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Studies on general vs. specific combining ability estimates from Diallel analysis for yield and its component traits in chilli (*Capsicum annuum* L. var. *acuminatum* Fingerh)

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Abstract
An experiment was conducted during 2016-2017 at Vegetable Research and Demonstration Block of college of horticulture, VCSG Uttarakhand University of Horticulture and Forestry, Bharsar. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Six diverse chilli lines *viz*. Byadgi Dabbi, Byadgi Kaddi, Arka Lohit, Arka Suphal, G-4 and Pant C-1 used as parents and were crossed in a diallel fashion (excluding reciprocals) to obtain fifteen cross combinations along with one check cultivar Arka Harita. Totally 22 genotypes were evaluated for the estimation of combining ability using six parents. The analysis revealed that parents and crosses differed significantly for general and specific combining ability effects. The relative magnitude of *gca* variances was higher than the *sca* variance, indicates the role of additive gene action component in the expression of all the traits. The parents Byadgi Dabbi for average fruit weight. Arka Lohit for fruit diameter, number of fruits /plant, fruit yield per plant and fruit yield per plot were found to be the best general combiner. The crosses Arka Lohit × Arka Suphal and Arka Lohit × Pant C-1 were the best specific crosses for green fruit yield and its contributing traits and can be further utilized commercially in crop breeding programme for the improvement of yield characters in chilli.

Keywords: Chilli, diallel, combining ability, variance, gene action

Introduction
Chilli (*Capsicum annuum* L. var. *acuminatum* Fingerhut.) is emerging as one of the commercial vegetable crops at the global level and is probably most important vegetable after Tomato. Chilli finds its place in spice as well as condiments. Particularly in India, there is no home which does not consume chilli. It is used both at green and dry stage and is used and marketed as a whole and as well as ground powder form. It finds a place in pharmaceuticals also. Southern states of India contribute maximum to India's area and production. Maximum diversity can be noticed among different cultivars available in India and outside with respect to shape, size, yield, quality and other traits. Identification of a variety better suited for a particular region and its improvement is of immediate task to exploit its potential. Chilli is a rich source of vitamin C. It also contains vitamin A, vitamin B and minerals. In India, dry chilli is grown over an area of 7.92 lakh hectares with a production of 12.23 lakh tonnes and the productivity of 1.5 tonnes per hectare. Indian chillies reach over 90 countries in the world. Sri Lanka, USA, UAE, Pakistan, Bangladesh, Saudi Arabia and Malaysia are the important markets for Indian chillies. The combining ability studies is one of the best options to select parents for heterosis breeding. It would be a useful to estimate the combining ability of parents, gene action and heterotic effects of crosses combining ability describes the breeding values of parental lines to produce hybrids. Sprague and Tatum used the term general combining ability *(gca)* to designate the average performance of a line in hybrid combinations and used the term specific combining ability *(sca)* to define those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the lines involved. Diallel crossing programs have been applied to achieve this goal by providing a systematic approach for the detection of suitable parents and crosses for the investigated characters. Hence an attempt has been made to assess the combining ability of 6 chilli inbreds in a diallel fashion for yield and its component traits.

Materials and Methods

The experimental materials comprised of six diverse parents *viz.*, Byadgi Dabbi, Byadgi Kaddi, Arka Lohit, Arka Suphal, G-4 and Pant C-1 along with its 15 F_1 hybrids generated by half-diallel in all possible combinations excluding reciprocals during 2016-2017. Arka Harita used as standard check. The experiment was laid out in randomized block design with three replications at the Vegetable Research and Demonstration Block, UUHF, Bharsar, Uttarakhand (India). Each plot consisted of 8 plants. Inter and intra row spacing was kept 60 and 45 cm, respectively. The observations were recorded on five randomly selected plants from each treatment and replications for fruit yield and component traits *viz*., fruitlength (cm), fruit diameter (cm), average fruit weight (g), number of fruits per plant, yield per plant (Kg) and yield per plot (Kg). Analysis of data for general and specific combining ability was carried out by following Griffing, (1956) Method II, Model I (fixed effect model). The statistical analysis was carried out using WINDOSTAT software.

Results and Discussion

The ANOVA revealed that the mean sum of squares due to general combining ability (GCA) and specific combining ability (SCA) were significant for all the characters under studied (Table 1). This implies both the additive and non-additive gene actions were playing significant role in the expression of these characters as suggested by Kamble *et al*. (2009) [5] and Singh *et al*. (2005) [12]. The knowledge on combining ability assists in the selection of suitable parental lines. Among the various biometrical techniques available, combining ability analysis proposed by Griffing had been extensively used by the breeders. It provides information on the performance of genotypes in hybrid combination and also the nature of gene action involved in the control of metric traits. The general and specific combining ability of parents and hybrids for the yield and its component traits are discussed hereunder.

Fruit length (cm)

Among all the parents only Byadgi Kaddi (1.71) was exhibited significant positive GCA effects and which indicated their good general combining ability (Table 2). The estimates of *sca* effects in respect of 15 hybrids for this trait revealed that the hybrids Arka Lohit × Pant C-1 (36.24), Arka Lohit × Arka Suphal (21.48), Byadgi Dabbi × G-4 (4.11), Byadgi Dabbi × Pant C-1 (3.53) were good specific cross combiners. These results are in agreement with those of Saritha *et al.* (2005) [9] Prasanth and Ponnuswami (2008) [7] who have opined that the non-additivity is prevailing for this trait.

Fruit diameter (cm)

The estimate of *gca* effect revealed that among the female parents, Arka Lohit was best general combiner as it recorded positive and desirable *gca* effect. The highest *sca* effect was found in the cross Arka Lohit × Arka Suphal (17.56) followed by Arka Lohit × Pant C-1 (10.00) and Arka Suphal × Pant C-1 (0.24) which indicates that, non-additive gene effect is prevailing. Similar trend was opined by Sabita and Baruah (2003) [8], Ajjappalavara (2003) [1], Singh and Chaudhary (2005) [12].

Average fruit weight (g)

The *gca* effect of parent revealed that Byadgi Dabbi (0.23) and Byadgi Kaddi (0.09) were best general combiners and considering the *sca* effect, the cross combination Arka Lohit × Pant C-1 (17.01), Byadgi Dabbi × G-4 (2.78) and Byadgi Dabbi × Byadgi Kaddi (2.71) showed maximum and significantly desirable *sca* effects for average fruit weight. Positive *gca* and *sca* effect for average fruit weight was reported by Shukla *et al.* (1999) [11], Chandan (2008) [2], Sharma *et al.* (2013) [10]. The trait was reported to be governed by the non-additive gene action.

Number of fruits per plant

The wide range of variation was prevailed among the parent and hybrids used in this study. The ratio of *gca* to *sca* variance was less than the unity indicating the predominant role of non-additive gene effect. The parents Arka Lohit and G-4 were best general combiners. Significant *sca* effect was exhibited by the hybrids Arka Lohit × Pant C-1 (11.83), Byadgi Dabbi × Byadgi Kaddi (2.87), Byadgi Kaddi × Arka Suphal (0.12), Byadgi Dabbi × Arka Suphal (0.04) Arka Lohit × G-4 (0.02) indicating the non-additive gene action. These results are in conformity with the findings of earlier of works of Srivastava *et al.* (2005) [14] and Hasanuzzaman *et al.* (2012) [4], Suryakumari *et al.* (2014) [15].

Table 1: Analysis of variance for combining ability of six parameters in chilli.

Sourced of variation	d.f.	Fruit Length (cm)	Fruit Diameter (cm)	Average Fruit Weight (gm)	Number of Fruits per Plant (numbers)	Yield per Plant (kg)	Yield per Plot (kg)
GCA	5	25.30**	0.494**	0.539**	16406.35**	0.043**	1.686**
SCA	15	2.34**	0.157**	0.154**	1211.93**	0.009**	0.298**
Error	40	0.00	0.004	0.002	1.22	0.000	0.000
Gca/sca ratio		10.79	3.155	3.487	13.537	4.769	5.658

*, ** significant at 5% and 1% level, respectively

Table 2: Estimates of general combining ability (GCA) effects of parents for six parameters in chilli.

S. No.	Parents	Fruit Length (cm)	Fruit Diameter (cm)	Average Fruit Weight (gm)	Number of Fruits /Plant (no)	Yield /Plant (kg)	Yield /Plot (kg)
1	BD	0.448**	0.098**	0.236**	-4.85**	0.025**	0.163**
2	BK	1.715**	-0.232**	0.097**	-14.25**	-0.004	-0.050**
3	AL	-0.867**	0.145**	-0.016	47.84**	0.065**	0.406**
4	AS	-0.910**	-0.034	-0.043*	-14.53**	-0.030**	-0.168**
5	G-4	0.293**	0.104**	-0.076**	10.09**	-0.001	0.008*
6	PC-1	-0.680**	-0.080	-0.198**	-24.30**	-0.055**	-0.359**
	SE (gi)	0.010	0.011	0.008	0.206	0.004	0.003
	Cd at 5%	0.022	0.024	0.018	0.456	0.009	0.007

Where,

BD = Byadgi Dabbi BK = Byadgi Kaddi AL = Arka Lohit AS = Arka Suphal PC-1 = Pant C-1

*, ** significant at 5% and 1% level, respectively

Table 3: Estimates of specific combining ability effects of crosses for six parameters in chilli.

S No.	Parents	Fruit Length (cm)	Fruit Diameter (cm)	Average Fruit Weight (gm)	Number of Fruits /Plant (no)	Yield /Plant (kg)	Yield /Plot (kg)
1	BDXBK	-11.45**	-8.39**	2.71**	2.87**	-0.33**	-6.05**
2	BDXAL	-0.31	0.00	-0.37**	-0.10	0.16**	-0.39**
3	BDXAS	-0.08	0.11*	0.10*	0.04	0.03	-0.11**
4	BDXG4	4.11**	-2.49**	2.78**	-4.91**	-0.52**	0.43**
5	BDXPC1	3.53**	-6.02**	-3.82**	-4.23**	-5.76**	1.77**
6	BKXAL	0.43**	-0.98**	-0.74**	-0.53	-0.22**	-0.01
7	BKXAS	-0.18*	0.23**	0.22**	0.12	0.11**	0.08*
8	BKXG4	0.11*	0.11*	0.18**	-0.03	0.05*	0.10*
9	BKXPC1	-0.58**	0.43**	-0.17**	-0.07	0.02	-0.17**
10	ALXAS	21.48**	17.56**	-9.68**	-40.85**	6.96**	8.77**
11	ALXG4	0.03	0.00	0.04	0.02	0.03	0.01
12	ALXPC1	36.24**	10.00**	17.01**	11.83**	7.01**	16.84**
13	ASXG4	0.06	0.04	0.00	-0.06	0.02	0.02
14	ASXPC1	0.38**	0.24**	0.06	-0.37	0.10**	0.16**
15	G4XPC1	-0.02	0.01	-0.01	-0.01	-0.02	-0.02
	SE (sij)	0.026	0.031	0.021	0.565	0.011	0.009
	CD at 5%	0.052	0.062	0.042	1.138	0.022	0.018

*, ** significant at 5% and 1% level, respectively

Yield per plant (kg) and Yield per plot (kg)

The variance due to general combining ability was highly significant in only two parents Byadgi Dabbi and Arka Lohit, indicating the predominance of non-additive gene action. The hybrids Arka Lohit × Pant C-1, Byadgi Dabbi × Pant C-1, Arka Lohit × Arka Suphal, Byadgi Dabbi × Arka Lohit exhibited highest positive *sca* effect and hence these crosses can be exploited for heterosis. Similar results were obtained by other workers Venkataramana *et al.* (2005) [16] and Patel *et al.* (2014) [6].

Based on the forgoing discussion, it can be concluded that non additive gene action has predominant role in the expression of traits. The parents Byadgi Dabbi for average fruit weight. Arka Lohit for fruit diameter, number of fruits /plant, fruit yield per plant and fruit yield per plot were found to be the best general combiner. The crosses Arka Lohit × Arka Suphal and Arka Lohit × Pant C-1 were the best specific crosses for green fruit yield and its contributing traits in chilli and can be further utilized commercially in crop breeding programme for the improvement of yield and its attributes in chilli.

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