

Cocoa (*Theobroma cacao* L.) genetic stocks–collection, evaluation and utilization

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SUMMARY

Cocoa is the only source of chocolate. Cocoa plantations around the world face severe biotic and abiotic stresses. To overcome these stresses new hardy varieties with superior qualities are essential. Collection of much diverse germplasm and its wise exploitation forms the basic step in this direction. Cocoa is comparatively new crop to India; hence the genetic base is narrow. The crop assumed commercial status and has emerged as one of the remunerative inter crops of peninsular India. Though cultivation was problem free during initial years, problems started to arise one by one. At this juncture, the Kerala Agricultural University has initiated cocoa research in 1979 and its main focus was on breeding with establishment of germplasm, its evaluation and exploitation. Thus the University has established the biggest assembly of germplasm in India with 564 accessions, by LOCAL collection and by import from the International Cocoa Quarantine Centre (ICQC), University of Reading U.K. The accessions were planted @ 4 plants each and were catalogued based on economic characters, pest and disease resistance. The present breeding thrusts are evolving varieties with high yield, bold bean size and quality attributes and resistance to vascular streak dieback disease and Phytophthora pod rot. Out of 564 types maintained in the germplasm, seven superior types were released as clonal varieties (CCRP 1 to CCRP 7). 51 were identified as better combiners and these have been utilized for planting in clonal garden. Among the 549 self incompatible types, 134 were utilized in breeding programme for yield improvement, 47 were exploited as parents in breeding for resistance to Vascular streak die back diseases and black pod diseases, 9 with bean size of above 2.5 g were utilized as parents in the programme for evolving bold bean type varieties. 17 criollo and criollo-like accessions were utilized for breeding programme for improvement of processing qualities. The superior hybrids CCRP 8,9,10 have been released for cultivation.

Key Words : Amelonado, Criollo, Germplasm, *Theobroma cacao*, Introduction

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Cocoa (*Theobroma cacao* L.) popularly known as Food of Gods', is a neotropical species occurring in primary and secondary regions of distribution in the Americas lying within 20° N and S of equator. The crop was introduced to India during 1960's. It is now cultivated in all south Indian states in a total area of 46,318 ha and production of 12, 954 tonnes. In

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spite of aggressive area expansion drive by Cadbury India Ltd, the demand - supply gap increases by 10 per cent every year and the present production meets only 45 per cent of the domestic demand. The gap is widening as consumption is increasing at a rate of about 15-20 per cent every year. Indian cocoa is preferred by chocolate makers due to its high quality, low global production, high import duty and high cost for transportation during import. Cocoa has now become the most remunerative inter crop of coconut and arecanut providing an additional income of not less than Rs.75, 000/ year/hectare.

The future of world cocoa mainly depends on the ready availability of improved planting materials. Significant improvement is warranted in resistance to major diseases

like vascular streak die back and *Phytophthora* pod rot, bean quality traits, bean size and adaptability to adverse weather conditions. To obtain any significant breakthrough in breeding, the cocoa breeders should have a very strong assembly of diverse germplasm. One of the serious limitations of cocoa breeding programmes in India is the narrow genetic base. Clones with unique characters are being collected through well organized explorations to the center of origin and neighbouring areas. Apart from this, many useful materials are being produced in different cocoa research institutes. The ICCD database (Wadworth *et al.*, 1997) lists 16,300 cocoa clones being collected/ cultivated/ used in breeding around the globe. All these improved and diverse genotypes should be accessible to the breeder to make effective genetic manipulations and evolve more desirable genotypes. Wonderful results through breeding can be achieved only through systematic collection, conservation and utilization of biodiversity. Thus, Kerala Agricultural University started collecting germplasm since 1979 both from farmer's field and through import. This paper explains the work conducted in Kerala Agricultural University (KAU) since 1979 on collection, evaluation and utilization of cocoa germplasm.

MATERIALS AND METHODS

In Kerala Agricultural University, germplasm enrichment is being accomplished both by LOCAL collection and by introduction from International Cocoa Quarantine Centre (ICQC), University of Reading U.K.

LOCAL collection :

Survey was conducted in farmers plot located in major cocoa belts of the state and farmer identified plants were observed for pod and bean characters and level of resistance to pests and diseases. Bud woods of selected plants were collected and multiplied by budding. The budded plants of the selected types were field planted @ 4 plants/ accession.

Import :

Accessions are introduced from the International Cocoa Quarantine Centre (ICQC), University of Reading U.K through National Bureau of Plant Genetic Resources (NBPGR). The accessions include those maintained in the International Gene banks in Trinidad (ICG,T) and Costa Rica (CATIE) and those received from the wild and National collections during major explorations to centres of genetic diversity. The procedure for import is described below:

ICQC supplies a list of accessions readily available for transfer. The clones in the list are then subjected to screening for desirable traits by referring the International Cocoa Germplasm Database (ICGD) (www.icgd.reading.ac.uk). The list of selected clones, application form for import permit along with prescribed fee for import are forwarded to National Bureau



Fig. 1: Cocoa

of Plant Genetic Resources (NBPGR) through Central Plantation Crops Research Institute (CPCRI), Kasaragod. NBPGR issues import permit and this permit along with the list of selected clones are sent to ICQC. The semi hard wood cuttings (2-10 numbers) of the clones, after waxing the cut ends are packed in moistened tissue paper and wrapped in poly bags. The packet is sent through courier to NBPGR, New Delhi. After subjecting the clones to quarantine procedures, the clones are repacked and transferred through post to Kerala Agricultural University. It takes 7-12 days to reach KAU after dispatch from University of Reading, U.K. Immediately after receiving the material they are budded to healthy hybrid seedlings inside quarantine house and properly labelled. Patch budding is the commonly adopted method. Budded plants are retained inside the quarantine house for one year for observation on incidence of any foreign pests and diseases. Feed back information on percentage of survival will be sent to NBPGR and ICQC. The successful clones are field planted @ 4 plants/ accession.

Both LOCAL and exotic types are evaluated for growth, vigour, yield, pod and bean characters, resistance to pests and diseases and incompatibility position. The criteria for selection from germplasm include more than double the average plot yield, pod weight > 350 g, wet bean weight > 120 g, dry bean weight > 1 g, number of beans > 35 g and husk thickness <1 cm are selected. Selected self incompatible ones are used in hybridization programmes as parents and self compatible ones are used in inbreeding.

RESULTS AND DISCUSSION

The field collection of germplasm initiated since 1979 includes budded plants of 564 diverse types, which is at present the biggest in the country. This includes 153 LOCAL types, 336 exotic types introduced from the University of Reading, UK and 75 types collected from Central Plantation Crops Research Institute, Regional Station, Vittal. Collection

is being continued. The age of accessions vary depending upon the year of collection. The imported types have been classified based on the centre of collection as provided in ICGD database. A brief description of the imported clones is given below:

Accessions from Brazil :

The list of clones from Brazil, Costa Rica, and Mexico is furnished in Table 1. Out of 51 accessions from Brazil, three were collected from the basin of River Gauma, six from River Branco, three from the basin of River Amazonas and 39 from the research stations CEPEC (*Almirante Centro de Estudos de Cacau, Centro do Pesquisas do Cacau*) / SIPLA (*Serviço de Introdução de Plantas*).

The types are three BE(*BElem*) -similar to comum type

i.e. with melon shaped fruits, six RB (Rio Branco) of mixed types collected during Brazilian International expedition,1965, one MA (*MAAnaus city*), two MAN (*MAAnaus*) from ICGT, Brasil. Out of CEPLEC/SIPLA accessions, there is one Amel x NA33, B (*Besse*) from Ivory Coast, three JA (*JAvilla*), five LP (*La Paz.*), two LP (*Large Vaelta*), three LX (*Large Vaelta X*), one LZ(*Large Vaelta Z*), one POR (*PORcelana- Venezuelan*), two SIAL (*Selecao Instituto Agronomica do Leste*), one SIC (*Selecao Instituto do Cacau*), one TJ (*TauJica*) an Amazonian type similar to Catongo, one MXC (*MeXico Chiapas*), one fully homozygous N type with smooth slight green pods from Nigeria (typical Amelonado), two TSA (*Trinidad Selected Amazonas*), three TSH (Trinidad Selected Hybrids) and six UF (United Fruit Selections from Costa Rica).

Table 1 : Accessions from Brazil

Centre/ country of collection	Accessions	Full forms
R. Guama, Brazil	BE 2 , BE 3, BE 10	Belem
R. Branco, Brazil	RB 29, RB 33/3, RB 39, RB 46, RB 47, RB 49	Rio Branco
R. Amazonas, Brazil	MA 12	MANus city
	MAN 15-2, MAN -15-60	Manus
Brazil	Amel x NA 33	
CEPEC (<i>Almirante Centro de Estudos de Cacau, Centro do Pesquisas do Cacau</i>)	B 13/1 (POU), B 137, B 184, B 5.7, B 53, B 7/14(POU), B 9/10-25 (POU)	Besse
SIPLA (<i>Servicio de introducao de Plantas</i>)	JA 1/19 (POU),JA 10/12, JA 1/9 (POU)	Javilla
	LP 141,LP 3/40 POU, LP 4/32,LP I/ 41(POU 1), LP3/4 (POU)	La Paz
	LV 20 (POU), LV 28	Large Vaelta
	LX 43, LX 6	Large Vaelta X
	LZ 8	Large Vaelta Z
	POR 3	PORcelana- (Venezuelan)
	SIAL 93, SIAL 339	<i>Selecao Instituto Agronomica do Leste</i>
	SIC 5	<i>Selecao Instituto de Cacau</i>
	TJ 1	<i>TauJica</i>
	MXC 67	<i>Mexico Chiapas</i>
	N 38	<i>Nigeria</i>
	TSA 654, TSA 792	Trinidad selected Amazonas
	TSH 516, TSH 774, TSH 775	Trinidad selected hybrids
	UF 221, UF 613 , UF 667	United fruit selections from costa Rica
	UF 676, UF 677 , UF 705	

Accessions from Costa Rica :

The collections from CATIE (*Centro Agronómico Tropical de Investigación y Enseñaza*), Costa Rica belong to nine major categories, and the details are furnished in Table 2. One ABC (*Arboleda Buritica Correa*), one CATIE, five CC (*Cacao Centre*), four COCA (R. Coca), one F (open pollinated Amelonado), one Ghana Red, one LF (*La Fortuna*) and one LAF. CATIE 1000 and LAF 1 are well known for resistance to black pod disease. Costa Rican cocoa population is considered to be unique with green fruited criollos and homozygous Matina types.

Accessions from Mexico :

The collection from Mexico (Table 3) comprises of nine types which include four R types and five RIM (Rozario Izapa Mexico) types, selections from the Pacific coast with Matina genes.

Accessions from Peru :

The germplasm of cocoa from Peru, French Guiana and Colombia is furnished in Table 4. The collection includes 25 types collected from Iquitos by Pound (1938). 16 collections

belong to selections from region around PARinari (PA) which is resistant to Witches' broom disease. The AMAZ types have been collected from the basin of the river Amazonas.

Accessions from French Guiana :

The 33 collections from French Guiana named as GU are characterized by pigmented flushes, green fruits with a clear basal constriction. The collections also include three KER (KERinioutou) types which are Witches' broom free tall trees with pigmented leaves and fruits of Amelonado shape. The four BORNE 7 types are resistant to Witches' broom. From CIRAD (*Centre de Coopération Internationale en Recherche Agronomique pour le Développement*), there are two GDL(*GauDeLoupe*) collections, one GF type of Amelonado nature and PINA, a green fruited Amelonado collected from Pina.

Accessions from Colombia :

The collections from Colombia include one type (APA 4 (*Amazonico Palmira*) and 11 collections from ICA (*Instituto Colombiano Agropecuario*) with six SC (*Selección Colombiana*), three SCA (*Scavina*) and two SPEC

Table 2: Accessions from Costa Rica

Centre/ country of collection	Accessions	Full forms
Costa Rica, CATIE (<i>Centro Agronómico Tropical de Investigación y Enseñaza</i>)	ABC 146 CATIE 1000 CC 11, CC 38, CC 41, CC 71, CC 252 COCA3308/1[CHA],COCA 3370-3, COCA 3348/52 CRIOLLO 22 (CRI) F 303 GHANA RED LF 1 LAF 1	<i>Arboleda Buritica Correa</i> <i>Centro Agronómico Tropical de Investigación y Enseñaza</i> <i>Cacao Centre</i> R. Coca open pollinated Amelonado Ghana Red <i>La Fortuna</i>

Table 3 : Accessions from Mexico

Centre/ country of collection	Accessions	Full forms
Mexico	R 10 (MEX),R 2,R 21, R 39(MEX) RIM 2, RIM 10, RIM 39, RIM 41, RIM 189	Rozario Izapa Mexico

Table 4: Accessions from Peru

Centre/ country of collection	Accessions	Full forms
Iquitos, Peru	POUND 4/B(POU)POUND 10 (MEX), POUND 7/B, POUND 15/A, POUND 16/A, POUND 16/B, POUND 18, POUND 18/A, POUND 19/A PA4,PA7,PA13,PA67,PA70 (PER.) PA 88,PA 107,PA 120,PA 137, PA156,PA169,PA175,PA194(PER), PA 279,PA 303 PA 7x NA 32	Collected by pound PARinari
R. Amazonas, Peru	AMAZ 10-1, AMAZ 12, AMAZ 15, AMAZ 15-15, AMAZ 3-2, AMAZ 5/2, AMAZ 6-3	Basin of the river Amazonas.

(*SPECimen*) types. Among SC types there are some self compatible types with calabacillo (small and nearly spherical) and cundeamor (deeply ridged warty with bolltle neck) fruits.

The SCA 6 is most exploited clone in the world with resistance to all known diseases of cocoa (Wood and Lass,1985; Iwaro *et al.*, 1997). These types have been collected by Pound from Peru, Rio Ucayali in 1938. SPEC types have been collected from Colombia are Amazonian types. Out of the collections from the basin of river Caqueta, the KAU has one (EBC- *Expedicion Botanico Caqueta*).

Accessions from Trinidad and Tobago (CRU - Cocoa Research Unit) :

The collections from Trinidad and Tobago are 87 in number (Table 7). Out of these there are three AM collections (Amazonian) resistant to witches’ broom, 12 C types (derivatives of crosses made prior to 1954 including material from Central America), one CEPEC collection, CERRO AZUL 10 from Colombia, one hybrid, two CL(*CLementina*) collected from Ecuador, CLM 90 (*CLementina Mixed*), five CRU (Cocoa Research Unit) clones, four DOM clones collected from Dominica (DOMinica), one FSC 13 from Barbados Quarantine Station, MAR 9 (*MARTinique*), MO 109(*MOrona*)-a WB resistant clone collected from Peru, 15 NA(*NANay*)- WB resistant clones collected by Pound in 1938, SJ 119(*San Juan*) from Ecuador, SLA 16(*Santa Lucia A*), three SLC(*Santa Lucia*

C), five TRD clones (*TRiniDad*), two TARS types, two U types and 25 ICS (Imperial College Selections) collected by Pound in 1930 from Trinidad.

The ICS clones include all known varieties, Criollo, Forastero and Trinitario and are widely utilized for breeding programmes around the globe.

Accessions from Ecuador :

The list of clones from Ecuador is furnished in Table. 8. Out of 50 accessions from Ecuador, 28 are from Estación Experimental Tropical (EET), Pichilingue, six from the river San Miguel basin and 16 from River Napo basin. IMC (*Iquitos Mixed Calabacillo*) types are noted for high yield and these have been extensively exploited for breeding programmes all over the world.

IMC 6 is resistant to red squirrel (Warren and Emamdie 1993) and IMC 67 is resistant to Witches broom disease and *Ceratocystis fimbriata* (Enriquez and Soria, 1967). It is also resistant to Vascular Streak Die back (Sharma, 1992). Three SPA accessions have their origin from Colombia and these have varying levels of resistance to major diseases. The six EQX collections from the River San Miguel represent Equador crosses. There are 16 LCT EEN (*London Cocoa Trade Est. Expt. Napo*) types collected from the basins of River Napo.

Table 5 : Accessions from French Guiana

Centre/ country of collection	Accessions	Full forms
R. Camopi, French Guiana	GU114/P, GU123, GU123C, GU 123/V, GU 125 C, GU 133/C, GU 136 H, GU 144 C, GU 147 H, GU 154 C, GU 168/H, GU 207 H, GU 171/C, GU 175/P, GU 183 H, GU 195/V, GU 219/F, GU 221 H, GU 221/C, GU 226/V, GU 255/P, GU 255/V, GU 259 C, GU 261/P, GU 263/V, GU 269/V, GU 277/G, GU 290 H, GU 307/F, GU 310, GU 322/P, GU 341 H, GU265/P	Guiana
	KER 2 E, KER 3, KER 9	KERinioutou
Borne 7, French Guiana	BORNE 7 A 6, Borne 7 B2, BORNE 7 B 4 , BORNE 7 B 5	Borne 7, French Guiana

Table 6 : Accessions from Colombia

Centre/ country of collection	Accessions	Full forms
Palmira, Colombia	APA 4	<i>Amazonico Palmira</i>
Colombia (ICA)	SC 10, SC 1, SC 20, SC 3, SC 4, SC 9	<i>Seleccion Colombiana</i>
<i>Instituto Columbiano</i>	SCA 6, SCA 9, SCA 19	<i>Scavina</i>
<i>Agropecuaria</i>	SPEC 160-9, SPEC 54-1	<i>SPECimen</i>
R.Caqueta, Colombia	EBC 5/S-401	

Accessions from West African countries :

Accessions from West African countries (Table 9) includes the collections from Cote’Divoire, CNRA (*Centre National de Recherche Agricole*) consists of MOQ 413, a type collected from Ecuador, Had MOQuique. These are extremely vigorous trees. T65/7 is the one collected from Ghana progenies of Venezuelan cocoa.

The collections from Nigeria (CRIN- Cocoa Research Institute of Nigeria) comprises of three W types of mixed seed origin from Trinidad. From Ghana (CRIG- Cocoa Research

Institute of Nigeria), there are two types (WA 40DR and PUCCALA1. From Togo, IRCC (*Institute de Recherches du Café et du Cacao*), there are five T types. T7/12 is a stress tolerant clone.

Accessions from South -east Asian countries :

From South East Asian countries (Table 10), the KAU has 20 types from Papua New Guinea resistant to *Phytophthora* pod rot. One Malaysian type available in the collection is PBC 123 (Prang Besar Clone) collected from

Table 7 : Accessions from Trinidad and Tobago (CRU)

Centre/ country of collection	Accessions	Full forms
Trinidad and Tobago (CRU) Cocoa Research Unit	AM 1/8(POU), AM 1/157 (POU), AM1/95 (POU)	Amazonian
	C -15-61, C 3,C 5,C 6,C 40,C 42, C 44,C 76,C 78,C 79,C 83,C-15-61	Derivatives of Central America
	CEPEC 42	CEPEC
	CERRO AZUL 10	CERRO AZUL
	CF 176 x T 19/5	
	CL 10/5,CL 1949	<i>CL</i> ementina
	CLM 90	<i>CL</i> ementina Mixed
	CRU 12,CRU 89, CRU100,CRU 111,CRU 271	Cocoa Research Unit
	DOM 4,DOM 14,DOM 25,DOM 30	DOMinica
	FSC 13	
Trinidad and Tobago (CRU)	MAR 9	<i>MAR</i> tinique
	MO 109	<i>MO</i> rona
	NA 26, NA 31, NA 33, NA 58, NA 99, NA 149, NA 232, NA 242, NA 246, NA 387, NA 670, NA 756, NA 804, NA 916	<i>NA</i> ny
	SJ 119	<i>San Juan</i>
	SLA 16	Santa Lucia A
	SLC 4, SLC 12, SLC 18	<i>Santa Lucia C</i>
	TRD 32,TRD44,TRD 45,TRD 85,TRD 109	<i>TRi</i> niDad
	TARS 14, TARS 31	
	U 45, U 70	
	ICS 1, ICS 5, ICS 6, ICS 10, ICS 15, ICS 16, ICS 29, ICS 35, ICS 39, ICS 40, ICS 41, ICS 43, ICS 46, ICS 47, ICS 48, ICS 60,ICS 68, ICS 70,ICS 75,ICS 84,ICS 95,ICS 100,ICS 147, ICS 45 x ICS 39,ICS 45 x ICS 40, ICS 45 x ICS 60	Imperial college selections

Table 8: Accessions from Ecuador

Centre/ country of collection	Accessions	Full forms
Ecuador - Pichilingue	EET 58, EET 59, EET 95, EET 272, EET 395, EET 397, EET 399, EET400	Estación Experimental Tropical
	IMC 6, IMC 10, IMC 11, IMC 14, IMC 16, IMC 20, IMC 27, IMC 31, IMC 47, IMC 50, IMC 54, IMC 55, IMC 57, IMC 67, IMC 71, IMC 83, IMC 105	<i>Iquitos Mixed Calabacillo</i>
	SPA 7 , SPA 9, SPA 16/1	Origin from Colombia
R. San Miguel, Ecuador	EQX 3161, EQX J/5 (CHA), EQX Z, EQX-3348-44, EQX-69, EQX-78	Ecuador crosses
R. Napo, Ecuador	LCT - EEN 37 A, LCT EEN 37 F, LCT EEN 37 I, LCT EEN 127, LCT EEN 136D, LCT EEN 15/5/3, LCT EEN 162-1010, LCT EEN 163 D, LCT EEN 241on 163B, LCT EEN 261/S-4, LCT EEN 302, LCT EEN 37 G, LCT EEN 46, LCTEEN 62/54, LCTEEN 86, LCTEEN341/S2	<i>London Cocoa Trade Est. Expt. Napo</i>

Table 9 : Accessions from West African countries

Centre/ country of collection	Accessions	Full forms
Cote D Ivoire, CNRA, Bingerville <i>Centre National de Recherche Agricole</i>	MOQ 413 T 65 /7	Had MOQuique Ghana progenies of Venezuelan cocoa.
Cameroon, IRAD	UPA 134	
Nigeria (CRIN) Cocoa Research Institute of Nigeria	W 5/1 (T 63/884), W 5/15 (T63/884), W 6/56 (T 63/970)	mixed seed origin from Trinidad
Ghana(CRIG)	WA 40 DR, PUCCALA 1	PUCCALA
Togo, IRCC <i>Institute de Recherches du Café et du Cacao</i>	T 17/ 11, T 30/10 x Na 32, T 7/12, T 85/799, T 86/2	

Table 10 : Accessions from South -east countries

Centre/ country of collection	Accessions	Full forms
Papua new guinea (CCRI)	PNG 87, PNG 110, PNG 139, PNG 153, PNG 155, PNG 197, PNG 210, PNG 214, PNG 215, PNG 218, PNG 224, PNG 250, PNG 290, PNG 296, PNG 299, PNG 336, PNG 340, PNG 386, PNG 414, PNG 418	Papua new guinea
Malaysia	PBC 123	Prang besar clone

Golden Hope.

The above results indicate that KAU at present possess collections from major centres of diversity. However, the variability available is so high that about 16,300 cocoa clones are being cultivated around the globe. Thus there is scope for further enriching the collection.

Classification of germplasm based on economic characters :

The collection has been classified based on economic characters and the types with specific traits have been utilized

in breeding programmes (Table 11).

The collection included 229 types with high yield, 53 with bold beans, 38 with thin pericarp, 15 self compatible, 53 with resistance to Ppr, six with resistance to VSD, 38 with resistance to WB, 2 with resistance to CSSV and one with resistance to red squirrel. The different varieties in the depositary include Criollo 5, Trinitario 18, Nacional 2, Amelonado 5 and Forastero 533. The accessions with suitable traits were included in hybridization programmes based on the breeding goals.

Table 11: Classification of cocoa germplasm maintained in Kerala Agricultural University

Characters	Accessions
High yield	229
Large beans	53
Thin pericarp	38
Self compatible	15
Resistant to phytophthora pod rot (Ppr)	53
Resistant to vascular streak die back (VSD)	6
Resistant to witches' broom (WB)	38
Resistant to cocoa Swollen shoot virus (CSSV)	2
Resistant to red squirrel	1 (IMC 6)
Criollo	5
Trinitario	18
Nacional	3
Amelonado	5
Forastero	533

Table 12 : Utilization of germplasm in various breeding programme in Kerala Agricultural University

Sr. No.	Breeding objectives	No. of accessions used	Result of the programme
1.	Yield improvement	219	7 clones and 3 hybrids released. Remaining hybrids used in various breeding programme and to establish clonal garden
2.	Resistance to vascular streak diseases	47	7 superior hybrids for further studies. 65 hybrids are utilized in various breeding programme. 5 better combiners planted in clonal garden
3.	Improved bean size	26	21 hybrids with high yield and large bean size (> 2.5 g). Evaluations of the hybrids are in progress
4.	Improved quality	17	240 hybrids field planted and evaluation in progress.
5.	Resistance to Phytophthora pod rot	128	615 hybrids are field planted and evaluation in progress. Programme on going.

Utilization of germplasm :

Details are furnished in Table 12. From 1987 to 2010, 219 high yielding clones were used for crossing programme. Selection of germplasm led to the release of 7 improved clones (CCRP 1-7) with high yield and resistance to VSD. Evaluation of hybrid progenies raised upto 1989 resulted in the release of three hybrids CCRP 8-10. For evolving varieties resistant to VSD, hand pollination programme was taken up from 1994 to 2002 using 47 resistant clones as parents. Evaluation of the F₁ hybrids resulted in selection of 7 Superior hybrids and these are under evaluation in comparative yield trials. Five better combiners have been planted in clonal seed gardens.

The other programmes started since 2003 are breeding for bold bean size, processing qualities and resistance to Ppr. For these programmes, the parents selected from the germplasm were 26, 17 and 128, respectively. The F₁ hybrid progenies are being observed for yield and other economic characters.

As a result of wise utilization of available germplasm 7 clones and three hybrids with high yield and tolerance to vascular streak disease were released. All the superior hybrids evolved from various breeding programmes are vegetatively propagated and planted in scientifically laid out clonal garden. Hybrid seedlings produced from this clonal garden are distributed to farmers. 80 per cent of cocoa plantation in India is established with hybrid seedlings from Kerala Agricultural University. During the last 10 years 30,000 ha of land are brought under cultivation using KAU hybrids. Average India yield is very high, 1.5 kg/plant/tree where as world average is only 0.5 kg/plant/year. In traditional cocoa cultivating tracts of Kerala yield is 5 kg/plant/year. Vascular streak die back which was a problem once faced by cocoa farmers was easily tackled with resistance planting material from KAU. Use of

improved KAU varieties and adoption of KAU agronomic practices will give a two to three fold increase in yield.

All these were possible only because KAU owns the biggest germplasm collection of cocoa in India and wise utilization of this germplasm

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