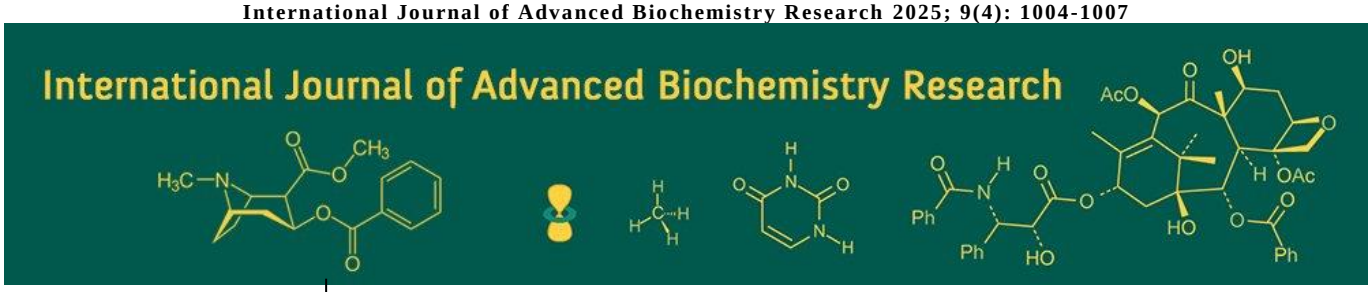

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Selection indices for yield, yield components and resistance to late leaf spot in groundnut (*Arachis hypogaea* L.)

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Abstract
Thirty one diverse genotypes of groundnut were evaluated in a randomized block design with three replications for the study of selection indices during *kharif* 2023. Sixty three selection indices involving pod yield/plant (X_1) and five yield components *viz*., number of primary branches/plant (X_2), dry haulm yield/plant (X_3), kernel yield/plant (X_4), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6) were constructed using the discriminant function technique. Discriminant function analysis indicated that selection efficiency of the function was improved by increasing the number of characters in the index. Among the single character indices, dry haulm yield/plant exhibited higher genetic advance and relative efficiency over straight selection for pod yield/plant. The index based on six characters *viz*., pod yield/plant (X_1) + number of primary branches/plant (X_2) + dry haulm yield/plant (X_3) + kernel yield/plant (X_4) + late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6) recorded the highest genetic advance as well as relative efficiency and selection efficiency. However, in practice, the plant breeder might be interested in maximum gain with minimum number of characters. In the present study, improvement of pod yield in groundnut could be achieved by selecting the parents with these four characters; number of primary branches/plant + dry haulm yield/plant + late leaf spot at 75 DAS + late leaf spot at 90 DAS which is more desirable and practically possible to use by breeder than the index that includes more number of characters.

Keywords: Discriminant function, relative efficiency, selection indices and groundnut

Introduction
Groundnut (*Arachis hypogaea* L.) is one of the most economic oilseed crops of the world. It is considered as the world's fourth largest source of edible oil and third most important source of vegetable protein (Desai *et al*., 1999) [4]. Yield in crops is a quantitative trait and has a complex genetic control mechanism and hence, direct selection is not much effective on it. Since the economic part of groundnut known as pod is developed under the soil, the prediction of its performance based on aerial morphological characters is almost difficult (Weiss, 2000) [15]. The most desirable approach to improve characteristics such as pod yield is simultaneous selection based on related traits (Bos and Caligri, 2007) [1]. This can be done using selection index, which is multiple regressions of genotypic values on phenotypic values of several traits (Falconer, 1996) [6]. The use of selection index is superior in improving complex traits (Hasel and Lush, 1942) [9]. Furthermore, the selection indices approach aimed at determining the most suitable combination of traits with the intention of indirectly improving the pod yield in groundnut was well documented (Dobariya *et al*., 2008) [5].

Certain desired plant characteristics are considered while selecting for particular genotype with varying weightage given to different traits for arriving on decisions. The better way of exploiting genetic correlations with several traits having high heritability is to construct an index which combines information on all the characters associated with yield. This suggests the use of selection index, which gives proper weight to each of the two or more characters to be considered. Selection index was proposed for the first time by Smith (1936) [14] on the basis discriminant function of Fisher (1936) [7]. Hazel and Lush (1943) [10] and Robinson *et al*. (1951) [13] showed that the selection based on such an index is more efficient than selecting individually for the various characters. Few studies on selection indices in

groundnut have been carried out earlier by Dobariya *et al*. (2008) [5]; Babariya *et al*. (2014) [2] and Gupta *et al*. (2015) [8]. However, in order to have a more comprehensive knowledge about genetic variability for yield and its attributing traits, it is important to find out a suitable selection indices for the improvement of pod yield in groundnut. Keeping these facts in view, the present study was undertaken in order to construct selection indices for efficient selection in groundnut breeding programme.

Materials and Methods

Thirty one genotypes of groundnut were sown in a Randomized Block Design (RBD) with three replications during *kharif* 2023. Each genotype was sown in 2 rows of 3 m length with a spacing of 30 cm between rows and 10 cm between plants within the row. The crop was raised under irrigated conditions and recommended dose of chemical fertilizers at the rate of 20 kg of N, 40 kg of P_2O_5 and 50 kg K_2O ha^{-1} in the form of urea, single super phosphate, murate of potash, respectively were applied during final ploughing operation and gypsum was added at the rate of 500 kg ha^{-1} at peak flowering stage followed by one hand weeding to remove weeds and to mix the gypsum properly in the soil. Apart from these cultural operations, need based plant protection measures were taken to control insect pests. Observations were recorded for all the genotypes separately on randomly chosen five competitive plants in each genotype in each replication for all the characters except for days to 50% flowering and days to maturity which were recorded on plot basis. Data were recorded for 15 characters *viz*., days to 50% flowering, days to maturity, plant height at harvest, number of primary branches/plant, number of secondary branches/plant, number of mature pods/plant, number of immature pods/plant, pod yield/plant, dry haulm yield/plant, harvest index percent, shelling percent, kernel yield/plant, sound mature kernel percent, hundred kernel weight, disease scoring of late leaf spot disease at 75 DAS and 90 DAS.

Discriminant function analysis described by Dabholkar (1992) [3] was used to construct the selection indices involving six characters, pod yield/plant (X_1), number of primary branches/plant (X_2), 100-kernel weight (X_3), biological yield/plant (X_4), harvest index (X_5) and days to maturity (X_6). For computing selection indices, pod yield/plant was considered as the dependent variable with the relative efficiency of 100%. The model suggested by Robinson *et al*. (1951) [13] was used for the construction of genetic advance as well as selection indices and development of a required discriminant function using six characters along with pod yield/plant.

Results and Discussion

High genetic advance coupled with high heritability estimates offers the most suitable condition for selection which indicates the presence of additive genes in the trait and further suggest reliable crop improvement through selection of traits (Ogunniyan and Olakojo, 2014) [11]. Therefore, total six characters out of fifteen characters under study with high genetic advance coupled with high heritability were used for construction of selection indices. A total of sixty three selection indices (Table 1) based on six characters constructed in all possible combinations revealed that the selection efficiency was high over straight selection when selection was based on individual components. Dry haulm yield/plant (g) showed a genetic advance of 23.17%, which was higher than those calculated for other characters including pod yield/plant suggested that dry haulm yield/plant (g) proved to be better selection index based on one character.

The highest genetic gain (Table 1) of 34.45% was obtained when selection was simultaneously based on discriminant function of two characters, e.g. pod yield/plant (X_1) and dry haulm yield/plant (X_3). When three characters, e.g. number of primary branches/plant (X_2), dry haulm yield/plant (X_3) and kernel yield/plant (X_4) were taken together, the genetic advance increased to 38.14%. Index based on combination of four characters, *i.e.* number of primary branches/plant (X_2), dry haulm yield/plant (X_3), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6) recorded high genetic gain of 46.82%. Index based on combination of five characters, *i.e.* number of primary branches/plant (X_2), dry haulm yield/plant (X_3), kernel yield /plant (X_4), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6) recorded high genetic gain of 49.01%. The maximum gain of 52.04% was achieved by taking six characters at a time, *i.e.* pod yield/plant (X_1), number of primary branches/plant (X_2), dry haulm yield/ plant (X_3), kernel yield/plant (X_4), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6).

Thus, the current study revealed that the index which includes more than one character, gave high genetic advance, suggesting the utility of constructing of selection indices for effecting simultaneous improvement in several characters. Hazel and Lush (1943) [10] stated that the superiority of selection based on index increases with an increase in the number of characters under selection. Smith (1936) [14], Rao (1974) [12], Dobariya *et al*. (2008) [5], Babariya *et al*. (2014) [2] and Gupta *et al*. (2015) [8] also with same opinion that inclusion of characters one by one in the function resulted in increasing genetic advance and that the selection indices improve the efficiency than the straight selection for yield alone.

The relative efficiency (RE%) of various selection indices presented in Table 1 indicated that when relative efficiency of single character index was measured over straight selection for pod yield/plant, the efficiency was declined to less than 100%. This observation indicated that the indirect selection through individual traits over straight selection for pod yield/plant alone would not be effective. Therefore, an increase in number of characters in combination with yield would be effective.

It is interesting to note that selection efficiency (Table 2) improved with an increase in number of characters in combination with yield. For example, average selection efficiency of 108.74%, when one character was included in selection function. Similarly, the selection efficiency was 236.27% for two characters, 341.16% for three characters, 458.11% for four characters, 488.40% for five characters and 532.01% for six characters selection indices improve the selection efficiency than the straight selection for yield alone with an increase in the number of characters under selection.

Table 1: Selection index, discriminant function, expected genetic advance in yield and relative efficiency from the use of different selection indices in groundnut

S. No.	Selection Index	Discriminant Function	Expected Genetic Advance (%)	Relative Efficiency (%)
1	X_1 Pod yield/plant (g)	0.7018 X_1	9.22	100
2	X_2 Number of primary branches/plant	0.8657 X_2	6.12	80.71
3	X_3 Dry haulm yield/plant (g)	0.9107 X_3	23.17	204.12
4	X_4 Kernel yield/plant (g)	0.6379 X_4	8.17	93.12
5	X_5 Late leaf spot at 75 DAS	0.8306 X_5	6.42	87.83
6	X_6 Late leaf spot at 90 DAS	0.8428 X_6	7.93	86.63
7	$X_1.X_2$	0.6976 X_1 + 1.1436 X_2	16.78	190.02
8	$X_1.X_3$	0.6984 X_1 + 0.9975 X_3	34.45	360.92
9	$X_1.X_4$	0.7521 X_1 + 0.8637 X_4	17.14	197.91
10	$X_1.X_5$	0.6838 X_1 + 0.6833 X_5	15.12	184.03
11	$X_1.X_6$	0.6812 X_1 + 0.7350 X_6	15.95	185.42
12	$X_2.X_3$	0.9468 X_2 + 0.9125 X_3	30.15	331.84
13	$X_2.X_4$	0.9729 X_2 + 0.6301 X_4	14.12	180.09
14	$X_2.X_5$	0.8207 X_2 + 0.8015 X_5	12.04	175.84
15	$X_2.X_6$	0.7565 X_2 + 0.7876 X_6	14.43	181.71
16	$X_3.X_4$	0.9446 X_3 + 0.6441 X_4	33.43	349.04
17	$X_3.X_5$	0.9111 X_3 + 0.8711 X_5	26.21	316
18	$X_3.X_6$	0.9046 X_3 + 0.8118 X_6	30.62	336.71
19	$X_4.X_5$	0.6021 X_4 + 0.6782 X_5	15.63	185.12
20	$X_4.X_6$	0.6306 X_4 + 0.7777 X_6	16.23	188.12
21	$X_5.X_6$	0.9096 X_5 + 0.8467 X_6	14.23	181.23
22	$X_1.X_2.X_3$	0.6940 X_1 + 1.1691 X_2 + 0.9957 X_3	36.12	375.04
23	$X_1.X_2.X_4$	0.7591 X_1 + 1.1217 X_2 + 0.8356 X_4	30.12	331.01
24	$X_1.X_2.X_5$	0.6843 X_1 + 1.0815 X_2 + 0.7141 X_5	26.73	316.34
25	$X_1.X_2.X_6$	0.6852 X_1 + 1.0189 X_2 + 0.7333 X_6	27.23	320.42
26	$X_1.X_3.X_4$	0.7705 X_1 + 0.9913 X_3 + 0.8159 X_4	37.15	381.14
27	$X_1.X_3.X_5$	0.6799 X_1 + 1.0008 X_3 + 0.7937 X_5	34.12	358.65
28	$X_1.X_3.X_6$	0.6812 X_1 + 0.9942 X_3 + 0.7574 X_6	33.23	348.94
29	$X_1.X_4.X_5$	0.7450 X_1 + 0.8303 X_4 + 0.6527 X_5	27.13	320.03
30	$X_1.X_4.X_6$	0.7285 X_1 + 0.8742 X_4 + 0.7607 X_6	30.14	331.42
31	$X_1.X_5.X_6$	0.6677 X_1 + 0.7930 X_5 + 0.8177 X_6	26.94	316.89
32	$X_2.X_3.X_4$	1.0306 X_2 + 0.9462 X_3 + 0.6296 X_4	38.14	380.04
33	$X_2.X_3.X_5$	0.9214 X_2 + 0.9133 X_3 + 0.8667 X_5	35.12	372.81
34	$X_2.X_3.X_6$	0.8352 X_2 + 0.9073 X_3 + 0.7741 X_6	36.03	374.02
35	$X_2.X_4.X_5$	0.8988 X_2 + 0.5994 X_4 + 0.6657 X_5	26.42	316.22
36	$X_2.X_4.X_6$	0.8425 X_2 + 0.6283 X_4 + 0.7391 X_6	23.43	304.91
37	$X_2.X_5.X_6$	0.7451 X_2 + 1.0056 X_5 + 0.7230 X_6	24.52	310.62
38	$X_3.X_4.X_5$	0.9437 X_3 + 0.6204 X_4 + 0.7533 X_5	32.64	342.43
39	$X_3.X_4.X_6$	0.9371 X_3 + 0.6416 X_4 + 0.7699 X_6	34.52	365.07
40	$X_3.X_5.X_6$	0.9080 X_3 + 1.2573 X_5 + 0.5777 X_6	31.83	340.83
41	$X_4.X_5.X_6$	0.6215 X_4 + 0.5957 X_5 + 0.9952 X_6	26.73	316.34
42	$X_1.X_2.X_3.X_4$	0.7770 X_1 + 1.1559 X_2 + 0.9899 X_3 + 0.7861 X_4	44.23	456.72
43	$X_1.X_2.X_3.X_5$	0.6766 X_1 + 1.1446 X_2 + 1.0006 X_3 + 0.8382 X_5	42.61	421.51
44	$X_1.X_2.X_3.X_6$	0.6838 X_1 + 1.0580 X_2 + 0.9930 X_3 + 0.7627 X_6	43.01	436.41
45	$X_1.X_2.X_4.X_5$	0.7548 X_1 + 1.0497 X_2 + 0.8087 X_4 + 0.6673 X_5	39.01	382.94
46	$X_1.X_2.X_4.X_6$	0.7420 X_1 + 1.0014 X_2 + 0.8495 X_4 + 0.7481 X_6	39.84	396.61
47	$X_1.X_2.X_5.X_6$	0.6720 X_1 + 1.0178 X_2 + 0.8855 X_5 + 0.7519 X_6	41.43	410.03
48	$X_1.X_3.X_4.X_5$	0.7578 X_1 + 0.9930 X_3 + 0.8000 X_4 + 0.7451 X_5	45.92	502.31
49	$X_1.X_3.X_4.X_6$	0.7492 X_1 + 0.9883 X_3 + 0.8278 X_4 + 0.7662 X_6	45.95	505.01
50	$X_1.X_3.X_5.X_6$	0.6611 X_1 + 1.0032 X_3 + 1.1870 X_5 + 0.5726 X_6	45.01	481.03
51	$X_1.X_4.X_5.X_6$	0.7127 X_1 + 0.8795 X_4 + 0.5942 X_5 + 0.9821 X_6	39.71	385.03
52	$X_2.X_3.X_4.X_5$	0.9801 X_2 + 0.9460 X_3 + 0.6108 X_4 + 0.7578 X_5	46.12	516.01
53	$X_2.X_3.X_4.X_6$	0.9044 X_2 + 0.9396 X_3 + 0.6335 X_4 + 0.7433 X_6	46.74	516.45
54	$X_2.X_3.X_5.X_6$	0.8204 X_2 + 0.9113 X_3 + 1.3538 X_5 + 0.4708 X_6	46.82	516.94
55	$X_2.X_4.X_5.X_6$	0.8342 X_2 + 0.6224 X_4 + 0.6909 X_5 + 0.8903 X_6	43.14	444.23
56	$X_3.X_4.X_5.X_6$	0.9392 X_3 + 0.6417 X_4 + 0.9675 X_5 + 0.7352 X_6	45.72	500.42
57	$X_1.X_2.X_3.X_4.X_5$	0.7643 X_1 + 1.1130 X_2 + 0.9926 X_3 + 0.7777 X_4 + 0.7729 X_5	44.11	450.04
58	$X_1.X_2.X_3.X_4.X_6$	0.7615 X_1 + 1.0410 X_2 + 0.9869 X_3 + 0.8028 X_4 + 0.7605 X_6	45.21	480.43
59	$X_1.X_2.X_3.X_5.X_6$	0.6638 X_1 + 1.0557 X_2 + 1.0025 X_3 + 1.2784 X_5 + 0.5146 X_6	44.62	460.83
60	$X_1.X_2.X_4.X_5.X_6$	0.7252 X_1 + 1.0014 X_2 + 0.8581 X_4 + 0.6787 X_5 + 0.9122 X_6	45.24	495.83
61	$X_1.X_3.X_4.X_5.X_6$	0.7225 X_1 + 0.9964 X_3 + 0.8479 X_4 + 0.9731 X_5 + 0.7346 X_6	48.52	520.13
62	$X_2.X_3.X_4.X_5.X_6$	0.8908 X_2 + 0.9420 X_3 + 0.6369 X_4 + 1.0607 X_5 + 0.6427 X_6	49.01	523.12
63	$X_1.X_2.X_3.X_4.X_5.X_6$	0.7337 X_1 + 1.0393 X_2 + 0.9954 X_3 + 0.8261 X_4 + 1.0563 X_5 + 0.6723 X_6	52.04	532.01

Table 2: Average selection efficiency of different combination of characters in groundnut

No. of characters in the index	Selection efficiency (%)
One	108.74
Two	236.27
Three	341.16
Four	458.11
Five	488.4
Six	532.01

Table 3: Highest selection efficiency with character combinations in groundnut

S. No.	Character	Selection Efficiency (%)
1	Dry haulm yield/plant	204.12
2	Pod yield/plant + Dry haulm yield/plant	360.92
3	Pod yield/plant + Dry haulm yield/plant + Kernel yield/plant	381.14
4	Number of primary branches/plant + Dry haulm yield/plant + Kernel yield/plant	380.04
5	Number of primary branches/plant + Dry haulm yield/plant + Late leaf spot at 75 DAS + Late leaf spot at 90 DAS	516.94
6	Number of primary branches/plant + Dry haulm yield/plant + Kernel yield/plant + Late leaf spot at 75 DAS + Late leaf spot at 90 DAS	523.12
7	Pod yield/plant + Number of primary branches/plant + Dry haulm yield/plant + Kernel yield/plant + Late leaf spot at 75 DAS + Late leaf spot at 90 DAS	532.01

Some of the selection indices with high relative efficiency listed in Table 1 indicated that the highest efficiency was observed with a combination of six characters (532.01%). Selection indices with six characters, i.e. pod yield/plant (X_1), number of primary branches/plant (X_2), dry haulm yield/plant (X_3), kernel yield/plant (X_4), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6), therefore, appear to be more useful. It can be seen that number of primary branches/plant (X_2), dry haulm yield/plant (X_3) and kernel yield/plant (X_4) were the characters being commonly involved in more number of the combinations, the next being pod yield/plant (X_1), late leaf spot at 75 DAS (X_5) and late leaf spot at 90 DAS (X_6) in order (Table 3).

Keeping in view, the basic idea 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. However, in practice, the plant breeder might be interested in maximum gain with minimum number of characters. In the present study, selection index based on four characters (number of primary branches/plant + dry haulm yield/plant + late leaf spot at 75 DAS + late leaf spot at 90 DAS) showing genetic gain (46.82%) and selection efficiency (516.94%) comparable to some extent of those based on five or more characters, which is more desirable and practically possible to use breeder than the index that includes more number of characters.

Conclusion

From this investigation, it is concluded that improvement of pod yield in groundnut could be achieved by selecting the parents with these four characters; number of primary branches/plant + dry haulm yield/plant + late leaf spot at 75 DAS + late leaf spot at 90 DAS.

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