GENETIC ADVANCE UNDER SELECTION IN SEGREGATING POPULATION IN OKRA (*Abelmoschus esculentus* L.)

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ABSTRACT

Six generations viz., P_1, P_2, F_1, F_2, BC_1 and BC_2 of five crosses [Cross I (Punjab 7 x Arka Anamika), Cross II (Punjab 8 x Parbhani Kranti), Cross III (Hissar Unnat × GAO 5), Cross IV (Varsha Uphar x Phule Utkarsha) and Cross V (Pusa Sawani x GAO 5)] developed from nine diversified cultivars of okra (Abelmoschus esculentus (L.) Moench) were evaluated during rabi 2016 at Agriculture College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari using Compact family Block Design replicated thrice. High genetic advance for cross I (Punjab 7 x Arka Anamika) and cross II (Punjab 8 x Parbhani Kranti) observed with high heritability and moderate genetic advance exploited with high heritability for cross III (Hissar Unnat x GAO 5 and cross V (Pusa Sawani x GAO 5) for fruit yield per plant, suggested that it would be desirable to follow cyclic method of breeding involving conventional breeding approach of selection of superior recombinants and their inter-mating for the development of elite homozygous recombinants having high quality and high yielding potentiality.

KEY WORDS: Generation mean, Genetic advance, Fruit Yield, Okra, Selection Pressure

INTRODUCTION

Okra known in many English-speaking countries as ladies' fingers or ochro, is a flowering plant in the *Malvaceae* family. Okra is an allopolyploid of uncertain parentage (proposed parents include *Abelmoschus ficulneus*, *A. tuberculatus* and a reported "diploid" form of okra). The species is a perennial, often cultivated as an annual in temperate climates. *Abelmoschus esculentus* is cultivated throughout the tropical and warm temperate regions of the world for its fibrous fruits or pods containing round, white seeds. It is among the most heat and drought tolerant vegetable species in the world and will tolerate soils with heavy clay and intermittent moisture, but frost can damage the pods. Okra is available in two varieties, green and red. Red okra carries the same flavour as the more popular green okra, but differs only in colour. When cooked, the red okra pods turn green. The products of the plant are mucilaginous, resulting in the characteristic slime when the seed pods are cooked; the mucilage contains soluble fiber. Immature fruits (green seed pods), which are consumed as vegetables, can be used in salads, soups and stews, fresh or dried, fried or boiled (Ndunguru and Rajabu, 2004). It is

very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Krishnamurthy, 1994). Okra may be used in developing countries to mitigate malnutrition and alleviate food insecurity. The composition of okra pods per 100 g edible portion is: water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, Ca 84.00 mg, P 90.00 mg, Fe 1.20 mg, β-carotene 185.00 µg, riboflavin 0.08 mg, thiamin 0.04 mg, niacin 0.60 mg and 47.00 mg ascorbic acid (Owolarafe and Shotonde 2004; Gopalan *et al.*, 2007).

India is a major okra producing country in the world comprising 72 per cent of total area under okra. In India, okra is commercially grown in the states of Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab in *kharif* and summer season. In India, it is cultivated in 5.32 lakh ha with the annual production of 63.46 lakh tons and average productivity of 11.90 MT/ha, while in Gujarat, its area, production and productivity is 0.65 lakh ha, 7.59 lakh tons and 11.05MT/ha, respectively (Anonymous, 2014).

Heritability expresses the relative amount of heritable portion of variation; however, its estimate along with genetic advance is more useful in predicting the resultant effect of selecting the best individuals. Therefore, in the present study, heritability in broad sense was estimated along with genetic advance in five crosses through generation mean analysis.

MATERIALS AND METHODS

Five crosses [Cross I (Punjab 7 x Arka Anamika), Cross II (Punjab 8 x Parbhani Kranti), Cross III (Hissar Unnat × GAO 5), Cross IV (Varsha Uphar x Phule Utkarsha) and Cross V (Pusa Sawani x GAO 5)] were generated by crossing of nine diverse parents during late kharif 2014. Backcrossing was done in late summer 2015 with its respective parents and also the selfing of F_1s was done in the same season (summer 2015) to get F_2s. The evaluation trial was conducted in *rabi* 2016 at Agriculture College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari following Compact Family Block Design replicated thrice. Six generations were then randomly allotted to each plot within a block. Each plot consisted one row of P_1, P_2, F_1, two rows of BC_1 and BC_2 and four rows of F_2 generations. Each row was five meters long. The row-to-row and plant-to-plant distances were kept as 60 cm and 45 cm, respectively. Recommended agronomic practices in vogue along with necessary plant protection measures were timely adopted for successful raising of the good crop. The observations *viz*., days to flowering, plant height (cm), intermodal length (cm), number of internodes per plant, number of branches per plant, fruit length (cm), fruit diameter (cm), number of fruits per plant, fruit yield per plant, chlorophyll content (SPAD), total leaf area (cm^2), total phenols (mg/g DW) and total sugars (mg/g DW) were recorded following standard procedure. The data were subjected to analysis of variance for Compact Family Block Design following Panse and Sukhatme (1985). The expected genetic advance at 5 per cent level of selection intensity was estimated by using the following formula.

$$E.G.A. = K \times h2\,(n) \times \hat{\sigma}p\ ,$$

Where,

h2 (n) = *Heritability in narrow sense*

$\hat{}$ = *Phenotypic Standard Deviation*

K = *Selection Differential*

(K=2.06 at 5 % selection pressure)

The broad sense heritability in percent was calculated by using formula suggested by Warner (1952) as follows:

$$h2(b) = \frac{V_{F2} - V_{F1}}{V_{F2}} \times 100$$

Where,

h2b = Heritability in broad sense,

V_{F2} = *Variance of* F_2 *generation*

V_{F1} = *Variance of* F_1 *generation*

RESULTS AND DISCUSSION

Selection is made on the basis of phenotype, and phenotype is produced by the joint action of genotype and environment. Therefore, the phenotypic superiority of selected plants or families over original population is not solely due to their genotypic superiority. Improvement in the mean genotypic value of the selected families over that of the base population is known as genetic advance under selection in segregating population. Genetic advance under selection is depends upon the phenotypic variability among different plants or families over base population; the heritability of the character under selection and the intensity of selection i.e. the proportion of plant or families selected. The formula for genetic advance under selection may be written as

$$Gs = (k)(\sqrt{Vp})(Vg/Vp)$$

Where,

Gs = Genetic advance;

k = selection differential;

Vp = phenotypic variance; and

Vg = genotypic variance

The value of expected genetic advance for various characters is demarcated into three categories viz., low, moderate and high, as follows (Johnson *et al.*, 1955).

Low genetic advance : 0 - 10%
Moderate genetic advance : 10 - 20 %
High genetic advance : > 20 %

The results obtained on these aspects for different characters studied in all the crosses are presented (Table 1 and 2) and discussed hereunder:

Days to flowering

The genetic advance for days to flowering varied from 7.53 per cent (Punjab 7 x Arka Anamika) to 24.30 per cent (Varsha Uphar x Phule Utkarsha) (Table 1). The crosses, Varsha Uphar x Phule Utkarsha (24.30 %) showed high genetic advance and cross Pusa Sawani x GAO 5 (12.07 %) exhibited moderate genetic advance. Crosses *viz*., Hissar Unnat x GAO 5 (9.79 %), Punjab 8 x Parbhani Kranti (8.08 %) and Punjab 7 x Arka Anamika (7.53 %) exhibited low genetic advance. Broad sense heritability was ranged from 60.24 per cent (Pusa Sawani x GAO 5) to 90.00 per cent (Hissar Unnat x GAO 5).

Plant height (cm)

The estimates of genetic advance were higher in cross Hissar Unnat x GAO 5 (20.90 %), moderate in crosses Punajb 7 x Arka Anamika (13.32 %), Pusa Sawani x GAO 5 (12.23 %) and Varsha Uphar x Phule Utkarsha (10.97 %) and low for cross Punjab 8 x Parbhani Kranti (7.62 %) (Table 1). The broad sense heritability ranged from 55.99 per cent to 71.30 per cent. All the five crosses depicted high broad sense heritability for plant height.

Internodal length (cm)

The estimates of predicted genetic advance varied from 0.45 per cent (Punjab 8 x Parbhani Kranti and Pusa Sawani x GAO 5) to 0.78 per cent (Varsha Uphar x Phule Utkarsha) (Table 1). All the crosses had low genetic advance. The estimates of broad sense heritability for this trait ranged from 59.34 per cent (Hissar Unnat x GAO-5) to 71.56 per cent (Varsha Uphar x Phule Utkarsha). All the crosses depicted high broad sense heritability for this trait.

Number of internodes per plant

The values of expected genetic advance was high for Hissar Unnat x GAO 5 (32.06 %), moderate for Pusa Sawani x GAO 5 (10.48 %) and all other crosses showed low genetic advance (Table 1). The estimates of high heritability was observed for cross Hissar Unnat x GAO 5 (82.90 %). The broad sense heritability ranged from 10.08 per cent (Punjab 7 x Arka Anamika) to 82.90 per cent (Hissar Unnat x GAO-5).

Three crosses Hissar Unnat x GAO-5 (82.90 %), Pusa Sawani x GAO-5 (75.04 %) and Varsha Uphar x Phule Utkarsha (66.94 %) had high broad sense heritability.

Number of branches per plant

The values of expected genetic advance were low for all the crosses ranging from 0.04 to 0.89 per cent (Table 1). Broad sense heritability ranged from 15.60 per cent to 52.48 per cent for this trait.

Fruit length (cm)

The estimates of genetic advance were low for all the crosses except Pusa Sawani x GAO 5 (13.21 %), which had moderate genetic advance (Table 1). For fruit length, the broad sense heritability ranged from 48.34 per cent (Hissar Unnat x GAO 5) to 70.09 per cent (Varsha Uphar x Phule Utkarsha). Broad sense heritability were high for three crosses Varsha Uphar x Phule Utkarsha (70.09 %), Punjab 8 x Parbhani Kranti (63.35 %) and Pusa Sawani x GAO 5 (62.78 %), whereas crosses Punajb 7 x Arka Anamika (59.36 %) and Hissar Unnat x GAO 5 (48.34 %) had moderate broad sense heritability.

Fruit diameter (cm)

The values of expected genetic advance were low for all the crosses, ranging from 0.01 per cent to 0.03 per cent (Table 2). The estimates of broad sense heritability ranged from 21.52 per cent (Varsha Uphar x Phule Utkarsha) to 66.59 per cent (Punjab 7 x Arka Anamika). Moderate heritability was noted in crosses Hissar Unnat x GAO 5 (44.79 %), Punjab 8 x Parbhani Kranti (40.85 %) and Pusa Sawani x GAO 5 (34.37 %).

Number of fruits per plant

The values of genetic advance were low for all the crosses, which was ranged from 1.98 per cent to 4.40 per cent for this trait (Table 2). Broad sense heritability ranged from 42.42 per cent (Varsha Uphar x Phule Utkarsha) to 69.43 per cent (Punjab 8 x Parbhani Kranti). Moderate range of broad sense heritability was observed in all the crosses except cross Punjab 8 x Parbhani Kranti (69.43 %) exhibited high broad sense heritability.

Fruit yield per plant (g)

Genetic advance ranged from 8.30 per cent (Varsha Uphar x Phule Utkarsha) to 74.29 per cent (Punjab 7 x Arka Anamika) for fruit yield per plant (Table 2). The estimated genetic advance was high in crosses Punjab 7 x Arka Anamika (74.29 %) and Punjab 8 x Parbhani Kranti (72.40 %) and remaining three crosses showed low genetic advance. For fruit yield per plant, broad sense heritability ranged from 62.35 per cent to 78.30 per cent. The values of broad sense heritability were high for all the crosses Punjab 8 x Parbhani Kranti (78.30 %), Hissar Unnat x GAO 5 (76.09 %), Varsha Uphar x Phule Utkarsha (75.65 %), Punjab 7 x Arka Anamika (75.10 %) and Pusa Sawani x GAO 5 (62.35 %).

Chlorophyll content (SPAD)

Genetic advance ranged from 80.08 per cent to 40.99 per cent. The high genetic gain was depicted by crosses Varsha Uphar x Phule Utkarsha (80.08 %), Pusa Sawani x GAO 5 (65.97 %) and Punjab 7 x Arka Anamika (65.80 %) (Table 2). The estimates of broad sense heritability ranged from 43.53 per cent (Pusa Sawani x GAO-5) to 85.52 per cent (Varsha Uphar x Phule Utkarsha). Moderate broad sense heritability was depicted by all the crosses under study except two crosses Varsha Uphar x Phule Utkarsha (85.52 %) and Punjab 8 x Parbhani Kranti (68.49 %).

Total leaf area (cm^2)

High genetic advance was recorded in crosses Pusa Sawani x GAO 5 (69.68 %), Punjab 8 x Parbhani Kranti (37.72 %), Punjab 7 x Arka Anamika (31.49 %) and Varsha Uphar x Phule Utkarsha (25.78 %). Moderate genetic advance was recorded in one cross Hissar Unnat x GAO 5 (13.21 %) (Table 2). The broad sense heritability

ranged from 29.14 per cent to 86.00 per cent. For total leaf area, broad sense heritability were observed higher in crosses *viz*., Punjab 8 x Parbhani Kranti (86.00 %) and Hissar Unnat x GAO-5 (70.97 %), while moderate in crosses Punjab 7 x Arka Anamika and Pusa Sawani x GAO-5 (41.33 %).

Total phenols (mg/g DW)

The values of expected genetic advance were low for all the crosses for this trait (Table 2). The estimates of broad sense heritability ranged from 17.31 per cent (Hissar Unnat x GAO-5) to 64.31 per cent (Punjab 8 x Parbhani Kranti). In case of broad sense heritability cross Punjab 8 x Parbhani Kranti (64.31 %) showed high heritability, where moderate heritability in crosses Punjab 7 x Arka Anamika (59.32 %) and Varsha Uphar x Phule Utkarsha (38.74 %) and low heritability depicted in crosses Pusa Sawani x GAO-5 (21.71 %) and Hissar Unnat x GAO-5 (17.31 %).

Total sugars (mg/g DW)

The values of expected genetic advance were low for all the crosses, which was ranged from 0.07 to 3.34 (Table 2). The estimates of broad sense heritability ranged from 20.52 per cent (Pusa Sawani x GAO-5) to 93.65 per cent (Punjab 8 x Parbhani Kranti) for this character. In case of broad sense heritability, two crosses Punjab 8 x Parbhani Kranti (93.65 %) and Varsha Uphar x Phule Utkarsha (63.92 %) showed high heritability, whereas moderate heritability was depicted in crosses Punjab 7 x Arka Anamika (50.79 %) and Hissar Unnat x GAO 5 (34.78 %) and low heritability depicted in cross Pusa Sawani x GAO 5 (20.52 %).

In crop improvement, only genetic component of variation is important since that component is transmitted to the next generation. Heritability indicates the effectiveness with the selection of genotypes could be based on phenotypic performance. This could be achieved through determining heritability and genetic gain under selection. In the present investigation, low genetic advance was recorded for almost all the traits except fruit yield per plant, chlorophyll content and total leaf area where high genetic advance was observed while only trait plant height revealed moderate genetic advance in cross Punjab 7 x Arka Anamika. In cross Punjab 8 x Parbhani Kranti, traits like fruit yield per plant, chlorophyll content and total leaf area recorded high genetic advance and remaining all the traits showed low genetic advance. High genetic advance was observed in traits like plant height, number of internodes and chlorophyll content, while traits fruit yield per plant and total leaf area revealed moderate range of genetic advance in cross Hissar Unnat x GAO 5. Remaining all other traits showed low genetic advance range for this cross. In cross Varsha Uphar x Phule Utkarsha, high genetic advance was observed in traits like days to flowering, chlorophyll content and total leaf area and moderate range for genetic advance was recorded for plant height, while all other traits exhibited low range for genetic advance. Genetic advance was higher in traits chlorophyll content and total leaf area in cross Pusa Sawani x GAO 5. However, some traits revealed moderate range *viz*., plant height, number of internodes per plant, fruit length and fruit yield per plant whereas, all other traits showed low range for genetic advance in this cross. These results are similar to the findings of different scientists *viz.*, Gandhi *et al*. (2001), Dhankhar and Dhankhar (2002), Joshi (2004), Indurani and Veeraragavathatham (2005), Kumar *et al.* (2005), Adeniji *et al.* (2007), Kumar *et al.* (2007), Nasit *et al.* (2009), Khanorkar and Kathiria (2010), Prakash *et al.* (2011), Kumar *et al.* (2012) and Nwangburuka *et al.* (2012).

Johnson *et al.* (1955) found it more useful to estimate heritability values together with genetic advance in predicting the ultimate choice of best individuals by selection. High genetic gain along with high heritability showed most effective condition for selection. High heritability coupled with high genetic advance for cross I (Punjab-7 x Arka Anamika) and cross II (Punjab-8 x Parbhani Kranti) and high heritability coupled with moderate genetic advance for cross III (Hissar Unnat x GAO-5 and cross V (Pusa Sawani x GAO-5) for fruit yield per plant indicated heritability was due to additive gene effects. Moderate to high heritability coupled with moderate to high expected genetic advance for most of the characters suggested that it would be desirable to follow cyclic method of breeding involving conventional breeding approach of selection of superior recombinants and their inter-mating for the development of elite homozygous recombinants having high quality and high yielding potentiality. Thus, population improvement approaches involving high volume crossing like bi-parental, recurrent and diallel selective mating design that take care of both additive and non-additive gene actions are more promising for the improvement of various characters studied.

CONCLUSION

In the present investigation, high genetic advance for cross I (Punjab 7 x Arka Anamika) and cross II (Punjab 8 x Parbhani Kranti) observed with high heritability and moderate genetic advance exploited with high heritability for cross III (Hissar Unnat x GAO 5 and cross V (Pusa Sawani x GAO 5) for fruit yield per plant, suggested that it would be desirable to follow cyclic method of breeding involving conventional breeding approach of selection of superior recombinants and their inter-mating for the development of elite homozygous recombinants having high quality and high yielding potentiality.

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Table 1: Estimates of heritability and genetic advance for days to flowering, plant height, internodal length, number of internodes per plant, number of branches per plant and fruit length in five crosses of okra

Estimates (%)	Days to Flowering	Plant Height (cm)	Internodal Length (cm)	Number of Internodes per Plant	Number of Branches per Plant	Fruit Length (cm)
Cross I (Punjab-7 x Arka Anamika)						
Heritability (BS) %	62.92	55.99	63.91	10.08	48.73	59.36
Genetic advance %	7.53	13.32	0.47	0.73	0.14	1.49
Cross II (Punjab-8 x Parbhani Kranti)						
Heritability (BS) %	68.27	57.54	65.52	49.97	39.09	63.35
Genetic advance %	8.08	7.62	0.45	0.97	0.04	4.83
Cross III (Hissar Unnat × GAO-5)						
Heritability (BS) %	90.00	61.11	59.34	82.90	36.02	48.34
Genetic advance %	9.79	20.90	0.56	32.06	0.89	1.31
Cross IV (Varsha Uphar x Phule Utkarsha)						
Heritability (BS) %	73.11	71.30	71.56	66.94	15.60	70.09
Genetic advance %	24.30	10.97	0.78	5.95	0.22	1.27
Cross V (Pusa Sawani x GAO-5)						
Heritability (BS) %	60.24	62.05	68.19	75.04	52.48	62.78
Genetic advance %	12.07	12.23	0.45	10.48	0.77	13.21

Table 2: Estimates of heritability and genetic advance for fruit diameter, number of fruits per plant, fruit yield per plant, chlorophyll content, total leaf area, total phenols and total sugars in five crosses of okra

Estimates (%)	Fruit Diameter (cm)	Number of Fruits per Plant	Fruit Yield per Plant (g)	Chlorophyll Content (SPAD)	Total Leaf Area (cm2)	Total Phenols (mg/g DW)	Total Sugars (mg/g DW)
Cross I (Punjab-7 x Arka Anamika)							
Heritability (BS) %	66.59	49.06	75.10	47.63	41.33	59.32	50.79
Genetic advance %	0.03	4.16	74.29	65.80	31.49	0.10	0.12
Cross II (Punjab-8 x Parbhani Kranti)							
Heritability (BS) %	40.85	69.43	78.30	68.49	86.00	64.31	93.65
Genetic advance %	0.01	1.98	72.40	40.99	37.72	3.44	1.91
Cross III (Hissar Unnat × GAO-5)							
Heritability (BS) %	44.79	59.34	76.09	46.35	70.97	17.31	34.78
Genetic advance %	0.02	4.40	14.96	54.58	13.21	0.23	0.33
Cross IV (Varsha Uphar x Phule Utkarsha)							
Heritability (BS) %	21.52	42.42	75.65	85.52	29.14	38.74	63.92
Genetic advance %	0.02	4.13	8.30	80.08	25.78	0.21	3.34
Cross V (Pusa Sawani x GAO-5)							
Heritability (BS) %	34.37	54.39	62.35	43.53	41.33	21.71	20.52
Genetic advance %	0.01	4.18	12.65	65.97	69.68	0.97	0.07

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