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Gene action studies on yield and quality traits in okra (*Abelmoschus esculentus* (L.) Moench)

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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 28 F_1 hybrids derived by crossing 8 parental lines. The present study indicated the preponderance of non-additive gene action for days to 50% flowering, nodes per plant, fruit length, fruit diameter, plant height, fruits per plant and mucilage and a preponderance of additive gene action for days to first picking, first fruit producing node, internodal length, average fruit weight and harvest duration. For fruit yield per plant and dry matter, only dominant component of variance was observed which revealed the presence of non-additive gene action, hence, heterosis breeding is required to be followed for exploitation of these traits.

Key words: Gene action, okra, variance, diallel, fruit yield.

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench) is a warm season vegetable in the tropical and subtropical countries of the world. It is native of Ethiopia (Vavilov, 1951). The immature young seed pods are the edible part of this plant, which are consumed as cooked vegetable, mostly fresh but sometimes sun-dried. Okra is gaining importance with regard to its nutritional, medicinal, and industrial value. Apart from nutritional and health importance, okra plays an important role in income generation and subsistence among rural farmers in developing countries like India. It has a vast potential as one of the foreign exchange earner crops and accounts for 70% of the export of fresh vegetables excluding potato, onion and garlic, the destinations being the Middle East, Western Europe and USA. It is commercially grown in the Indian states of Gujarat, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. The prominent position of okra among Indian vegetables can be due to its easy cultivation, dependable and regular yield, wider adaptability and year round cultivation. In spite of its importance, no major breakthrough has been made in this crop and the farmers are still growing their own local varieties or open pollinated varieties. Hence, there is a need for restructuring this vegetable crop for increasing the productivity.

Knowledge on the genetic system controlling the quantitative and quality traits is important for formulating an efficient selection program through the use of a suitable mating design. The information about the relative contribution of components of variation *viz*., additive and

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non-additive, is essential for effective crop improvement program (Azhar and Ajmal, 1999). In order to apply an optimum breeding strategy for targeted quantitative and quality traits, a genetic analysis of those traits needs to be performed. 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). Several workers studied gene action of the yield and yield attributes and determined that additive and non-additive variance components are important in the genetic control of yield and its associated traits in okra (Jaiprakashnarayan et al., 2008; 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.

MATERIALS AND METHODS

Eight okra genotypes viz., P-20, 9801, VRO-4, Parbhani Kranti (PK), P-8, Hisar Unnat (HU), Tulsi-I and SKBS-11 were chosen in this study to represent substantial amount of genetic diversity for different quantitative and quality traits and were maintained through selfing during 2011. These eight genotypes were involved in 8 × 8 half-diallel combinations to develop 28 F_1 hybrids during 2012. All the F_1's along with their parents were evaluated in a Randomized Block Design with three replications during summer-rainy season of 2013 at Experimental Farm of the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur. The crop was raised in three rows of 2.5 m length with inter and intra row spacing of 45 and 15 cm, respectively. Standard agronomic practices were followed and plant protection measures were taken as and when required. The observations were recorded on five competitive plants in each entry and replication for the parameters *viz*., days to 50% flowering, days to first picking, first fruit producing node, nodes per plant, internodal length (cm), average fruit weight (g), plant height (cm), harvest duration (days), fruits per plant, fruit yield per plant (g), dry matter (%) and mucilage (%). For the parameters *viz*., fruit length (cm) and fruit diameter (cm), a random sample of five fruits/entry/replication was drawn from fourth and eighth pickings. The data recorded on five plants per treatment was averaged for use in statistical analysis. Data were analyzed according to ANOVA techniques, as outlined by Panse and Sukhatme (1985), 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

An important step in a breeding programme is to adopt a suitable breeding strategy for the purposeful management of generated variability which largely depends upon type of gene action in the population for the traits under genetic improvement (Sprague, 1966). A knowledge of gene action helps to set an appropriate breeding strategy to accumulate fixable genes through selection. Genetic improvement in pod yield has always been a top priority of okra breeders. Pod yield and its related parameters are quantitative traits, which are controlled by several genes thus showing a range of values in segregating generation. Genetic analysis helps in identifying traits for improvement of yield potential. Dependable biometrical techniques dealing with the genetic analysis of important characters have greatly helped plant breeder in ascertain the nature of gene action. Among various techniques, genetic analysis formulated by Griffing (1956), provides a workable approach to assess the gene action involved in various attributes, so as to design an efficient breeding plan, for further genetic upgrading of the existing material.

Analysis of variance

The analysis of variance carried out for different traits of okra, *viz.,* days to 50% flowering, days to first picking, first fruit producing node, nodes per plant, internodal length, fruit length, fruit diameter, average fruit weight, plant height, harvest duration, fruits per plant, fruit yield per plant, dry matter and mucilage are presented in Table 1. Analysis of variance reported significant differences for all the traits studied except dry matter and revealed that sufficient genetic variability was generated for yield and related traits after crossing eight diverse genotypes of okra in a diallel mating design (excluding reciprocals).

Estimates of genetic components of variance

The nature of gene action has been inferred from the estimates of GCA and SCA variances. The estimates of combining ability variances (σ^2gca and σ^2sca) and the ratio of σ^2A/σ^2D have been presented in Table 2. The values of σ^2sca ranged from 0.016 (mucilage) to 507.988 (fruit yield per plant), while σ^2gca ranged from -5.483 (fruit yield per plant) to 68.226 (plant height). The estimates of σ^2sca were higher in magnitude as compared to σ^2gca for all the characters except for first fruit producing node and harvest duration. The preponderance of σ^2sca revealed the predominant role of non-additive gene action governing these traits.

In the present investigation, the comparative estimates of σ^2sca, σ^2gca, σ^2A, σ^2D and σ^2A/σ^2D revealed that non-additive gene action is controlling the expression of days to 50% flowering, nodes per plant, fruit length, fruit diameter, plant height, fruits per plant and mucilage. For fruit yield per plant and dry matter, only dominant component of variance (σ^2D) was observed which indicated the presence of non-additive gene action, hence, heterosis breeding is required to be followed for exploitation of these traits. The traits *viz*., days to first picking, first fruit producing node, internodal length, average fruit weight and harvest duration are controlled by additive gene action, as the ratio σ^2A/σ^2D is greater

Table 1. Analysis of variance for quantitative and quality traits in okra.

Traits	Mean squares			
	Sources	Replication	Treatment	Error
	df	2	35	70
Quantitative traits				
Days to 50 % flowering		1.676	10.651*	2.676
Days to first picking		8.951	12.519*	3.939
First fruit producing node		0.073	0.262*	0.062
Nodes per plant		0.100	2.950*	1.023
Internodal length (cm)		0.259	3.927*	0.344
Fruit length (cm)		0.209	0.945*	0.331
Fruit diameter (cm)		1.201	3.713*	0.901
Average fruit weight (g)		1.542	2.126*	1.067
Plant height (cm)		108.193	1123.172*	188.028
Harvest duration (days)		14.074	17.986*	9.459
Fruits per plant		1.715	4.441*	1.159
Fruit yield per plant (g)		117.264	1723.012*	536.737
Quality traits				
Dry matter (%)		0.623	0.815	0.539
Mucilage (%)		0.009	0.049*	0.010

*Significant at 5% level.

Table 2. Variance due to general and specific combining ability and their ratio for different quantitative and qualitative traits in okra.

Components / Traits	σ^2 gca	σ^2sca	σ^2A	σ^2D	σ^2A /σ^2D
Quantitative traits					
Days to 50% flowering	0.593	1.840	1.187	1.840	0.645
Days to first picking	0.816	1.535	1.632	1.535	1.063
First fruit producing node	0.026	0.019	0.052	0.019	2.737
Nodes per plant	0.053	0.670	0.107	0.670	0.160
Internodal length (cm)	0.338	0.647	0.677	0.647	1.046
Fruit length (cm)	0.040	0.156	0.080	0.156	0.513
Fruit diameter (cm)	0.235	0.583	0.471	0.583	0.808
Average fruit weight (g)	0.110	0.167	0.220	0.167	1.317
Plant height (cm)	68.226	219.078	136.452	219.078	0.623
Harvest duration (days)	1.127	0.736	2.254	0.736	3.063
Fruits per plant	0.025	1.306	0.049	1.306	0.038
Fruit yield per plant (g)	-5.483	507.988	-10.965	507.988	-0.022
Quality traits					
Dry matter (%)	-0.001	0.118	-0.003	0.118	-0.025
Mucilage (%)	0.000	0.016	0.001	0.016	0.063

σ^2gca = general combining ability variance; σ^2sca = specific combining ability variance; σ^2A = additive component of variance and σ^2D = dominant component of variance.

than unity. Hence, pedigree selection could be exploited for these traits. For the traits *viz*., days to first picking, internodal length and average fruit weight, where σ^2sca is higher than σ^2gca but, σ^2D is less than σ^2A. It suggests that the estimates of GCA variance include additive variance and also a portion of additive and higher order epistatic interactions. Under such conditions, recurrent selections shall prove effective. 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). However, contradictory reports are also available in literature with respect to gene action studies which can be due to different genetic material used in the present study. 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.

Conclusion

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

Conflict of Interests

The authors have not declared any conflict of interests.

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