dry bean yield	1.33 kg/tree/year	**Hardness**	Hard
Special features	Heavy bearer	**Colour pattern**	Green (immature), Yellow (ripe)
Plant habit	Intermediate	**No. of pods/ tree**	75
Girth (cm)	39.10	**No. of beans/ pod**	36.7
Total height (m)	4.16	**Single pod weight**	321 g
Canopy volume (m^3)	12.86	**Fat content**	42.50 %
Leaf character	Base - acute	**Bean Size**	1.05 g
Leaf apex	Long acuminate	**Shell percentage**	12 %

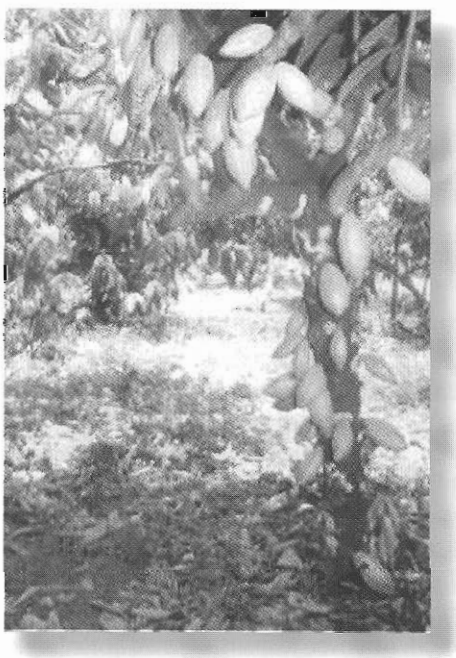

Figure 1: I-56 x I-67

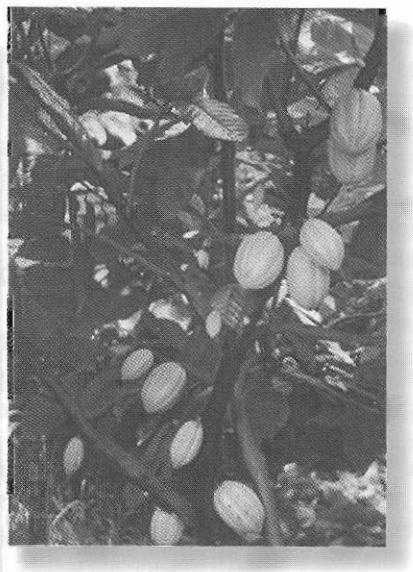

Figure 2: ICS 6 x SCA 6

Figure 3: NC 45/53