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Combining ability studies in okra [*Abelmoschus esculentus* (L.) Moench]

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Abstract

A line x tester analysis involving six diverse lines and three well adapted varieties as testers indicated significant differences among the lines (except fruits per plant), testers (except fruit length, fruit diameter, fruit weight and fruit yield per plant) and line x tester interactions (except node at which first flower appears, fruit length and fruit diameter). The lines, IC-90269, EC-169464 and IC-32398 and the tester, Parbhani Kranti were found to be the best general combiners, whereas the crosses ,EC-169468 x Parbhani Kranti, IC-32398 x Arka Anamika and EC-169464 x Arka Anamika were found to be the best specific combinations for fruit yield per plant and most of the component traits.

Introduction

Okra is one of the most common and principle vegetable crop grown all the year round in the country. It occupies an area of about 391.2 thousand hectares with a production of 4338.7 thousand tones (Anonymous 2003). In any crop improvement programme, the specific parental combinations that enter into the production of hybrid are the determinants of evolutionary trends, breeding progress and possibilities. Thus, the choice of the parents for hybridization is one of the critical and most difficult tasks for a breeder. The choice is relatively straight forward when qualitative characters are under consideration, but complex traits like yield, do not allow any easy handling. One of the two possible alternatives to choose the parents for hybridization involve careful study of as many parents as possible in multi location tests over many years. Secondly, one may resort to the production of large numbers of crosses between the selected parents followed by elimination of the poor ones. The ability of the parents to combine well with each other depends upon the complex interactions among the genes which cannot be judged by mere yield performance of the parents (Allard, 1960). Line x tester mating design as proposed by Kempthone (1957), offers means of obtaining useful information of differential parental combinations through an assessment of overall genetic architecture of the parental lines, in relation to the characters studied.

Material and Methods

A line x tester analysis involving six diverse lines of okra viz., VRO-4, EC-169464, EC-169468, IC-90269, IC-31850 and IC-32398 and three testers viz., P-8, Parbhani Kranti and Arka Anamika was carried out to study the combining ability effects. Thus nine parents and their 18 F_1s were evaluated in randomized block design at the experimental farm of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalya, Palampur, H.P during Kharif, 2005. Each experimental plot consisted of two rows of 1.5 m length. The plants were spaced at 60 cm row to row and 15 cm plant to plant. The Experimental Farm is located at an elevation of 1290.8 m above mean sea level, $32^0 6'$ N latitude and $76^0 3'$ E longitude, representing mid hill zone of Himachal Pradesh. The soil of the zone is podzolic type with pH ranging from 5-5.6. The data were taken on 10 competitive plants on some fruit characteristics viz., duration of the availability of marketable fruits, fruit length, fruit diameter, fruit per plants, fruit weight and fruit yield per plant. The replication wise mean values of F_1 generation of 18 crosses for each trait were subjected to statistical analysis using the model given by Kempthorne (1957).

Results and Discussion

Analysis of variance for combining ability revealed significant differences among genotypes (parents and hybrids) for all the traits studied viz., node at which first flower appears, days to 50% flowering, days to first picking, duration of availability of marketable fruits, fruit length, fruit diameter, fruits per plant, fruit weight and fruit yield per plant, thereby all these traits were subjected to combining ability analysis (Table 1). Analysis of variance for combining ability

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indicated significant differences among crosses for all the traits studied except for fruit length. Further partitioning of the mean squares of the crosses into lines, testers and line x tester interactions revealed that mean squares due to lines were significant for all the traits studied except for fruits per plant. Variances due to testers were found significant for node at which first flower appears, days to 50% flowering, duration of availability of marketable fruits and fruits per plant, when tested against error mean squares.

Table 1. Analysis of variance for design of experiment

Source of variation	Mean squares due to		
	Replication	Treatment	Error
Trait df	2	26	52
Node at which first flower appears	3.468*	0.777*	0.224
Days to 50% flowering	3.351	16.320*	2.587
Days to first picking	2.175	52.195*	7,757
Duration of availability of marketing fruits	2.161	3.649*	11.054
Fruit length	3.139*	2,709*	0.724
Fruit diameter	0.061*	0.045*	0.013
Fruits per plant	3.071*	5.185*	0.833
Fruit weight	11.711*	8.691*	1.153
Fruit yield per plant	502.011	2077.636*	204.856

*Significant at 5% level of significance

The mean squares due to line x tester interactions revealed significant differences for days to 50% flowering, days to first picking, duration of availability of marketable fruits, fruits per plant, fruit weight and fruit yield per plant (Table 2).

The results with regard to all the nine parents for combining ability were variable as no single parent exhibited significant general combining ability (GCA) effect for all the traits. However, the line, IC-90269 exhibited the highest GCA effect for fruit diameter, fruit weight and fruit yield per plant. The parent, IC-32398 had the highest negative general combining ability (GCA) effect for days to 50% flowering, days to first picking and duration of availability of marketable fruits and EC-169468 for fruit length and nodes per plant exhibited the highest GCA. However, the line, VRO-4 did not excel for majority of the traits but was observed as good general combiner for node at which first flower appears (Table 3).

Among the testers, Parbhani Kranti excelled other male parents with regard to days to 50% flowering, duration of availability of marketable fruits and fruits per plant. The tester, P-8 excelled others for node at which first flower appears. Similar observations pertaining to the general combining ability effects of the parents have also been reported by the earlier researchers (Nichal *et al.* (2001) and Singh and Singh (2003) in okra (Table 4).

Additive parental effects as measured by general combining ability (GCA) effects are of practical use to the breeders since non-allelic interactions are unpredictable. On the basis of present studies, it can be recommended to include the parental lines IC-90269, IC-32398 and EC-169468 for all possible mating, which will be subjected to biparental mating system.

Table 2. Analysis of variance of combining ability

Source of variation	Replication	Cross	Line	Tester	Line x Tester	Error
Trait df	2	17	5	2	10	34
Node at which first flower appears	1.698*	0.629*	0.575*	1.592*	0.464	0.224
Days to 50% flowering	4.500	16.120*	40.681*	5.314*	6.001*	1.605
Days to first picking	4.504	55.407*	129.262*	11.254	27.313*	8.648
Duration of availability of marketable fruits	3.700	43.403*	79.332*	46.944*	24.731*	9.623
Fruit length	1.080	2.130	4.952*	0.188	1.107	0.700
Fruit diameter	0.046*	0.052*	0.139*	0.001	0.021	0.010
Fruits per plant	3.798*	4.507*	2.531	6.615*	5.074*	1.034
Fruit weight	11.228*	10.268*	30.503*	1.330	1.939*	0.877
Yield per plant	866.592*	2110.912*	3941.133*	649.000	1488.183*	201.774

*Significant at 5% level of significance

Table 3. Estimates of general combining ability (GCA) effects of lines

Line	1	2	3	4	5	6	7	8
VRO-4	-0.35*	2.86*	5.52*	-3.09*	0.18	-0.10	-1.62*	-26.81*
EC-169464	0.17	2.14*	1.29	-2.55*	-0.65*	-0.11	-1.44*	-6.29
EC-169468	-0.08	-1.85*	2.73*	-1.95	1.27*	0.03	-0.75*	-5.97
IC-32398	-0.11	-2.23*	-4.28*	4.36*	0.29	0.01	0.32	-5.72
IC-90269	0.39*	0.27	-2.86*	1.70	-0.58*	0.22*	3.40*	36.76*
IC-31850	-0.01	-1.19*	-2.39*	1.53	-0.52	-0.05	0.10	-3.40
SE ($\hat{g}_i$)±	0.157	0.422	0.980	1.034	0.278	0.033	0.312	4.734
SE ($\hat{g}_i - \hat{g}_i$)±	0.223	0.597	1.386	1.462	0.394	0.047	0.441	6.96
CD (5%)	0.453	1.212	2.814	2.968	0.799	0.095	0.895	14.129

*Significant at 5% level of significance

1. Node at which first flower appears
2. Days of 50% flowering
3. Days to first picking
4. Duration of availability of marketable fruits
5. Fruit length
6. Fruit diameter
7. Fruit weight
8. Fruit yield per plant

Table 4. Estimates of general combining ability (GCA) effects to testers

Trait	Tester			SE ($\hat{g}_i$)±	SE ($\hat{g}_i - \hat{g}_j$)±	CD (P=0.05)
	P-8	Arka Anamika	Parbhani Kranti			
Node at which first flower appears	-0.30*	-0.29*	0.01	0.111	0.157	0.319
Days to 50% flowering	0.08	0.51	-0.59*	0.298	0.422	0.857
Duration of availability of marketable fruits	-0.92	-0.94	1.86*	0.731	1.034	2.099
Fruits per plant	0.12	-0.66*	0.54*	0.239	0.338	0.686

*Significant at 5% level of significance

Specific combining ability (SCA) effects include both dominance and epistatic genetic effects. In the present study, three cross combinations viz., EC-169468 x Parbhani Kranti, IC-32398 x P-8 and EC-169464 x Arka Anamika displayed significant negative SCA effects for days to 50% flowering. These cross combinations involved good x good, good x average and poor x average general combiners as their parents. The highest significant negative SCA effects were exhibited by the cross, EC-169468 x Parbhani Kranti which had parents with good x good general combining ability effects (Table 5).

Table 5. Estimates of sca effects of different cross combinations for different traits

Cross	1	2	3	4	5	6
VRO-4 x P-8	0.61	0.18	-0.70	0.68	-0.11	6.76
VRO-4 x Arka Anamika	-0.18	1.13	-1.08	0.11	-0.09	0.77
VRO-4 x Parbhani Kranti	-0.43	-1.32	1.78	-0.79	0.21	-7.52
EC-169464 x P-8	0.84	-1.06	1.04	-1.77*	-0.54	-29.93*
EC-169464 x Arka Anamika	-1.60*	0.39	-0.51	1.01	0.95	25.33*
EC-169464 x Parbhani Kranti	0.75	0.67	-0.52	0.76	-0.41	4.60
EC-169468 x P-8	0.27	-1.36	0.60	-0.71	-0.25	-11.75
EC-169468 x Arka Anamika	1.46*	2.96	-1.68	-1.41*	0.12	-17.97*
EC-169468 x Parbhani Kranti	-1.73*	-1.59	1.08	2.12*	0.12	29.71*
IC-32398 x P-8	-1.66*	-2.25	3.22	0.72	-0.65	3.60
IC-32398 x Arka Anamika	-0.58	-3.33*	2.77	0.41	0.99	16.28*
IC-32398 x Parbhani Kranti	2.23*	5.58*	-6.00*	-1.15*	-0.33	-19.89*
IC-90269 x P-8	-0.62	0.53	-1.29	0.63	0.98	19.89*
IC-90269 x Arka Anamika	0.35	0.68	-0.37	-0.60	-1.24*	-24.52*
IC-90269 x Parbhani Kranti	0.26	-1.21	1.66	0.00	0.26	4.63
IC-31850 x P-8	0.55	3.96*	-2.88	0.47	0.57	11.43
IC-31850 x Arka Anamika	0.53	-1.82	0.87	0.49	-0.73	0.10
IC-31850 x Parbhani Kranti	-1.09	-2.14	2.00	-0.96	0.15	-11.54
SE (sij)±	0.731	1.697	1.790	0.587	0.540	8.201
SE (sij - skl)±	1.034	2.401	2.532	0.830	0.764	11.598

*Significant at 5% level of significance; 1. Days to 50% flowering, 2. Days to first picking, 3. Duration of availability of marketable fruits, 4.Fruits per plant, 5. Fruit weight, 6. Yield per plant

Only one cross combination namely, IC-32398 x Arka Anamika had significant negative specific combining ability effects for days to first picking. This best cross combination involved its female parent as the good general combiner. For fruits per plant, only one cross was observed as good cross combination. This cross combination (EC-169468 x Parbhani Kranti) had the parents with average and good general combining ability effects, respectively.

The estimates of SCA effects for yield per plant revealed that out of 18 crosses, four cross combinations exhibited significant positive SCA effects. Out of these, the cross combination, IC-90269 x P-8 involved female parent as good combiner, whereas the remaining female parents of best cross combinations were average general combiners. The highest SCA effect for increased yield per plant was exhibited by the cross, EC-169468 x Parbhani Kranti which involved one of its parents as average general combiner. Majority of the combinations exhibiting desirable SCA effects, have at least one of the parents as good or average general combiner. Similar views have also been expressed by the earlier researchers (Partap and Dhankhar, 1980; Pawar *et al.*, 1999 and Rajani *et al.*, 2001). It is not necessary that the parents having high estimates of GCA effects would also give high estimates of SCA effects in the crosses. Apparently, the parents having low GCA effects have revealed relatively high magnitude of non-additive gene effects and this resulted in high estimates of specific combining ability effects.

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