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Combining ability analysis of yield and its component in okra

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ABSTRACT

The present investigation conducted with 45 F_1s and 45 F_2s developed through half-diallel by using ten okra (*Abelmoschus esculentus* (L.) Moench) namely, P-7, BO-2, KS-305, Arka Anamika, KS-442, KS-450, KS-439, KS-419, KS-446 and Azad Bhindi-2 in randomized block design with three replications. Parent BO-2 exhibited high general combining ability effect for all characters except length of fruit, width of fruit and days to flower, in F_1 and length of fruit, width of fruit, height of plant and number of branches per plant in F_2 generations. Genotypes *i.e.*, KS-305, KS-442 and Azad Bhindi-2 were good general combiner for yield appear to be worthy of exploitation in future breeding. It is suggested that involving these lines may be developed through multiple crossing to isolating high yielding varieties. The cross combination KS-305 × Arka Anamika showed high specific combining ability effects as well as per se performance for yield per plant. The crosses showing high specific combining ability effects and *per se* performance for yield per plant suggesting that these hybrids may be exploit in further breeding programme.

Key words: Okra, combining ability, gene action, diallel analsis.

INTRODUCTION

Okra is an important fruit vegetable crop of the tropical and subtropical regions of the world. It belongs to Malvaceae family and grown in *kharif* and *zaid* seasons. Its tender green fruits are used as vegetable and root and stem of okra are used for cleaning *gur, khald* or raw sugar. It is a good source of vitamins A, B and C, protein and mineral elements (Singh *et al.*, 7) analyzed fruit and reported 6.60 to 10.40% crude fibers 84.60 to 90.50% edible portion 14.40 to 18.60% protein as of total dry weight. Among minerals Ca ranged 99 to 198, P 34.50 to 56 and Fe 0.80 to 2.40 mg per 100 g of edible portion. Okra is an interesting crop to the breeders and geneticists for its monoadelphous condition of the stamens and large flower amendable to easy emasculation and its fruit bears large number of seeds.

The research efforts made have mostly been directed towards individual plant selection in naturally varying races and progeny selection followed by hybridization. However, varieties good in *per se* performance may not necessarily produce desirable progenies when used in hybridization. The sound knowledge of gene effects involved in the expiration of various yield attributes is the prime importance in for mutating any breeding methodology. The knowledge of combining ability analysis provide a guideline for the assessment of relative breeding potential of parental material for hybridization, understanding of inheritance of quantitative traits and also in identifying the promising cross for further use in breeding programme. Diallel fashion besides providing information on the parents and crosses also furnish the knowledge about the suitable parents and breeding methodology to be adopted. The present investigation in okra is undertaken with a view to identify the potential parents and promising crosses for their further use in breeding programme.

MATERIALS AND METHODS

The material for the present investigation comprised ten okra (*Abeimoschus esculentus* (L.) Moench) genotypes namely, P-7, BO-2, KS-305, Arka Anamika, KS-442, KS-450, KS-439, KS-419, KS-446 and Azad Bhindi-2 collected from the Department of Vegetable Science, C.S. Azad University of Agriculture and Technology, Kalyanpur, Kanpur. Half-diallel set attempted by using ten parents of okra during *zaid* 2007. Parents along with 45 F_1s were sown during *kharif* 2007 and half quantity of cross seed was saved to grow in next season and all F_1s and parents were selfed to produce next generation.

All 45 F_1s and 45 F_2s along with their (ten) parents were evaluated in randomized block design with three replications at research farm of D.A.V. (P.G.) College, Muzaffarnagar during *zaid* season 2008. The crop was raised in three rows of 5.0 m length with row to row and plant to plant spacing at 50 cm both. The observations were recorded on randomly selected five plants from parent and F_1s and 10 plants in F_2

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generation of each replication. The observations were recorded on days to 50% flowering, plant height, No. of branches per plant, No. of nodes per plant, fruit length, fruit width, number of fruits per plant, and yield per plant. The combining ability analysis was worked out as per method suggested by Griffing method-2 and method-1 (Griffing, 1).

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. The mean square due to general combining ability (gca) and specific combining ability (sca) were found highly significant for all attributes except for width of fruit in both F_1 and F_2 generations. Which indicate the presence of additive as well as non-additive gene action which confirms the findings of Singh *et al.* (7) and Kulkarni *et al.* (3), *Singh et al.* (6), (7), and Yadav *et al.* (11). Therefore, it would be beneficial to develop a heterogenous population by crossing these parent *inter se* before initiating random mating in F_2 to allow higher recombination. This it is likely to break unfavorable linkage and confer a wide genetic base.

The magnitude of general combining ability variance was more than the estimates of specific combining ability variance for all traits in both generations except for fruit width. General combining ability studies have successfully led to making choice of suitable parents. Genotype BO-2 exhibited high general combining ability effect for all characters except fruit length, width and days to flower, in F_1 and fruit length, fruit width, plant height and number of branches per plant in F_2 generations. General combining ability effect including both additive and additive x additive type of gene action (Katiyar *et al.*, 2; Yadav *et al.*, 11) which represents fixable genetic variance. Shekhavat *et al.* (4) reported that additive parental effects as measured by general combining ability effects are of practical importance and value whereas non-allelic interactions are impracticable and can not be manipulated.

The compression of general combining ability effects with mean performance revealed that parents BO-2 for days to flower, Azad Bhindi-2 for plant height, fruit width and yield per plant, KS-442 for number of branches per plant; KS-305 for number of nodes per plant; KS-446 for fruit length; and KS-305 for number of fruits per plant were common under both criteria suggesting a correspondence between general combining ability in both F_1 and F_2 generations and *per se* performance of the parents. The earlier workers. also reported the similar results (Shekhavat *et al.*, 4).

Consistent general combining ability effects over F_1 and F_2 may prove advantageous, while evaluating varieties for combining ability. (Singh *et al.*, 11) suggested that the cross might be studied for combining ability in F_2 instead of F_1 generation, when the aims are to breed pureline 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 the improvement in particular component, thereby effecting improvement in yield. Genotypes i.e., KS-305, KS-442 and Azad Bhindi-2 showed good general combiner for yield appear to be worthy of exploitation in practical breeding. It is suggested

Table 1. Analysis of variance for combining ability in okra.

Source of variation	Generation	d.f.	Mean sum of squares for different characters							
			Days to flowering	Plant height	No. of branches per plant	No. of nodes/ plant	Fruit length	Fruit width	No. of fruits/ plant	Yield per plant
GCA	F_1	9	22.999**	555.688**	0.989**	0.978**	6.256**	0.031	11.096**	2209.633**
	F_2	9	16.658**	291.6698**	0.446**	0.436**	7.375**	0.009	08.623**	21.995**
SCA	F_1	44	07.948**	199.883**	0.599**	0.496**	1.999**	0.007	05.988**	1201.005**
	F_2	44	04.658**	190.205**	0.455**	0.364**	1.898**	0.008	03.656**	7413.338**
Error	F_1	106	0.898	8.964	0.099	0.089	0.399	0.006	0.378	20.880
	F_2	106	0.833	3.369	0.069	0.056	0.279	0.004	0.325	12.885
GCA/ SCA	F_1	-	3.039	2.983	2.060	1.991	2.983	1.469	1.989	1.893
	F_2	-	4.388	1.669	1.669	1.493	3.899	0.746	2.986	3.060

**Significant at 1% level.

that involving these lines may be developed through multiple crossing to isolating high yielding varieties. The similar results were reported by, Shekhavat *et al.* (4, 5), and Singh *et al.* (7).

Specific combining ability effects represent dominance and epistatic component of variation which are non-fixable and hence, specific combining ability studies would not 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 segregation shown in the crosses. The specific combining ability effects and *per se* performance of cross is presented in Table 3**.** To confirm whether the crosses selected on the basis of specific combining ability effects were really the best performance ones, the best five crosses on basis of mean performance and specific combining ability effects were selected. It was observed that in F_1 out of five best crosses BO-2 × KS-442 for days to flowering. Arka Anamika × Azad Bhindi-2 for plant height; number of nodes per plant KS-305 × KS-446 for number of branches per plant; KS-305 × KS-442 for fruit length, KS-305 × Arka Anamika for length of fruits; BO-2 × KS-446 for width of fruit; KS-305 × KS-442 for number of fruits per plant and KS-305 × Arka Anamika 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 exploite in further breeding programme.

In F_2 generation out of five best crosses KS-446 × Azad Bhindi-2 for days to flowering, width of fruit and yield per plant, P-7 × KS-442 for plant height; number of branches per plant; Arka Anamika × KS-442 for number of nodes per plant; BO-2 × KS-450 for fruit length; KS-439 × Azad Bhindi-2 for number of fruits per plant showed high specific combining ability effects and good *per se* performance. It is a general observation that good cross combinations are obtain from high × high general combiner and poor ones between low × low general combiners. Best cross combinations involved high × high, high × low, high × moderate, moderate × moderate, moderate × low and low × low general combiners for all the characters under study. This has suggested that good cross combinations be not always obtain cross made between high general combiners by several workers (Singh, 7; Singh *et al.*, 8; Singh *et al.*, 9) in brinjal; Sparque, 11; Singh *et al.*, 6; Yadav *et al.*, 11) in okra also found crossed with specific combining ability effects emanating from low × low general combiners.

If the crosses showing high specific combining ability involved both the parents, which are good combiners that could be exploited in practical breeding. In case the crosses showing the high specific combining ability using high × moderate combiners. Such a combination may through up desirable trangressive segrigants, if the additive genetic system is present in the good combiner and complementary epistatic effect is present in the cross, act in the same direction so as to maximum the desirable attributes. Breeding for homozygous lines by conventional pedigree and back cross method could be use only partial exploitation of additive genetic variance. In order to exploit different types genes actions in a population is suggested that a breeding procedure which may accumulate the fixable type of gene effects and at the same time maintains considerable heterozygosity for exploitation dominance gene effects might prove most beneficial to improve the population of okra.

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Table 3. Estimates of specific combining ability effects for eight characters in okra.

Cross	Generation	Days to flowering	Plant height	No. of branches/ plant	No. of nodes/ plant	Fruit length	Fruit width	No. of fruits/ plant	Yield/plant
P-7 × KS-442	F_1	0.633	-1.263	-11.126**	0.158	1.048*	0.142	0.896	9.043*
	F_2	2.226**	-11.326**	0.173	0.848**	0.236	0.046	1.846**	1.393
P-7 × KS-439	F_1	-0.433	2.886	0.253	0.138	2.654**	0.136	2.316**	20.488**
	F_2	-1.578*	31.366**	0.048	0.038	2.456**	-0.169	0.098	7.986
BO-2 × KS-442	F_1	-3.623**	-8.888**	-0.033	-0.018	-0.633	-0.048	-2.368**	-22.266**
	F_2	-2.266**	7.126**	-0.588	-0.588*	-1.588**	0.053	1.086**	49.024**
BO-2 × KS-450	F_1	1.688*	2.533	0.686**	0.676*	-0.498	0.034	-1.885**	-24.356**
	F_2	-1.934*	22.215**	0.338	0.345	3.438**	0.144*	0.483	40.546**
BO-2 × KS-419	F_1	-0.627**	26.998**	-0.639*	-0.644*	-0.368	0.047	0.864	39.036**
	F_2	-1.166	-0.286	0.349	0.236	-1.486**	0.039	0.146	-5.446
BO-2 × KS-446	F_1	-2.062*	8.286	-0.528*	0.542	0.306	0.159*	-0.356	14.246**
	F_2	4.068**	29.689**	0.188	0.126	-0.488	0.086	-2.386**	-40.433**
BO-2 × Azad Bhindi-2	F_1	0.523	-13.986**	0.123	0.168	0.048	0.044	1.696**	53.044**
	F_2	0.723	-5.518**	0.369	0.296	0.276	-0.056	0.286	-9.974
KS-305 × KS-442	F_1	-0.496	-20.696**	-1.076	-11.004	-1.883**	0.026	-3.686**	-57.064**
	F_2	2.016*	13.696**	0.376	0.364	3.024*	0.058	1.348**	32.038**
KS-305 × KS-450	F_1	-1.033	-7.025**	0.176	0.104	0.390	0.076	1.846**	71.343**
	F_2	3.786*	8.888**	0.636	0.614	0.348	0.066	-0.334	7.896
KS-305 × KS-446	F_1	-1.608*	0.738	-1.466**	1.446**	0.346	-0.265*	0.344	9.036*
	F_2	0.032	-2.938	-1.363**	-1.388**	-1.547**	0.168	-2.855**	-28.346**
KS-305 × KS-Azad Bhindi-2	F_1	3.106**	9.068**	-0.156	-0.146	-1.858**	-0.038	-4.611**	42.024**
	F_2	0.896	3.524**	-0.186	-0.124	-0.614	-0.096	1.494**	-1.536
ArkaAnamika × KS-419	F_1	5.033	-7.464**	0.534*	0.569*	0.185	-0.033	2.549**	64.163**
	F_2	2.243**	-6.484**	-0.842**	-0.897**	-0.624	-0.038	0.134	-11.825**
ArkaAnamika × KS-Azad	F_1	0.436	5.036*	1.533*	1.568	4.367**	-1.024	3.359**	68.359**
Bhindi-2	F_2	1.866*	-4.042*	0.436	0.124	0.188	-0.035	-2.041**	-23.482
KS-442 × KS-450	F_1	0.633	1.522	-0.649	0.084	0.514	0.168	2.085**	62.023**
	F_2	1.266	-3.689	0.356	0.244	-2.433**	0.046	-1.543**	-13.442**
KS-442 × KS-439	F_1	0.935	-3.236	0.046	0.004	0.644	0.088	0.740	21.298**
	F_2	0.228	-3.547*	1.428	0.0043	0.435	-0.053	0.789	10.088**
KS-442 × KS-419		0.347	23.039**	0.846**	0.804**	0.646	-0.049	3.133**	45.049**
		-3.269**	-3.086	0.349	-0.334	-0.845	-0.066	-0.344	-8.338
KS-439 × Azad Bhindi-2		3.424	6.024**	-0.424	0.169	-2.186**	-0.036	-1.298*	-20.042**
		0.288	3.966*	0.698	-0.088	-0.796	0.014	2.883**	60.062**
KS-446 × Azad Bhindi-2		0.486	-9.043**	-0.549*	-0.564*	-1.743**	-0.086	-0.026	-2.605
		-4.176**	3.034	-0.386*	-0.364*	-0.048	0.231**	2.541**	60.621**
SE (Sij + SK)		0.825	2.169	0.266	0.344	0.565	0.069	0.509	4.176
		0.746	1.620	0.274	0.346	0.446	0.066	0.399	3.393
SE (Sij - S) +		0.146	4.033	0.465	0.399	0.786	0.145	0.732	6.089
		0.108	2.340	0.346	0.238	0.669	0.096	0.569	4.890
SE (Sij - SKL) +		1.106	3.686	0.398	0.286	0.699	0.162	0.969	5.841
		1.035	2.301	0.368	0.338	0.616	0.094	0.556	4.650

*, ** Significant at 5 and 1% levels, respectively, PK = Parbhani Kranti PS = Pusa Sawani

Table 2. Estimates of general combining ability effects for eight characters in okra.

Genotype	Generation	Days to flowering	Plant height	No. of branches/ plant	No. of nodes/ plant	Fruit length	Fruit width	No. of fruits/ plant	Yield/ plant
P-7	F_1	1.238**	-3.037**	0.160*	0.185**	-0.526**	0.029	-1.532**	-21.068**
	F_2	0.325	-3.035**	0.237*	0.226*	-0.209	-0.027	-1.035**	-20.036**
BO-2	F_1	-1.638**	-6.628**	-0.149**	-0.146**	-0.573**	-0.026	0.138	-6.878**
	F_2	-1.468**	-4.038**	-0.365**	-0.366**	-0.198	-0.046	0.988**	2.038
KS-305	F_1	-0.399**	5.215**	0.399**	0.460**	-0.206	-0.036	1.835**	20.697**
	F_2	-0.988**	-0.226	0.133*	0.150*	0.089	-0.079**	1.339**	12.237**
Arka Anamika	F_1	1.986**	-1.524	0.449**	0.446**	0.348	0.031	-0.023	-0.435
	F_2	0.530*	-1.353*	0.098	0.109	0.798**	0.047	-0.539**	-8.586**
KS-442	F_1	-0.633**	1.494	-0.139	-0.126	2.613**	-0.049	-0.395**	4.063*
	F_2	-0.382	2.036**	-0.267*	-0.226*	1.938**	0.038	-0.648**	7.589**
KS-450	F_1	0.332	-6.766**	0.038	0.036	-0.086	-0.036	-0.399*	-8.033**
	F_2	0.422	-1.338*	0.128	0.133	-0.598*	0.028	-0.488*	-9.988**
KS-439	F_1	-1.330**	6.893**	-0.499**	-0.569**	0.289	0.034	0.837**	2.396
	F_2	-1.030**	3.889**	0.143	0.245	-0.343	-0.029	0.295*	12.037**
KS-419	F_1	1.844**	9.012**	0.298**	0.395**	0.433**	0.039	-1.095**	17.088**
	F_2	2.849**	2.026**	0.220*	0.233*	0.633**	0.020	-0.398*	-1.335
KS-446	F_1	0.369	-11.005**	-0.163**	-0.265**	-0.936**	-0.071*	1.226**	-13.486**
	F_2	0.198	-8.926**	0.039	0.049	-1.698**	0.021	-1.065**	13.989**
Azad Bhindi-2	F_1	-1.669**	6.358**	0.334**	9.689**	0.588*	0.078	0.337**	4.163*
	F_2	-3.358**	9.689**	0.165	0.325**	0.188	0.596**	1.386	20.327**
SE (gi) ±	F_1	0.258	0.825	0.078	0.199	0.149	0.129	0.156	1.239
	F_2	0.236	0.496	0.076	0.207	0.139	0.026	0.130	1.009
SE (gi-gi) ±	F_1	0.366	1.139	0.123	0.225	0.226	0.046	0.229	1.928
	F_2	0.346	0.698	0.098	0.208	0.199	0.039	0.187	1.483

*, **, Significant at 5 and 1% levels, respectively.

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