Genetic Behavior of Families Selected from Some Local Okra (*Abelmoschus esculentus* L. Moench) Populations in Egypt

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ABSTRACT The objectives of the study were to investigate the genetic behavior of some biological and economical traits of 14 okra populations collected from Dakahlia Governorate, which underwent two cycles of inbreeding with selection. Selection of individual plants based on earliness, high number of pods, and minimum neck/pod ratio was carried out in all generations. The results showed that the means and ranges of all studied traits for all families became smaller in the S₂ generation than those in the S₀ generation. Highly significant variations were observed among populations for all the studied traits. The mean performance clearly indicated the agronomic superiority of some families over the others. Family 9 followed by family 12 showed the earliest flowering plants and the highest yield per plant. Phenotypic variances were higher than the corresponding genotypic variances indicating predominance of environmental effects on the expression of these characters. The magnitude of phenotypic and genotypic coefficients of variation varied from one trait to another. High broad-sense heritability coupled with high genetic advance as percent of mean were shown by the different traits, especially, plant height, number of branches per plant, number of pods per plant, pod length, neck/pod ratio and plant yield. This implicates that these traits were under the control of additive genetic effects, and could be effectively improved through selection. Plant yield had positive and highly significant correlation at genotypic and phenotypic level with number of pods per plant, plant height and neck/pod ratio.

Keywords *Abelmoschus esculentus*, Okra, Inbred families, Variances, Heritability, Genetic advance, Correlation coefficients, Selection

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is a popular summer vegetable crop in Egypt. The cultivated area in Egypt for okra was nearly 17 thousand feddan (one fed. = 4200m²), and produced about 97 thousand ton in 2012 cropping season (EMARS 2013). It is a rich source of many nutrients, including fibers and vitamins (Moyin-Jesu 2007).

The most widely produced okra cultivars in Egypt are known as Balady. Mostly, this cultivar is cultivated based on local open-pollinated seeds, which are maintained by farmers, produced for self-consumption and sold at local market.

Various okra cultivars show a lot of variability in many characters, such as yield, days to first flower appearance, number of pods per plant and plant height (Abo El-Khar

2003; Masoud *et al.* 2007). There are great variations in vegetative growth, earliness, productivity and pods quality in okra plants especially those that are grown in Dakahlia Governorate. Hence, they are considered as a rich source of variation and can be used as a main selection material in breeding programs to improve the characteristics of this crop. Accordingly, it is crucial to exploit effective breeding programs for okra improvement depending on selection assessments.

Inbreeding with selection was very sufficient in recovering desirable families from okra. In this respect, Hussein (1994), Moualla *et al.* (2005) and Masoud *et al.* (2007) studied the biological and economic features of some families, resulting from applying individual plant selection to some okra populations. They found the considerable variability in all studied traits, and they reported that improv-

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ing these characters should be effective and rewarding during selection, and selected families can be used for breeding programs to produce new cultivars.

Therefore, this study was conducted to select superior families from local okra populations (collected from different locations in Dakahlia Governorate) through inbreeding and selection programs.

MATERIALS AND METHODS

Plant growth conditions

This investigation was carried out at El-Baramoon Experimental Farm, Dakahlia Governorate (latitude 31°04'31" N, longitude 31°37'67" E and altitude 19 m above sea level) during the three summer seasons of 2010, 2011 and 2012. The soil texture at the experimental site is clay-loam.

Plant material and experimental procedure

A total of 14 mature pods were obtained from 14 okra populations collected from different locations in Dakahlia Governorate. Seeds were separately extracted from each pod. Each genotype was cultivated on April 5, 2010 in two rows. The row was 5 m long and 70 cm wide with 30 cm in-row spacing. The seedlings were thinned out to only one plant per hill. The culture practices were applied as recommended for okra production.

Plants were self-pollinated to produce S₁ seeds. The following traits were recorded in selected individual plants: days to first flower appearance, number of pods per plant, pod length (cm), pod diameter (cm), neck/pod ratio (expressed as neck weight/ pod weight X 100) and pod yield per plant (g), moreover, plant height (cm) and number of branches per plants were recorded at 90 days after planting.

Days to first flower appearance, neck/pod ratio and pod yield per plant were used as the basis of selection of plants in all generations. The best plant from each family was selected and kept separately. The selected families were denoted (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13 and 14).

In 2011 season, seeds of selected plants after first cycle (S₁) were separately sown on March 28. The cultural practices were conducted similarly as the first season. The 14 selected

families were self-pollinated to continue the inbreeding program. The plants were selected from each family to produce S₂ families.

In 2012 season, all S₂ selected families were sown on March 26 using a randomized complete block design with three replications. Each experimental unit contained three rows, 5 m long and 70 cm wide, while plants were 30 cm apart within each row.

The field procedures were the same as in the first and second seasons. A random sample of ten plants from each plot was used for taking observations on the eight above-mentioned traits as in the 2010 season.

Data analysis

The data were statistically analyzed according to Snedecor and Cochran (1982). Comparisons among means of families were tested using LSD values at 5% and 1% levels.

The components of variance were computed using the observed mean square values as outlined by Johnson *et al.* (1955) by using the following formulae:

$$\sigma^2_g = (MS_g - MS_e) / r, \sigma^2_e = MS_e \text{ and } \sigma^2_{ph} = \sigma^2_g + \sigma^2_e$$

where σ^2_g , σ^2_e and σ^2_{ph} are the variances due to genotypes, experimental error and phenotypes, respectively. MS_g , MS_e and r are the mean squares of genotypes, mean squares of error and number of replicates, respectively.

Phenotypic (PCV) and genotypic (GCV) coefficient of variation were evaluated according to the methods of Johnson *et al.* (1955) and Hanson *et al.* (1956) as follows:

$$PCV = [\sqrt{\sigma^2_{ph} / X}] \times 100$$

$$GCV = [\sqrt{\sigma^2_g / X}] \times 100$$

where σ^2_{ph} , σ^2_g and X are the phenotypic variances, genotypic variances and grand mean for each trait, respectively.

Broad-sense heritability (h^2_B) was calculated according to Allard (1999) as the ratio of the genotypic variance (σ^2_g) to the phenotypic variance (σ^2_{ph}).

Expected genetic advance after one generation of selection

(GA) and GA as percentage of the mean assuming selection of the superior 5% of the genotypes were estimated according to the formulae given by Johnson *et al.* (1955) as follows:

$$\begin{aligned} \text{GA} &= K \cdot h^2 B \cdot \sqrt{\sigma^2_{ph}}; \text{GA (as \% of the mean)} \\ &= (\text{GA}/X) \times 100 \end{aligned}$$

where K is the selection differential (2.06 for selecting 5% of the genotypes).

In order to estimate the genotypic and phenotypic correlations between pairs of traits, a covariance analysis was made between all possible pairs of studied traits, and they were calculated from the following equations as outline by Singh and Choudhary (1979):

$$\begin{aligned} \text{Genotypic correlation } (r_g) &= \text{Cov } g_1g_2 / (\sigma^2_{g_1} \cdot \sigma^2_{g_2})^{1/2} \\ \text{Phenotypic correlation } (r_{ph}) &= \text{Cov } ph_1ph_2 / (\sigma^2_{ph_1} \cdot \sigma^2_{ph_2})^{1/2} \end{aligned}$$

Where: Cov g_1g_2 = the genotypic correlation between any pairs of traits.

Cov ph_1ph_2 = the phenotypic correlation between any pairs of traits.

$\sigma^2_{g_1}$ and $\sigma^2_{g_2}$ are the genotypic variance of the first and second trait, respectively.

$\sigma^2_{ph_1}$ and $\sigma^2_{ph_2}$ are the phenotypic variance of the first and second trait, respectively.

The significance of the r_g and r_{ph} were tested with “t” test as described by Cochran and Cox (1957).

RESULTS

Response to selection

The results of the selection program for 14 families were recorded in Tables 1 and 2. These tables represent the means and ranges for each selected generation for each of the 14 families. The mean performance of selected families show a remarkable change in all studied traits in S_2 generation compared in S_0 generation. A decrease in mean values of all studied traits were observed from S_0 to S_2 generation. At the same time, the results show that the ranges of all

studied traits for all selected families became smaller in the S_2 generation than those in the S_0 generation.

Moreover, the analysis of variance for the studied traits showed that the differences among genotypes were highly significant for all studied traits (Table 3).

Behavior of the 14 selected families in S_2 generation

The means of the 14 selected families of the second cycle for all studied traits are presented in Table 4. Obtained results clearly indicate that all 14 selected families in the second cycle exhibited highly significant differences for all studied traits. The mean performance showed a clear indication of agronomic superiority of some families over the other. Data revealed that plants in families 12 and 9 were the earliest to flower (65.2 days) and (67.0 days), respectively. On the other hand, plants in family 5 were the latest ones to flower (78.3 days) compared with the other families. Regarding to plant height, the tallest plants (150.9 cm) belong to family 12 whereas, family 11 plants exhibited the shortest growth (97.1cm). For number of branches per plant, family 1 showed the profuse plants (9.14) whereas the family 4 possessed the lowest branched plants (3.32). For number of pods per plant, family 1 possessed the highest values for number of pods (91.8) among the 14 genotypes. On the other hand, family 5 possessed the lowest value (56.1). Results also showed that family 2 possessed the highest value for pod length (3.8 cm), but family 5 possessed the lowest value (2.3 cm). Family 12 had maximum pod diameter (2.1 cm), whereas, family 1 had the lowest mean (1.3 cm). Family 11 had maximum neck/pod ratio (30.04), while family 5 had the lowest mean (18.98). For yield per plant families 9 and 12 exhibited the highest value of 403.8 and 394.1 g/plant, respectively. On the other hand, family 5 exhibited the lowest value (255.5 g/plant) compared with the other families.

Genetic variation

The data presented in Table 5 showed that the genotypic and phenotypic estimated variances of all traits being studied appeared large, in comparison with the estimated values of error variance. Furthermore, phenotypic variances were higher than the corresponding genotypic variances.

Table 1. The means of all studied traits for 14 selected families of okra at S₀, S₁ and S₂ generations.

Families		Days to first flower appearance	Plant height (cm)	No. branches	No pods /plant	Pod length (cm)	Pod diameter (cm)	Neck/pod ratio	Plant yield (g)
1	S ₀	78.1	120	8.9	99.3	3.9	1.8	30.3	397
	S ₁	75.6	113	8.9	94.5	3.5	1.5	29.9	378
	S ₂	73.5	108	8.8	91.8	3.2	1.3	28.9	361
2	S ₀	78.3	116	7.6	63.1	4.5	2.1	28.8	356
	S ₁	74.4	108	7.2	59.3	4.1	1.9	26.8	325
	S ₂	71.3	104	6.9	57.0	3.8	1.7	25.5	309
3	S ₀	81.0	113	7.1	72.2	4.2	1.9	28.5	348
	S ₁	79.5	107	6.3	68.4	3.8	.7	27.0	321
	S ₂	77.5	102	5.4	65.5	3.5	1.5	25.9	299
4	S ₀	79.3	156	5.5	76.5	3.9	2.2	30.0	337
	S ₁	76.7	150	4.3	72.7	3.5	1.9	28.6	311
	S ₂	73.1	146	3.3	68.9	3.1	1.7	27.2	288
5	S ₀	81.8	137	7.4	61.5	2.9	2.1	22.1	295
	S ₁	79.6	131	6.3	58.1	2.6	1.8	20.2	269
	S ₂	78.3	128	5.1	56.1	2.3	1.5	19.0	256
6	S ₀	79.4	125	7.8	69.0	4.0	2.2	29.4	340
	S ₁	75.6	119	7.1	65.7	3.7	1.9	27.6	311
	S ₂	73.2	116	6.3	62.2	3.4	1.7	26.1	293
7	S ₀	77.7	149	6.7	95.3	4.1	2.4	29.7	382
	S ₁	73.8	143	5.8	89.6	3.8	2.2	27.5	363
	S ₂	70.4	139	5.4	86.6	3.6	2.0	26.3	349
8	S ₀	79.8	127	7.7	85.3	4.0	1.8	24.5	335
	S ₁	77.6	121	7.1	81.8	3.6	1.6	22.9	309
	S ₂	75.9	117	6.3	78.2	3.3	1.4	21.6	293
9	S ₀	73.4	135	7.2	89.6	3.9	2.2	27.2	438
	S ₁	69.5	130	6.6	85.3	2.6	1.9	25.2	416
	S ₂	67.0	127	5.2	81.5	3.2	1.7	23.9	404
10	S ₀	76.7	135	6.4	81.4	3.2	2.0	28.9	356
	S ₁	72.6	128	5.3	77.9	2.8	1.8	26.8	329
	S ₂	69.3	127	4.2	74.4	2.5	1.6	25.5	311
11	S ₀	77.1	106	6.7	83.1	3.3	1.9	32.4	358
	S ₁	73.3	101	6.0	78.3	3.0	1.7	31.1	333
	S ₂	70.7	97	5.1	75.7	2.8	1.6	30.0	315
12	S ₀	74.0	158	6.3	96.6	4.1	2.5	29.9	436
	S ₁	68.2	153	5.6	92.7	3.8	2.3	28.3	410
	S ₂	65.2	151	4.4	89.3	3.5	2.1	27.1	394
13	S ₀	79.5	149	6.8	97.1	3.3	1.6	31.7	412
	S ₁	76.7	145	6.2	93.4	2.9	1.4	30.1	390
	S ₂	73.6	143	5.1	90.7	2.7	1.3	29.7	377
14	S ₀	76.4	144	6.5	87.6	4.2	2.1	24.1	398
	S ₁	72.6	139	5.3	82.1	3.9	1.9	21.8	370
	S ₂	70.9	136	4.4	78.2	3.6	1.8	20.6	353

Table 2. The ranges of all studied traits for 14 selected families of okra at S₀, S₁ and S₂ generations.

Families		Days to first flower appearance	Plant height (cm)	No. branches	No pods /plant	Pod length (cm)	Pod diameter (cm)	Neck/pod ratio	Plant yield (g)
1	S ₀	66-81	94-129	8-9	80-103	2.7-4.1	1.2-2.2	24.0-31.1	318-416
	S ₁	69-78	99-121	8-9	84-98	2.8-3.7	1.2-1.9	25.4-30.3	329-399
	S ₂	71-75	102-115	8-9	86-96	2.9-3.5	1.2-1.6	26.6-29.2	341-382
2	S ₀	65-80	92-124	5-8	49-68	3.4-4.7	1.3-2.3	21.6-29.5	281-383
	S ₁	66-77	95-116	5-7	52-64	3.5-4.4	1.3-2.1	22.9-28.0	292-358
	S ₂	68-73	97-109	5-7	54-61	3.6-4.1	1.4-1.9	24.1-16.8	299-353
3	S ₀	67-83	103-122	5-8	54-76	3.1-4.5	2.1-2.2	21.2-29.8	248-386
	S ₁	70-81	95-115	5-7	58-72	3.2-4.2	2.1-2.0	22.5-28.5	266-354
	S ₂	73-79	89-109	5-7	61-79	3.3-3.9	2.2-2.8	23.9-26.7	271-321
4	S ₀	65-81	128-166	3-6	56-81	2.7-4.1	1.2-2.4	21.9-31.2	249-373
	S ₁	67-78	135-159	3-5	61-76	2.8-3.6	1.4-2.2	23.9-29.9	261-342
	S ₂	70-75	140-151	3-5	64-73	2.9-3.3	1.5-2.0	25.1-28.8	271-310
5	S ₀	66-83	11-149	4-8	50-65	2.1-3.1	1.1-2.3	17.1-23.6	208-327
	S ₁	71-81	118-138	4-7	52-62	2.1-2.7	1.2-2.1	17.5-21.4	220-292
	S ₂	74-80	122-134	4-8	54-59	2.2-2.5	1.3-1.9	17.8-20.3	234-273
6	S ₀	65-81	99-137	5-8	51-73	3.1-4.1	1.1-2.4	22.1-30.6	221-386
	S ₁	67-77	103-131	5-7	54-68	3.1-3.8	1.3-2.2	23.2-28.9	249-351
	S ₂	70-74	109-124	5-7	57-65	3.2-3.6	1.4-2.0	24.1-27.8	262-328
7	S ₀	63-79	120-159	5-7	72-100	3.1-4.2	1.3-2.6	21.5-31.0	296-405
	S ₁	66-75	126-150	5-6	77-94	3.3-4.0	1.5-2.4	24.0-29.8	315-378
	S ₂	68-73	131-144	5-6	81-91	3.4-3.8	1.7-2.2	25.1-28.1	324-367
8	S ₀	67-82	104-138	5-8	62-92	2.9-4.1	1.1-2.1	18.0-27.2	250-371
	S ₁	70-80	109-130	5-8	67-87	3.0-3.8	1.2-1.9	19.1-22.7	267-329
	S ₂	72-78	113-125	5-7	71-83	3.1-3.5	1.2-1.7	20.3-23.5	278-318
9	S ₀	60-75	111-148	4-8	65-95	2.7-4.1	1.1-2.4	19.5-29.5	419-451
	S ₁	63-72	117-142	4-7	70-89	2.9-3.8	1.3-2.2	20.1-27.1	395-438
	S ₂	65-69	122-135	4-6	73-86	3.0-3.5	1.4-2.0	21.6-25.4	372-427
10	S ₀	61-79	102-144	3-7	55-88	2.0-3.5	1.1-2.3	20.9-29.9	318-381
	S ₁	64-75	113-137	3-6	60-82	2.1-3.2	1.3-2.1	22.2-28.2	287-348
	S ₂	66-72	119-134	3-5	63-78	2.2-3.0	1.3-1.9	23.3-27.8	273-329
11	S ₀	60-79	84-121	4-7	60-89	2.2-3.7	1.1-2.1	24.3-32.9	326-386
	S ₁	63-76	90-115	4-7	65-84	2.4-3.4	1.3-1.9	26.1-32.5	305-354
	S ₂	65-73	94-109	4-6	69-81	2.5-3.1	1.3-1.8	27.2-31.2	276-329
12	S ₀	60-77	119-167	3-7	65-101	2.7-4.2	1.3-2.6	21.8-31.6	330-458
	S ₁	62-72	124-162	3-6	71-95	3.0-4.0	1.5-2.4	23.1-30.5	355-431
	S ₂	63-69	130-158	3-6	73-92	3.2-3.8	1.7-2.3	24.4-29.4	368-418
13	S ₀	65-81	112-158	4-7	71-104	2.0-3.6	1.1-1.9	24.6-32.6	317-440
	S ₁	67-78	117-152	4-7	78-98	2.2-3.2	1.2-1.7	26.1-31.4	331-411
	S ₂	69-75	121-148	4-6	82-96	2.4-3.0	1.2-1.5	27.2-30.2	343-385
14	S ₀	63-80	113-157	3-7	58-92	2.8-4.4	1.1-2.4	17.2-27.0	296-421
	S ₁	66-76	120-151	3-7	64-87	3.1-4.1	1.3-2.2	17.9-24.4	314-396
	S ₂	68-73	126-144	3-6	67-83	3.3-3.9	1.5-2.0	18.5-22.7	326-372

Table 3. Analysis of variance for all studied traits in 14 selected families of okra after two cycles of pedigree selection.

Source of variation	df	Days to first flower appearance	Plant height (cm)	No. branches	No pods/plant	Pod length (cm)	Pod diameter (cm)	Neck/pod ratio	Plant yield (g)
Replicates	2	0.81	0.14	0.01	0.54	0.003	0.001	10.38	1.26
Genotype	13	36.76**	919.03**	7.54**	438.18**	0.605**	0.164**	32.63**	5896.38**
Error	26	2.27	9.89	0.44	9.72	0.026	0.026	0.13	205.71

Table 4. Mean performance of 14 selected families of okra after two cycles of pedigree selection for studied traits.

Families	Days to first flower appearance	Plant height (cm)	No. branches	No. pods/plant	Pod length (cm)	Pod diameter (cm)	Neck/pod ratio	Plant yield (g)
1	73.5	108.2	8.81	91.8	3.2	1.3	28.94	360.9
2	71.3	103.7	6.87	57.0	3.8	1.7	25.54	308.7
3	75.5	101.5	5.35	65.5	3.5	1.5	25.89	299.2
4	73.1	146.4	3.32	68.9	3.1	1.7	27.17	288.3
5	78.3	127.7	5.11	56.1	2.3	1.5	18.98	255.5
6	73.2	115.8	6.27	62.3	3.4	1.7	26.14	293.1
7	70.4	139.4	5.43	86.6	3.6	2.0	26.34	348.6
8	75.9	117.3	8.25	78.2	3.3	1.4	21.60	292.7
9	67.0	127.2	5.18	81.5	3.2	1.7	23.93	403.8
10	69.3	124.2	4.23	74.4	2.5	1.6	25.52	311.4
11	70.7	97.1	5.08	75.7	2.8	1.6	30.04	315.0
12	65.2	150.9	4.36	89.3	3.5	2.1	27.08	394.1
13	73.6	142.6	5.12	90.7	2.7	1.3	29.71	376.5
14	70.9	136.0	4.40	78.2	3.6	1.8	20.55	353.3
General mean	72.0	124.1	5.6	75.4	3.2	1.6	25.5	328.7
L.S.D.								
0.05	2.53	5.28	1.12	5.23	0.270	0.271	0.61	24.07
0.01	3.42	7.14	1.51	7.07	0.365	0.367	0.82	32.54

Table 5. Genetic estimates of all studied traits in 14 selected families of okra after two cycles of inbreeding with selection.

Traits	Variance		Coefficient of variation		Heritability h^2B	GA*
	σ^2_g	σ^2_{ph}	σ^2_{gl}	GCV (%)		
Days to first flower appearance	11.49	13.77	2.27	4.71	5.15	0.83
Plant height (cm)	303.05	312.94	9.89	14.02	14.25	0.97
No. branches	2.37	2.81	0.44	27.57	30.05	0.84
No. pods/plant	142.82	152.54	9.72	15.84	16.37	0.94
Pod length (cm)	0.193	0.219	0.026	13.83	14.73	0.88
Pod diameter (cm)	0.046	0.072	0.026	13.12	16.43	0.64
Neck/pod ratio	10.83	10.96	0.13	12.89	12.97	0.99
Plant yield (g)	1896.89	2102.60	205.71	13.25	13.95	0.90

*GA = Genetic advance as percent of mean

Table 5 data set also revealed that the magnitude of phenotypic and genotypic coefficients of variation varied from one trait to another. The phenotypic coefficient of variation (PCV) was higher than genotypic coefficient of variation (GCV) for all studied traits. In particular, a higher PCV and GCV estimates were found for number of branches per plant. The moderate PCV and GCV estimates were found for pod diameter (16.43, 13.12), number of pods per plant (16.37, 15.84), pod length (14.73, 13.83), plant height (14.25, 14.02), plant yield (13.95, 13.25) and neck/pod ratio (12.97, 12.89). Minimum values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were recorded for days to first flower appearance (5.15, 4.71). A narrow range of difference between PCV and GCV was recorded for days to first flower appearance, plant height, number of pods per plant, pod length, neck/pod ratio and plant yield (Table 5). On the contrary, a wide difference between PCV and GCV was observed for pod diameter and number of branches per plant.

The broad-sense heritability estimates were generally high for all the characters under study except for pod diameter which registered moderate value (0.64) (Table 5). High broad-sense heritability coupled with high genetic advance as percent of mean were shown by the different

traits, especially, plant height, number of branches per plant, number of pods per plant, pod length, neck/pod ratio and plant yield (Table 5). Pod diameter showed moderately high heritability (0.64) with high genetic advance as percent of mean (21.59). High heritability (0.83) but low genetic advance as percent of mean (8.86) was noted for days to first flower appearance trait.

Association between studied traits

Genotypic and phenotypic correlations for all possible combinations for traits under study are presented in Table 6. The results clearly show that the magnitudes of the genotypic correlations were almost similar or very close to the corresponding phenotypic correlation.

Plant yield had positive and highly significant correlation at genotypic and phenotypic level with number of pods per plant, plant height and neck/pod ratio (Table 6).

Days to first flower appearance showed negative and significant association with plant height, number of pods per plant, pod diameter and plant yield at genotypic and phenotypic level (Table 6).

Plant height was positively and significantly correlated with number of pods per plant and pod diameter while it had negative and highly significant association with number of branches per plant at genotypic and phenotypic level

Table 6. Estimates of genotypic (r_g) and phenotypic (r_{ph}) correlations among all studied traits of S_2 okra.

Traits		Plant height (cm)	No. branches	No. pods/ plant	Pod length (cm)	Pod diameter (cm)	Neck/ pod ratio	Plant yield (g)
Days to first flower appearance	r_g	-0.31*	0.41**	-0.45**	-0.35*	-0.70**	-0.30*	-0.73**
	r_{ph}	-0.33 *	0.24 ^{ns}	-0.47 **	-0.19 ^{ns}	-0.67 **	-0.30 *	-0.73 **
Plant height (cm)	r_g		-0.60**	0.39**	-0.05 ^{ns}	0.46**	-0.12 ^{ns}	0.36*
	r_{ph}		-0.48 **	0.41 **	-0.09 ^{ns}	0.44 **	-0.10 ^{ns}	0.39 **
No. branches	r_g			0.09 ns	0.30*	-0.62**	0.014 ^{ns}	-0.08 ^{ns}
	r_{ph}			0.16 ns	0.14 ^{ns}	-0.31 *	0.04 ^{ns}	0.04 ^{ns}
No. pods/plant	r_g				0.09 ^{ns}	-0.001 ^{ns}	0.43**	0.81**
	r_{ph}				0.01 ^{ns}	0.115 ^{ns}	0.43**	0.82**
Pod length (cm)	r_g					0.61**	0.03 ^{ns}	0.32*
	r_{ph}					0.30*	0.01 ^{ns}	0.18 ^{ns}
Pod diameter (cm)	r_g						-0.09 ^{ns}	0.23 ^{ns}
	r_{ph}						-0.05 ^{ns}	0.34*
Neck/pod ratio	r_g							0.34*
	r_{ph}							0.34*

(Table 6).

Negative and significant correlations were observed between number of branches per plant and pod diameter at genotypic and phenotypic level. Number of pods per plant showed positive and significant correlation with plant height and neck/pod ratio at genotypic and phenotypic level. Pod length was found to be positively and significantly correlated with pod diameter (Table 6).

DISCUSSION

The narrow ranges of values which were noticed in the S₂ generation indicate that all studied traits reached a certain degree of uniformity and less degree of variability due to inbreeding and direct selection. These results are in agreement with those obtained by Hussein (1994), Moualla *et al.* (2005) and Masoud *et al.* (2007) who found that the selection in okra is the most effective in improving quantitative traits.

The highly significant differences detected among the means of the 14 selected families of the second cycle for all studied traits indicated that there was a wide range of variation among the studied genotypes for all studied traits which provides an opportunity for selecting suitable genotypes with better performance for the traits. This result also implied that these populations of okra genotypes would respond positively to selection. Similar results were obtained by Martinello *et al.* (2001), Abo El-khar (2003), Omonhinmin and Osawaru (2005), Bello *et al.* (2006), Jindal *et al.* (2010), Das *et al.*, (2012), El-Gendy (2012), Thirupathi *et al.* (2012) and Simon *et al.* (2013).

For all the studied traits, the genotypic and phenotypic estimated variances appeared large, in comparison with the estimated values of error variance; such result seemed to indicate that the number of replicates used in the evaluation experiment of these genotypes were adequate to give a better estimation for the error variance. Furthermore, phenotypic variances were higher than the corresponding genotypic variances indicating predominance of environmental effects on the expression of these characters. Moreover, the genotypic variance contributed a major proportion of total variance in all the studied traits suggesting that these traits were

under the genetic control. The present findings were in conformity with the reports of AdeOluwa and Kehinde (2011). The estimates of phenotypic coefficient of variation (PCV) in general, were higher than the estimates of genotypic coefficient of variation (GCV) for all the characters, which suggested that the apparent variation is not only due to the genotypes but also due to the influence of environment. Number of branches per plant showed high PCV and GCV estimates. While, the characters *viz.* pod diameter, number of pods per plant, pod length, plant height, plant yield and neck/pod ratio showed moderate PCV and GCV estimates. These suggest that this character is under genetic control. Hence, these characters can be subjected to selection for further improvement. Similar results were also reported by Bendale *et al.* (2004), Mehta *et al.* (2006), Magar and Madrap (2009), Jindal *et al.* (2010), AdeOluwa and Kehinde (2011), Das *et al.* (2012), Thirupathi *et al.* (2012) and Jagan *et al.* (2013). Days to first flower appearance had minimum values of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV). This type of findings indicate that very minimum variation existed among the genotypes with respect to this trait. The characters like days to first flower appearance, plant height, number of pods per plant, pod length, neck/pod ratio and plant yield showed a narrow range of difference between PCV and GCV indicating less environmental influence on the phenotypic expression of these traits and they are mostly governed by genetic factors. Hence, selection of desired character simply on the phenotypic value may be effective. On the contrary, a wide difference between PCV and GCV was observed for pod diameter and number of branches per plant indicating higher influence of environment on these traits thus, selection on the phenotypic basis would not be effective for the genetic improvement of such traits. Similar results were obtained by Chaurasia *et al.* (2011), Das *et al.* (2012) and Thirupathi *et al.* (2012).

The high estimates of heritability for all the characters under study except for pod diameter which registered moderate value suggest the feasibility of selection for these traits. In this respect, Khanorkar and Kathiria (2010) reported that the higher values of narrow-sense heritability for a particular character indicated that it is controlled largely by genes acting in an additive effect. Thus, if

heritability is high for a trait, the plant breeder can go for selection of individuals or group of individuals. In crops like okra high narrow-sense heritability estimates may be helpful for the development of improved varieties. These results are in close conformity with the findings of Bendale *et al.* (2004), Mehta *et al.* (2006), Mulge *et al.* (2006), Magar and Madrap (2009), Jindal *et al.* (2010), Das *et al.*, (2012), El-Gendy *et al.* (2013) and Jagan *et al.* (2013).

However selection should be made very carefully as heritability is measured in broad-sense, which may be influent. High heritability does not mean a high genetic advance for a particular quantitative character. Johnson *et al.* (1955) suggested that heritability estimates along with genetic advance were more useful in predicting the effect of selecting the best individual. Therefore, genetic advance was also computed as percentage of mean.

High broad-sense heritability coupled with high genetic advance as percent of mean for plant height, number of branches per plant, number of pods per plant, pod length, neck/pod ratio and plant yield, deserve greater attention in future breeding programs for developing better okra, and it is suggested that pedigree phenotypic selection method is a useful breeding program for improving these traits. A similar findings were reported by Jindal *et al.* (2010), Das *et al.* (2012), El-Gendy *et al.* (2013) and Jagan *et al.* (2013). Moderately high heritability with high genetic advance as percent of mean suggest that effective selection based on pod diameter trait might be effective for increasing pod yield. High heritability with low genetic advance as percent of mean was reported for the trait of days to first flower appearance. It revealed non-additive gene action was involved for expression of this trait. The high heritability was exhibited due to influenced of favorable environment rather than genotype and selection for such trait may not be rewarding. This result is also similar with those reported by Abdelmageed (2010), El-Gendy *et al.* (2013) and Jagan *et al.* (2013).

The inheritance of quantitative traits is often influenced by variation in other traits, which may be due to genetic linkage or pleiotropy. So, Estimation of genotypic and phenotypic correlations among traits is necessary in plant breeding. A positive correlation between desirable characters is valuable to the plant breeder because it helps in determining

the extent of improvement that could be brought in the characters and also in selecting suitable genotypes. In the present study, the magnitudes of the genotypic correlations were almost similar or very close to the corresponding phenotypic correlation. These results were expected, since the magnitude of the error covariance was relatively small compared with the respective values of genotypic covariance. The results emphasize that selection based on number of pods per plant, plant height or neck/pod ratio will be essential enough in improving plant yield. The results are in line with the findings of Ahmed (2001), Magar and Madrap (2009), Ramya and Senthilkumar (2009), Rashwan (2011) and El-Gendy (2012). Moreover, selection for early flowering resulted in an increased number of pods per plant, ultimately led to an increased yield. Similar results were obtained by Ahmed (2001), Ramya and Senthilkumar (2009), Rashwan (2011) and Simon *et al.* (2013).

In conclusion, our study demonstrated that inbreeding with selection program is very efficient in improving the yield and yield component traits of okra. Selection based on number of pods per plant, plant height and neck/pod ratio is essential enough to effectively improve the yield of okra.

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