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Studies on Gene action for Yield and Quality Traits in Okra (*Abelmoschus esculentus* (L.) Moench)

A Rajani, L Naram Naidu, R V S K Reddy, K Uma Jyothi, D Ratna Babu and K Umakrishna
Horticulture Research Station, Lam, Guntur, A. P.

ABSTRACT

Selection of suitable breeding methodologies in bringing desirable improvement in crop plant require the complete knowledge about the nature of gene action involved in the inheritance of quantitative and quality traits. Gene action of fruit yield and quality traits in okra (*Abelmoschus esculentus* (L.) Moench) were studied through half diallel analysis of 15 F1 hybrids derived by crossing 6 parental lines (VRO-3, VRO-6, 440-10-1, TCR-1674, JPM-20-16-39 and HRB-9-2). The ratio of *gca* to *sca* variances revealed that non-additive gene action was predominant over additive gene action in the inheritance of all the characters studied except internodal length and number of fruits per plant. Hence, heterosis breeding is required to be followed for exploitation of these traits.

Keywords: *Diallel, Fruit yield, Gene action,Okra and Variance.*

Okra [*Abelomoschus esculentus* (L.) Moench] commonly known as lady's finger belongs to the family Malvaceae. It is native to Tropical Asia. Okra is an allopolyploid with the most observed chromosome number of 2n=8x=130. It is an often crosspollinated crop. Tender okra fruits are used as vegetable in countries like India, Brazil, West Africa and is also available in dehydrated and canned forms. The sun-dried (Africa, India), frozen and sterilized (USA) fruits are other important market products. Okra fruit contains 90% water, 3% dietary fibre, 7% carbohydrates, 2% protein, good quantities of minerals, vitamin C and A and moderate contents of thiamin, folate and magnesium (Chopra *et al*., 1956). The roots and stems of okra are used for cleaning the cane juice. Mature fruits and stems containing crude fibre are used in the paper industry (Chauhan, 1972).

For developing promising hybrids through hybridizations, the choice of parents is a matter of great concern to the plant breeder. A high yielding genotype may or maynot tranmit its superiority to its progenies. Therefore, the success of a breeding programme is determined by useful gene combinations in the form of high combined inbred.The knowledge of nature of gene action governing the expression of various traits could be helpful in predicting the effectiveness of selection. The efficient partitioning of genetic variance into its components *viz*; additive, dominance and epistasis will help in formulating an effective and sound breeding programme.

The cases where cost of hybrid seed is of greater importance, the use of additive gene effects of parents could be used to retain the vigour in subsequent generations. Diallel mating design has been used extensively by several researchers to measure gene action for yield and yield components in okra (Jindal *et al.,* 2009; Singh *et al*., 2009). The present investigation was, therefore, undertaken with a set of half -diallel crosses to elicit information about the nature and magnitude of gene action for yield and its components in okra so as to formulate suitable breeding strategy.

MATERIAL AND METHODS

Six okra genotypes *viz.,* VRO-3, VRO-6, 440-10-1, TCR-1674, JPM-20-16-39 and HRB-9-2 were chosen in this study to represent substantial amount of genetic diversity for different quantitative and quality traits and were maintained through selfing during 2017. These six genotypes were involved in 6 × 6 half-diallel combinations to develop 15 F_1 hybrids during *Kharif,* 2018. All the F1's along with their parents were evaluated in a Randomized Block Design with three replications during late *Rabi* season of 2018 at three locations HRS, Lam; KVK, V.R.Gudem and KVK, Vonipenta, Andhra Pradesh. The crop was raised in three rows of 3 m length with inter and intra row spacing of 60 and 30 cm, respectively. All recommended package of practices were followed to raise a successful crop. Ten randomly selected plants from each entry were tagged in each replication for recording observations on different characters *viz.,* plant height (cm), days to first flowering, internodal length (cm), first flowering node, days to 50% flowering, days to first picking, days to last picking (days), number of fruits per plant, fruit length (cm), fruit girth (cm), fruit weight (g), number of seeds per fruit, test weight (g/100), fruit yield per plant (g), fruit

Table 1.Pooled analysis of variance for combining ability (Half-diallel) for yield and quality attributes in okra.

Source	Df	Plant height (cm)	Days to first flowering	Internodal length (cm)	Days to 50% flowering	First flowering node	Days to first picking	Days to last picking	Number of fruits per plant	Fruit length (cm)
Replicates	2	43.468	2.393	0.143*	3.699	0.039	2.559	0.245	0.052	2.192**
Treatments	20	122.251	2.432	0.220**	3.530*	1.260**	3.594**	4.026*	7.508**	0.814**
Parents	5	145.478	4.008*	0.309**	3.197	1.614**	5.209**	4.165	14.480**	0.285
Hybrids	14	116.921	0.694	0.185**	0.946	1.111**	1.128	4.181*	5.533*	0.599*
Parent Vs.Hybrids	1	80.936	18.880**	0.261*	41.385**	1.565*	30.041**	1.163	0.299	6.479**
Error	40	66.779	1.491	0.042	1.508	0.262	1.342	1.702	2.193	0.25
Total	62	83.921	1.824	0.103	2.231	0.576	2.108	2.405	3.838	0.494
GCA	5	101.916**	1.005	0.232**	0.527	0.709**	1.576**	1.986*	7.554**	0.349**
SCA	15	20.362	0.746	0.021	1.394**	0.324**	1.072*	1.127*	0.819	0.245**
Error	40	22.26	0.497	0.014	0.503	0.087	0.447	0.567	0.731	0.083

Source	Df	Fruit girth (cm)	Fruit weight(g)	Number of seeds per fruit	Test weight of seeds (g)	Yield per plant (g)	Yield (t/ha)	Fibre content (%)	Asorbic acid content (mg/100 mg)	Shelf life (days)
Replicates	2	0.044	0.486	1.658	0.475*	41.321	0.082	0.022	0.156	0.022
Treatments	20	0.189*	9.642**	113.109**	0.359**	6301.180**	16.946*	0.454**	29.829**	1.026*
Parents	5	0.189	1.174	137.777**	0.667**	5812.716*	17.958	0.707**	33.940**	0.703**
Hybrids	14	0.122	4.771*	97.250**	0.216	4664.188*	11.954	0.389**	29.260**	1.164**
Parent Vs.Hybrids	1	1.110**	120.171**	211.804**	0.823*	31661.390**	81.792**	0.085	17.244**	0.700**
Error	40	0.086	1.987	12.678	0.143	2351.297	7.35	0.125	1.201	0.045
Total	62	0.118	4.408	44.72	0.223	3550.938	10.211	0.228	10.402	0.361
GCA	5	0.023	1.447	101.832**	0.244**	3858.510**	10.683	0.543**	25.701**	0.901**
SCA	15	0.076**	3.803**	16.327**	0.078	1514.354*	3.971	0.021	4.691**	0.156**
Error	40	0.029	0.662	4.226	0.048	783.766	2.45	0.042	0.4	0.015

** 1% level of significance,* 5% level of significance

Table 2. Estimates of general and specific combining ability variances and proportionate gene action for various characters in okra

Source of Variation	Plant height				Days to first flowering				Internodal length (cm)			
	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	6.009	20.339	3.777	9.956	0.174	0.087	-0.02	0.063	0.012	0.009	0.05	0.027
σ^2sca	15.809	10.267	-69.034	-1.897	1.012	0.833	0.292	0.248	0.013	-0.03	-0.031	0.006
σ^2gca/σ^2sca	0.38	1.981	-0.054	-5.246	0.172	0.104	-0.068	0.255	0.887	-0.31	-1.578	4.183
	Days to 50 % flowering				First flowering node				Days to first picking			
Source of Variation	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	-0.003	0.147	-0.054	0.003	0.117	0.177	0.01	0.077	0.305	0.139	0.058	0.141
σ^2sca	2.14	1.587	0.256	0.89	0.771	0.093	0.157	0.236	1.253	1.044	1.1	0.624
σ^2gca/σ^2sca	-0.001	0.092	-0.213	0.003	0.152	1.892	0.067	0.329	0.243	0.133	0.053	0.226
	Days to last picking				Number of fruits per plant				Fruit length (cm)			
Source of Variation	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	0.237	0.125	0.561	0.177	0.697	1.453	0.608	0.853	0.044	0.079	-0.01	0.033
σ^2sca	1.168	0.535	1.659	0.56	1.093	0.403	-0.856	0.088	0.376	0.231	0.217	0.162
σ^2gca/σ^2sca	0.203	0.234	0.338	0.316	0.638	3.605	-0.71	9.693	0.117	0.342	-0.046	0.204

Table 2 Cont...

Source of Variation	Fruit girth (cm)				Fruit weight(g)				Number of seeds per fruit			
	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	-0.003	-0.001	-0.002	-0.001	-0.072	0.473	-0.146	0.098	53.136	8.01	5.24	12.2
σ^2sca	0.113	0.078	0.017	0.047	4.025	2.136	6.906	3.14	67.257	21.571	7.264	12.1
σ^2gca/σ^2sca	-0.027	-0.013	-0.118	-0.021	-0.018	0.221	-0.021	0.031	0.79	0.371	0.721	1.008
	Test weight of seeds (g)				Fibre content (g/100mg)				Asorbic acid content (mg/100g)			
Source of Variation	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	0.121	0.008	-0.008	0.024	0.062	0.061	0.066	0.063	2.579	3.571	3.449	3.162
σ^2sca	0.324	-0.013	-0.036	0.03	-0.024	-0.016	-0.012	-0.021	2.942	6.159	4.931	4.29
σ^2gca/σ^2sca	0.373	-0.615	0.222	0.8	-2.583	-3.813	-5.5	-3	0.877	0.58	0.699	0.737
	Shelf life (Days)				Yield per plant (g)				Yield (t/ha)			
Source of Variation	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled	V.R Gudem	Lam	Vonipenta	Pooled
σ^2gca	0.124	0.093	0.119	0.11	250.98	661.55	284.158	384.343	0.626	1.909	0.724	1.029
σ^2sca	0.137	0.146	0.136	0.14	2333.7	482.85	1422.933	730.588	7.204	0.923	3.563	1.52
σ^2gca/σ^2sca	0.905	0.637	0.875	0.786	0.108	1.37	0.2	0.526	0.087	2.068	0.203	0.677

yield per hactare (t), fibre content (%), ascorbic acid content (mg/100g) and shelf life (days). The data recorded on ten plants per treatment was averaged for use in statistical analysis. Data were analyzed according to ANOVA techniques, as outlined by Panse and Sukhatme

(1978), to determine the significant differences among genotypes for all the characters. Components of genetic variance were estimated from the data obtained on the diallel crosses by the method given by Griffing's Method-II and Model-I (Griffing, 1956) as outlined by Singh and Chaudhary (1979).

RESULTS AND DISCUSSION

The analysis of variance carried out for different traits of okra are presented in Table 1. The analysis of variance revealed significant differences among treatments for all the yield and quality traits indicating the presence of appreciable genetic diversity among the parents and cross combinations. This indicates the existence of wide variability in the material studied and there is a good scope for identifying promising parents and hybrid combinations, and improving the yield through its components. These results are in conformity with the findings of Artiverma and Soniasood (2015), Tiwari *et al.* (2016) and Shwetha *et al.* (2018) in okra.

The nature of gene action has been inferred from the pooled estimates of GCA and SCA variances. The individual and pooled estimates of combining ability variances (ó^{2}gca and ó^{2}sca) and the ratio of ó^{2}gca/ó^{2}sca have been presented in Table 2. In the present investigation, the magnitude of *sca* variance greater than that of *gca* variance suggests the predominance of the non additive gene action for majority of the traits *viz.*, plant height, days to first flowring, first flowering node, days to first picking, days to last picking, fruit length, fruit girth, fruit weight, test weight, yield per plant, shelf life, fibre content and ascorbic acid content. However, for intermodal length, number of fruits per plant and number of seeds per fruit, maginitude of gca variance greater than sca variance suggests the predominance of additive gene action. Hence, pedigree selection could be exploited for these traits. These results of the present investigation are in conformity to the findings of Kachhadia *et al*., (2011), Parmar *et al*., (2012) and Kumar *et al.,* (2014). Since both additive and non-additive variances were found to be important in the genetic control of all quantitative and quality traits in the present study, the use of a population improvement method in the form of diallel selective mating or mass selection with concurrent random mating might lead to release of new varieties with higher yield in okra.

The estimates of GCA effects revealed that none of the parents were found good general combiners simultaneously for all the traits studied. Among the parents, two parents *viz*., HRB-9-2 and VRO-3 were observed to be good general combiners for fruit yield per plant. In addition to yield per plant the parent HRB-9-2 was also observed to be good general combiner for traits like days to last picking, internodal length, fruit girth, fruit length, fruit weight, number of fruits per plant, seeds per fruit while the parent VRO-3 was observed to be good general combiner for traits like days to first flowering, plant height, internodal length, days to 50% flowering and first flowering node. Thus these two parents were observed to be good combiners for fruit yield along with most of the other yield contributing triats. The identified superior general combiners (HRB-9-2 and VRO-3) can be used in future breeding programmes.

The estimates of specific combining ability effects indicated that none of the hybrids was found to be superior for all the traits under investigation. Among the hybrids, only one cross i.e 440-10-1 x HRB-9-2 recorded significant and positive *sca* effects for fruit yield per plant. The crosses VRO-6 x HRB-9-2, VRO-6 x JPM-20-16-39, VRO-3 x TCR-1674 were the other genotypes which recorde positive *sca* effects for yield and yield attributing characters. All the top crosses which exhibited high *sca* effects for fruit yield involved at leaset one good general combiner. Similar findings were earlier reported by Desai (1990), Patel *et al*.(1990), Poshiya and Vashi (1995), Pawar *et al*.(1999), Prakash *et al.* (2002), Pal and Sabesan (2009) and Dabhi *et al.*(2010) in okra. The identified hybrids could be exploited through heterosis breeding and it would be worth while to use them for improvement in fruit yield.

CONCLUSION

The presence of non-additive gene action revealed that heterosis breeding is required to be followed for further improvement of okra. Sufficient genetic variability was generated for yield and related traits after crossing six diverse genotypes of okra in a diallel mating design (excluding reciprocals).

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