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Research Paper

Selection indices for improvement of fruit yield in okra [*Abelmoschus esculantus* (L.) Moench]

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ABSTRACT

Sixty-eight advanced breeding lines of okra along with their seven parents and a check variety were evaluated for twelve characters. Genetic differences were significant for all the traits. The magnitudes of GCV and PCV were higher for fruit yield per plant, primary branches and fruits per plant. However, internodal length, plant height, primary branches, fruit length, ten fruit weight and fruit yield per plant exhibited moderate heritability with moderate to high genetic advance, indicative of reliability of such characters for effective selections. Discriminant function analysis based on six characters, namely fruit yield per plant, nodes per plant, plant height, internodal length, primary branches and ten fruit weight indicated that selection efficiency of the function was improved by increasing number of characters in the index. The index involving all the six traits recorded the highest genetic gain and selection efficiency. However, the index with three parameters, *i.e.* fruit yield per plant + plant height + ten fruit weight was comparable and practically possible to use for selecting suitable plant types.

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Key words : *Abelmoschus esculantus*, Discriminant function analysis, Fruit yield, Component traits, Selection efficiency

INTRODUCTION

Variability is the prerequisite for success in improvement of any crop plants. Also, it is a key factor that determines the amount of progress expected from selection. The another important aspect in plant breeding programme is the selection indices, which are useful in understanding the extent of improvement that can be effected in yield by combination of characters. Discriminant function analysis developed by Fisher (1936) and first applied by Smith (1936) gives information on proportionate weightage that should be given to a particular yield component. Few studies on selection indices in okra have been carried out earlier. Lal (1986) studied selection indices for improving earliness, pod yield and seed yield and Singh and Singh (1978a) for fruit yield. However, in order to have a more comprehensive knowledge about genetic variability for yield and its attributing traits and to find out a suitable selection indices for the improvement of fruit yield in okra, the present investigation was conducted using advanced breeding lines derived from nine crosses.

MATERIALS AND METHODS

Experimental material consisted of 68 advanced breeding lines derived through pedigree method of selection from nine crosses in okra. Four lines of the cross D l-87-5 x GO 2, four of D 1-87-5 x Arka Anamica, nine of D 1-87-5 x Lorm 1, nine of D 1-87-5 x HRB 55, eleven of D 1-87-5 x Parbhani Kranti, twelve of GO 2 x HRB 55, five of GO 2 x Parbhani Kranti, seven of Parbhani Kranti x Chhodawadi and seven of HRB 55 x Chhodawadi along with their seven parents and a check variety Pusa Sawani were evaluated in randomized block design with three replications. A single replication comprised of one row of each genotype. There were ten plants in a row spaced 30 cm apart; the row-to-row spacing was 60 cm. All the agronomic practices including plant protection measures were followed for harvesting good crop. Fourteen picking were done for harvesting marketable green fruits. The observations were recorded on five plants selected at random from each plot for twelve characters namely days to 50% flowering, days to first picking, plant height, primary branches per plant, nodes per plant, internodal length, fruit length, fruit girth, fruit shape index, fruits per plant, ten fruit weight and fruit yield per plant. Genotypic and phenotypic coefficients of variation as per Burton (1952) and heritability and genetic advance according to Allard (1960) were estimated for all the above twelve characters. Whereas, discriminant function analysis described by Dabholkar (1999) was used to construct the selection indices involving six characters, *viz*., fruit yield per plant (X_1), nodes per plant (X_2), plant height (X_3), internodal length (X_4), primary braches per plant (X_5) and ten fruit weight (X_6). For computing selection indices, fruit yield per plant was considered as the dependant variable with the relative efficiency of 100 per cent. The expected genetic advance and relative efficiency of index selection were calculated according to Robinson *et al.* (1951).

RESULTS AND DISCUSSION

Significant differences among the genotypes were observed for all the characters (Table 1), indicating wide spectrum of variation in the material studied. GCV values ranged from 4.39 to 16.70 % among the characters studied. The magnitude of this parameter was low for days to 50% flowering, days to first picking, nodes per plant, internodal length, fruit girth and fruit shape index , but moderate for plant height, primary branches, fruit length, fruits per plant, ten fruit weight and fruit yield per plant. None of the characters manifested high magnitude of GCV. PCV values ranged from low of 8.22% for days to 50% flowering to high of 23.00% for primary branches. Though, the magnitude of PCV was low for days to first picking and high for fruit per plant and fruit yield per plant. Remaining characters expressed moderate values of PCV. In general, there was a larger difference between the estimates of GCV and PCV, indicating that the characters under investigation were largely influenced by environmental factors.

Broad sense heritability was high for internodal length and moderate for fruit yield per plant, plant height, fruit length, days to 50% flowering and primary branches. The maximum genetic advance was seen only in fruit yield per plant, while moderate values were obtained for plant height, primary branches, fruit length and fruits per plant. Moderate to high heritability coupled with moderate to high genetic advance was reported by Hazra and Basu (2000) and Gandhi *et al*. (2001), while Singh and Singh (1978 b) suggested the effectiveness of selection based on phenotypic expression of these traits. In the present study, however, it was noted that high heritability for internodal length was associated with moderate genetic advance and moderate heritability for fruit yield per plant was accompanied with high genetic advance. Such antagonistic estimates for heritability and genetic advance might be due to higher or lower estimates of phenotypic standard deviation.

A total of sixty three selection indices (Table 2) based on six characters constructed in all possible combinations revealed that the selection efficiency was not higher over straight selection when selection was based on individual components. Fruit yield per plant showed a genetic advance of 59.00% while other individual characters recorded still lower genetic advance (Table 2), suggested that fruit yield per plant itself proved to be better index for selection based on one character. Singh and Singh (1978 a) also reported similar results.

The highest genetic gain of 77.46% was obtained when selection was simultaneously based on discriminant

Table 1 : Mean, range, genotypic (GCV) and phenotypic (PCV) coefficients of variation, heritability (h^2) and genetic advance (GA) for twelve characters in advanced breeding lines of okra

Character	Mean	Range	GCV (%)	PCV(%)	h^2 (%)	GA as % of mean
Days to 50% flowering	44.66	39.57 - 52.33**	5.70	8.22	48.11	8.15
Days to first picking	50.72	45.67 - 58.67**	4.39	8.44	27.09	4.71
Plant height	81.08	39.41 -119.71**	12.58	17.58	51.17	18.53
Primary branches	2.34	1.20 - 3.20*	14.80	23.00	41.38	19.61
Nodes / plant	22.29	11.47 -26.60*	9.42	16.66	32.00	10.98
Internodal length	7.16	5.83 - 8.70**	8.72	10.99	62.90	14.25
Fruit length	12.01	9.27 -18.62**	11.24	16.07	48.95	16.20
Fruit girth	5.36	3.79 - 6.19*	4.99	10.03	20.41	4.64
Fruit shape index	45.71	34.01 - 60.30*	7.20	17.13	17.66	6.23
Fruits / plant	13.92	7.20 - 18.73**	13.37	22.59	34.98	16.28
Ten fruit weight	160.38	116.27 - 32.27**	10.73	16.02	14.84	14.80
Fruit yield / plant	221.71	108.00 - 325.40**	16.70	21.60	59.80	26.61

* and ** indicate significance of values at P= 0.05 and P=0.01 probability, respectively

Table 2 : Selection indices, their expected genetic advance (Δ_G) and relative efficiency (RE) for different combinations of yield component traits in okra

Sr. No.	Selection indices	Δ_G	RE
1.	$0.60X_1$	59.00	100.00
2.	$0.32X_2$	2.45	4.15
3.	$0.51X_3$	15.03	25.47
4.	$0.63X_4$	1.02	1.73
5.	$0.41X_5$	0.45	0.76
6.	$0.45X_6$	23.74	40.24
7.	$0.60X_1+ 0.14X_2$	59.15	100.265
8.	$0.64X_1+ 0.20X_3$	66.96	113.49
9.	$0.59X_1+4.37X_4$	59.70	101.18
10.	$0.67X_1-17.52X_5$	61.70	104.58
11.	$0.62X_1+0.50X_6$	77.46	131.29
12.	$-0.26X_2+0.65X_3$	17.55	29.75
13.	$0.28X_2+1.30X_4$	3.45	5.84
14.	$0.35X_2-0.26X_5$	2.54	4.30
15.	$0.43X_2+0.45X_6$	24.53	41.57
16.	$0.38X_3+5.25X_4$	17.30	29.32
17.	$0.65X_3+5.49X_5$	15.93	27.01
18.	$0.51X_3+0.44X_6$	30.05	50.93
19.	$0.71X_4+0.42X_5$	1.39	2.37
20.	$3.16X_4+0.43X_6$	24.54	41.59
21.	$0.26X_5+0.45X_6$	23.79	40.31
22.	$0.69X_1+1.68X_2+0.13X_3$	67.72	114.79
23.	$0.58X_1-0.23X_2+5.89X_4$	60.10	101.87
24.	$0.68X_1+1.71X_2-23.31X_5$	62.72	106.30
25.	$0.64X_1+0.16X_2+0.51X_6$	77.80	131.86
26.	$0.67X_1+0.26X_3+14.19X_4$	69.96	118.57
27.	$0.64X_1+0.78X_3-24.87X_5$	70.32	119.18
28.	$0.72X_1+0.04X_3+0.49X_6$	84.77	143.68
29.	$0.65X_1+9.37X_4-21.92X_5$	63.40	107.46
30.	$0.63X_1+6.01X_4+0.47X_6$	78.37	132.83
31.	$0.72X_1-19.58X_5+0.48X_6$	80.05	135.69
32.	$-0.16X_2+0.48X_3+5.57X_4$	19.79	33.55
33.	$-0.22X_2+0.80X_3-6.89X_5$	18.71	31.71
34.	$0.01X_2+0.59X_3+0.44X_6$	31.78	53.56
35.	$0.31X_2+1.59X_4-0.60X_5$	3.73	6.32
36.	$0.21X_2+3.92X_4+0.43X_6$	25.53	43.28
37.	$0.50X_2-0.94X_5+0.45X_6$	24.59	41.69
38.	$0.51X_3+5.67X_4-6.09X_5$	18.33	31.07
39.	$0.28X_3+9.01X_4+0.41X_6$	32.93	55.82
40.	$0.65X_3-5.59X_5+0.44X_6$	30.56	51.80
41.	$3.70X_4-1.34X_5+0.43X_6$	24.68	41.83
42.	$0.78X_1+2.91X_2-0.99X_3+16.55X_4$	71.39	121.01
43.	$0.71X_1+2.03X_2+0.42X_3-27.21X_5$	71.64	121.42
44.	$0.85X_1+3.52X_2-0.78X_3+0.43X_6$	86.24	146.17
45.	$0.52X_1-11.44X_2+21.39X_4+14.62X_5$	58.77	99.61

Table 1 Contd...

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Sr. No.	Selection indices	Δ_G	RE
46.	$0.63X_1-0.30X_2+7.60X_4+0.48X_6$	78.94	133.79
47.	$0.75X_1+1.98X_2-26.46X_5+0.45X_6$	81.27	137.75
48.	$0.68X_1+0.32X_3+15.48X_4-26.72X_5$	73.69	124.91
49.	$0.78X_1-0.58X_3+18.93X_4+0.38X_6$	88.64	150.24
50.	$0.72X_1+0.63X_3-25.14X_5+0.48X_6$	87.48	148.27
51.	$0.72X_1+12.07X_4-25.41X_5+0.42X_6$	82.26	139.42
52.	$-0.10X_2+0.64X_3+6.08X_4-7.56X_5$	21.09	35.74
53.	$-0.01X_2+0.39X_3+2.29X_4-0.45X_6$	30.66	51.97
54.	$0.05X_2+0.75X_3-7.06X_5+0.44X_6$	32.48	55.06
55.	$0.35X_2+4.54X_4-2.47X_5+0.43X_6$	25.76	43.66
56.	$0.42X_3+9.49X_4-6.66X_5+0.40X_6$	33.63	56.99
57.	$0.80X_1+3.43X_2-0.50X_3+18.34X_4-24.58X_5$	75.79	128.46
58.	$1.04X_1+6.01X_2-2.26X_3+24.74X_4+0.23X_6$	91.83	155.65
59.	$0.74X_1+1.16X_2+12.00X_4-30.75X_5+0.39X_6$	83.33	141.24
60.	$0.87X_1+3.96X_2-0.24X_3-28.04X_5+0.40X_6$	89.51	151.72
61.	$0.79X_1+0.01X_3+20.48X_4-27.54X_5+0.36X_6$	91.81	155.61
62.	$0.28X_2+0.47X_3+10.07X_4-8.27X_5+0.40X_6$	35.69	60.49
63.	$1.09X_1+6.79X_2-1.81X_3+27.25X_4-32.27X_5+0.18X_6$	95.89	162.53

X_1=Fruit yield per plant, X_2=Nodes per plant, X_3=Plant height X_4=Internodal length, X_5=primary branches, X_6=Ten fruit weight

function of two characters, e.g. fruit yield per plant (X_1) and ten fruit weight (X_6). When three characters, e.g. fruit yield per plant (X_1), plant height (X_3) and ten fruit weight (X_6) were taken together, the genetic advance increased to 84.77%. Combination of four characters, *i.e.* fruit yield per plant (X_1) + plant height (X_3) + internodal length (X_4) + ten fruit weight (X_6) at a time still recorded highest genetic gain of 88.64%.The maximum gain was achieved to 91.83% and 91.81% by taking five characters at a time, *i.e.* fruit yield per plant (X_1) + nodes per plant (X_2) + plant height (X_3) + internodal length (X_4) +ten fruit weight (X_6) and fruit yield per plant (X_1) + plant height (X_3) + internodal length (X_4) + primary branches (X_5) + ten fruit weight (X_6), respectively (Table 2). The function that includes all the six characters gave the highest genetic advance (95.89%).

Thus, study revealed that the index, which includes more than one character, gave high genetic advance, suggesting the utility of construction of selection indices for effecting simultaneous improvement of several characters. Hazel and Lush (1943) stated that the superiority of selection based on index increases with an increase in the number of characters under selection. Singh and Singh (1978a) were of the same opinion that inclusion of characters one by one in the function resulted in increasing genetic advance of selection in okra. However, Lal (1986) obtained higher genetic gain when three characters were included in the development of selection indices.

The relative efficiency, RE (%), of various selection indices presented in Table 2 indicated that when relative efficiency of single character index was measured over straight selection for fruit yield per plant, the efficiency was declined to less than 100 per cent. This observation indicated that the indirect selection through individual traits over straight selection for fruit yield per plant alone would not be effective.

It is interesting to note that selection efficiency improved with an increase in number of characters in combination with yield. For example, average selection efficiency was 28.73% when one character was included in selection function (Table 3). Similarly, the selection efficiency was 54.92% for two characters, 80.14% for three characters and 162.63% for six characters. Such trend of rising efficiency was emphasized by Singh and Singh (1978 a) in okra and Tyagi (1994) in cotton.

Table 3 : Average selection efficiency of different combinations of indices in okra

No. of characters in the index	Selection efficiency (%)
One	28.73
Two	54.92
Three	80.14
Four	104.40
Five	132.20
Six	162.53

Some of the selection indices with high relative efficiency listed in Table 4 indicated that the highest efficiency was observed with six characters combination (162.53%). Selection indices with six characters, *i.e.* fruit yield per plant (X_1), nodes per plant (X_2), plant height (X_3), internodal length (X_4), primary branches (X_5) and ten fruit weight (X_6), therefore, appear to be more useful. It can be seen that fruit yield per plant (X_1) was the character, which was commonly being involved in all the combinations, the next being ten fruit weight (X_6) and plant height (X_3) in order (Table 4). Robinson *et al*. (1951) indicated that relative efficiency of function could be increased with the inclusion of yield per plant in selection index. Nodes per plant (X_2), internodal length (X_4) and primary branches (X_5) were the characters with little effect on relative

Table 4 : Selection indices with the highest selection efficiency in okra

Selection index #	Selection efficiency (%)
X_1	100.00
X_1, X_6	131.29
X_1, X_3, X_6	143.68
X_1, X_2, X_3, X_6	146.17
X_1, X_3, X_4, X_6	150.54
X_1, X_3, X_5, X_6	148.27
X_1, X_2, X_3, X_4, X_6	155.65
X_1, X_3, X_4, X_5, X_6	155.61
$X_1, X_2, X_3, X_4, X_5, X_6$	162.53

Character codes as in Table 2

efficiency of the index when added in the combination of fruit yield per plant (X_1) + plant height (X_3) + ten fruit weight (X_6).

Keeping in view the basic philosophy of saving time and labour in a selection programme, it would be desirable to base the selection of few characters. In the present study, selection index based on six characters gave maximum genetic gain and high efficiency over straight selection, but practically it is more cumbersome to use in the selection exercise. Hence, a practical plant breeder usually prefer the index which includes as minimum as possible the characters at a time and can give as maximum as possible genetic gain. In the present study, selection index based on three characters (fruit yield per plant+ plant height+ ten fruit weight) showing genetic gain (84.77%) and selection efficiency (143.68%) comparable to those based on four or more characters, which is more desirable and practically possible to use than the index that includes more number of characters.

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