Indian J. Pl. Genet. Resources 7(1) : 23-29, 1994

AUGMENTATION AND UTILIZATION OF COFFEE GERMPLASM IN INDIA

A. S. Ram, N.S. Prakash, D.P. Jyothi, M.K. Mishra, M.S. Srinivasan and R. Naidu

Central Coffee Research Institute,
Coffee Research Station, Chikmagalur 577 117 (Karnataka)

Exploitation of indigenous and exotic coffee germplasm in India is reviewed. The thrust areas of breeding research and the basis of evolution of selections utilizing the rust resistant genes and genes conferring agmomic traits such as plant type, yield and quality is described. A brief outline of future strategy to exploit the heterosis of F_1 hybrids is also presented.

Key words : *Coffea arabica* L, breeding, selection, rust resistant genes

Coffea arabica L. is the only tetraploid species of the genus with the chromosome number 2n=2x=44. It is also the most important species in coffee trade since 17th century. While coffee was believed to have been introduced into India in the early 17th century, its commercial exploitation began in the early 19th century with the British enterpreneurs establishing plantations (Smith, 1985). The earliest coffee cultivar grown in India was known as Chiks. Leaf rust disease of arabica coffee caused by *Hemileia vastatrix* B *et* Br. appeared in India on an epidemic scale in the late 19th century (Coffee Board, 1985). Enterprising planters tried to produce arabica cultures with resistance such as Coorg and Kents from the Old Chiks. Besides this, efforts were also made to introduce disease hardy species like *Coffea liberica* and *C. canephora* (Robusta) (Vishveshwara, 1974). When all these endeavours failed to produce plant materials with stable resistance and quality yield, the need for an organised research programme was felt, paving the way for the establishment of the Central Coffee Research Institute (CCRI) in 1925 (then known as Mysore Coffee Experiment Station).

The success of any breeding programme depends on the proper evaluation and judicious utilization of the available genetic resources. The plant breeding group of CCRI started collecting the various coffee types in an effort to establish a germplasm bank. Between 1925 and 1940, different coffee types from the various states in India were collected and exploited to increase coffee

productivity (Sreenivasan and Ramaiah, 1988). Early coffee selections (Sin. 1, Sin. 2 and Sin. 3) emanated from these collections.

Exotic germplasm

After 1940, arabica germplasm from various exotic sources was added to the gene bank at CCRI. The exotic germplasm contributed a great deal to the evolution fo coffee selections in India as explained below.

Thrust areas

Soon it was realied that S26 (putative hybrid of *C. arabica and C. liberica*)- and descendant selections (Sin.1, Sin.2 and Sin.3) tend to produce considerable quantitites of deformed/malformed beans collectively termed Triage (Narasimhaswamy *et al.*, 1961; Narasimhaswamy and Vishveshwara, 1962). Thus, the efforts were directed to evolve arabica types with resistance and quality with particular emphasis on eliminating triage and increasing A grade beans in the produce (Vishveshwara, 1971, 1974; Srinivasan and Vishveshwara, 1980; Sreenivasan, 1991). Cup quality traits like body and acidity are evaluated by the Quality Control Division of Coffee Board. Adaptability of the evolved types is being tested in the Coffee Demonstration Farms and Regional Coffee Research Stations located in various agro-climatic zones (Reddy *et al.*, 1986). In other words, breeding for resistance, quality, adaptability and improved productivity became the main thrust areas of research at CCRI. Genes from exotic germplasm were generously utilized in achieving the above objectives.

Rust resistance genes

While there are approximately 360 surviving collections of *C. arabica*, the promising ones are Agaro, Cioccie (J-type), Geisha (C-type) S_{12} Kaffa (I-type) and Tafarikela (HR) from Ethiopia, Bourbon and San Ramon (E-type) from Guatemala and Hibrido-de-Timor (HDT) (A Type) and Catimor (complex of A and R types) from Portugal. These materials primarily served as the sources of major genes (S_H genes) conferring resistance to leaf rust. The ghenes S_H 4 and S_H 5 of Agaro and Cioccie, S_H 1 and S_H 4 of S_{12} Kaffa, S_H 1 and S_H 5 of Geisha, S_H 6, 7, 8, 9 of HDT were targetted to be incorporated into the locally adopted cultures S288 and/or S795. S288 and S795 manifest G (S_H 3 & S_H 5) and H (S_H 2, 3, 5) types of rust reaction respectively. Thus, the present day arabica populations in India comprise an assemblage of S_H 1 to S_H 9 factors in a wide array of combinations conferring variable degrees of resistance to the leaf rust disease (Table 1).

Horizontal resistance observed in Rume Sudan (S881) and Tafarikela collections was also exploited, primarily to evolve plant type combining vertical and horizontal resistance (Sreenivasan *et al.* 1993).

Table 1. Impact of germplasm introductions on Arabica coffee production

S.No.	Year	Germplasm	Genes exploited	Cultivars	Yield (kg/ha)	% Increase of yield	
1.	1940	S.26 (S.288) Kents	C-type $S_H3, 5$ D-type $S_H2, 5$	Typica (T) Typica (T)	Sin.3	225.00	
2.	1960	Hibrido-de-Timor(HDT)	A-type $S_H6, 7, 8, 9$	Typica(T)	Sin.8	450.00	100.00
3.	1970	Agaro	J-type $S_H4, 5$	Typica(T)			
		Cioccie	J-type $S_H4, 5$	Typica(T)			
		Geisha	C-type $S_H1, 5$	Typica(T)	Sin.4	580.00	157.78
		S_{12}Kaffa	I-type $S_H1, 4$	Typica (T)			
		Tafarikela	HR	Typica(T)			
		San Ramon	E-type S_H5	Dwarf (Sr)	Sin.7	600.00	166.67
4.	1975	Tafarikela	HR	Typica (T)			
		HDT	A-type	Typica (T)	Sin. 90	630.00	180.00
		Caturra	E-type	Semi-dwarf(Ct)			
		Cioccie	J-type	Typica (T)	Sin. 10	650.00	188.89
		S.795	H-type $S_H2, 3, 5$	Typica(T)			
5.	1985	Caturra	E-type	Typica (T)	Catimor/	775.00	244.44

Genes conferring agronomic trait

Plant type : Concomittant with improving the disease resistance, characters conferring compactness and dwarf nature were also exploited leading to the evolution of dwarf (San Ramon) and semi dwarf (Caturra) plant types. The genes Sr (San Ramon) and Ct (Caturra) are dominant and facilitated quick increase of the frequency of dwarf and semi-dwarf types in the descendant progenies of appropriate parentage. As original San Ramon and Caturra are both highly susceptible to leaf rust (E-type, S_H 5), the resistance factors were introduced into these types through hybridization with S 795, Cioccie/Agaro, Geisha and HDT.

Thus, San Ramon was crossed with S 795 to introduce resistance to races I and II of *H. vastatrix* (Sin. 7.1) and with Cioccie/Agaro to impart resistance to race VIII (Sin. 7.2) and finally with HDT to incorporate maximum possible resistance (Sin. 7.3). Caturra was involved in a double cross [(Caturra x S. 795) × (Cuturra × S_6 Cioccie)] to impart resistance to races I, II and VIII (Sin.

10) and Catimor/Cauvery is a descendant of Caturra × HDT. Selection was exercised in the progenies for a combination of resistance and plant type. However, the present day dwarf and semi-dwarf coffee populations of the sub-continent present an assemblage of variable resistance which needs critical assessment.

Yield : Considering the release of S 795 (Sln. 9) as a landmark event in the improvemenmt of coffee yield in India, the present day production patterns reflect a vast advancement of this particular character (Fig. 1, Table 2). Ad-

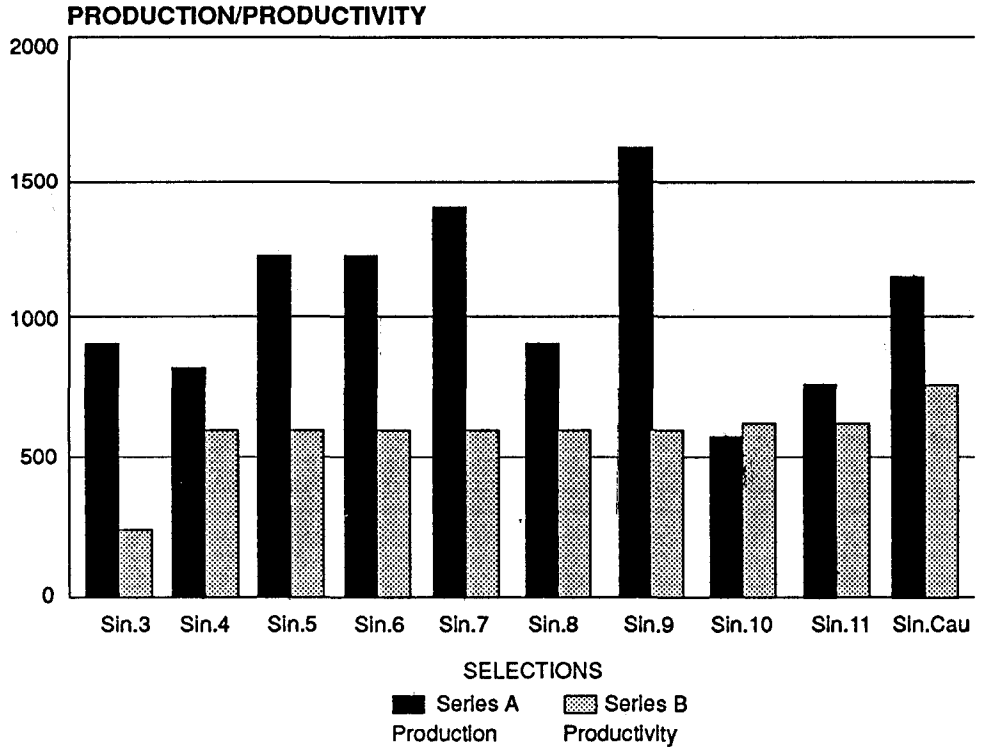


Fig. 1. Production and productivity of various coffee selections

mittedly, this is a result of the adoption of a good package of practices (sometimes grower innovations) superimposed on the improved materials with a high degree of resistance and production potential.

Quality : Improvement of quality was primarily through reducing triage and increasing large bean grades in the produce (Sreenivasan, 1991). Ethiopian landraces Agaro and Cioccie are known to produce bold beans and are utilized

in the breeding programmes to evolve plant types producing quality coffee (Coffee Board, 1985).

The Future

The exploitation of F_1 hybrids of coffee for vigour, resistance and yield was considered as the best strategy in increasing coffee production atleast since the early 1980's and efforts were made to evolve techniques for the production of F_1 hybrid seed of *C. arabica* (Van der Vossen and Walyaro, 1981; Ram and Ramaiah, 1991; Agawanda, 1993). The F_1 hybrids of Ethiopian landraces Geisha, Tafarikela and S_{12} Kaffa and other arabicas and HDT are known to be superior in yield, resistance and growth characters (Sreenivasan and Ram, 1992). A good strategy for exploiting them should combine generative and vegetative selection methods (Scheme 1) as follows:

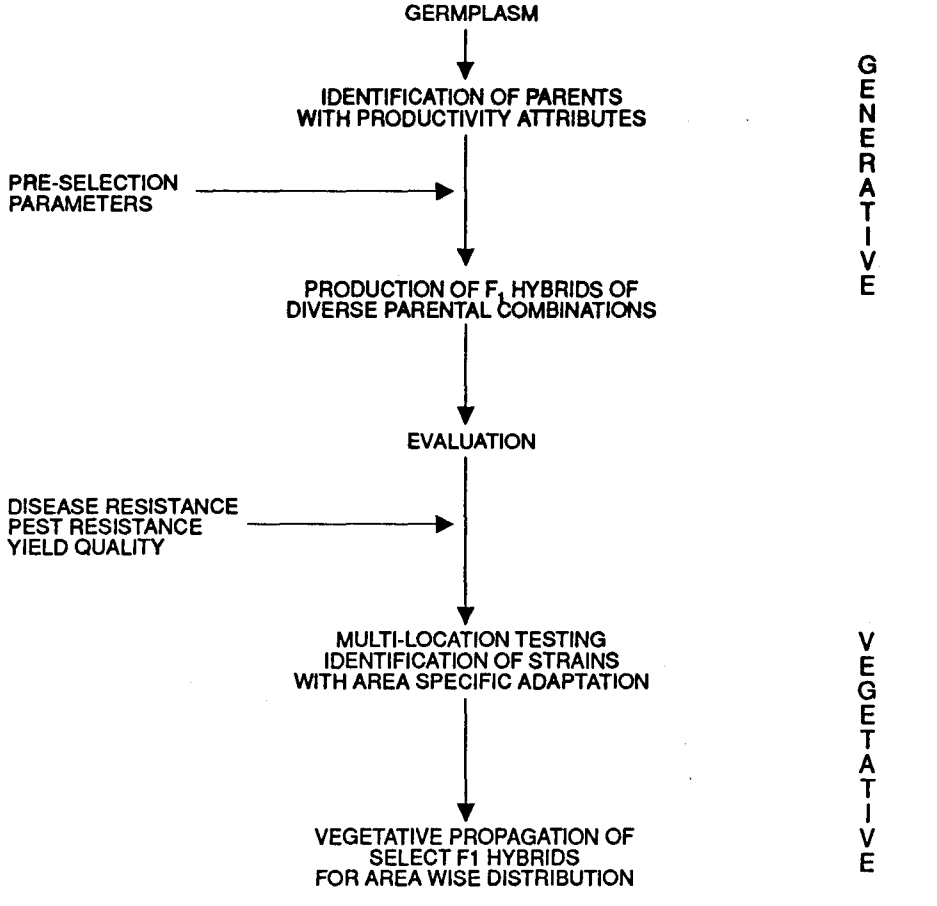
i) The generative component : Pre-testing the F_1 hybrids of various parental combinations to understand the combining ability and heterosis patterns (Bayetta-Bellachew *et al.*, 1993).

ii) The vegetative component : Propagating the superior F_1 hybrids through vegetative means on a mass scale.

This method is advantageous on account of the large genetic base of the hybrids conferred by the generative selection and requisite residual genetic variation (required for adaptability) among the vegetative descendants. In an effort to further exploit the available germplasm, identification of gene sources to obtain resistance against pests and environmental adversaries and their utilization in breeding is contemplated with the objective of producing varieties amenable for organic farming. Another approach which may be followed by the breeders is the adequate understanding of pre-selection parameters (Walyaro and Van der Vossen, 1979; Srinivasan, 1982) and their possible use in parent selection (Scheme 1).

In conclusion, the considerable increase in coffee productivity in India can be mainly attributed to the utilization of exotic germplasm in the breeding programmes and evolution of newer selections (Sin. 4, 5, 7, 8, 9, 10 and Cauvery) as the recommended package of practices remained essentially the same over the period 1940-1990 (Coffee Board, 1987). Efforts are now in progress to evolve Double Cross and Multi-Parent hybrids to further improve coffee productivity in India.

SCHEME 1
FUTURE STRATEGIES OF GERMPLASM UTILIZATION IN COFFEE



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