Selection Response for Fruit Yield in Okra (*Abelmoschus esculentus* (L.) Moench)

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Field trials were conducted with 904 accessions of indigenous and exotic okra (*Ablemoschus esculetus* (L.) Moench) germplasm from 1999 to 2001 to identify high yielding genotypes and to study the selection response for fruit yield. Both inter and intra population selection was carried out. Fortyone out of 904 accessions recorded high yield over check variety Arka Anamika. Accessions IC 45802 exhibited significantly more fruits per plant (13.00) followed by EC 329386 and EC 305609. Three accessions namely, IC 69304, EC 305609 and IC 140929 II outperformed for fruit weight per plant. Accession EC 305609 registered consistently superior yield over years and is hence worthy for commercial exploitation. The direction of selection response was positive as well as negative. Selection response was high and positive when fruit yield per plant in the parental population (X_0) was low and *vice versa*. The results of the study revealed that in the initial phase of breeding programme, selection between accessions for yield might be useful. However, once the yield level reached a ceiling limit or plateau point, recombination breeding or heterosis breeding would be most effective as this trait was governed by polygene with additive as well as non-additive gene action.

Key Words: Selection response, Genetic gain, Okra, *Abelmoschus esculentus*

The genetic composition of a population can be changed in many ways. Selection is one among them. There are two agencies involved in carrying out selection; one is by nature known as natural selection and the other is by man known as artificial selection. The purpose of artificial selection is to isolate superior genotypes from the population with diverse genetic base. While doing so the phenotypic value of the selected population *vis-à-vis* the frequency of yield contributing alleles are shifted towards favourable direction. Bhindi, being often cross pollinated crop, offer much scope for genetic improvement through breeding methods that are normally applicable to self as well as cross pollinated crops including by selection (Hussein, 1994). This study was conducted to identify high yielding okra genotypes from 'active germplasm collection' and to assess the response to selection for fruit yield.

Materials and Methods

The study was conducted in the Research Farm of NBPGR Regional Station, Thrissur. Nine hundred and four accessions of okra germplasm collected from several Asian countries constituted the base population for the study. The base population was derived from open pollinated flowers. Twelve seeds from each of the 904 accessions were sown in augmented design during 1999. Simple phenotypic selections for fruit yield have been exercised to identify high yielding accessions. Arka Anamika was considered as check variety. The selected high yielding accessions henceforth referred as parental population (X_0). Twenty-four seeds from each of the X_0 population were raised in replicated trial during June 2000. Observations on individual plants were recorded and high yielding individual plants within each accession (X_0) were selected, selfed and harvested separately. They are henceforth, referred as progeny (X_p) population. During May 2001, seeds from X_p and X_0 populations were planted in RBD with two replications. Observations on number of fruits per plant and fruit weight per plant were recorded from each of the X_p and X_0 population. Selection response (R) was calculated as the differences between the mean phenotypic value of (X_p) and (X_0) population (Sharma, 1994). Selection response as percentage of mean of parents was also calculated.

Results and Discussion

The analysis of variance for number of fruits and fruit weight per plant for 904 accessions (base population) showed significant differences. The accessions had high degree of variability. Number of fruits per plant varied from 3.25 to 18.67, while fruit weight ranged from 39.50 g to 418.33 g. Accessions in the base population recorded, on an average, 6.62 fruits per plant while the check variety Arka Anamika recorded 4.67 fruits per plant. Arka

Anamika yielded 119.26 g fruits per plant whereas the grand mean for base population was 75.40 g. Forty-one out of 904 accessions that recorded significantly high yield (number and weight basis) than Arka Anamika were selected. These 41 accessions constituted parental (X_0) populations for next cycle of selection. The selection intensity between accessions was therefore, 4.5 per cent. In the subsequent trial, high yielding plants (X_p) within each accession were selected. The selection intensity within accessions varied from 4.1 to 8.2 per cent.

The fruit yield from replicated trial laid during May 2001 for each of X_0 and X_p plants are given in Table 1 and 2. The grand mean for parents was 8.6 fruits per plant while it was 9.6 fruits for plants selected from each of the X_0 accessions. Among the parents, IC 45802 exhibited significantly more fruits per plant (13.00) followed by EC 329386 and EC 305609. Accessions IC 218896, IC 218896 II and EC 305746 had few fruits per plants and on par. Among the progenies IC 282298 and IC 140929 were the poor yielders. They were at par. An exotic collection EC 305609 recorded the maximum of 17 fruits per plant followed by three indigenous collections *viz.*, IC 218887, AA selection and IC 43736.

As regard to fruit weight per plant, the range was from 56.67 g to 246.15 g among parents and from 49.5 g to 332.50 g among progenies. Three accessions namely, IC 69304, EC 305609 and IC 140929 II outperformed for this trait and were at par. This was followed by accessions EC 329386 and IC 140929. For number of fruits per plant, IC 140929 did not figure in the top list,

Table 1. Passport information of the selected parental lines

S. No.	Accession No.	Collector's No./NIC No.	Place of Collection	District	State/Country
1	IC 32855 C			Dhule	Maharashtra
2	IC 33182			Singli	Madhya Pradesh
3	IC 33206 A			Nasik	Maharashtra
4	IC 33340				Madhya Pradesh
5	IC 33350				Madhya Pradesh
6	IC 43736				Kerala
7	IC 45791				Tamil Nadu
8	IC 45802				Tamil Nadu
9	IC 45813				Tamil Nadu
10	IC 45824				Tamil Nadu
11	IC 69242	105/82-8	Pazhayannur	Thrissur	Kerala
12	IC 69250	109/82-48	Thonippadam	Palakkad	Kerala
13	IC 69272				Kerala
14	IC 69304				Kerala
15	IC 218874	V-4549		Kannur	Kerala
16	IC 218874 A	V-4549 A		Kannur	Kerala
17	IC 282240	V-89/O-22		Coimbatore	Tamil Nadu
18	IC 218887	V-89/O-59		Cuddappah	Andhra Pradesh
19	IC 218896	V-90/O-81	Thekkumpadam	Malappuram	Kerala
20	IC 218896 II	V-90/O-81 II		Malappuram	Kerala
21	EC 305746				Bangladesh
22	IC 140915	TZA/91-231	Payyanadu	Malappuram	Kerala
23	IC 140915 II	TZA/91-231 II	Payyanadu	Malappuram	Kerala
24	IC 140920	TZA/91-330	Meenkolli	Wynad	Kerala
25	IC 140929				Kerala
26	IC 140929 II				Kerala
27	IC 282298	TZA/91-412		Calicut	Kerala
28	IC 128055	T 91/75	Barestri	Goa	Goa
29	IC 128075	PSR 2043	Mohammadnagar	Nizamabad	Andhra Pradesh
30	IC 128078	NIC 9494	Bussapur	Nizamabad	Andhra Pradesh
31	IC 140877				Kerala
32	EC 329380	V 91/O-294	Piple	Makwanpur	Nepal
33	IC 128096	PSR 2163	Kudurupaka	Karimnagar	Andhra Pradesh
34	IC 140897	H 2150	Shimpong	West Siang	Andaman & Nicobar
35	EC 329386	V 91/O-290	Darimtar	Makwanpur	Nepal
36	EC 329406	V 91/O-316	Parbas	Palpa	Nepal
37	EC 329406 II	V 91/O-316 II	Parbas	Palpa	Nepal
38	EC 305609				Bangladesh
39	AA Selection				Bangladesh
40	IC 69242 II	105/82-8 II	Pazhayannur	Thrissur	Kerala
41	IC 43736 II				Kerala

Table 2. Selection response for number of fruits per plant

S.No.	Accession No.	Number of fruits/plant		Selection response	Selection response
		Progeny (X_p)	Parents (X_o)	$R= X_p - X_0$	as % of parent mean
1	IC 32855 C	8.62 cd	10.00 abcd	- 1.38	- 16.05
2	IC 33182	9.60 bcd	7.33 bcd	2.27	26.40
3	IC 33206 A	8.41 cd	8.67 abcd	- 0.26	- 3.02
4	IC 33340	8.90 cd	11.00 abcd	- 2.10	- 24.42
5	IC 33350	7.02 cd	7.67 abcd	- 0.65	- 7.56
6	IC 43736	11.62 bc	7.33 bcd	4.29	49.88
7	IC 45791	9.69 bcd	9.00 abcd	0.69	8.02
8	IC 45802	11.25 bcd	13.00 a	- 1.75	- 20.35
9	IC 45813	10.91 bcd	7.00 bcd	3.91	45.47
10	IC 45824	9.43 bcd	9.67 abcd	- 0.24	- 2.79
11	IC 69242	8.90 cd	6.67 bcd	2.23	25.93
12	IC 69250	10.37 bcd	8.00 abcd	2.37	27.56
13	IC 69272	7.50 cd	8.31 abcd	- 0.81	- 9.42
14	IC 69304	10.51 bcd	9.00 abcd	1.51	17.56
15	IC 218874	9.43 bcd	10.00 abcd	- 0.57	- 6.63
16	IC 218874 A	9.57 bcd	9.67 abcd	- 0.10	- 1.16
17	IC 282240	9.97 bcd	9.33 abcd	0.64	7.44
18	IC 218887	14.25 ab	7.67 abcd	6.58	76.51
19	IC 218896	7.37 cd	6.00 d	1.37	15.93
20	IC 218896 II	8.78 cd	6.00 d	2.78	32.33
21	EC 305746	10.88 bcd	6.00 d	4.88	56.74
22	IC 140915	10.50 bcd	7.00 bcd	3.50	40.70
23	IC 140915 II	8.08 cd	7.00 bcd	1.08	12.56
24	IC 140920	7.01 cd	6.33 cd	0.68	7.91
25	IC 140929	7.11 cd	8.00 abcd	- 0.89	- 10.35
26	IC 140929 II	6.30 d	8.00 abcd	- 1.70	- 19.77
27	IC 282298	6.25 d	9.00 abcd	- 2.75	- 31.98
28	IC 128055	8.66 cd	9.33 abcd	- 0.67	- 7.79
29	IC 128075	11.03 bcd	10.67 abcd	0.36	4.19
30	IC 128078	10.18 bcd	9.33 abcd	0.85	9.88
31	IC 140877	10.43 bcd	9.00 abcd	1.43	16.63
32	EC 329380	9.16 bcd	10.67 abcd	- 1.51	- 17.56
33	IC 128096	8.07 cd	9.33 abcd	- 1.26	- 14.65
34	IC 140897	10.32 bcd	8.67 abcd	1.65	19.19
35	EC 329386	11.03 bcd	12.00 ab	- 0.97	- 11.28
36	EC 329406	9.57 bcd	7.67 abcd	1.90	22.09
37	EC 329406 II	9.00 bcd	7.67 abcd	1.33	15.47
38	EC 305609	17.00 a	11.67 abc	5.33	61.98
39	AA Selection	12.10 bc	7.65 abcd	4.45	51.74
40	IC 69242 II	9.34 bcd	8.90 abcd	0.44	5.12
41	IC 43736 II	9.85 bcd	7.33 bcd	2.52	29.30
Mean	9.62	8.60			
Check: Arka Anamika		5.66			

Values followed by same alphabet do not differ significantly

however, due to high individual fruit weight its yield was high. T-test comparisons between parents and progenies for fruit yield showed significant mean differences indicating a shift in the phenotypic value of selected population from the base population for both these traits. Bagchi (1995) reported similar results in Teak.

Selection response (R) is the deviation of the progeny mean from the original population mean. It is often reflected as genetic gain under selection, which is the real success of a selection exercise. The value for R varied from - 2.75 to 6.58 fruits per plant and - 43.95 g to 108.77 g fruit weight per plant. The direction of selection response was both positive as well as negative, suggesting that response to selection need not always be positive. In fact, 16 and 21 out of 41 accessions showed negative response for fruit number and fruit weight per plant respectively. Wu (1999) observed decline in response after each generation of selection in forest trees.

An appraisal of heritability values and genetic advance gives an idea on the nature of gene action governing a particular trait. High heritability (h^2= 68.20 %) and moderate genetic advance (28.63 %) among parents for number of fruits per plant suggests the importance of additive gene action. Hence, simple

Table 3. Selection response for fruit yield (g)/plant

S. No.	Accession No.	Fruit weight (g)/plant		Selection response $R = X_p - X_0$	Selection response as % of parent mean
		Progeny (X_p)	Parents (X_0)		
1	IC 32855 C	95.06 nop	125.90 ijk	−30.84	−20.43
2	IC 33182	118.06 lmn	101.37 kl	16.69	11.05
3	IC 33206 A	107.42 no	126.32 ijk	−18.90	−12.52
4	IC 33340	97.29 nop	136.18 hi	−38.89	−25.76
5	IC 33350	155.38 efghijk	198.58 bc	−43.20	−28.61
6	IC 43736	188.46 cd	130.62 hij	57.84	38.31
7	IC 45791	136.62 ijklm	142.11 ghi	−5.49	−3.64
8	IC 45802	141.67 ghijkl	181.09 bcdef	−39.42	−26.11
9	IC 45813	115.14 mno	82.95 lm	32.19	21.32
10	IC 45824	161.97 efghi	186.53 bcde	−24.56	−16.27
11	IC 69242	165.70 defg	140.27 ghi	25.43	16.84
12	IC 69250	169.05 def	145.04 ghi	24.01	15.90
13	IC 69272	146.42 fghijk	188.14 bcde	−41.72	−27.63
14	IC 69304	259.24 b	246.15 a	13.09	8.67
15	IC 218874	163.54 defgh	194.80 bcd	−31.26	−20.70
16	IC 218874 A	49.52 q	56.67 n	−7.15	−4.73
17	IC 282240	166.42 defg	174.19 cdef	−7.77	−5.15
18	IC 218887	266.00 b	157.24 fgh	108.77	72.04
19	IC 218896	159.79 efghi	122.34 jjk	37.45	24.80
20	IC 218896 II	169.24 def	124.08 ijk	45.16	29.91
21	EC 305746	93.62 nop	88.74 lm	4.88	3.23
22	IC 140915	137.21 ijklm	119.00 ijk	18.21	12.06
23	IC 140915 II	142.54 ghijkl	134.47 hi	8.07	5.35
24	IC 140920	99.77 nop	134.13 hi	−34.36	−22.76
25	IC 140929	159.82 efghij	201.52 b	−41.70	−27.62
26	IC 140929 II	195.41 c	239.36 a	−43.95	−29.11
27	IC 282298	157.03 efghij	144.00 ghi	13.03	8.63
28	IC 128055	161.19 efghi	196.77 bcd	−35.58	−23.57
29	IC 128075	159.90 efghij	170.83 def	10.93	−7.24
30	IC 128078	82.04 p	83.97 lm	−1.93	−1.28
31	IC 140877	131.38 klm	126.63 ijk	4.75	3.15
32	EC 329380	138.12 hijklm	181.39 bcdef	−43.27	−28.66
33	IC 128096	80.21 p	106.46 jkl	−26.25	−17.38
34	IC 140897	139.52 hijklm	130.40 hij	9.12	6.04
35	EC 329386	169.51 def	203.64 b	−34.13	−22.61
36	EC 329406	180.99 cde	162.68 efg	18.31	12.13
37	EC 329406 II	134.66 jklm	129.09 ij	5.57	3.69
38	EC 305609	332.50 a	242.50 a	90.00	59.61
39	AA Selection	260.70 b	180.39 bcdef	80.31	53.19
40	IC 69242 II	166.28 defg	178.09 bcdef	−11.81	−7.82
41	IC 43736 II	90.96 op	75.87 mn	15.09	10.00
Grand mean		152.32	150.98		
Check: Arka Anamika		128.67			

Values followed by same alphabet do not differ significantly

selection would be rewarding for improvement of this trait. However, progenies after one cycle of selection exhibited high heritability (h^2= 71.40 %) and low genetic advance (3.12 %) thus suggesting the contribution of non-additive gene action and improvement of this trait warrants heterosis breeding as also reported by Hussein (1994).

A perusal of Table 3 shows interesting results. Selection response was high and positive when number of fruits per plant was below nine in parents. Lower the yield of parental accession greater was the genetic gain in the progeny derived from them as exemplified in IC Nos. 33182, 43736, 45813, 69242, 69250, 218887, 218896-II, 140915, 140915-II and EC 305746. Selection response was approaching unity when the number of fruits per plant in the parents was nine as in IC Nos. 282240, 128078, 69242-II and 45791. When number of fruits per plant exceeds nine in the parents, selection response was low and negative. It was also observed that more the fruits per plant in the parents greater would be the genetic gain but in negative direction. Yield data recorded from IC Nos. 32855 C, 45802, 33340, 218874, EC 329380 and EC 329386 could testify this point.

The above results could be interpreted as follows. The accessions in the parental generation with fruit number less than nine fruits per plant were the unimproved populations, derived from open pollinated seeds. They are the rich sources of variability and contain high amount of additive genetic variance as also explained by Sharma (1994). As a matter of fact, the frequency of desirable alleles available for selection was high and hence they responded positively for selection pressure. On the other hand, accessions (parents) with around nine fruits per plant might be considered as partially improved accessions. As a consequence of previous selection, they are expected to carry low or moderate additive genetic variance. This was reflected in the gradual approach in performance of these accessions to the ceiling or plateau point of nine fruits per plant under Kerala conditions. As selection proceeds for greater than six fruits per plant, it is obvious that they may not respond positively since the residual variation in the parental population is additive. The same holds good for fruit weight per plant. Therefore, from the results it is clear that the number of fruits and fruit weight per plant in okra is conditioned by polygenes with additive as well as non-additive gene action. Under such circumstances, at initial stage of breeding programme, selection between accessions (inter-population selection) of large germplasm collection would be effective. However, after few cycles of selection, recombination breeding or heterosis breeding would be more effective.

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