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Research Note

Genetic variability and selection indices for improving seed yield in soybean (*Glycine max* L. Merrill)

H. R. Adsul[1] and B. A. Monpara[2]*
[1]Department of Genetics and Plant Breeding, Junagadh Agricultural University, Junagadh-362001, Gujarat
[2]Agricultural Research Station, Junagadh Agricultural University, Keriya Road, Amreli
Email: bamonpara@yahoo.com

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Abstract
Variability and selection indices were studied involving 100 germplasm lines of soybean. High heritability was accompanied by high genetic advance and moderate to high GCV observed for all the characters under consideration, indicating the possibility of improving these traits through selection. Discriminant function analysis indicated that almost all the selection indices were found to be more efficient than straight selection based on seed yield alone. Selection efficiency of the function was improved by increasing number of characters in the index. The index consisting of all the six traits gave the highest genetic gain and selection efficiency. Inclusion of pods per plant in selection index appears to increase its relative efficiency. For practical view point, the selection index based on four characters, *viz*., clusters per plant + pods per plant + biological yield per plant + harvest index, is recommended for yield improvement in soybean.

Key wards:
Soybean, germplasm, heritability, selection indices

Soybean (*Glycine max* L. Merrill) is one of the world's leading sources of vegetable oil and plant protein, both of which are very well adapted to the nourishment of human beings. It contains about 37-42% good quality protein and about 17-24% oil (Zafar *et al*., 2010). Soybean tops in the world production of both oilseeds and edible oil. It is cultivated at broadly diverse geographical locations and under many different growing conditions. In India, it is grown in an area of 10.8 million hectares and accounting production of 11.5 million tonnes with productivity of 1065 kg/ha (FAO, 2012). Soybean is well suited to semi-arid regions of the country. Indeed, it is one of the few crops that can produce sustainable yield in relatively harsh environments.

Variability is the prerequisite for success in improvement of any crop plant and determines the amount of progress expected from selection. In addition, the plant breeder has certain desired plant characteristics in his mind while selecting for a particular genotype and for this he applies various weights to different traits for arriving on decisions. This suggests the use of selection index which gives proper weight to each of the characters to be considered. Hazel and Lush (1943) showed that the selection based on such an index is more efficient than selecting individually for various 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. Selection based on indices permits maximizing the response to selection for one or a group of traits. Selection index have been an effective criterion to increase grain yield in soybean (Costa *et al.,* 2008). Many researchers have used selection index as an effective selection criterion in their breeding programs on different crops, however, the conditions determining the usefulness of an appropriate selection index may vary with individual plant breeder. In order to have a comprehensive knowledge about genetic variability for yield and its five contributing traits and to find out suitable selection indices using all possible combinations of contributing traits, the present study in soybean was under taken.

The experimental material comprised of one hundred genotypes of soybean obtained from the Agricultural Research Station, Junagadh Agricultural University, Amreli. The study was conducted in randomized block design with three replications during rainy season 2011 at the Instructional Farm, Junagadh Agricultural University, Junagadh. Each entry was accommodated in a single row of 4.0 m length with a spacing of 45 x 10 cm. The observations were recorded on five randomly selected plants from each entry per replication for six characters (Table 1) and their mean values were used for statistical analysis.

Genotypic and phenotypic coefficients of variation as per Burton (1952) and heritability and genetic advance according to Allard (1960) were estimated. Discriminant function analysis described by Dabholkar (1999) was used to construct the selection indices involving six characters, *viz.*, yield per plant (X1), pods per cluster (X2), clusters per plant (X3), pods per plant (X4), biological yield per plant (X5) and harvest index (X6). For computing selection indices, seed yield per plant was considered as the dependant variable with the relative efficiency of 100 percent. The expected genetic advance and relative efficiency of index selection were calculated according to Robinson *et al.* (1951).

Variations among the genotypes were significant for all the characters (Table 1). Enormous variability for all the six traits was observed, as is evident from the estimates of variability parameters. Estimates of PCV and GCV ranged from 16.85 to 40.22% and 14.15 to 35.84 % respectively. Moderate to high magnitude of both the parameters revealed that genotypic effects accounted for appreciable portion of this variability for all the characters. The heritability and genetic advance as percentage of mean were high for all the traits under consideration. These results are in agreement with the earlier reports of Gohil *et al.* (2007) and Sirohi *et al.* (2007) in soybean.

The breeder is seldom faced with a situation in which modification of single attribute is desired. Normally, modifications are desired in several attributes. The theory of manipulating several contributing traits simultaneously a selection index has been provided by Smith (1936) and Hazel (1943). In order to have a more comprehensive knowledge about the relative role of component traits towards the improvement of complex and economically important trait like seed yield, the discriminant function analysis made to find out suitable selection indices for the complex trait in soybean.

A total of 63 selection indices (Table 2) based on six characters constructed in all possible combinations revealed that selection efficiency was higher over straight selection when the selection was based on individual components. Pods per plant (Table 2), showed a genetic advance of 13.46% which was higher than those calculated for other characters including seed yield per plant. This suggests that pods per plant proved to be better index selection based on one character.

The highest genetic gain of 23.24% was obtained when selection was made simultaneously based on discriminant function of two characters, e.g. pods per plant (X4) and harvest index (X6). When three characters, e.g. clusters per plant (X3), pods per plant (X4), harvest index (X6) were taken together, the genetic advance increased to 27.66%. Combination of four characters, *i.e* clusters per plant (X3), pods per plant (X4), biological yield per plant (X5), and harvest index (X6) at a time recorded still high genetic gain (30.39%). The genetic gain of 32.73% was achieved by taking five characters at a time, *i.e.* seed yield (X1), clusters per plant (X3), pods per plant (X4), biological yield per plant (X5) and harvest index (X6) (Table 2). The function that includes all the six characters gave the highest genetic advance (33.12%).

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 Dalal (1979) in soybean and Sarvaliya (1993), Samal and Jagadev (1996), Sable *et al*. (2003) and Raval and Dobariya (2005) in chickpea also opined that an increase in performance of individual trait results in an increase of genetic gain and relative efficiency. Costa *et al*. (2008) suggested that the use of indices is advantageous over direct selection in soybean segregating populations. While studying selection indices with F_2 populations of interspecific crosses in soybean, Mannur *et al.* (1991) opined that the efficiency of index improves with increase in number of characters up to four, after which it was decreased.

A perusal of the data presented in Table 3 indicated that selection efficiency improved with an increase in number of characters in combination with yield. For example, average selection efficiency was 262.53% when one character was included in selection function. It was increased to 488.71% with two, 703.41% with three, 912.75% with four, 1119.70% with five and 1324.86% with six characters.

It is interesting to note that when pods per plant was combined with any other character, the expected genetic gain improved (Table 2). The importance of increasing pods per plant for improving seed yield through involving this trait in selection indices have been earlier reported by Mannur *et al*. (1991) in soybean.

Some of the selection indices with high relative efficiency listed in Table 4 indicated that the highest efficiency was observed with six characters combination (1324.86%). Selection indices with six characters, *i.e.* seed yield per plant (X1), pods per cluster (X2), clusters per plant (X3), pods per plant (X4), biological yield (X5) and harvest index (X5), therefore, appear to be more useful. Comprehensive examination of this table indicated that pods per plant (X4), harvest index (X6), clusters per plant (X3) and biological yield per plant (X5) were in order of X4>X6>X3>X5 being involved in more number of character combinations. On the other hand, seed yield per plant (X1) and pods per cluster (X2) appeared only in three and two combinations, respectively.

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 four characters (clusters per plant + pods per plant + biological yield per plant + harvest index) showing higher genetic gain (30.39) and selection efficiency (1215.57%) comparable to some extent of those based on more characters, is desirable and practically possible to use.

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Table 1. Variability parameters for major yield components in soybean

Characters	Mean	Range	PCV (%)	GCV (%)	h^2 (%)	GA as % mean
Seed yield/plant (g)	4.00	8.80*	38.45	34.14	78.83	62.45
Pods/Cluster	1.66	1.52*	22.55	20.41	81.97	38.07
Clusters/plant	12.33	16.13*	32.64	27.53	71.14	47.83
Pods/plant	20.46	37.47*	40.22	35.84	79.40	65.80
Biological yield/plant (g)	7.40	9.53*	29.03	27.06	86.91	51.97
Harvest index (%)	53.25	47.17*	16.85	14.15	70.55	24.49

* Significant at P=0.01 level

Table 2. Selection index, discriminant function, expected genetic advance and relative efficiency for different selection indices in Soybean

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)
1	X1(Seed yield/plant)	X1	2.50	100.00
2	X2 (pods/cluster)	X2	0.63	25.20
3	X3 (Clusters/plant)	X3	5.90	236.00
4	X4 (Pods/plant)	X4	13.46	538.40
5	X5 (Biological yield/ plant)	X5	3.85	154.00
6	X6 (Harvest index)	X6	13.04	521.60
7	X1.X2	0.766X1 + 1.124X2	2.93	117.17
8	X1.X3	0.997X1 + 0.645X3	7.93	317.02
9	X1.X4	1.028X1 + 0.759X4	15.77	630.83
10	X1.X5	0.414X1 + 1.132X5	6.20	247.92
11	X1.X6	0.824X1 + 0.691X6	14.67	586.95
12	X2.X3	1.365X2 +0.714 X3	6.04	241.71
13	X2.X4	2.336X2 + 0.756X4	13.93	557.02
14	X2.X5	0.947X2 + 0.867X5	4.19	167.48
15	X2.X6	2.855X2 + 0.679X6	13.44	537.51
16	X3.X4	0.435X3 + 0.921X4	18.68	747.00
17	X3.X5	0.570X3 + 1.212X5	9.30	371.84
18	X3.X6	0.588X3 + 0.704X6	15.84	633.56
19	X4.X5	0.683X4 +1.386 X5	16.88	675.12
20	X4.X6	0.845X4 + 0.642X6	23.24	929.77
21	X5.X6	0.791X5 + 0.694X6	14.24	569.69
22	X1.X2.X3	0.847X1 + 1.521X2 + 0.689X3	8.15	326.15
23	X1.X2.X4	1.105X1 + 2.717X2 + 0.698X4	16.24	649.79
24	X1.X2.X5	0.353X1 + 1.423X2 + 1.135X5	6.57	262.94
25	X1.X2.X6	0.533X1 + 3.526X2 + 0.690X6	15.13	605.23
26	X1.X3.X4	1.079X1 +0.388 X3 + 0.897X4	20.94	837.70
27	X1.X3.X5	0.055X1 +0.589 X3 + 1.676X5	11.53	461.24
28	X1.X3.X6	1.824X1 +0.387 X3 + 0.614X6	17.93	717.10
29	X1.X4.X5	-0.100X1 +0.753 X4 +1.762X5	19.26	770.20
30	X1.X4.X6	1.155X1 +0.811 X4 + 0.607X6	25.45	1017.88
31	X1.X5.X6	4.421X1 +-1.119X5 + 0.392X6	16.36	654.56
32	X2.X3.X4	1.468X2 + 0.519X3 + 0.873 X4	19.02	760.74
33	X2.X3.X5	0.691X2 + 0.567X3 + 1.231X5	9.50	380.18
34	X2.X3.X6	3.580X2 + 0.631X3 + 0.660X6	16.26	650.24
35	X2.X4.X5	2.832X2 + 0.621X4 + 1.442X5	17.34	693.57
36	X2.X4.X6	4.846X2 + 0.741X4 + 0.644X6	23.80	952.01
37	X2.X5.X6	3.613X2 + 0.632X5 +0.669 X6	14.73	589.38
38	X3.X4.X5	0.338X3 + 0.771X4 + 1.766X5	22.18	887.37
39	X3.X4.X6	0.002X3 + 1.181X4 + 0.584X6	27.66	1106.36
40	X3.X5.X6	0.411X3 + 1.345X5 + 0.691X6	17.94	717.48
41	X4.X5.X6	0.852X4 +0.883 X5 + 0.621X6	25.70	1028.05

Table 2. Contd..

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)
42	X1.X2.X3.X4	1.114X1 +1.785X2 + 0.510X3 + 0.819X4	21.30	851.82
43	X1.X2.X3.X5	-0.098X1 + 1.656X2 + 0.642X3 + 1.652X5	11.79	471.59
44	X1.X2.X3.X6	1.263X1 + 3.289X2 + 0.535X3 +0.618X6	18.30	731.98
45	X1.X2.X4.X5	-0.066X1 + 3.159X2 + 0.678X4 + 1.813X5	19.72	788.89
46	X1.X2.X4.X6	1.340X1 + 5.269X2 + 0.671X4 +0.600X6	26.02	1040.78
47	X1.X2.X5.X6	3.966X1 + 3.747X2 + -1.041X5 + 0.402X6	16.86	674.41
48	X1.X3.X4.X5	-0.746X1 + 0.262X3 + 0.921X4 + 2.405X5	24.55	982.18
49	X1.X3.X4.X6	1.608X1 +-0.056 X3 + 1.110X4 + 0.527X6	29.95	1197.95
50	X1.X3.X5.X6	3.274X1 +0.422 X3 + 0.039X5 +0.479X6	20.19	807.80
51	X1.X4.X5.X6	3.577X1 + 0.851X4 + -0.571X5 + 0.386X6	28.04	1121.65
52	X2.X3.X4.X5	1.152X2 + 0.383X3 +0.745 X4 +1.769X5	22.53	901.08
53	X2.X3.X4.X6	-2.018X2 + -0.334X3 + 1.391X4 + 0.583X6	28.04	1121.56
54	X2.X3.X5.X6	3.602X2 + 0.594X3 + 0.974X5 +0.643X6	18.33	733.33
55	X2.X4.X5.X6	5.154X2 + 0.708X4 + 1.011X5 +0.630X6	26.27	1050.68
56	X3.X4.X5.X6	-0.058X3 +1.110X4 + 1.302X5 + 0.587X6	30.39	1215.57
57	X1.X2.X3.X4.X5	-0.768X1 + -0.269X2 + 0.135X3 +1.000 X4 + 2.427X6	24.90	996.09
58	X1.X2.X3.X4.X6	1.592X1 + -1.610X2 + -0.342X3 + 1.291X4 + 0.527X6	30.33	1213.20
59	X1.X2.X3.X5.X6	3.249X1 + 3.915X2 + 0.626X3 +-0.360X5 + 0.428X6	20.61	824.37
60	X1.X2.X4.X5.X6	3.137X1 + 5.371X2 + 0.702X4 +-0.205X5 + 0.430X6	28.61	1144.26
61	X1.X3.X4.X5.X6	0.743X1 + -0.105X3 + 1.139X4 +1.346 X5 + 0.574X6	32.73	1309.37
62	X2.X3.X4.X5.X6	-1.938X2 + -0.386X3 + 1.308X4 + 1.329X5 + 0.587X6	30.77	1230.94
63	X1.X2.X3.X4.X5.X6	-0.176X1 + -2.673X2 +-0.545X3 + 1.403X4 + 1.865X5 + 0.645X6	33.12	1324.86

Table 3. Average selection efficiency of different combination in soybean

No. of character in an index	Selection Efficiency (%)
One	262.53
Two	488.71
Three	703.41
Four	912.75
Five	1119.70
Six	1324.86

Table 4. Highest selection efficiency with character combination in soybean

Character	Relative efficiency
pods /plant	538.4
pods/plant + harvest index	929.77
Pods/plant + biological yield/plant + harvest index	1028.05
Clusters/plant + pods/plant + harvest index	1106.36
Seed yield/plant + clusters/plant + pods/plant + harvest index	1197.95
Clusters/ plant + pods/plant +biological yield/plant + harvest index	1215.57
Pods /cluster + clusters /plant + pods/plant + biological yield/plant + harvest index	1230.94
Seed yield/plant + clusters/plant + pods/plant + biological yield/plant + harvest index	1309.37
Seed yield/plant + pods/cluster + clusters /plant + pods/plant + biological yield/plant + harvest index	1324.86