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Combining ability studies in bitter gourd (*Momordica charantia* L.) for yield and yield attributes

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Abstract
The experiment was conducted at Bagusala Instructional Farm, M. S. Swaminathan School of Agriculture, Centurion University of Technology and Management, Paralekhemundi, Odisha to study the combining ability for yield and yield attributing characters. Evaluation of parents for all the thirteen characters indicated West Godavari (short) and Special Bolder Uccha are the good general combiners. Similarly evaluation of hybrids revealed Galaxy (Selection 9) x Special Bolder Uccha, Galaxy (Selection 9) x Meghdut Korola and West Godavari (short) x Meghdut Korola are considered as the best specific combiners.

Keywords: Bitter gourd, combining ability

Introduction
Bitter gourd (*Momordica charantia* L.) is one of the important vegetable crop which belongs to family Cucurbitaceae. It is highly cross pollinated dur to monoecious nature and has high degree of heterozygosity. The crop is extensively grown in China, Japan, South East Asia, tropical Africa and South America. In India, Karnataka, Maharashtra, Tamil Nadu and Kerala are the major bitter gourd growing states. Inspite of the potential economic and medicinal importance of the crop, due attention s fro enhancing yield potentiality and quantity components (Bhatt *et al.* 2017) [1]. Half diallel analysis provides reliable information on the components of variance, general combining was not given towards a need based crop improvement programme (Laxuman *et al.* 2012) [6]. Among the various mating designs, half diallel cross techniques has been most frequently used to determine general and specific combining ability variances and their effects in many self, often cross and cross pollinated crops. Due to efforts of vegetable breeders, improved varieties and hybrids have been developed. Crop improvements involves strategieability (GCA), specific combining ability (SCA) variances and their effects. The concept of combining ability helps the breeder to determine the nature of gene action involved in the expression of quantitative traits of bitter gourd (Thangamani *et al.* 2011) [9].

Material and methods
The present investigation entitled "Combining ability studies in bitter gourd (*Momordica charantia* L.) for yield and yield attributes" was carried out during late *kharif* season of the year 2019 at Bagusala Instructional Farm, Department of Horticulture, M. S. Swaminathan of School of Agriculture, Centurion University of Technology and Management, Paralakhemundi, Odisha. The details of experimental techniques, materials and methods adopted for the study are presented in this chapter. The experimental material comprised of five genetically diverse parents *viz.,* Shivam (Selection 12), Galaxy (Selection 9), West Godavari (short), Special Bolder Uccha and Meghdut Korola were crossed in half diallel design without reciprocal to develop 10 F_1 crosses. The 10 F_1 crosses, 5 parents comprised the material for heterosis and combining ability studies in bitter gourd which were evaluated in randomized block design with three replication. Observations were recorded in five randomly selected plants in each replication for vine length (m), days to opening of first female flower, number of node bearing first female flower, fruit length (cm), fruit diameter (cm), fruit weight (g), number of fruits per vine and fruit yield per vine (kg). The mean values were utilized for statistical analysis. Estimation of general and specific combining ability was done as per the procedures outlined by Griffing (1956) [2].

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Results and Discussion

In any crop breeding programme is essential to eliminate the undesirable types, which can be achieved by studying the performance of parents and hybrids. The combining ability for each character was analysed. The study clearly revealed that variances due to GCA and SCA were significant for all the characters, as suggested by Griffing (1956) [2]. The analysis of variance for various yield and yield attributing characters are presented in Table 1.

Analysis of variance showed significant differences among the parents for all the traits except vine length (m), days to opening of first female flower, number of node bearing first male flower, number of node bearing first female flower, fruit weight (g), number of fruits per vine. The present results showed consistency in gca effects. The parent Special Bolder Uccha (0.13) had shown significant positive GCA effects. The crosses Shivam (Selection 12) x Special Bolder Uccha (0.2) had shown highly positive significant sca effect. Similar results was reported by Bhatt *et al.* (2017) [1], and Khan *et al.* (2017) [5]. Days to opening of first female flower is one of the important earliness parameter, it shows the early fruit bearing. Special Bolder Uccha (0.91) had shown the good general combiner and West Godavari (Short) x Special Bolder Uccha (2.11) had shown the high positive significant sca effects among the all crosses. Similar results was reported by Mishra *et al.* (2018) [8]. Number of node bearing first female flower, the parent West Godavari (Short) (-1.44) had shown positive significant gca effect are presented in Table 2. The crosses West Godavari (Short) x Special Bolder Uccha (2.4) had shown high

positive significant sca effects are presented in Table 3. Similar results was reported by Thangamani *et al.* (2011) [9]. West Godavari (Short) (0.45) has shown positive significant of general combiner and cross Galaxy (Selection 9) x Meghdut Korola (1.21) had shown high positive significant sca effect in fruit length (cm). Similar results was reported by Thangamani *et al.* (2011) [9]. In fruit diameter (cm), among the parents West Godavari (Short) (0.18) had shown positive significant effects considered as good general combiner and cross Galaxy (Selection 9) x West Godavari (Short) (0.38) had shown high positive significant sca effects. Fruit weight (g), parent West Godavari (Short) (1.76) and Meghdut Korola (1.77) had shown positive significant effects considered as good GCA. The hybrids which gave good performance also expressed favourable high sca effects. The cross Galaxy (Selection 9) x Meghdut Korola (4.38) had shown positive significant sca effect. Similar results was reported by Kaniti *et al.* (2015) [4].

General combiner Special Bolder Ucchs (1.05) had shown positive significant effects. Among the cross Galaxy (Selection 9) x Special Bolder Uccha (2.94) had shown the highest positive significant sca effect in number of fruits per vine. Similar results was reported by Bhatt *et al.* (2017) [1]. In fruit yield per vine (kg), parent West Godavari (Short) (38.75) had shown positive significant effect considered as good gca. Among the cross West Godavari (Short) x Meghdut Korola (151.77) had shown the highest positive significant sca effect. Similar results was reported by Khan *et al.* (2017) [5], Jadav *et al.* (2018) [3] and Mallikarjunarao *et al.* (2018) [7].

Table 1: Analysis of variance for combining ability for fruit yield and yield contributing characters

Source of variation	d.f.	Vine length (m)	Days to opening of first female flower	No. of node bearing first female flower	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)	Number of fruits per vine	Fruit yield per vine (kg)
GCA	4	0.09**	2.75*	5.71**	0.15**	1.28**	23.07**	9.56**	17333.53**
SCA	10	0.02	1.25	1.93	0.05**	0.78**	6.13	1.67	8934.52**
Error	28	0.01	0.85	1.15	0.013	0.08	2.85	1.45	1987.07

Table 2: Estimation of general combining ability (gca) of parents for different parameters

Parents	Vine length (m)	Days to opening of first female flower	No. of node bearing first female flower	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)	Number of fruits per vine	Fruit yield per vine (kg)
Shivam (Selection 12)	-0.107 *	0.192	0.598	-0.138 *	-0.544 *	-2.532 *	-2.011 *	-80.222*
Galaxy (Selection 9)	-0.115 *	-0.293	0.517	-0.069	-0.359 *	-0.479	0.309	-16.664
West Godavari (Short)	-0.014	-0.789 *	-1.445 *	0.182 *	0.451 *	1.765 *	0.395	38.75*
Special Bolder Uccha	0.134 *	0.911 *	0.665	-0.118 *	0.261 *	-0.528	1.051 *	29.449
Meghdut Korola	0.102 *	-0.022	-0.335	0.143 *	0.191	1.774 *	0.255	28.686
S.Em.(gi) (±)	0.04	0.312	0.364	0.038	0.101	0.571	0.407	15.07
CD at 5%	0.063	0.421	0.575	0.06	0.16	0.903	0.644	23.827

Table 3: Specific combining ability (sca) effects of 10 crosses for different parameters

Crosses	Vine length (m)	Days to opening of first female flower	No. of node bearing first female flower	Fruit diameter (cm)	Fruit length (cm)	Fruit weight (g)	No. of fruits per vine	Fruit yield per vine (kg)
Shivam (Selection 12) x Galaxy (Selection 9)	0.05	1.08*	1.89**	-0.24**	-0.56**	0.09	0.89	22.89
Shivam (Selection 12) x West Godavari (Short)	-0.14*	-1.59**	-1.74**	0.37**	0.9**	3.09**	1.02	-25.14
Shivam (Selection 12) x Special Bolder Uccha	0.2**	0.97*	1.75**	-0.09	0.44**	1.34	1.12*	72.26**
Shivam (Selection 12) x Meghdut Korola	-0.18**	-0.82	-1.54**	0.02	-0.28*	-1.93*	0.93	-65.98**
Galaxy (Selection 9) x West Godavari (Short)	0.01	-1.05*	-1.26*	0.38**	0.72**	2.69**	1.03	75.64**
Galaxy (Selection 9) x Special Bolder Uccha	0.2**	-1.38*	-2.11**	-0.11*	-0.44**	2.25**	2.94**	129.86**
Galaxy (Selection 9) x Meghdut Korola	0.16**	0.16	-0.59	0.28**	1.21**	4.38**	1.04	107.33**
West Godavari (Short) x Special Bolder Uccha	0.03	2.11**	2.4**	-0.2*	0.69**	-1.9*	0.74	3.8
West Godavari (Short) x MeghdutKorola	0.19**	-0.75	-1.09*	0.26**	0.86**	3.41**	2.12**	151.77**
Special Bolder Uccha x Meghdut Korola	-0.02	-0.58	-1.27*	0.14**	-0.64**	0.74	0.25	36.96
S.Em.(si)(±)	0.1	0.4	0.94	0.1	0.26	1.48	1.05	38.91
CD at 5%	0.11	0.51	1	0.1	0.28	1.56	1.12	41.27

Conclusion

From the present study, it is concluded that there is spectacular scope for the development of crosses in bitter gourd. The general combining ability studies revealed that, the parents Shivam (Selection 12) and West Godavari (Short) were considered as a good general combiners. Specific combining ability studies revealed that the cross combinations Shivam (Selection 12) x West Godavari (Short), Shivam (Selection 12) x Special Bolder Uccha and Galaxy (Selection 9) x Special Bolder Uccha were considered as best specific combiners for yield and yield contributing characters. These crosses could be better utilized for the improvement of the characters concerned. It is noticed that the best F_1 crosses which expressed higher performance for a particular attribute also exhibited desirable significant gca and sca effect for other traits but this drift is not always stable, the best specific combining cross may or may not be the parent with high performance.

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