Scholars Academic Journal of Biosciences (SAJB) **ISSN 2321-6883 (Online)**
Sch. Acad. J. Biosci., 2014; 2(2): 157-167 **ISSN 2347-9515 (Print)**

(An International Publisher for Academic and Scientific Resources)
www.saspublishers.com **DOI:** 10.36347/sajb.2014.v02i02.016

Research Article

Phenotypic variation in F_1 population of inter-varietal crosses of *Coffea arabica* L.

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Abstract: Most of the commercially cultivated coffee varieties are heterogeneous in nature and produce variation in the plant population in further generation for phenotypic characters. Use of such varieties in crossing leads to breed the variable plant population in F_1 generation. In this context, a study on degree of phenotypic variation in eight F_1 progenies derived from various cross combinations of dwarf and tall varieties was undertaken at Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka during 2008-10. The vegetative characters such as bush spread, primary thickness, intermodal length, leaf length and breadth as well as yield parameters in the F_1 progenies of Dwarf and Tall crosses exhibited variation caused by the influence of female parent. Cultivars used as female parent in crossing with the other cultivars showed dominant effects over male for the above mentioned characters by expressing higher plant frequencies in the class-intervals. The percentage of high yielding plants were more in the F_1 progenies derived from Tall x Dwarf crosses as compared to the Dwarf x Tall progenies. Variation in the F_1 population was due to involvement of heterogeneous breeding material. Selection of plants from the F_1 based on the desirable traits and their multiplication will be useful for character stabilization and commercial exploitation.
Keywords: coffee, phenotypic characters, F_1 progenies

INTRODUCTION

The best known arabica varieties are 'Typica' and 'Bourbon'. These two varieties became the major source for evolution of several other strains and cultivars such as Caturra (Brazil, Colombia), Mundo Novo (Brazil), Tipo (Central America), dwarf San Ramon and the Jamaican Blue Mountain. It is a species of self-fertile nature and often produces true breeding lines through single plant selection and multiplication [1]. Coffee is the plant that is highly sensitive to the environmental changes and possesses the ability to withstand adverse circumstances. Beside the prominent attributes of the genus *Coffea* for huge range of morphological variation between the species, there is wide adaptability to the various environmental situations [2]. Crossing the species within one group of Coffea was found easier than crossing with other group [3]. The primary objective of coffee breeding and selection program is to develop high yielding, excellent bean quality and disease resistant (especially rust) cultivars which are adapted to specific growing conditions.

Van der Vossen reported that dwarf effect coupled with short internodes in arabica coffee variety 'Caturra' is controlled by a single dominant gene 'Ct' that reduced the intermodal length by about 50 percent [8]. This genetic factor was found helpful in improving production by increasing plant density, early yield and easy cultural operations besides trouble-free harvesting process. He experienced that the F_1 hybrids produced with the combination of parents carrying 'Ct' genotype would exhibit compact bush habit like the parents. Amaravenmathy and Srinivasan, assessed nine arabica progenies for phenotypic and genotypic variation and plant architecture and reported greater than 20 percent phenotypic coefficient variation in the progenies for number of primaries plant^{-1}, primary length and fruiting nodes primary^{-1} [4]. Kufa *et al.*, reported the variations in plant phenotypes according to the change in the climatic conditions when coffee planted under different areas [5]. This showed differences in the vegetative characters such as bush span, leaf area, inter-node length and seed growth. Plant density and shade pattern

had considerable effect on plant growth characters and seed development. Kebede and Bellachew, carried out the work on morphological characterization of 100 accessions of coffee gene bank and found significant variation in the accessions for all the characters studied [6]. The maximum variation was noticed for stem girth, and length of longest primary branch. Kumar *et al.*, studied the genotypic and phenotypic variability and heritability in the F_1 hybrid population derived from several crosses of arabica cultivars and observed higher magnitude of genetic variance for length of primary branch [7].

Keeping in view the above findings related to variation in phenotypic characters of various coffee varieties, a study was conducted on eight F_1 progenies evolved by crossing Dwarf and Tall varieties of Arabica with an objective to find out the phenotypic variation and its probable causes.

MATERIALS AND METHOD

The study was carried out during 2008-09 and 2009-10 on eight F_1 progenies derived from Dwarf x Tall and Tall x Dwarf crosses established during 1997-98 at Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka, India. This area receives an average annual rainfall of 1500 mm, temperature range of 10 to 30 ºC and 40 to 90 percent R.H. The soil is red laterite, acidic with high level of organic carbon with the pH range of 6.0 to 6.5 in the experimental block. The experimental plant material was maintained at 6' x 5' spacing in the same environmental conditions as indicated above with uniform shade and normal agronomical practices. Total plant population was classified into three categories viz; 'Cauvery' type, intermediate and tall type based on the frequency distribution for each morphological parameters recorded. F_1 progenies used for the study are mentioned in the following table.

Table:1. The F_1 progenies of different parental cross combinations used for the study

Sl. No.	Dwarf x Tall	Sl. No.	Tall x dwarf
1.	S.4842 (Cauvery x Sln.9)	5.	S,4852 (Sln.9 x Cauvery)
2.	S.4845 (Cauvery x S.881)	6.	S.4854 (S.881 x Cauvery)
3.	S.4848 (Cauvery x Devamachy)	7.	S.4860 (Sln.5B x Cauvery)
4.	S.4855 (Cauvery x Tafarikela)	8.	S.4876 (Sln.6 x Cauvery)

Data on morphological characters such as bush spread, stem girth, primary thickness, intermodal length, leaf length and breadth and number of fruits per cluster, were recorded using 320 and 212 plants under Dwarf x Tall and Tall x Dwarf cross combinations respectively. Fruit length and breadth were also observed in similar fashion.

RESULTS AND DISCUSSION

Vegetative Parameters

Plant classification is the basis to postulate the heritable behaviors of the variable plant population generated through the inbred lines of diverse genetic back ground with the help of measurable parameters. The studies on the morphological classification of the F_1 hybrids bred out of Dwarf x Tall group of crosses indicated that the plants with 'Cauvery' type bush stature varied from 31.48 to 51.61 percent. Cauvery x Tafarikela progeny had the highest of 51.61 percent plant population like Cauvery (Table. 1a). Population of intermediate plants was in the range of 48.39 to 66.67 percent. The highest numbers of medium type plants were recorded in Cauvery x Sln.9 progeny. The plants with tall type bush spread were in low range of 0.0 to 5.69 percent only. Frequency of the plants with thin stem girth like 'Cauvery' parent ranged from 9.68 to 26.02 percent with the highest frequency in Cauvery x Devamachy followed by Cauvery x Sln.9 progeny. Progeny of Cauvery x Tafarikela exhibited the highest frequency of 80.65 percent of intermediate types and 68.52 percent in Cauvery x Sln.9 hybrid population. The plants with intermediate stem girth were 65.52 percent and 59.35 percent in the population developed by crossing Cauvery with S.881 and with Devamachy parent respectively. The population of plants with thick stem girth like tall type was as low as 8.33 percent. Progeny of Cauvery x S.881 showed 24.14 percent of plant population had stem thickness on par with tall parents (Table.1a).

A considerable numbers of plants were observed between 12.90 percent and 32.52 percent in Dwarf x Tall crosses that had the primary girth character in resemblance with 'Cauvery' cultivar. Population of plants with intermediate primary thickness was in the range of 56.91 to 74. 19 percent and with tall type thick primary was 6.48 to 18.97 percent.

Dwarf x Tall progenies indicated the presence of short internodes character like 'Cauvery' in 6.45 to 34.48 percent of the plant population. The frequency of plants with intermediate intermodal length was higher than the short internoded plants. Tall type plants with long internodes ranged from 0.0 to 22.76 percent. The highest percentage of plants with close internodes of

secondary branches were observed in Cauvery x Tafarikela progeny to an extent of 77.42 percent that had the remaining population of 22.58 percent only with medium intermodal length. No plants were seen having long internodes like tall cultivars. As far as number of secondary branches is concerned, the majority of the plants expressed their presence in the low range of 3-9 percent (Table. 1b). The plants in the medium and high range were from 22.58 to 32.76 percent and from 0.0 to 6.90 percent respectively. The plants with less leaf length were up to 8.62 percent while the frequency of plants with medium size leaf length was as high as 100 percent in Cauvery x Tafarikela progeny. Higher leaf length was noticed in 40.74 percent of the hybrid population of Dwarf x Tall crosses where, Cauvery x S.881 progeny indicated the highest of 34.48 percent plants with narrow leaf breadth as compared to the other progenies of the same group. The highest of 93.55 percent plant population was found in Cauvery x Tafarikela progeny that had medium leaf breadth. Plant population of Cauvery x Devamachy progeny exhibited maximum of 22.76 percent plants with comparatively broader leaves (Table.1b).

As compared to Dwarf x Tall group of crosses, the Tall x Dwarf group produced low number of plants of 'Cauvery' type bush stature ranging from 23.33 to 37.21 percent as against 31.48 to 51.61 percent. Medium types of plants were also comparatively low (30.31 percent) in Tall x Dwarf progeny than Dwarf x Tall hybrid population (58.13 percent). Similarly, the number of tall type plants was also higher as 4.25 percent in Tall x Dwarf progeny as against 3.44 percent in Dwarf x Tall crosses (Table.1a and 2a).

The stem girth in the F_1 population of Tall x Dwarf crosses, 19.34 percent, 59.43 percent and 21.23 percent of the plants had fallen under Dwarf (Cauvery), medium type and Tall type categories respectively as against 20.63 percent, 65.63 percent and 13.73 percent under the same categories of Dwarf x Tall progenies (Table.1a and 2a). This result indicated that comparatively higher influence of the genetic factor controlling the stem girth character in the offspring population inherited from the tall female parents. Observation on primary thickness showed that 'Cauvery' as male parent had stronger effect on the frequency of plants having the low primary thickness like'Cauvery' by producing 33.96 percent of the plants whereas, as a female parent it had 25.31 percent frequency of such plants. The frequency of plants under tall type primary thickness of Dwarf x Tall and Tall x Dwarf groups was almost same. The percentage of plants with intermediate primary thickness was 54.72 percent in Tall x Dwarf as against 63.75 percent in Dwarf x Tall progenies. Internodal length character indicated the frequency of 18.87 percent under tall category as compared to 8.96 percent under dwarf type. The average percentage of plants with medium length of internodes was 72.17 percent where, Sln.9 and Sln.5B in cross combination of Cauvery male parent exhibited the similar character in 83.10 and 83.33 percent respectively (Table. 2b). The percentage of plants with short intermodal length was higher (18.75 percent) in the crosses of Dwarf x Tall cultivars when compared with Tall x Dwarf progeny. The character number of secondary branches indicated the plant frequencies in the similar fashion as in case of Dwarf x Tall progenies.

A frequency of 30.23 percent and 13.33 percent plant with low leaf length was noticed in Sln.6 x Cauvery and Sln.5B x Cauvery F_1 population (Table. 2b). The highest of 98.53 percent plant frequency was in S.881 x Cauvery cross combination with medium type leaves. The frequency of plant with long leave length was 27.91 percent as highest in Sln.6 x Cauvery hybrids as compared to the hybrids of the other Tall x Dwarf crosses. Comparing the progenies of Dwarf x Tall and Tall x Dwarf crosses, it was found that the percentage of plants with higher leaf length was more in Dwarf x Tall while the percentage of plants with low leaf length was more in Tall x Dwarf population (Table. 4b). Under the low leaf breadth category, Sln.5B x Cauvery hybrids showed the highest frequency of 93.33 percent, while under medium and high range it was 6.67 percent and nil respectively. However, the frequency (30.66 percent) of plants with low leaf breadth was higher in Tall x Dwarf crosses than the frequency (18.75 percent) in Dwarf x Tall crosses (Table. 4b). The combination of frequency was reverse in case of higher leaf breadth in the progenies. The data indicated that male parent had greater genetic influence on leaf breadth than the female.

Yield parameters

The F_1 population resulted from the various crosses of coffee cultivars in the present study were grouped into three classes of low, medium and high for yield, 100 fruit weight and volume and percent fruit floats. The classification on yield parameters indicated the highest percentage of 56.47 percent plants of Cauvery x Devamachy progeny produced the fruit yield between the low range (0.0 to 2.0 kg) whereas in Cauvery x Tafarikela hybrids, 54.84 percent population had yield in the medium range (2.0 to 4.0 kg plant^{-1}). The percentage of plants in the high yielding range was highest (45.37 percent) in F_1 population of Cauvery x Sln.9 cross combination (Table. 3a). The results showed that Cauvery x Sln.9 F_1 generation had high yield potential that could be exploited to breed a high yielding arabica variety. Beside this, Cauvery x Tafarikela and Cauvery x S.881 hybrids are medium yielder and favorably suitable for breeding a cultivar with average yielding behavior. Weight of 100 fruits in the progenies showed that Cauvery x Tafarikela progeny had 3.23 percent plants that could be placed

under higher category of 200 to 250 gm per 100 fruit weight. In addition, this progeny exhibited 87.10 percent plant population that had medium size of fruits weighing between 150 to 200 gm per 100 fruits. Cauvery x Sln.9 progeny had the highest of 91.67 percent of plant population that produced the fruits in the medium range. These progenies performed almost in same fashion of frequency distribution for 100 fruit volume also. Cauvery x Devamachy progeny exhibited the highest plant frequency of 30.60 percent under low fruit weight and volume (Table. 3a).

Production of fruit floats in a cultivar is caused by the formation of empty locules and considered to be one of the highly adopted criteria to judge the yield potential of a coffee variety because, increase in the quantum of floats reduce the coffee yield drastically (Haarer, 1956). Among the Dwarf x Tall progenies, 76.80 percent of the population in Cauvery x S.881 crosses was classified under low float category of 0.0 to 10.0 percent floats and 31.48 percent of plants in Cauvery x Sln.9 were in medium range of fruit float formation. The 22.58 percent of the plant population of Cauvery x Tafarikela exhibited their presence in the category of high range of fruit float production. The results of the plant classification indicated that although, the F_1 progeny of Cauvery x Sln.9 had a higher frequency of plants under high yielding and medium size fruit categories but, 22.58 percent plant population had fruit floats ranging from 10 to 20 percent. In this context, Cauvery x S.881 progeny that had 76.80 percent population under low range (0.0 to 10.0 percent) was found to be better than the other genotypes (Table. 3a).

Out of 320 plant population developed from Dwarf x Tall crosses, it was noted that 36.34 percent plants yielded below 2.0 kg, 45.4 percent above 2.00 and below 4.0 kg and 18.24 percent yielded above 4.0 kg of ripe fruits plant^{-1}. As the fruit weight and volume is concerned, 15.70 percent, 82.30 percent and 2.00 percent of the plants had fruit weight under low, medium and high range respectively while, 20.90 percent, 75.32 percent and 3.78 percent plant population found their place under low, medium and higher limits of fruit volume accordingly. Low level of fruit float formation was recorded in 67.07 percent of the population and remaining population of 17.31 percent and 15.62 percent exhibited float formation under medium and high level respectively (Table. 5).

Like, Cauvery x Sln.9 progeny, Sln.9 x Cauvery F_1 population also had the plants frequency of 42.65 percent under high yield category followed by 29.31 percent plant population of Sln.6 x Cauvery under the same category (Table. 3b). Majority of the plant population (75 to 90 percent) in Tall x Dwarf crosses had the 100 fruit weight under medium class. The similar trend was noticed for 100 fruit volume also in the above progenies. The F_1 population of 93.55 percent of Sln.5B x Cauvery showed low production of fruit floats whereas, Sln.9 x Cauvery expressed 44.12 percent as the lowest frequency under low category of fruit floats. (Table. 3b).

While evaluating the progenies of both the groups of crosses viz; Dwarf x Tall and Tall x Dwarf, it was summarized that there was no considerable differences between their plant frequencies for yield parameters. Among Dwarf x Tall, the percentage of plant under low, medium and high yield categories were 36.34 percent, 45.42 percent and 18.24 percent respectively whereas, in Tall x Dwarf progenies, the frequencies were 38.71 percent, 39.62 percent and 21.67 percent for low, medium and high range. However, high yielding and low yielding plants were found to be more in Tall x Dwarf progenies than the Dwarf x Tall while, the plants yielding medium crop were more in Dwarf x Tall population (Table. 5). The same trend was noticed for fruit weight character also. There was no much variation in the plant frequencies recorded for fruit volume. In addition to this, numbers of plants were more in Dwarf x Tall progenies that indicated fruit floats in low range besides, the greater number of plants with high float percentage.

CONCLUSION

In the entire plant population of 532 numbers of plants, 37.53 percent were low yielder, 42.52 percent medium and around 20 percent high yielding plants among which, 18.0 percent plants recorded 100 fruit weight in low range, around 80 percent medium and 2 percent high range. Parameter on 100 fruit volume followed the same pattern of frequency distribution. The 64.55 percent of the plants yielded with low range of fruit floats and 21.65 percent population in the progenies showed the percent float formation in medium range. Approximately, 14 percent of the plants produced the floats to the higher extent (Table. 5). Among the F_1 populations of Dwarf x Tall and Tall x Dwarf group of crosses, the characters such as bush spread, primary thickness, internodal length, leaf length and leaf breadth had expressed dominance of female parent cultivar. This phenomenon of genetic transmission is believed to be the result of cytoplasmic inheritance. The greater genetic influence of long leaf and broad leaf characters was found in the F_1 progeny. The percentage of high yielding plants expressed the higher frequency in F_1 population of Tall x Dwarf as compared to the progeny of Dwarf x Tall crosses due to improvement in the bush canopy.

Table. 1a. Classification 320 numbers of total F_1 population derived from Dwarf x Tall cross combinations (percent plant type)

Bush spread (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
120-180	Cauvery type	31.48	36.21	42.28	51.61	38.44
180-240	Intermediate type	66.67	60.34	52.03	48.39	58.12
240-300	Tall type	1.85	3.45	5.69	0.00	3.44
Total						100
Stem girth (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
3.0-4.5	Cauvery type	23.15	10.34	26.02	9.68	20.63
4.5-6.0	Intermediate type	68.52	65.52	59.35	80.65	65.63
6.0-7.5	Tall type	8.33	24.14	14.63	9.68	13.74
Total						100
Primary's thickness (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
0.5-1.5	Cauvery type	22.22	22.41	32.52	12.90	25.31
1.5-2.5	Intermediate type	71.30	58.62	56.91	74.19	63.75
2.5-3.5	Tall type	6.48	18.97	10.57	12.90	10.94
Total						100
Primary's Internodal length (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
2.5-4.0	Cauvery type	15.74	34.48	17.07	6.45	18.74
4.0-5.5	Intermediate type	73.15	55.17	60.16	93.55	66.88
5.5-7.0	Tall type	11.11	10.34	22.76	0.00	14.38
Total						100
Secondary's Internodal length (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
2.0-3.5	Cauvery type	12.04	15.52	19.51	77.42	21.88
3.5-5.0	Intermediate type	67.59	75.86	63.41	22.58	63.12
5.0-6.5	Tall type	20.37	8.62	17.07	0.00	15.00
Total						100

Table. 1b. Classification 320 numbers of total F_1 population derived from Dwarf x Tall cross combinations (percent plant type)

Number of secondaries primary^{-1}	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
3.0-9.0	Cauvery type	69.44	60.34	65.85	77.42	67.19
9.0-15.0	Intermediate type	29.63	32.76	31.71	22.58	30.31
15.0-21.0	Tall type	0.93	6.90	2.44	0.00	2.50
Total						100
Leaf length (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
11.0-14.0	Cauvery type	3.70	8.62	0.81	0	3.13
14.0-17.0	Intermediate type	55.56	86.20	67.48	100.00	70.00
17.0-20.0	Tall type	40.74	5.17	31.71	0.00	26.88
Total						100
Leaf breadth (cm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean
5.0-7.0	Cauvery type	15.74	34.48	17.07	6.45	18.75
7.0-9.0	Intermediate type	73.15	55.17	60.16	93.55	66.88
9.0-11.0	Tall type	11.11	10.34	22.76	0.00	14.38
Total						100

Table. 2a. Classification 212 numbers of total F_1 populatEion derived from Tall x Dwarf cross combinations (percent plant type)

Bush spread (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean
120-180	Cauvery type	26.76	26.47	37.21	23.33	28.30
180-240	Intermediate type	70.42	64.71	60.47	76.67	67.45
240-300	Tall type	2.82	8.82	2.33	0.00	4.25
Total						100
Stem girth (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean
3.0-4.5	Cauvery type	12.678	17.65	27.91	26.67	19.34
4.5-6.0	Intermediate type	59.15	57.35	53.49	73.33	59.43
6.0-7.5	Tall type	28.17	25.00	18.60	0.00	21.23
Total						100

Table.2b. Classification of 212 numbers of total F_1 population deriveEd from Tall x Dwarf cross combinations (percent plant type)

Primary's thickness (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
0.5-1.5	Cauvery type	40.85	33.82	27.91	26.67	33.96
1.5-2.5	Intermediate type	45.07	55.88	55.81	73.33	54.72
2.5-3.5	Tall type	14.08	10.29	16.28	0.00	11.32
Total						100
Primary's internodal length (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
2.5-4.0	Cauvery type	9.86	14.71	4.65	0.00	8.96
4.0-5.5	Intermediate type	83.10	70.59	48.84	83.33	72.17
5.5-7.0	Tall type	7.04	14.71	46.51	16.67	18.87
Total						100
Secondary's internodal length (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
2.0-3.5	Cauvery type	9.86	19.12	9.30	0.00	11.32
3.5-5.0	Intermediate type	84.51	73.53	30.23	66.67	67.45
5.0-6.5	Tall type	5.63	7.35	60.47	33.33	21.23
Total						100
Number of secondaries primary^{-1}	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
3.0-9.0	Cauvery type	63.38	83.82	81.40	20.00	67.45
9.0-15.0	Intermediate type	29.58	14.71	18.60	76.67	29.25
15.0-21.0	Tall type	7.04	1.47	0.00	3.33	3.30
Total						100
Leaf length (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
11.0-14.0	Cauvery type	2.82	0.00	30.23	13.33	8.96
14.0-17.0	Intermediate type	80.28	98.53	41.86	63.33	75.94
17.0-20.0	Tall type	16.90	1.47	27.91	23.33	15.10
Total						100
Leaf breadth (cm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (%)
5.0-7.0	Cauvery type	9.86	14.71	46.51	93.33	30.66
7.0-9.0	Intermediate type	83.10	70.59	51.16	6.67	61.79
9.0-11.0	Tall type	7.04	14.71	2.33	0.00	7.55
Total						100

Table. 3a. Classification of 320 numbers of total F_1 population derived fErom Dwarf x Tall cross combinations (percent plant type)

Fruit yield (kg) plant^{-1}	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean (%)
0.0-2.0	Low	14.81	32.14	56.47	41.94	36.34
2.0-4.0	Medium	39.81	48.22	38.82	54.84	45.42
4.0-6.0	High	45.36	19.64	4.71	3.22	18.24
Total						100.00
100 Fruit wt. (gm)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean (%)
100-150	Low	6.48	16.06	30.60	9.68	15.70
150-200	Medium	91.67	82.14	68.22	87.10	82.30
200-250	High	1.85	1.80	1.18	3.22	2.00
Total						100.00
100 Fruit vol. (ml)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean (%)
90-140	Low	9.26	21.43	40.00	12.90	20.90
140-190	Medium	88.89	75.00	60.00	77.42	75.32
190-240	High	1.85	3.57	0.00	9.68	3.78
Total						100.00
Fruit floats (percent)	Plant type	Cauvery x Sln.9	Cauvery x S.881	Cauvery x Devamachy	Cauvery x Tafarikela	Mean (%)
0.0-10.0	Low	54.63	76.80	65.88	70.97	67.07
10.0-20.0	Medium	31.48	12.50	18.82	6.45	17.31
20.0 -30.0	High	13.89	10.70	15.30	22.58	15.62
Total						100.00

Table. 3b. Classification 212 numbers of total F_1 population derived from Tall x Dwarf cross combinations (percent plant type)

Fruit yield plant^{-1} (kg)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (percent)
0.0-2.0	Low	19.12	38.24	36.21	61.30	38.71
2.0-4.0	Medium	38.24	47.06	34.48	38.70	39.62
4.0-6.0	High	42.65	14.71	29.31	0.00	21.67
Total						100.00
100 Fruit wt. (gm)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (percent)
100-150	Low	7.35	41.18	6.90	25.81	20.31
150-200	Medium	88.24	57.35	89.66	74.19	77.36
200-250	High	4.41	1.47	3.45	0.00	2.33
Total						100.00
100 Fruit vol. (ml)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (percent)
90-140	Low	10.29	38.24	13.79	19.35	20.42
140-190	Medium	85.29	60.29	84.48	80.65	77.68
190-240	High	4.41	1.47	1.72	0.00	1.90
Total						100.00
Fruit floats (percent)	Plant type	Sln.9 x Cauvery	S.881 x Cauvery	Sln.6 x Cauvery	Sln.5B x Cauvery	Mean (percent)
0.0-10.0	Low	44.12	58.82	51.72	93.55	62.05
10.0-20.0	Medium	35.30	29.42	32.76	6.45	25.98
20.0 -30.0	High	20.58	11.76	15.52	0.00	11.97
Total						100.00

Table. 4a. Summary of classification on growth characters

Bush spread (cm)	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
120-180	Cauvery type	38.44	28.30	33.37
180-240	Intermediate type	58.12	67.45	62.78
240-300	Tall type	3.44	4.25	3.85
Total		100	100	
Stem girth (cm)				
3.0-4.5	Cauvery type	20.63	19.34	19.98
4.5-6.0	Intermediate type	65.63	59.43	62.53
6.0-7.5	Tall type	13.74	21.23	17.58
Total		100	100	
Primary's thickness (cm)				
0.5-1.5	Cauvery type	25.31	33.96	29.64
1.5-2.5	Intermediate type	63.75	54.72	59.24
2.5-3.5	Tall type	10.94	11.32	11.13
Total		100	100	
Primary's internodal length (cm)				
2.5-4.0	Cauvery type	18.74	8.96	13.85
4.0-5.5	Intermediate type	66.88	72.17	69.53
5.5-7.0	Tall type	14.38	18.87	16.62
Total		100	100	

Table. 4b. Summary of classification on growth characters

Secondary's Internodal length (cm)	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
2.0-3.5	Cauvery type	21.88	11.32	16.60
3.5-5.0	Intermediate type	63.12	67.45	65.28
5.0-6.5	Tall type	15.00	21.23	18.12
Total		100	100	
Number of secondary shoots primary^{-1}				
3.0-9.0	Cauvery type	67.20	67.45	67.33
9.0-15.0	Intermediate type	30.30	29.25	29.77
15.0-21.0	Tall type	2.50	3.30	2.90
Total		100	100	
Leaf length (cm)				
11.0-14.0	Cauvery type	3.12	8.96	6.04
14.0-17.0	Intermediate type	70.00	75.94	72.97
17.0-20.0	Tall type	26.88	15.10	20.99
Total		100	100	
Leaf breadth (cm)				
5.0-7.0	Cauvery type	18.74	30.65	24.70
7.0-9.0	Intermediate type	66.88	61.80	64.34
9.0-11.0	Tall type	14.38	7.55	10.96
Total		100	100	

Table.5. Summary of classification based on yield characters of 532 plants population

Fruit yield (kg) plant^{-1}	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
0.0-2.0	Low	36.34	38.71	37.53
2.0-4.0	Medium	45.42	39.62	42.52
4.0-6.0	High	18.24	21.67	19.95
Total		100.00	100.00	100.00
100 Fruit wt. (gm)	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
100-150	Low	15.70	20.31	18.00
150-200	Medium	82.30	77.36	79.82
200-250	High	2.00	2.33	2.18
Total		100.00	100.00	100.00
100 Fruit vol. (ml)	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
90-140	Low	20.90	20.42	20.66
140-190	Medium	75.32	77.68	76.50
190-240	High	3.78	1.90	2.84
Total		100.00	100.00	100.00
Fruit floats (percent)	Plant type	Dwarf x Tall	Tall x Dwarf	Mean
0.0-10.0	Low	67.07	62.05	64.55
10.0-20.0	Medium	17.31	25.98	21.65
20.0 -30.0	High	15.62	11.97	13.80

ACKNOWLEDGEMENT

Authors are thankful to Dr. Jayarama, Director of Research, CCRI and Dr. Y. Raghuramulu, Joint Director (Projects), Coffee Board, Bangalore Karnataka for their encouragement and valuable suggestions during the course of study. Authors would like to express their deep sense of gratitude to Sri N. Ramamurthy, Deputy Director (Research), CRSS, Chettalli, Kodagu District, Karnataka and Sri. C.B. Prakashan, Deputy Director (Research), RCRS, Chundale, Wyanad, Kerala for their support during the research work. Authors are also grateful to Professor R. Udayakumar, Dean Faculty of Agriculture and Animal Husbandry, G.R.U. Gandhigram, Dindigul District, Tamil Nadu for his unconditional support and encouragement.

REFERENCES

1. Van Der Vossen HAM; Challenges to coffee plant improvement in the 21st century. Proc. International Coffee Symposium on Coffee, Bangalore, India. 2000;20-30.
2. Wrigley G; COFFEE: Tropical Agriculture Series London. John Wily & Son, Inc., New York, U.S.A., 1988.
3. Carvalho A and Monaco LC; Genetic relationship of selected *Coffea* species. Ciencia Cultura. 1967; 19:151-165.
4. Amaravenmathy VS, Srinivasan CS; Phenotypic and genotypic variation for yield and plant Architecture in some hybrid progenies of Arabica coffee. J. Coffee Res, 2003; 31(2):99-105.
5. Kufa T, Burkhardt J, Goldbach H; Eco-physiological Variability of Forest Arabica Coffee Populations in Hydraulic Characteristics along a Climatic Gradient in Ethiopia: Morphological and Physiological Variability. ASIC, 20th International Conference on Coffee Science, Bangalore2004;929-939.
6. Kebede M, Bellachew B; Morphological Characterization of Hararge Coffee (*Coffea arabica*L.) Germplasm Accessions for Qualitative Characters. ASIC, 20th International Conference on Coffee Science, Bangalore, 2004; 1113-1117, 2004b.
7. Kumar A, Ganesh S; Awati MG; Genotypic and phenotypic variability, heritability and correlation of morphological traits in F1 hybrids of Arabica coffee. J. Coffee Res, 2008; 36 (1&2):10-24.
8. Van der Vossen HAM; Coffee selection and breeding. In-Coffee, botany, biochemistry and production of beans and beverage, M.N. Clifford, K.C. Willsons (eds.) Crom Helm Ltd, 1985;48-96.