

Short Communication

A new mathematical model for quantification of genetic traits transmission in F₁ hybrids of arabica coffee (*Coffea arabica* L.)

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Abstract: There are several methods adopted for genetic analysis of commercially important crops however, no such mathematical models are developed to quantify the parental traits transmission in the F₁ progenies derived through hybridization in commercial crops like coffee. In this context, an attempt was made to design a formula that could enumerate the genetic traits contributed by the paternal and maternal lines to the offspring. Calculation of quantitative traits transmission was carried out based on an example of the morphological parameters recorded on the dwarf and tall parents of arabica coffee and their F₁ hybrid progeny. Formula revealed that 'Cauvery' as a dwarf female parent had stronger influence (85.7%) on bush spread in the progenies as compared to the tall parents (14.3%). This indicated that cultivar 'Cauvery' had genetic dominance over Sln.9 a tall parent. Similarly, taking tall as a dominant character in another example, the traits transmission was worked out in Cauvery x Sln.9 cross combination. The new formula was found very handy to study the degree of paternal and maternal influence separately in the F₁ progeny of any commercial crops and also applicable in future breeding programme.

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

INTRODUCTION

Generally, two types of traits are noticed in the plants, one qualitative and the other one quantitative. The genetic analysis of qualitative traits are carried out by Mendelian law of inheritance while, the analysis of quantitative traits is done by several statistical tools designed to study the genetic variability, heritability, combining ability, genetic advance and genetic gain [6]. Apart from these, there are some other statistical methods such as, characters correlation, genetic penetrance, heterosis and response to selection are also applied for genetic analysis of the parents as well as progeny. Genetic variability and selection for important traits are vital components that every plant breeder needs its application to achieve better success in evolving cultivars of high yield potential and other desirable agronomic traits.

The quantitative traits association between genotype and phenotype is a very complex subject and not yet completely understood by the biological scientists. This provides information to the breeders to locate the genetic basis for emergence of several qualitative and quantitative phenotypic characters [3,7,5]. Subsequently, the quantitative traits are governed by the polygenic action where, the expression of one character depends not only on one but on other several genetic factors [2]. In this context, studying the genetic behavior and correlation between the characters plays a crucial role in plant breeding program to find out the inter-relationship of one character with other

and their magnitude of closeness [4]. All the above techniques have different applications in genetic analysis of plant population but none of them are useful for quantification of parental traits and the degree of influence of each parent that are usually transmitted to the F₁ offspring. Therefore, an effort was made to develop, a new formula to measure the percentage of genetic influence by each parent cultivar involved in crossing for the quantitative traits. The percent parental influence for quantitative traits transmission in F₁ hybrids was determined with the help of new formula considering an example indicated in the following para with the help of figures.

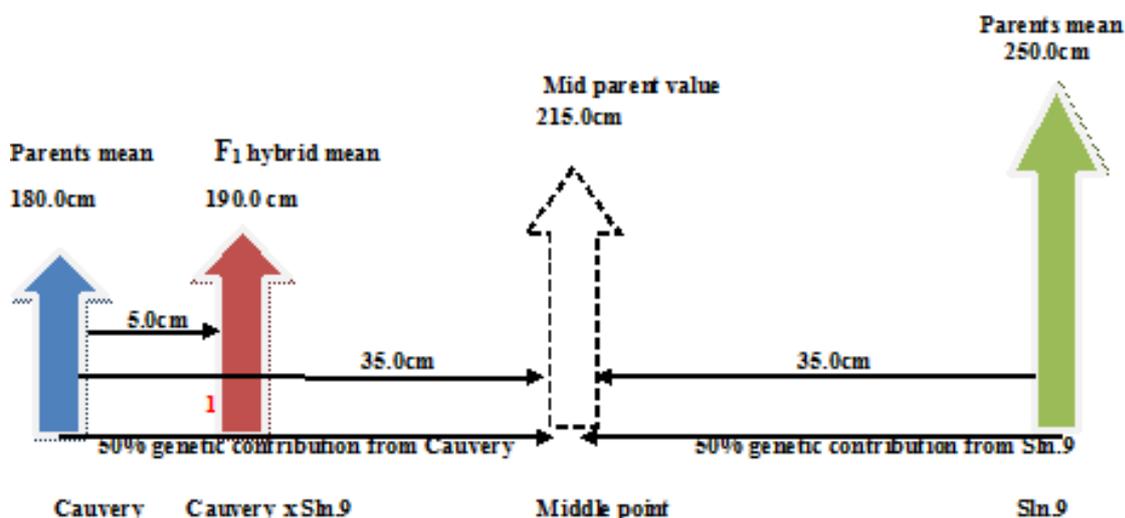
RESEARCH NOTES

During the hybridization process each parent contributes 50% of its genetic traits which forms 100% in the F₁ 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 [1]. 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. The deviation may be

plus (+) or minus (-). For example, a dwarf variety with 180cm plant bush spread when crossed with another variety of 250cm bush spread the F₁ hybrid expressed 190cm bush spread. If, it was the case of co dominance, the F₁ hybrid could have produced a bush spread of (180+250)/2=215cm. But, the F₁ had 190cm bush spread which is an indication of dominance of dwarf variety. When, a state of complete dominance is witnessed, the F₁ hybrid was expected to have a bush spread similar to its dwarf parent with 180cm. The difference between the dwarf parent and its F₁ hybrid (190-180=10cm) was caused most likely by some influence of tall variety. Further, the difference between mid parent value and the value of each parent is [(215-180=35cm) and (250-215=35cm)] 35cm. The difference in the bush span of 35cm is caused by 50%

influence of each parent therefore, to cause 1.0cm difference it would influence (50/35)=1.43%. Thus, value 1.43 can be used as a factor and be multiplied by the value of increase or decrease to find out the percent genetic contribution by the parent for a given trait. Hence, 1.43x10=14.3% contribution was from tall parent and the remaining was 100-14.3=85.7% contribution from dwarf parent. Though the both the parents have contributed 50%-50% in F₁ but their influence for expression of the character varied depending on the genetic dominance.

Method I: Calculation based on the dominant dwarfing genes inherited from dwarf parent (Cauvery) to F₁ progeny of Cauvery x Sln.9 cross combination



In the situation of complete dominance, the F₁ hybrid could have the plant bush spread of similar to its dwarf parent with 180cm. The difference between the dwarf parent and its F₁ hybrid (190-180= 10cm) was caused most likely due to some influence of tall variety. Further, the difference between mid parent value and the value of each parent is [(215-180=35cm) and (250-215=35cm)] 35cm. The difference in the bush spread of 35cm is caused by 50% influence of each parent combined with environmental involvement therefore, to cause 1.0cm difference it would influence

(50/35)=1.43%. This value 1.43 can be used as a factor and be multiplied by the value of increase or decrease to find out the percent genetic contribution by the parent for a given trait. Hence, 1.43x10=14.3% contribution was from tall parent and the remaining was 100-14.3=85.7% contribution from dwarf parent. Though the both the parents have contributed 50%-50% in F₁ but their influence for expression of the character varied depending on the genetic dominance which is an inbuilt genetic strength in the living beings.

A. % Parental influence of cv. Cauvery the dwarf female parent for bush spread

Example:

- | Sl. No. | Genotype | Bush spread (cm) |
|---------|--|------------------|
| 1. | Female Parent - Cauvery (Ω_F)= | 180.0 |
| 2. | Male Parent- Sln.9 (Ω_M) = | 250.0 |
| 3. | Dwarf type F ₁ hybrid of Cauvery x Sln.9 (Ψ_D) = | 190.0 |
| 4. | Mid parent value (\emptyset) = $\frac{\Omega_F + \Omega_M}{2} = \frac{180 + 250}{2} =$ | 215.0 |
| 5. | Difference between mid parent value & one parent $\Delta = (\emptyset - \Omega_F) = 215.0 - 180.0 =$ | 35.0cm |

6. Difference between progeny & female parent $\theta_D = (\Psi_D - \Omega_F) = 190.0 - 180.0 = 10.0$ cm
7. Genetic contribution by the individual parents (C) = 50%
8. Factor $(\bar{a}) = \frac{C}{D} = 50/35 = 1.43$
9. % effect of male parent Sln.9 $E_M = \bar{a} \times \theta_D = 1.43 \times 10.0 = 14.3$
10. % effect of female parent 'Cauvery' $E_F = 100 - (\bar{a} \times \theta_D) = (100 - (1.43 \times 10.0)) = 85.7$

Formula to quantify the effect of male parent $E_M = \left[\frac{C}{\left(\frac{\Omega_F + \Omega_M}{2} \right) - \Omega_F} \right] \times \Psi_D - \Omega_F$

$$E_M = \left[\frac{50}{\left(\frac{180 + 250}{2} \right) - 180} \right] \times 190 - 180 = 14.3\%$$

OR $E_M = \bar{a} \times \theta_D = 1.43 \times 10 = 14.3$

Therefore, the effect of female $E_F = 100 - (\bar{a} \times \theta_D)$

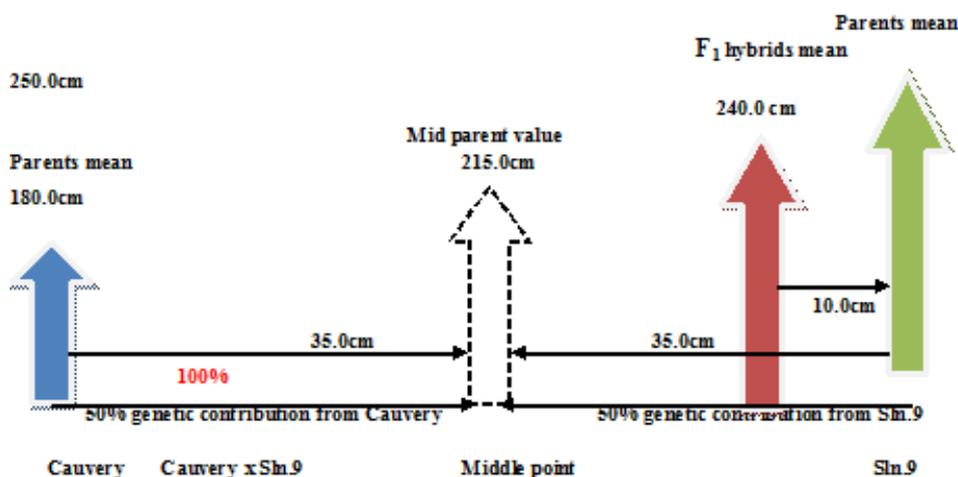
OR $E_F = 100 - (1.43 \times 10) = 85.7\%$

Based on the above formula the parental contribution for inherent quantitative traits in the F₁ progeny was worked.

Method II: Considering transmission of dominant genes from tall parent (Sln.9) in Cauvery x Sln.9 cross combination

Similarly, the effect of tall parent also can be worked out using the same formula. For example, when a tall plant with 250cm (Ω_M) bush spread was crossed

with a dwarf plant of 180cm (Ω_F) bush spread, it bred the F₁ hybrid of tall types with 240cm (Ψ_T) bush spread. In this case, the bush spread of 240cm in F₁ indicated the dominance of tall character which can be calculated based on the following equation.



$$\text{Mid parent value} = \frac{\Omega_F + \Omega_M}{2} = \frac{180 + 250}{2} = 215.0\text{cm}$$

The distance between tall parent value and F₁ hybrid value $\theta_T = (\Omega_M - \Psi_T) = 250 - 240 = 10\text{cm}$

The distance between mid parent value and tall parent value $D = (\Omega_M - \bar{\theta}) = 250 - 215 = 35\text{cm}$

Factor $(\bar{a}) = \frac{C}{D} = (50/35) = 1.43\%$

The effect of dwarf parent $E_F = (\bar{a} \times \theta_T) = 1.43 \times 10 = 14.3\%$

The effect of tall parent $E_M = (100 - E_F) = 100 - 14.3 = 85.7\%$

Formula $E_F = \left[\frac{C}{\left(\frac{\Omega_F + \Omega_M}{2} \right) - \Omega_M} \right] \times (\Omega_M - \Psi_T)$

$$\text{Therefore, } E_F = \left[\frac{50}{\left(\frac{180 + 250}{2} \right) - 250} \right] \times (250 - 240) = 14.3\%$$

OR $E_F = \bar{a} \times \theta_T = 1.43 \times 10 = 14.3\%$

and $E_M = 100 - (\bar{a} \times \theta_T) = 100 - (1.43 \times 10) = 85.7\%$

Based on the above equation, the dwarfing effect of cv. Cauvery was=14.3% and tall effect of Sln.9 was =85.7% when both the parents had equal contribution of 50-50% each for bush spread. Though, both the parents had equal contribution but the genetic influence of the parents for bush spread was not equal due to the differences in their gene strength which we call it genetic dominance [1]. The term co dominance is used when both parents have equal genetic strength that reflects in the F₁ progeny as intermediate character.

Limitations of the new formula:

1. This cannot produce accurate result when the parents and the progeny are grown under two different environmental conditions.
2. This can be used for estimation of transmission of only quantitative traits.
3. This can be applicable for estimation of trait transmission only in F₁ progeny.

The study showed that the above formula developed for measurement of quantitative traits transmission can well be applied in the F₁ plant population to understand the degree of individual parental influence for a given trait. This also facilitates identification of dominant traits in the progeny came either from male or female parent in the potential crop breeding agenda.

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