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Studies on combining ability analysis in okra

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ABSTRACT

The present experiment was conducted with 21 F_1s and F_2s developed through diallel hybridization technique excluding reciprocals along with seven parents in RBD with three replications. Varieties KS-387, KS-404 and Pusa Sawani showed good general combining ability for yield appear to be worthy of exploitation in future hybrid development. It is suggested that population involving these lines may be developed through multiple crossing isolating high yielding varieties. The specific combining ability effects indicated that choice of parents could be based on *per se* performance. The selection in okra crop can be based on the combination of two characters, *i.e.,* length of first fruiting node with length of fruit and length of fruit with width of fruit and number of fruits per plant for higher yield over straight selection. The cross combinations of KS-401 x Pusa Sawani showed high specific combining ability effects as well as *per se* performance in F_1 and F_2 generations.

Key words: Analysis of variance, general and specific combining ability effects, okra.

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench], an important vegetable crop of India, owes its origin to Ethiopia, from where it proliferated into Arabia down the Nile valley and was introduced into Europe by the Moors and further into Louisceana during the early 1700's by the French Colonist (Woodruff, 12). India is also considered its native place as various ancestral wild forms are met with (Yawalkar, 13). It belongs to Malvaceae family and grown in *kharif* and *zaid* seasons. Its green edible fruits are consumed for vegetable purpose. It is an important vegetable crop of the tropical and sub-tropical regions of the world, grown successfully both in the plains and hills. It is predominantly a self-fertilized crop but natural crossing to the extent of 6.75% has been reported (Purewal and Randhawa, 5). It is an interesting crop to breeders and the geneticists, for its monoadelphous condition of the stamens and large flowers are amendable to easy emasculation and its capsule bears large number of seeds. Being a short duration crop two generations can be grown in one year.

Combining ability refers to the ability of a genotype to transient superior performance to its ceases the *gca* variance provides and estimate to additive genetic variance, which is required for the estimation of narrow sense heritability. It also provides information about the gene action involved in the expression of various quantitative characters and thus, helps in deciding the breeding procedure for genetic improvement of such traits.

MATERIALS AND METHODS

The materials for the present investigation comprised seven genotypes of okra [*Abelmoschus esculentus* (L.) Moench] namely, KS-312, KS-387, KS-401, KS-404, KS-410, Parbhani Kranti and Pusa Sawani collected from the germplasm stock maintained in Department of Vegetable Science, C.S. Azad University of Agriculture and Technology, Kanpur. These comprised of commercial varieties and indigenous collections from different parts of India. All the homozygous parents were sown during the *zaid* season. All the possible 21 F_1 crosses, excluding reciprocals were made among these seven parents. For building up of the F_2 population of these F_1 crosses. All the 21 F_1s were sown during the next *kharif* season. All these F_1s were selfed for procuring the F_2 seeds. The parents were also maintained through selfing.

All the 21 F_1s and F_2s along with seven parents were sown in a randomized block design with three replications during the season of *kharif*. Parents and F_1s were sown in single rows while F_2s in double rows, with ten plants in each row. The rows were 5 m long and spaced 50 cm apart. The plant to plant spacing was maintained at 50 cm. The observations were recorded on randomly selected five plants in each parent

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and F_1 and ten plants in each F_2 populations from each replication. The selected plants were tagged and properly labeled before flowering for recording the observations *viz.,* days to flowering, plant height, number of branches per plant, length of first fruiting node, length of fruit, width of fruit, number of fruits per plant and yield per plant. The combining ability analysis was carried out by the procedure suggested by Griffing (2). The experimental method-II and Model-I Robinson (7), and Robinson (8) was taken to be the most appropriate for the material under study.

RESULTS AND DISCUSSION

The analysis of variance for combining ability was carried out separately for all the eight attributes in F_1 and F_2 generations and the results are presented in Table 1. Highly significant variances were observed for general and specific combining ability both in F_1 and F_2 generations for all the characters except width of fruit. However, the relative magnitude of general combining ability variance indicating thereby that the additive component was major importance in the expression of all the characters in each generation except width of fruit in F_2 which was found to be under the control of equal proportion of genes. These findings are in agreement with those of Kulkarni *et al.* (3) and Singh *et al.* (11) for number of fruits per plant and Rao and Sathyavathi (6) for days to flower and yield under such situation where both additive and non additive, maximum production may be attained with a system that can exploit additive and non additive genetic effects simultaneously.

The compression of general combinig ability effects with mean performance revealed that parents KS-312 for days to flower; Pusa Sawani for plant height; KS-404 for number of branches per plant; KS-387, Parbhani Kranti and KS-312 for length of first fruiting node; KS-404 for fruit length; Pusa Sawani for width of fruit; KS-387 for number of fruits per plant and KS-387, KS-404 and Pusa Sawani for yield per plant were common under both criteria (Table 2) suggesting a correspondence between general combining ability in both F_1 and F_2 generations and *per se* performance of the parents. The similar findings were observed by Kulkarni *et al.* (3). Consistent general combining ability effects over F_1 and F_2 may prove advantageous while evaluating varieties for combining ability. Bhullar *et al,* (1) suggested that the cross might be studied for combining ability in F_2 instead of F_1, when the objectives are to breed pure varieties. However, this suggestion still needs substantiation before it could be adopted for practical utilization. Further the varieties showing good general combining ability for particular component may be used in component breeding for bringing improvement in particular component, thereby effecting improvement in yield. Varieties KS-387, KS-404 and Pusa Sawani showing good general combining ability for yield appear to be worthy of exploitation in practical plant breeding. It is suggested that population involving these lines may be developed through multiple crossing isolating high yielding varieties. The similar results were observed by Kulkarni *et al.* (3), Singh *et al.* (11), and Shekhawat *et. al.* (10).

Specific combining ability effects represent dominance and epistatic component of variation, which are non-fixable, and hence, specific combining ability studies would not tangible contribute to the improvement in self-pollinated crops except in cases where commercial exploitation of heterosis is feasible. However, in the production of homozygous lines breeder's interest usually rests upon transgressive

Table 1. Analysis of variance for combining ability for eight characters in seven-parent diallel cross of F1 and F2 generations in okra.

Source of Variation	Gene-ration	d.f.	Mean Sum of squares for different characters							
			Days to flowering	Plant height	No. of branches per plant	First fruiting node length	Fruit length	Fruit width	No. of fruits per plant	Yield per plant
GCA	F1	6	21.999**	555.088**	0.988**	20.025**	6.150**	0.011	11.000**	2206.433**
	F2	6	18.554**	290.668**	0.440**	31.066**	7.275**	0.006	08.023**	20.695**
SCA	F1	20	07.847**	199.773**	0.499**	07.033**	1.998**	0.008	05.478**	1199.995**
	F2	20	04.558**	190.105**	0.355**	9.994**	1.888**	0.008	03.456**	711.228**
Error	F1	52	0.888	7.964	0.089	0.850	0.299	0.005	0.278	19.889
	F2	52	0.822	3.200	0.060	0.555	0.270	0.003	0.215	12.775
GCA/SCA	F1	-	3.025	2.882	2.000	2895	2.999	1.455	1.999	1.793
	F2	-	4.288	1.569	1.663	3.000	3.998	0.716	2.486	2.968

** Significant at 1% level.

Table 2. Ranking of the best parents for general combining ability effects and *per se* performance for character under 7 x 7 parental diallel mating design in okra.

Character	*Per se* performance	GCA effects		Common parent
		F_1	F_2	
Days to flowering	KS-312	KS-312	KS-312	KS-312
	KS-387	P. Sawani	KS-387	—
	KS-410	KS-404	- -	—
Plant height	P.Sawani	P. Sawani	P, Sawani	P. Sawani
	KS-401	KS-387	KS-404	—
	KS-404	KS-387	- -	—
No. of branches/plant	KS-404	KS-404	KS-404	KS-404
	P. Kranti	KS-387	—	—
	KS-312	- -	—	—
First fruit node length	KS-387	KS-387	P. Kranti	KS-387
	P. Kranti	P. Kranti	KS-387	P. Kranti
	KS-312	KS-312	KS-312	KS-312
Fruit length	KS-404	KS-404	KS-404	KS-404
	P. Sawani	P. Sawani	KS-401	—
	KS-401	- -	—	—
Fruit width	P. Sawani	P. Sawani	P. Sawani	P. Sawani
	KS-404	- -	—	—
	KS-410	- -	—	—
No. of fruits/plant	KS-387	KS-387	P. Sawani	KS-387
	KS-312	- -	KS-387	—
	P. Sawani	- -	KS-312	—
Fruit yield/plant	KS-387	KS-387	P. Sawani	KS-387
	KS-404	P. Sawani	KS-387	KS-404
	P. Sawani	KS-404	KS-404	P. Sawani

segregation shown in the crosses. The specific combining ability effects and *per se* performance of crosses is presented in Table 3. To confirm whether the crosses selected on the basis of specific combining ability effects were really the best performer ones, the bests three crosses on basis of mean performance and specific combining ability effects were selected. It was observed that in F_1 out of three best crosses KS-410 x Pusa Sawani for days to flowering; KS-404 x Pusa Sawani for plant height, KS-401 x Pusa Sawani for number of branches per plant; KS-387 x KS-404 for length of first fruiting node; KS-401 x Pusa Sawani for fruit length; KS-312 x Parbhani Kranti for widh of fruit; KS-404 x Pusa Sawani for number of fruits per plant and KS-401 x Pusa Sawani for yield per plant also showed high specific combining ability effects as well as *per se* performance. The crosses showing high specific combining ability effects and *per se* performance for yield per plant suggesting that these hybrids may be exploited in heterosis breeding programme. These findings are in agreement with those of Rao and Sathyavathi (6), and Singh *et al.* (11).

In F_2 out of five best crosses, Parbhani Kranti x Pusa Sawani for days to flowering; KS-401 × KS-404 for plant height; KS-401 x KS-404 for number of branches per plant; KS-404 × Pusa Sawani for length of first fruiting node; KS-387 x KS-404 for length of fruit; Parbhani Kranti x Pusa Sawani for width of fruit, number of fruits per plant and yield per plant showed high specific combing ability effects and good *per se* performance. Similar findings were observed by Bhullar *et al.* (1), Singh *et al.* (11), and Shekhawat *et al.* (10).

It is a general observation that good cross combinations are obtained between high x high and poor ones between low x low general combiners in present study. Best cross combinations involved high x high, high x low, high x moderate, moderate x moderate, moderate x low and low x low general combiners for the characters under study (Table 4). This has suggested that good cross combinations be not always obtained between high general combiners. Shekhawat *et al.* (10) also found crossed with specific combining ability effects emanating from low x low general combiners.

Table 3. Best crosses on the basis of mean value and specific combining ability effects for character under 7 x 7 parental diallel mating design in okra.

Character	Best crosses on the basis of mean values	
	F_1	F_2
Days to flowering	KS-410 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
	KS-312 x KS-404	KS-312 x KS-387
	KS-312 x KS-387	KS-312 x KS-404
Plant height	KS-404 x Pusa Sawani	KS-401 x KS-404
	KS-387 x Pusa Sawani	KS-410 x Pusa Sawani
	KS-401 x Pusa Sawani	KS-312 x KS-410
No. of branches/plant	KS-387 x Pusa Sawani	KS-401 x KS-404
	KS-387 x Pusa Sawani	KS-387 x KS-410
	KS-387 x Pusa Sawani	KS-401 x Pusa Sawani
Length of first fruiting node	KS-387 x KS-404	KS-404 x pusa Sawani
	KS-312 x KS-387	Parbhani Kranti x Pusa Sawani
	KS-312 x KS-410	KS-410 x Parbhani Kranti
Length of fruit	KS-401 x Pusa Sawani	KS-404 x Pusa Sawani
	KS-404 x Pusa Sawani	KS-387 x Pusa Sawani
	KS-401 x KS-410	KS-401 x KS-410
Width of fruit	KS-312 x Parbhani Kranti	Parbhani Kranti x Pusa Sawani
	KS-387 x Parbhani Kranti	KS-410 x Parbhani Kranti
	KS-387 x Pusa Sawani	KS-410 x Pusa Sawani
Number of fruits/plant	KS-404 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
	KS-401 x Pusa Sawani	KS-312 x Pusa Sawani
	KS-387 x KS-410	KS-312 x KS-387
Fruits yield/plant	KS-401 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
Days to flowering	KS-401 x KS-410	KS-312 x KS-404
	KS-404 x KS-410	KS-387 x KS-404
	Best crosses on the basis of sca effects	
	F_1	F_2
Days to flowering	KS-410 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
	KS-312 x KS-404	KS-401 x Parbhani Kranti
	KS-312 x KS-387	KS-404 x Parbhani Kranti
Plant height	KS-404 x Pusa Sawani	KS-401 x KS-404
	KS-410 x Parbhani Kranti	KS-312 x Parbhani Kranti
	KS-387 x Pusa Sawani	KS-312 x KS-410
No. of branches/plant	KS-401 x Pusa Sawani	KS-401 x KS-404
	KS-387 x Parbhani Kranti	KS-387 x KS-410
	KS-404 x Parbhani Kranti	KS-404 x Pusa Sawani
Length of first fruiting node	KS-387 x KS-404	KS-404 x Pusa Sawani
	Parbhani Kranti x Pusa Sawani	KS-312 x KS-404
	KS-312 x KS-404	Parbhani Kranti x Pusa Sawani
Length of fruit	KS-401 x Pusa Sawani	KS-387 x KS-404
	KS-312 x KS-387	KS-312 x KS-410
	KS-404 x Pusa Sawani	KS-401 x KS-404
Width of fruit	KS-312 x Parbhani Kranti	Parbhani Kranti x Pusa Sawani
	KS-312 x KS-410	KS-312 x KS-404
	Parbhani Kranti x Pusa Sawani	KS-404 x KS-410
No. of fruits/plant	KS-404 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
	KS-401 x Pusa Sawani	KS-410 x Parbhani Kranti
	KS-404 x KS-410	KS-387 x Pusa Sawani
Fruits yield/plant	KS-401 x Pusa Sawani	Parbhani Kranti x Pusa Sawani
	KS-410 x Parbhani Kranti	KS-312 x KS-404
	KS-387 x Pusa Sawani	KS-312 x KS-410

Table 4. Relationship of specific combining ability of cross combinations with gca effect of the parents in okra.

Character	Cross combinations with maximum SCA effect in F_1	CGA effect of parents
Days to flowering	KS-410 x Pusa Sawani	Moderate x High
	KS-312 x KS-404	High x Low
	KS-312 x KS-387	High x Low
Plant height	KS-404 x Pusa Sawani	Moderate x High
	KS-410 x Parbhani Kranti	Low x Low
	KS-387 x Pusa Sawani	High x High
No. of branches/plant	KS-401 x Pusa Sawani	High x Low
	KS-387 x Parbhani Kranti	High x Low
	KS-404 x Parbhani Kranti	High x Low
Length of first fruiting node	KS-387 x KS-410	High x Low
	Parbhani Kranti x Pusa Sawani	High x Low
	KS-312 x KS-404	High x Low
Length of fruit	KS-401 x Pusa Sawani	Moderate x High
	KS-312 x KS-387	Low x Low
	KS-404 x Pusa Sawani	High x High
Width of fruit	KS-312 x Parbhani Kranti	Low x Low
	KS-312 x KS-387	Low x low
	Parbhani Kranti x Pusa Sawani	Low x Moderate
No. of fruits/plant	KS-404 x Pusa Sawani	Low x Moderate
	KS-401 x Pusa Sawani	Low x Moderate
	KS-404 x KS-410	Low x Low
Fruits yield/plant	KS-387 x KS-410	High x Moderate
	KS-401 x Pusa Sawani	Low x High
	KS-404 x KS-410	High x Low
	Cross combinations with maximum SCA effect in F_2	CGA effect of parents
Days to flowering	Parbhani Kranti x Pusa Sawani	Moderate x Moderate
	KS-401 x Parbhani Kranti	Low x Moderate
	KS-404 x Parbhani Kranti	Moderaw x Moderate
Plant height	KS-312 x Parbhani Kranti	Low x Low
	KS-410 x Parbhani Kranti	Low x High
	KS-387 x Pusa Sawani	Low x Low
No. of branches/plant	KS-401 x KS-404	Moderate x Low
	KS-387 x KS-410	Moderate x Low
	KS-404 x Parbhani Kranti	Low x Low
Length of first fruiting node	KS-404 x Pusa Sawani	Low x Low
	KS-312 x KS-404	High x Low
	Parbhani Kranti x Pusa Sawani	High x Low
Length of fruit	KS-312 x KS-410	Low x Low
	KS-387 x KS-404	Low x Low
	KS-401 x KS-404	High x High
Width of fruit	Parbhani Kranti x Pusa Sawani	Moderate x High
	KS-312 x KS-410	Moderate x moderate
	KS-387 x KS-404	Low x Low
No. of fruits/plant	Parbhani Kranti x Pusa Sawani	Low x High
	KS-410 x Parbhani Kranti	Low x Low
	KS-387 x Pusa Sawani	High x High
Fruits yield/plant	Parbhani Kranti x Pusa Sawani	Low x High
	KS-312 x KS-401	Moderate x Low
	KS-312 x KS-410	Moderate x High

If crosses showing high specific combining ability involved both parents, which are good general combiners. They could be exploited in practical breeding. In case the crosses showing the high specific combining ability involve one good combiner and other moderate combiner. Such a combination may through up desirable transgressive segregates, if the additive genetic system is present in the good combiner and complementary epistatic effect if present in the cross, act in the same direction so as to maximum the desirable plant attributes. Breeding for homozygous lines by routine pedigree method could mean only partial exploitation of additive genetic variance, in order to exploit different type of gene actions in a population. It is suggested that a breeding procedure which may accumulate the fixable type of gene effects and at the same time maintains considerable heterozygosity for exploiting the dominance gene effects might prove most beneficial in improving the populations under study.

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