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Comparison of Selection Indices using Different Weights in Okra [*Abelmoschus esculentus* (L.) Moench]

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ABSTRACT

The data on six different biometrical characters of fifty six genotypes/hybrids of okra were used in the present study and four different weights *viz.* equal weight, simple correlation coefficients, genotypic correlation and phenotypic correlation as weight were given to different characters to construct selection indices to select the optimum index in okra. The genotypic differences in respect of all the six characters were highly significant. The simple correlation coefficient of the fruit yield per plant had positive and significant correlation with fruits per plant. The results of genotypic correlation observed that the fruit yield per plant had positive and significant correlation with plant height (0.3125), numbers of internodes on main stem (0.2969), fruit length (0.3684), fruits per plant (0.586) and fruit weight (0.5131). The results of phenotypic correlation was found significant and positive for fruit yield with all the characters. The selection index I_{12356} which is combination of fruit yield per plant, plant height, number of internodes on main stem, number of fruits per plant and fruit weight is suggested to select the genotypes for okra fruit yield improvement with equal weight method. Hybrid GAO 5 X Kashi Kranti (P1XP5) was suggested as top ranking genotype in all the weight methods.

Key words : Selection index, Genotype, Equal weight, Genotypic correlation, Phenotypic correlation

INTRODUCTION

Okra [*Abelmoschus esculentus* (L.) Moench] is also known as Lady's finger and it is an annual vegetable crop grown in tropical and subtropical region of the world. India ranks first in the world with annual production of 60,03,000 tones produced from 5,07,000 hectares area with a productivity of 11.8 tones/ha (Anonymous, 2017).The important okra growing states in India are Gujarat, Maharashtra, Andhra Pradesh, Uttar Pradesh, Tamil Nadu, Karnataka, Haryana and Punjab, in which it is cultivated as a *Kharif* as well as summer season crop. In Gujarat, main okra growing districts are Surat, Vadodara, Junagadh, Surendranagar, Gandhinagar, Banaskantha, Kheda and Anand.

It has been recognized that most rapid improvement in the economic value is expected from selection applied simultaneously to all the characters which determine the economic value of a plant, when appropriate weights are assigned to each character according to their relative economic importance. There is no standard procedure to assign weights to the biometrical characters in selection index. Therefore, an attempt has been made to construct selection index by assigning different weight such as equal weight, simple correlation coefficients, genotypic correlation coefficients and phenotypic correlation coefficients as weight to different biometrical characters.

MATERIALS AND METHODS

The data on six different biometrical characters of fifty six genotypes/hybrids of okra were collected from Main Vegetable Research Station (MVRS), A.A.U., Anand during *kharif* season of the year 2018 for the present study. The experimental material consisted of ten parents *viz*. GAO 5, AOL 12-59, AOL 13-144, Phule Prajatika, Kashi Kranti, Arka Abhay, VRO 6, Red One Long, JF 5, JF 108-02; forty five hybrids and one check *viz*. GJOH 4.

Let us assume that economic value of a plant is determined by different variables and the merit of a plant is H. Then

$H = a_1G_1 + a_2G_2 + a_3G_3 + \ldots + a_nG_n = \sum_{i=1}^{n} a_iG_i$

Where,

Gi= Genotypic value of the character

ai= Weight assigned to the respective characters.

The phenotype (I) is linearly expressed as

$I = b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n = \sum_{i=1}^{n} b_iX_i$

$I = b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_nX_n$....... (1)

$H = a_1G_1 + a_2G_2 + a_3G_3 + \ldots + a_nG_n$ .... (2)

These I and H were estimated in such way that regression of I on H was maximized.

Thus, $b = [X^{-1}][G][a]$

Selection index was calculated by substituting value of the character and bi values in following equation

$I = b_1X_1 + b_2X_2 + b_3X_3 + \ldots\ldots + b_nX_n$

Selection index for all possible combination of six characters can be calculated and the combination which provides the higher relative efficiency is selected. Genetic gain and percent relative efficiency (PRE) were calculated by using the following formulae. Selection index for single or combination of characters which provides the high PRE is selected

The expected genetic advance is calculated as

$GA = (Z/P)((\sum\sum a_ib_iG_{ij}) / (\sum\sum b_ib_jp_{ij})^{1/2})$

Where Z/P = Selection intensity *i.e.* 2.06 at 5% level of significance.

Percent Relative efficiency (PRE)

$$PRE = \frac{\text{Genetic gain of selection index}}{\text{Genetic gain of fruit yield}} \times 100$$

RESULTS AND DISCUSSION

Mean, range and coefficient of variation

The results presented in Table 1 revealed that the fruit yield per plant recorded by genotype/hybrid GAO 5 (P1) x Kashi Kranti (P5) was most significant compared to other genotypes. The value of broad sense heritability was 79.76 % which was second highest after fruit weight. The maximum plant height was recorded for the genotype Arka Abhay (P6) X VRO 6 (P7). The maximum numbers of internodes on main stem were recorded for genotype Kashi Kranti (P5) x Arka Abhay (P6). The maximum fruit length was found for the genotype Kashi Kranti (P5) X Arka Abhay (P6). The maximum fruits per plant were recorded for genotype ALO 13-144 (P3) X VRO 6 (P7). The maximum fruit weight was recorded for genotype Phule Prajatika (P4) X Red One Long(P8) and it was statistically at par with GAO 5 (P1),Phule Prajatika (P4), Red One Long (P8),GAO 5 (P1) X Phule Prajatika (P4) and GAO 5 (P1) XVRO 6 (P7).These results are in accordance with Prakash *et al.* (2011) and Nwangburuka *et al.* (2012) in okra.

Simple correlation coefficients

The result of simple correlation coefficients (Table 2) revealed that fruit yield per plant had positive and significant correlation with plant height (0.2519), number of internodes on main stem (0.2831), fruit length (0.2011), fruits per plant (0.7471) and fruit weight (0.6794).

It was also found that plant height had significant and positive correlation with number of internodes on main stem (0.4328), fruit length (0.3995), fruits per plant (0.1816) and fruit weight (0.1874). It was also found that number of internodes on main stem had significant and positive correlation with fruits per plant (0.4161). Fruit length had significant and positive correlation with fruit weight (0.3163).

Positive and significant correlation between fruit yield and fruit weight observed in this study was also reported by Akinyele and Osekita (2006) , Reddy *et al.* (2013) and Balai *et al.* (2014). Also, same result in potato by Lamboro *et al.* (2014). The positive and significant correlation between fruit yield and number of internodes on main stem and fruit length were observed by Mihretu Yonas *et al.* (2014), Kumar and Reddy (2016) and Dwivedi and Sharma (2017) in okra.

Genotypic and Phenotypic correlation coefficients

The correlation coefficients between fruit yield per plant and its component traits among themselves were estimated at genotypic and phenotypic levels. The results of genotypic and phenotypic correlation coefficients between fruit yield per plant and its components are given in Table 3. Positive and significant genotypic correlation between fruit yield with all the characters were observed. Fruits per plant had the highest genotypic correlation with fruit yield followed by fruit weight. Similar trend was also observed for phenotypic correlation with yield. Plant height had also significant genotypic correlation with fruit length (0.9582), number of internodes on main stem (0.6712) and fruit weight (0.2138). Significant and positive phenotypic correlation of fruit yield was found with all the character. Plant height was found phenotypically significant with all the character except fruit weight (0.1107). The results of remaining characters revealed that positive and significant correlation of number of internodes on main stem with fruit length and fruits per plant, while fruit length with fruit weight was also found significant and positive at genotypic and phenotypic level.

Positive and significant genotypic and phenotypic correlation between fruit yield and plant height was observed by Nwangburuka *et al.* (2012), Duggi *et al.* (2013). Similarly positive and significant genotypic and phenotypic association of fruit yield with number of internodes on main stem, fruit length, number of fruits per plant and fruit weight were observed by Reddy *et al.* (2013) and Balai *et al.*(2014) in okra.

Selection indices using different weights

Selection indices were worked out taking six biometrical characters and were constructed taking all possible combinations of the characters. Total sixty three selection indices were constructed using equal weight (W_1), simple correlation coefficient (W_2), genotypic correlation coefficients (W_3) and phenotypic correlation coefficients (W_4) for all characters.

Expected genetic gain and relative efficiency (%) for single character

The selection indices were constructed for single character separately. Total six selection indices were constructed for each weight methods (W_1, W_2, W_3 and W_4). The genetic gain in okra fruit yield per plant (63.7069) with equal weight was considered as a base in all single as well as combinations of characters. Relative to this, the efficiency was worked out for selection of single character for different methods.

Per cent relative efficiency (PRE) for selection index of biometrical characters ranged from 1.12 to 100.00, 3.17 to 100.00, 0.33 to 100.00, 0.32 to 100.00 for W_1, W_2, W_3 and W_4 respectively. The highest PRE were observed for fruit yield per plant in equal weight methods. The lowest PRE were observed for number of internodes on main stem in all weight methods. In general, the percent relative efficiency was higher in equal weight method as compared to other methods. This result in accordance with Chattopadhyay *et al*. (2011), Bashar *et al*. (2015) in brinjal, Premalakshmi *et al*. (2014) and Sherpa *et al*. (2014) in tomato also found in equal weight is dominating method same as Silva *et al*. (2018) found the same result in potato. Also fruit yield had 100 per cent relative efficiency were found in equal weight method, genotypic correlation and phenotypic correlation as weight methods.

Expected genetic gain and relative efficiency (%) for combination of two characters

All possible combinations of two characters were used to construct selection indices using different weights (W_1 to W_4). Total fifteen selection indices in each weight method were constructed. The genetic gain for fruit yield (single character) with equal weight method (63.7069) was considered as base and the efficiency was worked out for all selection indices of all possible combinations of six characters for different weights. PRE ranged between 3.13 (number of internodes on main stem and fruit length) to 109.06 (fruit yield and plant height) for equal weight method,0.74 (number of internodes on main stem and fruit length) to 106.28 (fruit yield and plant height) for simple correlation coefficients weight method, 1.06 (number of internodes on main stem and fruit length) to 107.18 (fruit yield and plant height) for genotypic correlation weight method, 0.76 (number of internodes on main stem and fruit length) to 106.96 (fruit yield and plant height) for phenotypic correlation weight method. In general, it was observed that the per cent relative efficiency was the highest in equal weight method (W_1) followed by simple correlation coefficients weight method (W_2), genotypic correlation weight method (W_3), phenotypic correlation weight method (W_4).

The highest PRE were observed for fruit yield and plant height combination in all weight methods. The lowest PRE was observed for number of internodes on main stem and fruit length combination in all weight method.

Expected genetic gain and relative efficiency (%) for combination of three characters

Out of six biometrical characters all possible combinations of three characters were taken at a time to construct selection indices using different weights. Total twenty indices consisting different combinations of characters were constructed. The genetic gain for fruit yield per plant (63.7069) alone with equal weight method was used as base to workout per cent relative efficiency for all selection indices. Per cent relative efficiency ranged from 5.77 (number of internodes on main stem, fruit length and fruit weight) to 122.13 (fruit yield, plant height and number of internodes on main stem) for equal weight method. The ranged from 2.95 (number of internodes on main stem, fruit length and fruit weight) to 109.85 (fruit yield, plant height and number of internodes on main stem) for simple correlation weight method. The ranged from 2.58 (number of internodes on main stem, fruit length and fruit weight) to 110.75 (fruit yield, plant height and number of internodes on main stem) for genotypic correlation weight method, while for phenotypic correlation weight method, ranged from 2.03 (number of internodes on main stem, fruit length and fruit weight) to 110.52 (fruit yield, plant height and number of internodes on main stem).

Among all possible combinations, the highest per cent relative efficiency was observed for combination of fruit yield per plant, plant height, number of internodes on main stem (I_{123}) with W_1, W_2, W_3, W_4 weight method.

Expected genetic gain and relative efficiency (%) for combination of four characters

Out of six biometrical characters any four were taken at a time to construct selection indices using different weights. There were fifteen different possible combinations of four characters and were used to determine selection indices with different weights. Thus, 60 indices were constructed. The genetic gain for fruit yield per plant with equal weight method (63.7069) was considered as 100 per cent relative efficiency. Relative to this genetic gain, the efficiencies were worked out for selection index of all possible combinations of four characters for all the four weight methods (W_1 to W_4). The results revealed that PRE ranged from 8.28 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 124.91 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for equal weight method (W_1), 4.95 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 111.86 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for (W_2), 4.11 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 112.36 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for genotypic correlation weight method (W_3), 3.54 (I_{3456}) [number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 112.02 (I_{1235}) [fruit yield, plant height, number of internodes on main stem, fruits per plant] for phenotypic correlation weight method (W_4).

It was reported that the higher per cent relative efficiency was observed in equal method as compared to rest of the weight methods as the numerical value of weight was higher as compared to all method. Index (I_{1235}) gave highest PRE in equal weight (124.91), genotypic correlation as weight (112.36) phenotypic correlation as weight (112.02).

Expected genetic gain and relative efficiency (%) for five characters

Out of six characters all possible combinations of five different characters were taken at a time to construct selection indices using different weight methods. Six different indices were constructed for each weight methods so total twenty four indices were constructed using this method. The genetic gain for fruit yield per plant (63.7069) alone with equal weight method was used as base to workout per cent relative efficiency for all the selection indices. Per cent relative efficiency ranged from 32.73 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 127.13 (I_{12356})[fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for equal weight method, 9.87 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.43 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for simple correlation weight method , 11.07 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.55(I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for genotypic correlation weight method, 10.13 (I_{23456}) [plant height, number of internodes on main stem, fruit length, fruits per plant and fruit weight] to 113.02 (I_{12356}) [fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight] for phenotypic correlation weight method.

The highest PRE was observed in the selection index (I_{12356}) consisting fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight in all weight methods as compared to different combinations of biometrical characters within the respective weight method. Among different weight methods equal weight (W_1) had highest PRE followed by genotypic

Table 1 : Mean, range and coefficient of variation for different characters of okra

Parameters	Yield (g)	Plant Height (cm)	No. of Internodes	Fruit length (cm)	No. Fruits per Plant	Fruit Weight (g)
Mean	278.18	141.33	19.31	14.15	20.15	13.90
Range	206.33-399.99	98.73-168.40	16.53-21.87	11.71-16.01	16.60-24.07	11.54-17.03
S.Em. ±	16.93	8.70	0.90	0.52	1.03	0.46
CD at 5%	47.45	24.38	2.53	1.45	2.88	1.29
CV (%)	10.54	10.66	8.08	6.32	8.82	5.75
Broad sense heritability	79.76	59.82	44.57	66.96	71.73	86.69

Table 2 : Simple correlation coefficients between fruit yield and different characters of okra genotypes

CHARACTERS	FY	PH	NOIMS	FL	FP	FW
FY	1.0000	-	-	-	-	-
PH	0.2519*	1.0000	-	-	-	-
NOIMS	0.2831*	0.4328*	1.0000	-	-	-
FL	0.2011*	0.3995*	0.1391	1.0000	-	-
FP	0.7471*	0.1816*	0.4161*	0.0049	1.0000	-
FW	0.6794*	0.1874*	-0.0370	0.3163*	0.0277	1.0000

*, ** significant at 0.05 and 0.01 level of significance, respectively
Where, **FY**: Fruit yield per Plant, **PH**: Plant Height, **NOIMS**: Number of Internodes on Main Stem, **FL**: Fruit Length, **FP**: Fruits per Plant, **FW**: Fruit Weight.

Table 3 : Genotypic and Phenotypic correlation coefficients between different characters in okra

CHARACTERS	PARAMERERS	FY	PH	NOIMS	FL	FP	FW
FY	rg	1.0000	0.3125*	0.2969*	0.3684*	0.5860*	0.5131*
	rp	1.0000	0.2978*	0.2894*	0.2061*	0.5395*	0.4281*
PH	rg	-	1.0000	0.6712*	0.9582*	0.1298	0.2138*
	rp	-	1.0000	0.4393*	0.3967*	0.1720*	0.1107
NOIMS	rg	-	-	1.0000	0.6053*	0.4745*	-0.0060
	rp	-	-	1.0000	0.1332	0.4126*	-0.0270
FL	rg	-	-	-	1.0000	0.0866	0.3873*
	rp	-	-	-	1.0000	0.0638	0.2399*
FP	rg	-	-	-	-	1.0000	0.1375
	rp	-	-	-	-	1.0000	0.0658
FW	rg	-	-	-	-	-	1.0000
	rp	-	-	-	-	-	1.0000

r_g= genotypic correlation r_p =phenotypic correlation
*, ** significant at 0.05 and 0.01 level of significance, respectively
Where, **FY**: Fruit Yield per Plant, **PH**: Plant Height, **NOIMS**: Number of Internodes on Main Stem, **FL**: Fruit Length, **FP**: Fruits per Plant, **FW**: Fruit Weight.

Table 4: Top three ranking selection indices in different weight methods with okra fruit yield per plant

Combinations	Top Rank	Equal Wt. $[W_1]$	Corr.Wt. $[W_2]$	GCWt. $[W_3]$	PCWt. $[W_4]$
Combinations of two characters	1	I_{12} (109.06)	I_{12} (106.28)	I_{12} (107.18)	I_{12} (106.96)
	2	I_{16} (103.38)	I_{16} (102.61)	I_{16} (102.22)	I_{16} (102.02)
	3	I_{15} (102.78)	I_{15} (102.07)	I_{15} (101.62)	I_{15} (101.49)
Combin ations of three characters	1	I_{123} (122.13)	I_{123} (109.85)	I_{123} (110.75)	I_{123} (110.52)
	2	I_{125} (121.15)	I_{125} (108.51)	I_{125} (109.00)	I_{125} (108.66)
	3	I_{124} (120.48)	I_{124} (108.50)	I_{124} (109.00)	I_{124} (108.58)
Combinations of four characters	1	I_{1235} (124.91)	I_{1235} (111.86)	I_{1235} (112.36)	I_{1235} (112.02)
	2	I_{1236} (124.43)	I_{1236} (111.47)	I_{1236} (111.99)	I_{1236} (111.57)
	3	I_{1234} (124.18)	I_{1234} (110.54)	I_{1234} (111.21)	I_{1234} (110.79)
Combinations of five characters	1	I_{12356} (127.13)	I_{12356} (113.43)	I_{12356} (113.55)	I_{12356} (113.02)
	2	I_{12345} (126.83)	I_{12345} (112.10)	I_{12345} (112.82)	I_{12345} (112.28)
	3	I_{12346} (126.47)	I_{12346} (111.71)	I_{12346} (112.45)	I_{12346} (111.83)

Parenthesis value indicates per cent relative efficiency (PRE)

Table 5: Rank correlations between different weight methods based on best selection index of respective weight methods including okra fruit yield per plant

Weight	Equal wt.	Corr. Wt.	GC Wt.	PC Wt.
Equal Wt.	1.000**	0.999**	0.999**	0.999**
Corr. Wt.	-	1.000	1.000**	1.000**
GCWt.	-	-	1.000	1.000**
PCWt.	-	-	-	1.000

*, ** significant at 0.05 and 0.01 level of significance, respectively; n = 56

correlation (W_3), Simple correlation (W_2), phenotypic correlation (W_4) as weight to different characters. Also, the selection index (I_{12356}) gave higher genetic gain in all weight methods, which is combination of fruit yield, plant height, number of internodes on main stem, fruits per plant and fruit weight.

Expected genetic gain and relative efficiency (%) for six characters

Combinations of all six biometrical characters were used to construct selection indices using different weights. The genetic gain for fruit yield alone (63.7069) with equal weight was considered as 100 PRE. Per cent relative efficiencies were 129.06, 113.67, 114.01 and 113.27, for equal weight, simple correlation, genotypic correlation and phenotypic correlation taken as weight respectively. Higher percent relative efficiency was observed in equal weight method as compared to rest of the weight methods.

Comparison of three ranking selection indices

The results presented in table 4 showed that the selection index (I_{12356}) which was combination of fruit yield per plant, plant height, number of internodes on main stem, fruits per plant and fruit weight possessed highest PRE for all the weight method. Thus, based on this results taking of equal weight method the per cent relative efficiency was highest and one can use equal weight (W_1) of characters for construction of selection indices to achieve higher genetic gain followed by simple correlation (W_2) genotypic correlation (W_3), phenotypic correlation (W_4).

Selection score with rank for fifty six genotypes based on different indices

The index score values were worked out for all four weight methods for all genotypes in respect of highest PRE given by different combination of characters. The results (Table 4) indicated that in general PRE with equal weight was higher than rest of the weights in all combinations of indices. The rank correlation among different methods for selection score values (Table 5) were positive and highly significant indicating agreement with all methods.

CONCLUSION

The selection index $I_{12356} = 0.793 X_1 + 1.009X_2 - 5.443X_3 - 0.948X_5 + 1.206X_6$ Where, X_1 = fruit yield per plant (g), X_2 = plant height (cm), X_3 = number of internodes on main stem, X_5 = number of fruits per plant and X_6 = fruit weight (g) was suggested to select the genotypes for okra fruit yield improvement with equal weight method. Thus, based on these results taking equal weight method the per cent relative efficiency was the highest and one can use equal weight (W_1) of characters for construction of selection indices to achieve higher genetic gain followed by simple correlation (W_2) genotypic correlation (W_3) and phenotypic correlation (W_4). Hybrid GAO 5 X Kashi Kranti (P1 X P5) was suggested as top ranking genotype in all the weight methods.

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