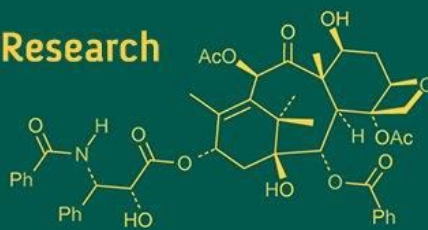


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Association of yield and yield components in segregating populations derived from crosses involving varying number of parents in Chilli

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Abstract

Green fruit yield in chilli (*Capsicum annuum* L.) is a complex trait governed by several interrelated yield components. The present study was conducted to assess the association among yield and its component traits through correlation and path coefficient analysis in segregating populations derived from crosses involving different numbers of parents. Nine F₂ populations developed from di-, tri-, tetra-, and multi-parental crosses, were evaluated during the Rabi-summer season of 2020-21 at the University of Agricultural Sciences, Bengaluru. Phenotypic correlation and path analyses were performed for green fruit yield per plant and its component traits. Correlation analysis revealed significant positive associations of green fruit yield with number of fruits per plant, average fruit length, fruit width, and average fruit weight. Path coefficient analysis indicated that number of fruits per plant had the highest positive direct effect on green fruit yield, followed by average fruit weight. The study suggests that these traits can be effectively exploited as selection criteria for improving green fruit yield in chilli.

Keywords: Chilli (*Capsicum annuum* L.), green fruit yield, correlation analysis, path coefficient analysis, yield components, segregating populations

Introduction

Chilli (*Capsicum annuum* L.) is one of the most important commercial and export-oriented vegetable and spice crops in India and ranks as the second most traded spice commodity globally after black pepper (*Piper nigrum* L.) (Bosland & Votava, 2012; Kothari *et al.*, 2010) [9, 19]. India is a major producer and exporter of chilli due to its wide adaptability and rich genetic diversity.

Chilli is a diploid species ($2n = 2x = 24$) belonging to the family Solanaceae, which includes economically important crops such as tomato, potato, tobacco, and brinjal (Kim *et al.*, 2016) [18]. The genus *Capsicum* comprises 27 species, of which five are domesticated, namely *C. annuum*, *C. frutescens*, *C. baccatum*, *C. chinense*, and *C. pubescens* (Pickersgill, 1997; Carrizo García *et al.*, 2016) [21, 10]. Among these, *C. annuum* is the most widely cultivated species in India due to its pungent and non-pungent fruit types and broad adaptability (Kaur *et al.*, 2017) [17].

Chilli is an often cross-pollinated crop, with natural out-crossing ranging from 7 to 90% under field conditions, which contributes to high genetic variability and provides ample scope for genetic improvement through selection in segregating populations (Singh *et al.*, 1992; Falconer & Mackay, 1996) [27, 15].

Correlation analysis provides information on the degree and direction of association among traits but does not reveal the actual cause-effect relationship. Path coefficient analysis, as proposed by Dewey and Lu (1959) [13], enables partitioning of correlation coefficients into direct and indirect effects, thereby identifying traits that exert the greatest influence on yield. Several studies in chilli have reported significant positive associations of green fruit yield with traits such as number of fruits per plant, average fruit weight, and fruit length, emphasizing their importance as key selection criteria (Rao *et al.*, 2003; Sharma *et al.*, 2010; Yadav *et al.*, 2016) [23, 25, 32].

Segregating populations derived from crosses involving different numbers of parents are expected to generate broader genetic variability and novel recombinants compared to conventional bi-parental crosses due to increased recombination and allele diversity (Allard, 1960; Cavanagh *et al.*, 2008) [2, 11]. Such populations offer greater scope for effective selection of superior genotypes; however, information on the association among yield components and their direct and indirect effects in multi-parent derived segregating populations of chilli is limited.

In this context, the present investigation was undertaken to study correlation and path coefficient analysis for green fruit yield and its component traits in segregating populations of chilli derived from crosses involving varying numbers of parents, with the objective of identifying key yield-contributing traits for effective selection and genetic improvement.

Materials and Methods

Experimental Material

The experimental material comprised nine segregating populations (F₂) of chilli (*Capsicum annum* L.) derived from crosses involving different numbers of parents. Details of the parental lines and the cross combinations used for generating the segregating populations are presented in Table 1.

The field experiment was conducted during the Rabi-summer season of 2020-21 at the experimental fields of the Department of GPB, UAS, Bengaluru. The nine F₂ segregating populations derived from di-, tri-, tetra-, and multi-parental crosses were planted in separate contiguous blocks. A spacing of 75 cm between rows and 45 cm between plants within rows was maintained. Data on green fruit yield per plant (g) were recorded by selecting five randomly chosen plants from each block.

Table 1: Segregating populations derived from Crosses with varying number of parents

Segregating populations derived from			
Single crosses (involving two parents)	Three-way crosses (involving three parents)	Double crosses (Involving four parents)	8-way crosses (involving eight parents)
GB × Ti	(BK × CMS 8B) × Ti	(PC1 × CMS 10B) × (JL × CMS 8B)	D1 × D2
PC1 × BK	(GB × CMS 7B) × CMS 8B	(CMS 8B × GB) × (Ti × CMS 7B)	D3 × D2
CMS 8B × GB			

Note:

D1 × D2 = [(LG174 × BD) × (vang × CA14)] × [(PC1 × CMS 10B) × (JL × CMS 8B)]

D3 × D2 = [(LG174 × BK) × (vang × CA14)] × [(PC1 × CMS 10B) × (JL × CMS 8B)]

Byadgi Dabbi = BD, Gouribidanur = GB, Tiwari = Ti, Byadgi Kaddi = BK, Japani Long = JL, Vangara = Vang, CMS 7B = 7B, CMS 8B = 8B, CMS 10B = 10B, Pant C1 = PC1

Statistical analysis

Estimation of correlation coefficients

To determine the degree of association of component traits with dependent trait green fruit yield plant⁻¹, the correlation coefficients were computed using the following formula (Al-Jibouri *et al.*, 1958) [1].

$$r_{xy} = \text{CoV}_{xy} / \sqrt{\text{Var}_x \times \text{Var}_y}$$

Where,

r_{xy} = Phenotypic correlation coefficient between the characters x and y

CoV_{xy} = Phenotypic covariance between characters x and y

Var_x = Phenotypic variance of the character x

Var_y = Phenotypic variance of the character y

Field assayable traits like plant height, primary branches plant⁻¹, secondary branches plant⁻¹, average fruit length, average fruit width, average fruit weight, fruits plant⁻¹ were considered as surrogate traits for indirect selection.

Path coefficient analysis was performed using phenotypic correlation coefficients of yield components with yield, following the methodology proposed by Wright (1921) and subsequently illustrated by Dewey and Lu (1959) [13]. For path coefficient analysis, data were pooled across all segregating populations derived from crosses involving different numbers of parents to obtain stable estimates of direct and indirect effects of yield component traits on green fruit yield per plant. The pooled analysis was aimed at identifying common yield-determining traits across diverse genetic backgrounds.

Results and Discussion

Correlation coefficient analysis, as proposed by Pearson

(1902) [20], provides an estimate of both the magnitude and direction of association between two or more traits. In the present study, green fruit yield per plant was observed to be a complex trait influenced by the combined effects of several yield-contributing characters along with environmental factors. Therefore, understanding the interrelationships among different characters is of prime importance for effective selection in breeding programmes. The association among characters plays a crucial role in determining the response to selection, as improvement in one trait can be achieved indirectly through selection for another positively correlated trait. Establishing such relationships helps in identifying key component characters that contribute significantly to yield. Hence, knowledge of character associations offers valuable guidance in formulating selection strategies aimed at enhancing green fruit yield per plant.

With the objective of understanding the nature and magnitude of relationships between green fruit yield per plant and its component traits, phenotypic correlation coefficients were estimated (Table 2). Among the traits studied, number of fruits per plant exhibited a significant and positive correlation with green fruit yield per plant across all the segregating populations. These findings are in agreement with earlier reports by Shwetha *et al.*, 2018 [26]; Dixitha *et al.*, 2015 [14]; Pradeep *et al.*, 2014 [22]; Vijaya *et al.*, 2014 [30]; Baseerath *et al.*, 2013 [6]; Bijalwan and Mishra, 2013 [7]; Datta and Jana, 2010 [12]; Gupta *et al.*, 2009 [16]; Sarkar *et al.*, 2009 [24]; Singh *et al.*, 2009 [16] and Sreelathakumary and Rajamony, 2002 [29] in biparental-derived segregating populations of chilli.

Average fruit length also showed a significant and positive association with green fruit yield per plant in all the segregating populations. This is in conformity with the

observations of Amit *et al.*, 2014b^[3, 4]; Shwetha *et al.*, 2018^[26]; Vijaya *et al.*, 2014^[30]; Baseerath *et al.*, 2013^[6]; Bijalwan and Mishra, 2013^[7]; Gupta *et al.*, 2009^[16] and Sreelathakumary and Rajamony, 2002^[29] reported in biparental-derived segregating populations of chilli.

Average fruit weight exhibited a significant and positive correlation with green fruit yield per plant in segregating populations derived from the single cross hybrids GB × Ti, PC1 × BK and 8B × GB, as well as in the three-way cross hybrids (BK × 8B) × Ti and (GB × 7B) × 8B. Similar positive associations between fruit weight and yield have been reported earlier by Shwetha *et al.*, 2018^[26]; Dixitha *et al.*, 2015^[14]; Amit *et al.*, 2014a, 2014b^[3, 4]; Pradeep *et al.*, 2014^[22]; Baseerath *et al.*, 2013^[6]; Bijalwan and Mishra 2013^[7]; Datta and Jana 2010^[12]; Sarkar *et al.*, 2009^[24]; Singh *et al.*, 2009^[16] and Sreelathakumary and Rajamony, 2002^[29] in biparental-derived chilli populations.

In contrast, average fruit width showed a negative

correlation with green fruit yield per plant in some of the segregating populations derived from three-way cross hybrids. These results are in contradiction to the findings of Amit *et al.*, 2014a^[3, 4]; Pradeep *et al.*, 2014^[22]; Baseerath *et al.*, 2013^[6] and Datta and Jana, 2010^[12], who reported a positive association between fruit width and yield in biparental-derived populations of chilli.

Path Analysis

All the traits exhibited positive direct effect with green fruit yield per plant except secondary branches per plant. Fruit number per plant has highest positive direct effect ($r = 0.87$) among all the traits followed by average fruit weight (Shwetha *et al.*, 2018)^[26]. Though fruit length exhibited strong correlation ($r = 0.48$) with green fruit yield per plant, it exhibited smaller magnitude of positive direct effect and indirect positive effects was through fruit number per plant (Table 3).

Table 3: Phenotypic path coefficient analysis showing direct and indirect effects of component traits on green fruit yield per plant in chilli

Trait	Plant height	Fruit length	Fruit width	Average fruit weight	Fruit number	Primary branches	Secondary branches	Green fruit yield
Plant height	0.00726	0.00236	-0.00058	0.00282	0.09775	0.02375	-0.01893	0.1144 **
Fruit length	0.00026	0.06497	0.00572	0.08613	0.32689	0.00384	-0.00316	0.4847 **
Fruit width	-0.00009	0.00822	0.04525	0.1165	0.02871	0.00086	-0.00094	0.1985 **
Average fruit weight	0.00008	0.02163	0.02037	0.25875	0.00176	0.00333	-0.00273	0.3032 **
Fruit number	0.00082	0.02444	0.00149	0.00052	0.86902	0.00098	-0.00119	0.8961 **
Primary branches	0.00292	0.00422	0.00066	0.01457	0.01443	0.0591	-0.04675	0.0491 NS
Secondary branches	0.00282	0.00422	0.00087	0.01449	0.02134	0.05679	-0.04865	0.0519 NS

Table 2: Estimates of Pearson's phenotypic correlation coefficients between green fruit yield per plant and its component traits in F₂ segregating populations derived from crosses involving varying numbers of parents in chilli

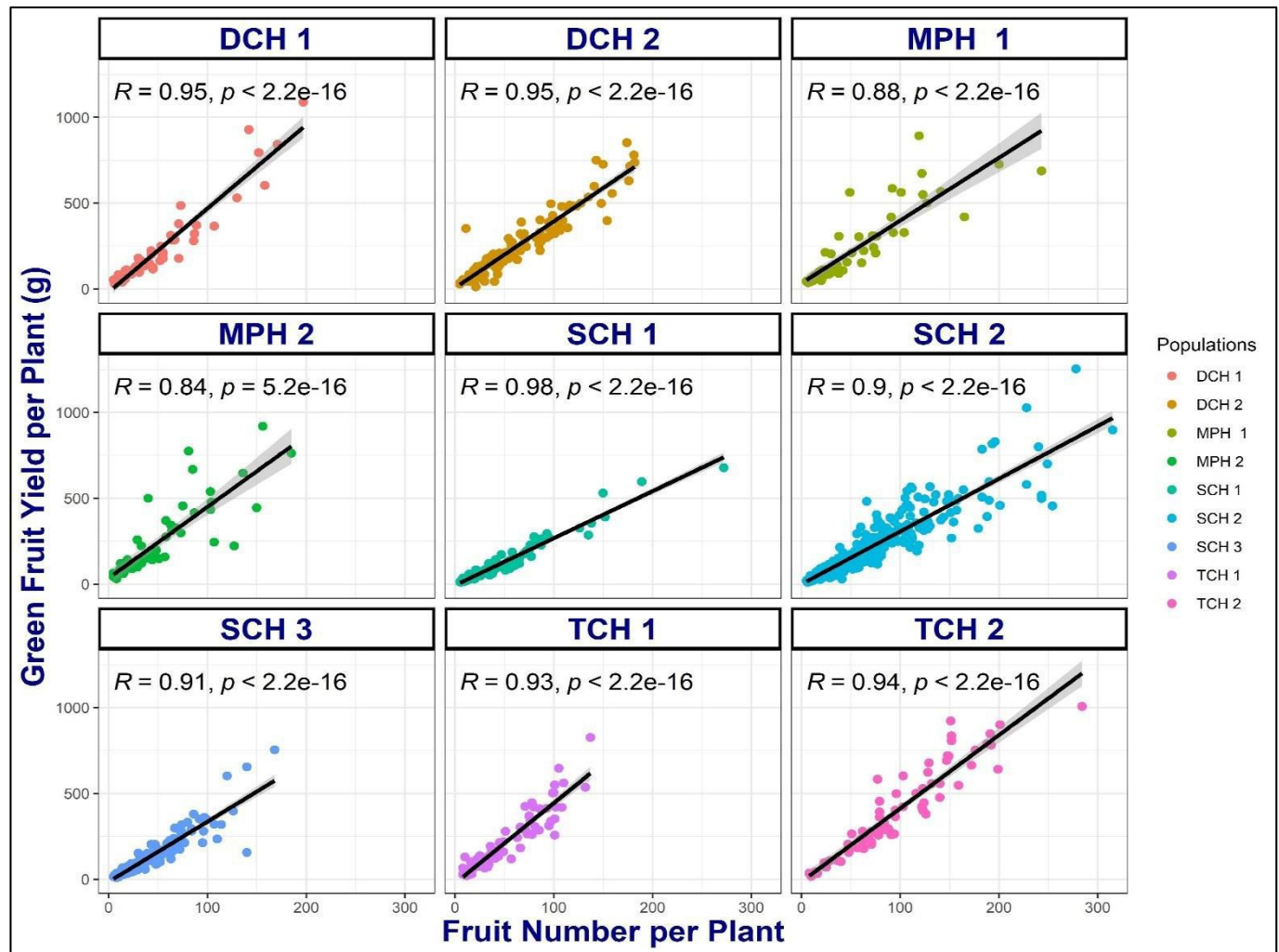
Segregating populations derived from	Trait Parentage	Number of parents involved		Plant height (cm)	Primary branches plant ⁻¹	Secondary branches plant ⁻¹	Average fruit length (cm)	Average fruit width (cm)	Average fruit weight (g)	Fruits plant ⁻¹
Single cross Hybrids	GB × Ti	Two	Green fruit yield plant ⁻¹ (g)	0.25**	0.12	0.14	0.26**	0.03	0.38**	0.98**
	PC1 × BK			0.1	0.01	0.04	0.42**	0.13*	0.43**	0.90**
	CMS 8B × GB			0.15	0.19*	0.20*	0.43**	0.25**	0.54**	0.91**
Three-way cross Hybrids	(BK × CMS 8B) × Ti	Three		0.32**	0.18	0.18	0.47**	-0.01	0.33**	0.93**
	(GB × CMS 7B) × CMS 8B			0.2	0.08	0.12	0.53**	-0.1	0.59**	0.94**
Double cross Hybrids	(CMS 8B × GB) × (Ti × CMS 7B)	Four		0.37**	0.2	0.2	0.58**	0.31*	0.04	0.95**
	(PC1 × CMS 10B) × (JL × CMS 8B)			0.04	0.09	0.1	0.61**	0.16	0.06	0.95**
Multi parent Hybrids	D1 × D2	Eight		0.09	-0.04	-0.09	0.50**	0.29*	0.11	0.88**
	D3 × D2			0.16	0.12	0.12	0.47**	0.22	0.07	0.85**

*, Correlation at 0.05 level, **, Correlation at 0.01 level

Double cross Hybrids: D1 = [(LG174 × Byadgi Dabbi) × (Vangara × CA14)]

D2 = [(Pant C1 × CMS 10B) × (Japani Long × CMS 8B)]

D3 = [(LG174 × Byadgi Kaddi) × (Vangara × CA14)]



SCH-Single cross hybrid TCH-Three way cross hybrid DCH-Double cross hybrid MPH-Multiparent hybrid

Fig 1: Pearson phenotypic correlation coefficients of average fruit length with green fruit yield plant⁻¹ among F₂ segregating populations derived from crosses involving varying number of parents in chilli

Conclusion

Based on the present findings, it is concluded that number of fruits per plant and average fruit length are effective non-destructive, field-measurable proxy traits for green fruit yield per plant. Selection based on these characters would facilitate the identification of high-yielding segregants in populations derived from crosses involving varying numbers of parents.

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