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Quantification of genetic traits transmission in F_1 progeny of dwarf x tall crosses of *Coffea arabica* L.

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A B S T R A C T

Several techniques for enumeration of genetic data have been developed for commercially cultivated crops but, no reliable models are evolved to quantify the parental traits transmission in the hybrid progenies of coffee cultivars. In this perspective, an effort was made to quantify the genetic traits contributed by the male and female parents to the offspring using a new mathematical model developed by Kumar and Ganesh (2013). Data on morphological traits were recorded taking 7 plants per progeny and per replication into account. The total parental influence for the inherent traits of dwarf and tall parents was divided into two parts, one paternal and other maternal. The study revealed that 'Cauvery' as a female parent had stronger influence (92.16%) on bush spread in the progenies as compared to the tall parents (7.84%). When, 'Cauvery' used as a male partner, the effect was reduced from 92.16% to 61.69% while, the tall female partner expressed the improvement in the bush spread from 7.84% to 38.31%. This behavior of the hybrids indicated the complete dominance of mutant Caturra 'Ct' genes inherited from the cultivar 'Cauvery' over tall cultivars for bush spread character. The 'Caturra' gene exhibited almost similar effect on stem girth character when 'Cauvery 'was used either as male or female parent. The tall parents showed slightly lower influence on expression of this trait. This trend of parental trait transmission indicated a case of incomplete dominance for stem girth character. Like bush spread, the primary thickness and primary's internodal length character were also greatly influenced by the 'Ct' gene transmitted through 'Cauvery' used as a female parent. 'Cauvery' had equal contribution for primary's internodal length when crossed with tall female. The leaf characters showed higher genetic contribution of tall parents except S.881 parent to an extent of almost 70%

Keywords: *Genetic analysis, F1 hybrids, quantification of traits, genetic transmission, morphological traits, character inheritance, variability, quantitative traits.*

INTRODUCTION

The principal objective of coffee breeding and selection agenda is to develop high yielding, excellent bean quality and disease resistant (especially rust) cultivars which are adapted to specific growing conditions. Four major goals have been set to fulfill the major objectives of coffee breeding. Firstly, breeding strategies needs to be developed secondly, techniques required to be evolved and implemented and thirdly, the procedures for vegetative propagation needs to be standardized and lastly, potentially elite individual plants needs to be selected from existing coffee plantations and propagated asexually (Van der Vossen, 2000). Bayetta, (1997) reviewed the achievements made in coffee breeding programme in arabica cultivars in Ethiopia and reported the release of 17 CBD resistant genotypes out of 279 promising selections screened from a population of 1380 indigenous and exotic accessions, in addition to three recently released cultivars. He indicated the inheritance of traits of commercial interest and heterosis for yield to be beneficial in genetic analysis of desirable lines and their exploitation in breeding. Coffee plant breeders strongly felt that for a rapid increase in the production and productivity, exploitation of hybrid varieties could be the best option (Van der Vossen, 2000). Ameha (1990) recorded 30-60% heterosis for yield over better parents in arabica coffee. Similar observations were made by Cilas, (1998), Bertrand, (1997), Walyaro (1983) and Srinivasan and Vishveshwra (1978). In most of the commercial crops, emphasis has been given to improve the productivity either by way of conventional breeding or through molecular techniques. Both breeding protocol involves the parents of desirable traits to evolve the progeny of higher genetic potential by the contribution of their genetic strength. Measurement of parental genetic potential capable of expression of its degree of dominance transmitted in the offspring need to be enumerated for both inbred lines. During process of hybridization, each parent contributes 50% of its genetic traits which forms 100% in the F_1 progeny. The dominant character that comes from one parent suppresses the character transmitted from other parent. Under this situation, the character suppressed is known as recessive character. Whereas, in the case of co dominance, both the parents exhibit equal effect on F1 offspring that produces intermediate character (Atherly, 1999) In quantitative traits, the intermediate is measured in terms of mid parent value. Any deviation in the character from the mid parent value is an indication of parental influence combined with environmental impact. When the parents and the progeny are nurtured under the same environment, any deviation from the mid parent value can be considered to be due to parental influence.

Therefore, in the present study, a new formula was applied to quantify the genetic contribution of the parent cultivars for the quantitative characters inherited to the progeny (Kumar and Ganesh, 2013).

MATERIALS AND METHODS

In a breeding program, dwarf and tall cultivars of *Coffea arabica* namely; were crossed to produce a progeny with semi-dwarf and compact bush, short internodes, bold fruits and resistant to leaf rust. The parent 'Cauvery' also known as Catimor was used as a dwarf female and male parent to cross with the tall cultivars such as Sln.5B, Sln.6, Sln.9, S.881 (Rume Sudan Wild arabica), Devamachy (a natural hybrid of arabica x robusta coffee) and Tafarikela variety. F_1 progenies of these crosses were used to determine the parental traits transmission in the progenies with the help of morphological parameters recorded. A total of eight F_1 progenies and seven parent cultivars with four replications were chosen for the present study. Seven plants per replication were randomly selected for recording data on morphological characters like, bush spread, stem diameter, primary thickness, internodal length of primary shoots, leaf length and breadth in addition to leaf area. Mean values of the parameters recorded were subjected to the new formula developed by Kumar and Ganesh (2013) for quantification of genetic traits transmission in the F_1 progenies. The present study was conducted at Coffee Research Sub Station, Chettalli, Kodagu District, Karnataka, India during the year 2008-10 and findings are presented in the following paragraphs.

Effect of male parent $E_M = \left[\frac{C}{\frac{(\Omega F + \Omega M)}{2} - \Omega F}\right] x\ \Psi_D - \Omega_F$ therefore, $E_F = 100 - E_M$

Where, $\Omega_F =$ observed value of the female parent, $\Omega_M =$ observed value of male parent, Ψ_D = dwarf type F_1 hybrid value and C = 50.

RESULTS AND DISCUSSION

Parental Traits Transmission

The percent parental contribution for genetic traits transmission in F_1 hybrids was determined with the help of new formula and the results are presented herein. The genetic influence of dominant Caturra mutant gene transmitted through 'Cauvery' as female parent was noticed in the F_1 progeny of Dwarf x Tall crosses to the higher degree of magnitude. In the crosses, where 'Cauvery' was used as female inbred line in combination with the tall cultivars, it affected the bush spread character in the range of 94.33 to 100.00% while, as a male parent line it had shown the effect ranging from 62.19 to 80.12% (table-1). The stem girth and primary thickness was affected from 51.21 to 60.95% and from 40.76 to 93.77% respectively by the female parent 'Cauvery' whereas; the influence in the range of 52.32 to 66.01% and 64.95 to 100.00% was measured in the F_1 population with 'Cauvery' as male parent for stem girth and primary thickness respectively. The percent effect of 'Cauvery' as a female and male parent varied from 44.64 to 86.69% and from 27.18 to 77.90% for primary's intermodal length respectively (fig.1). Being a male as well as female inbred line, cultivar 'Cauvery had expressed its 100.00% influence (complete dominance) on leaf length and breadth, and leaf area when crossed with S.881 variety (fig.3) but 'Cauvery' as a female parent could not show its genetic potential on these heritable traits in the progenies produced by crossing with Sln.9 and Tafarikela varieties. However, in case of Cauvery x Devamachy progeny, 'Cauvery' expressed its presence in terms of leaf characters in the range of 10.22 to 24.99%. In the cross combinations of Sln.9 x Cauvery, the progenies exhibited zero effect of 'Cauvery' (as male parent) on leaf characters (fig.2). The effect of male parent was also zero in the progeny developed from Sln.6 x Cauvery cross on leaf length, besides 100% influence on leaf breadth and leaf area (fig.7). In the progeny derived from Sln.5B x Cauvery hybridization, the leaf breadth and leaf area had nil effect while, leaf length showed 25.05% effect of 'Cauvery' cultivar (fig.8).

Figure 1. to 4 Maternal and paternal influence on morphological traits of F_1 hybrids

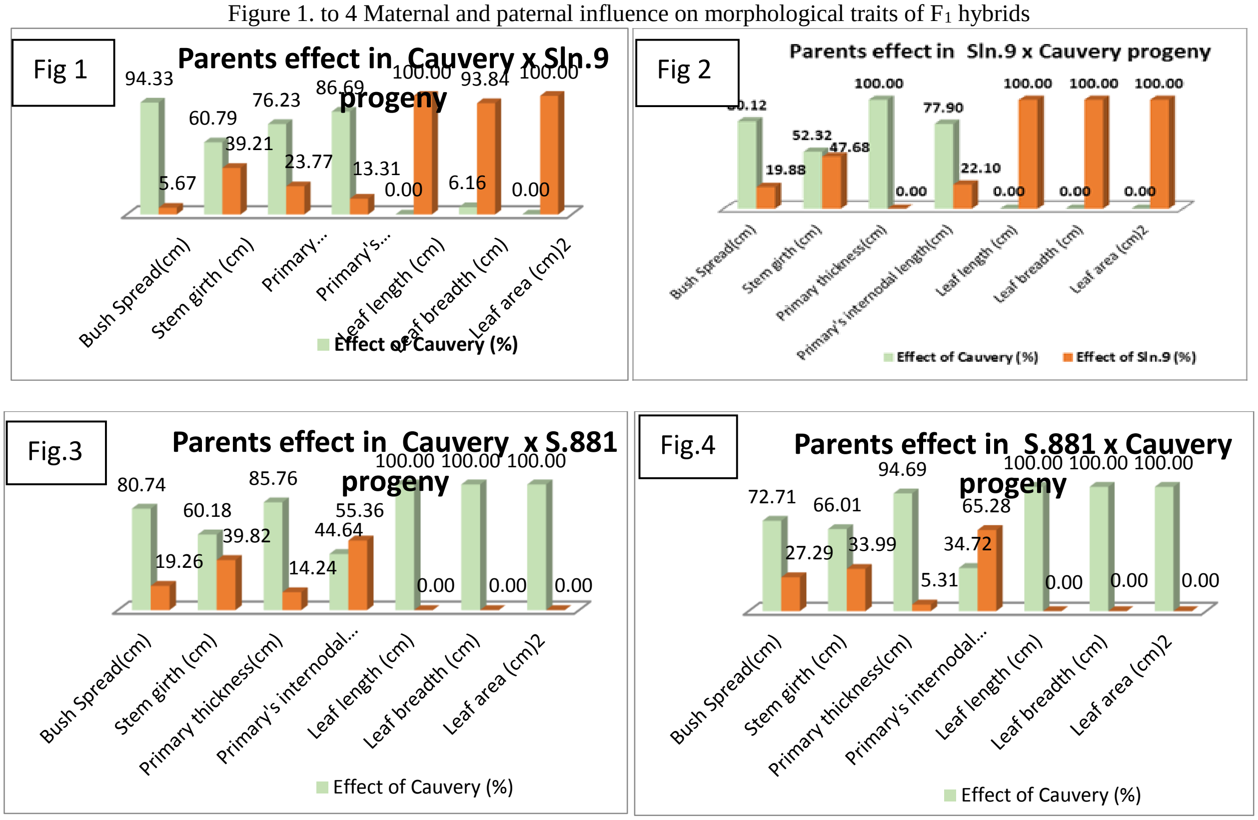
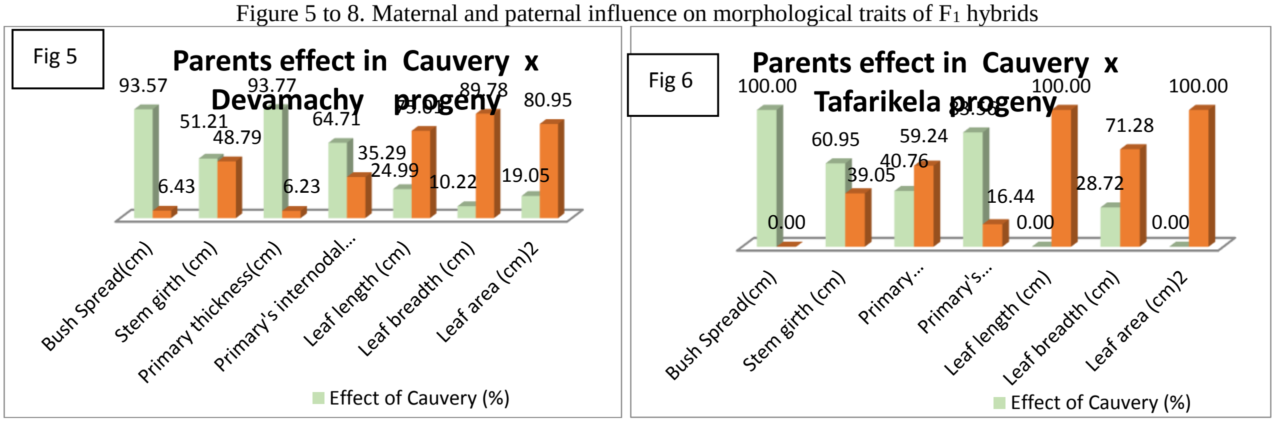
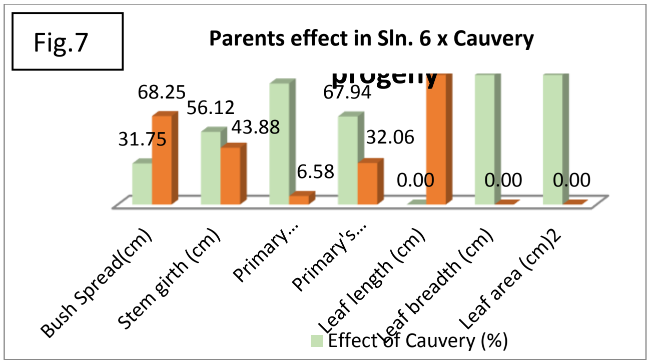
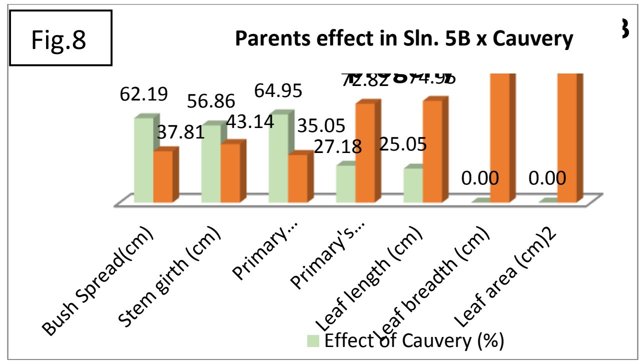


Figure 5 to 8. Maternal and paternal influence on morphological traits of F_1 hybrids







Among the Tall x Dwarf progenies, the maternal effect of Sln.6 was the highest to an extent of 68.25% for bush span and 100% for leaf length as well as no effect on leaf breadth and leaf area. Sln.9 caused the highest impact of 47.68% for stem girth with zero effect on primary thickness which indicated the presence of recessive genes for primary thickness character in Sln.9 that was suppressed by the Caturra 'Ct' mutant genes transmitted by the male parent 'Cauvery'. Sln.5B had shown its dominance over the male parent 'Cauvery' by producing 72.82% influence on internodal length of primary branches in the F_1 progeny. This cultivar also affected the leaf length by 74.94% and leaf breadth and leaf area by 100% (table-1).

The paternal genetic pressure of tall varieties on morphological characters in the F_1 generation of Tall x Dwarf cross combinations was observed to be low ranging from 0.00 to 19.26% for bush spread behavior. For the characters like stem girth and primary thickness, the paternal forces were in the range of 39.05 to 48.79% and 6.23 to 59.26% respectively. Tall varieties as the male inbred lines could not influence the primary internodal length more than 55.36% in the progenies especially in case of Cauvery x S.881 cross combination. The tall male parents such as Sln.9 and Tafarikela expressed their dominance over 'Cauvery' by 100% for leaf length and leaf area in the progenies. In the cross combination of Cauvery x Devamachy, the male parent had its greater part of character contribution for leaf length, leaf breadth and leaf area as 75.01%, 89.78% and 80.95% respectively as against 24.99%, 10.22% and 19.05% contributed by the female parent 'Cauvery (fig.5)'. Similarly, Tafarikela in combination with 'Cauvery' transmitted its 100% dominance for leaf length and leaf area (fig.6), while its dominance towards leaf breadth was 71.28% and the remaining part of character transmission was 28.72% made by the female parent 'Cauvery' (table-1).

3.2. Identification of maternal and paternal traits

The study revealed that the genetic factors responsible for growth of main stem and bush spread character was transmitted by the female parent. In the crosses of either inter-varietal or inter-specific, the dwarf cultivar like 'Cauvery' had expressed greater influence as female rather than as male. As a female parent 'Cauvery' had contributed 92.16% and as a male its contribution was 61.70% for bush spread character. The contribution of male and female tall parent was 7.84% and 38.31% respectively. This finding indicated that the morphological traits such as bush spread and its dependent components like; internodal length of primary and secondary branches, were transmitted by the female parents. Dominance of the female parent could be due to cytoplasmic inheritance from the dwarf mutant cultivar 'Cauvery' as this genetic transmission was associated with mutant strains (Burns and Bottino, 1989). It is obvious that the bush spread in coffee cultivars is governed by the length of primary shoots which has the dependency on the internodal length of primaries. Hence, longer the space between the inter-nodes, there would be higher the primary's length and lastly this results in widening the bush spread of the genotype.

The correlation study showed that in F_1 progenies, the bush spread had positive and strong correlation with the stem girth and primary thickness therefore, with transmission of bush spread character the related traits like stem girth and primary thickness were also inherited to the progeny (Kumar, 2008). Almost equal influence of 'Cauvery, as a male and female was noticed on the stem girth character. While primary thickness in the progenies exhibited the greater genetic control of male parent over primary's growth by recording 88.26% influence. The influence of 'Cauvery' as female was 74.13% comparatively lower than 'Cauvery' as male parent.

Cultivar 'Cauvery' had greater influence on internodal length of primary and secondary shoots in the F_1 generation plant population but the influence of Cauvery as female was higher (69.90%) than the same cultivar as male (51.94%) parent. Subsequently, the tall cultivars used as a female parent also had shown its influence on internodal length to the higher magnitude as compared to the male. This emphasized that the character internodal distance is largely governed by the female parent in the progenies. As far as leaf character is concerned, it was found to be transmitted by both of the parents either as male or female but long leaf character was noticed to be dominant over short leaf length. The tall cultivars with longer leaf length used as male or female parents had expressed higher degree of genetic transmission for leaf length character in the progenies. However, the paternal effect on leaf length had been more prominent in the progenies as compared to maternal outcome.

Similarly, broader leaf character was found to be the dominant over narrow leaf breadth. Consequently, the parents with narrow leaf breadth such as S.881 and Sln.11 when crossed with the cultivars having broader leaves, it had produced the progenies with broader leaf phenotype. The male parents exhibited their larger contribution towards increase in leaf breadth in the progenies.

CONCLUSION

Precisely, the total influence of the genetic traits of dwarf and tall parents on quantitative traits transmission was partitioned into two portions, one paternal and other maternal to articulate the individual share of genetic transmission in the F_1 hybrids derived from various cross combinations of dwarf and tall parent cultivars. The data revealed that 'Cauvery' as a female parent had 92.16% influence on bush spread in the progenies as against 7.84% effect caused by the tall parents. Further, 'Cauvery' as a male partner exhibited 61.69% effect on bush spread as against 38.31% expressed by the tall female partner. This indicated the complete dominance of mutant Caturra 'Ct' genes over tall cultivars for bush spread character (table-2). The degree of genetic penetrance of the mutant gene appeared to be higher through the female parent than the male. The 'Caturra' gene had almost equal effect through male as well as female parent on stem girth character while, tall parents showed slightly lower influence on expression of this trait. This trend of parental trait transmission indicated a case of co dominance in the F_1 hybrids. Like bush spread, the primary thickness character was also greatly influenced by the 'Ct' gene. The 'Ct' gene transmitted through 'Cauvery' female parent exhibited stronger influence on primary's intermodal length than transmitted by the male parent. Cauvery male parent with tall female contributed about 50% of the total strength of the genetic character for intermodal length whereas 'Cauvery' as a female parent expressed approximately 70% share as against 30% by tall male. The genetic contribution of tall parents except S.881 for leaf characters was higher than the dwarf parent cultivars. The present mathematical model was found to be a useful tool for estimation of parental traits transmission and its degree of influence on the F_1 hybrids when both parents and offspring were grown under the same environment.

Table 1. Paternal and maternal genetic contribution to the F_1 progeny of Dwarf x Tall and Tall x Dwarf crosses for morphological traits (%)

Crosses	Parents used	Effect of genotype (%)	Bush Spread	Stem girth	Primary thickness	Internodal length	Leaf length	Leaf breadth	Leaf area
Cau x Sln.9	Female	Effect of Cauvery	94.33	60.79	76.23	86.69	0.00	6.16	0.00
Cau x S.881	Female	Effect of Cauvery	80.74	60.18	85.76	44.64	100.00	100.00	100.00
Cau x D. machy	Female	Effect of Cauvery	93.57	51.21	93.77	64.71	24.99	10.22	19.05
Cau x Tafarikela	Female	Effect of Cauvery	100.00	60.95	40.76	83.56	0.00	28.72	0.00
Mean			92.16	58.28	74.13	69.90	31.25	36.27	29.76
Sln.9 x Cau	Male	Effect of Cauvery	80.12	52.32	100.00	77.90	0.00	0.00	0.00
S.881 x Cau	Male	Effect of Cauvery	72.71	66.01	94.69	34.72	100.00	100.00	100.00
Sln.6 x Cau	Male	Effect of Cauvery	31.75	56.12	93.42	67.94	0.00	100.00	100.00
Sln.5B x Cau	Male	Effect of Cauvery	62.19	56.86	64.95	27.18	25.05	0.00	0.00
Mean			61.69	57.83	88.26	51.94	31.26	50.00	50.00
Sln.9 x Cau	Female	Effect of Sln.9	19.88	47.68	0.00	22.10	100.00	100.00	100.00
S.881 x Cau	Female	Effect of S.881	27.29	33.99	5.31	65.28	0.00	0.00	0.00
Sln.6 x Cau	Female	Effect of Sln.6	68.25	43.88	6.58	32.06	100.00	0.00	0.00
Sln.5B x Cau	Female	Effect of Sln.5B	37.81	43.14	35.05	72.82	74.95	100.00	100.00
Mean			38.31	42.17	11.74	48.06	68.74	50.00	50.00
Cau x Sln.9	Male	Effect of Sln.9	5.67	39.21	23.77	13.31	100.00	93.84	100.00
Cau x S.881	Male	Effect of S.881	19.26	39.82	14.24	55.36	0.00	0.00	0.00
Cau x D. machy	Male	Effect of D. machy	6.43	48.79	6.23	35.29	75.01	89.78	80.95
Cau x Tafarikela	Male	Effect of Tafarikela	0.00	39.05	59.24	16.44	100.00	71.28	100.00
Mean			7.84	41.72	25.87	30.10	68.75	63.73	70.24

Table 2. Paternal and maternal effect on F1 hybrids of Dwarf x Tall and Tall x Dwarf for morphological traits

Parents	Bush Spread	Stem girth	Primary thickness	Primary's internodal length	Leaf length	Leaf breadth	Leaf area
Cauvery as female	92.16	58.28	74.13	69.90	31.25	36.27	29.76
Cauvery as Male	61.69	57.83	88.26	51.94	31.26	50.00	50.00
Tall as female	38.31	42.17	11.74	48.06	68.74	50.00	50.00
Tall as male	7.84	41.72	25.87	30.10	68.75	63.73	70.24

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