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Research Note

Selection indices in Virginia groundnut (*Arachis hypogaea* L.)

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Abstract
Sixty diverse genotypes of Virginia groundnut were evaluated in a randomized block design with three replications to study of selection indices under rainfed conditions during *kharif* 2013. Sixty-three selection indices involving pod yield per plant (X_1) and five yield components *viz.*, 100-kernel weight (X_2) shelling out-turn (X_3), biological yield per plant (X_4), harvest index (X_5) and kernel yield per plant (X_6) were constructed using the discriminant function technique. Discriminant function analysis indicated that selection efficiency of the function was improved by increasing number of characters in the index. Among the single character index, 100-kernel weight exhibited higher genetic advance and relative efficiency over straight selection for pod yield per plant. The index based on four characters *viz*., pod yield per plant, 100-kernel weight, shelling out-turn and kernel yield per plant recorded the highest genetic advance as well as relative efficiency and selection efficiency. These characters could be advantageously exploited in the groundnut breeding programmes.

Keywords
Groundnut, discriminate function, relative efficiency, selection indices.

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). 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). The most desirable approach to improve characteristics such as pod yield is simultaneous selection based on related traits (Bos and Caligari, 2007). This can be done using selection index, which is multiple regressions of genotypic values on phenotypic values of several traits (Falconer, 1989). 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 (Shettar, 1974; Bandyopadhyay *et al*., 1985 and Dobariya *et al*., 2008).

The plant breeder has certain desired plant characteristics in his mind while selecting for particular genotype and for this he applies various weights 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) on the basis discriminant function of Fisher (1936). Hazel and Lush (1942) and Robinson *et al*. (1951) showed that the selection based on such an index is more efficient than selecting individually for the various characters. Keeping these facts in view the present study was undertaken in order to construct selection indices for efficient selection in groundnut breeding programme.

Sixty genotypes of groundnut were sown in a Randomized Block Design (RBD) with three replications during *kharif* 2013. Each genotype was accommodated in a single row of 3.0 m length with a spacing of 60 cm between rows and 15 cm between plants within the row. The experiment was surrounded by two guard rows to avoid damage and border effects. The fertilizers in the experimental area was applied at the rate of 12.5 kg N_2 ha^{-1} and 25.0 kg P_2O_5 ha^{-1} as it is a recommended dose for *kharif* cultivation of groundnut in the region. Other recommended agronomical practices in vogue were followed for reaping good crop. Data were recorded on randomly selected five plants from each genotype and average value was used for the statistical analysis for 15 characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of primary branches per plant, number of mature pods per plant, 100-pod weight (g), 100-kernel weight (g), sound mature kernel (%), shelling out-turn (%), biological yield per plant (g), harvest index (%), kernel yield per plant (g), pod yield per plant (g), oil content (%) and protein content (%). Discriminant function analysis described by Dabholkar (1999) was used to construct the selection indices involving six characters, seed yield per plant (X_1), number of primary branches per plant (X_2), 100-seed weight (X_3), biological yield per plant (X_4), harvest index (X_5) and days to maturity (X_6). For computing selection indices, seed yield per plant was considered as the dependent variable with the *relative efficiency of 100 per cent.* The model suggested by Robinson et al. (1951) 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 seed yield per plant.

A total of sixty three selection indices based on six characters constructed in all possible combinations revealed that the selection efficiency was higher over straight selection when selection was based on individual components (Table 1). 100-kernel weight showed a genetic advance of 13.85%, which was higher than those calculated for other characters including pod yield per plant suggested that 100-kernel weight proved to be better index selection based on one character.

The highest genetic gain of 20.24% was obtained when selection was simultaneously based on discriminant function of two characters, *e.g*. shelling out-turns (X_3), biological yield per plant (X_4). When, three characters, *e.g.* pod yield per plant (X_1), shelling out turn (X_3), kernel yield per plant (X_6) were taken together, the genetic advance increased to 25.24%. The maximum gain was achieved to 45.746% by taking four characters at a time, *i.e.* pod yield per plant (X_1), 100- kernel weight (X_2), shelling out turn (X_3), kernel yield per plant (X_6) (Table 3). Combination of five characters, *i.e.* pod yield per plant (X_1), 100-kernel weight (X_2), shelling out turn (X_3), harvest index (X_5), kernel yield per plant (X_6) at a time still recorded high genetic gain of 27.64%. The function that includes all the six characters gave the highest genetic advance (27.61%).

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 (1942) stated that the superiority of selection based on index increases with an increase in the number of characters under selection. Dhumale *et al.* (1992), Rao (1974), Dobariya *et al*. (2008) and Smith (1936) also were with the same opinion that an increase in characters results in an increase in genetic gain and that the selection indices improve the efficiency than the straight selection for yield alone.

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 of 241.123% when one character was included in selection function. Similarly, the selection efficiency was 400.60% for two characters, 534.66% for three characters, 672.84% for four characters, 751.04% for five characters and 835.99% 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 2).

Some of the selection indices with high relative efficiency listed in Table 3 indicated that the highest efficiency was observed with six characters combination (835.99%). Selection indices with six characters, *i.e*. pod yield per plant (X_1), 100-kernel weight (X_2), shelling out turn (X_3), biological yield per plant (X_4), harvest index (X_5) and kernel yield per plant (X_6), therefore, appear to be more useful.

It can be seen that pod yield/plant (X_1), 100-kernel weight (X_2), shelling out turn (X_3), kernel yield per plant (X_6) were the characters being commonly involved in more number of the combinations, the next being biological yield per plant (X_4) and harvest index (X_5) in order (Table 2).

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 and can give as maximum as possible genetic gain. In the present study, selection index based on four characters (pod yield per plant + 100-kernel weight + shelling out-turn + kernel yield per plant) showing genetic gain (45.75%) and selection efficiency (1385.16%) comparable to some extent of those based on more characters is desirable and practically possible to use. Breeders usually prefer the index which includes as minimum as possible the characters at a time.

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Table 1. Average selection efficiency of different combination of chara

No. of characters in the index	Selection Efficiency (%)
One	241.123
Two	400.600
Three	534.656
Four	672.840
Five	751.044
Six	835.992

Table 2. Highest selection efficiency with character combinations in Virginia groundnut

Sr. No.	Character	Selection Efficiency (%)
1	100-kernel weight	419.35
2	Shelling out-turn + biological yield/plant	612.76
3	Pod yield/plant + shelling out-turn + kernel yield/plant	764.33
4	100-kernel weight + shelling out-turn + harvest index	726.33
5	Pod yield/plant + 100-kernel weight + shelling out-turn + kernel yield/plant	1385.16
6	100-kernel weight + shelling out-turn + harvest index + kernel yield/plant	812.80
7	Pod yield/plant + 100-kernel weight + shelling out-turn + harvest index	785.51
8	Pod yield/plant + 100-kernel weight + shelling out-turn + harvest index + kernel yield/plant	837.05
9	Pod yield/plant + 100-kernel weight + shelling out-turn + biological yield/plant + harvest index + kernel yield/plant	835.99

Table 3. Selection index, discriminant function, expected genetic advance in yield and relative efficiency from the use of different selection indices in Virginia groundnut

Sr. No.	Selection Index	Discriminant Function					Expected Genetic Advance	Relative Efficiency (%)
1	2	3					4	5
1	X_1 Pod yield/plant (g)	0.752 X_1					3.303	100.00
2	X_2 100-kernel weight (g)	0 .916X_2					13.849	419.35
3	X_3 Shelling out-turn (%)	0.627X_3					8.673	262.64
4	X_4 Biological yield/plant (g)	0.810X_4					10.748	325.46
5	X_5 Harvest index (%)	0.574X_5					8.194	248.13
6	X_6 Kernel yield/plant (g)	0.730 X_6					3.010	91.17
7	$X_1.X_2$	0.604 X_1	+	0.937X_2			15.106	457.41
8	$X_1.X_3$	0.847 X_1	+	0.643X_3			10.873	329.23
9	$X_1.X_4$	0.671 X_1	+	0.837X_4			12.638	382.68
10	$X_1.X_5$	0.511 X_1	+	0.576X_5			10.305	312.05
11	$X_1.X_6$	1.070 X_1	+	0.611X_6			11.087	335.72
12	$X_2.X_3$	0.959 X_2	+	0.645 X_3			17.762	537.84
13	$X_2.X_4$	0.896 X_2	+	0.799 X_4			16.026	485.28
14	$X_2.X_5$	1.012 X_2	+	0.549 X_5			18.996	575.21
15	$X_2.X_6$	0.577 X_2	+	0.684 X_6			13.228	400.55
16	$X_3.X_4$	1.005 X_3	+	1.202 X_4			20.236	612.76
17	$X_3.X_5$	0.228 X_3	+	0.188 X_5			4.699	142.31
18	$X_3.X_6$	1.171 X_3	+	0.634 X_6			10.759	325.79
19	$X_4.X_5$	0.724 X_4	+	0.569 X_5			9.231	279.53
20	$X_4.X_6$	0.979 X_4	+	0.644 X_6			13.872	420.06
21	$X_5.X_6$	0.876 X_5	+	0.629 X_6			13.626	412.60
22	$X_1.X_2.X_3$	0.805 X_1	+	0.965 X_2	+	0.664X_3	23.550	713.10
23	$X_1.X_2.X_4$	0.673 X_1	+	0.916 X_2	+	0.829X_4	18.063	546.94
24	$X_1.X_2.X_5$	0.494 X_1	+	1.041 X_2	+	0.547X_5	20.656	625.46
25	$X_1.X_2.X_6$	0.008 X_1	+	0.944 X_2	+	1.509X_6	16.727	506.51
26	$X_1.X_3.X_4$	0.923 X_1	+	0.645 X_3	+	0.803X_4	15.883	480.95
28	$X_1.X_3.X_6$	-10.02X_1	+	0.764 X_3	+	0.588 X_5	25.242	764.33
29	$X_1.X_4.X_5$	1.367 X_1	+	1.770 X_3	+	15.08 X_6	12.617	382.04
30	$X_1.X_4.X_6$	4.760 X_1	+	0.532 X_4	-	0.264 X_5	15.085	456.77
31	$X_1.X_5.X_6$	0.516 X_1	+	0.495 X_4	+	4.756 X_6	10.973	332.26
32	$X_2.X_3.X_4$	0.939 X_2	+	0.562 X_5	+	0.703 X_6	19.095	578.21
33	$X_2.X_3.X_5$	1.035 X_2	+	0.656 X_3	+	0.802 X_4	23.987	726.33
34	$X_2.X_3.X_6$	0.857 X_2	+	0.736 X_3	+	0.597 X_5	21.968	665.20
35	$X_2.X_4.X_5$	0.983 X_2	+	0.808 X_3	+	2.499 X_6	18.098	548.02
36	$X_2.X_4.X_6$	0.946 X_2	+	0.718 X_4	-	0.549 X_5	16.332	494.53
37	$X_2.X_5.X_6$	1.045 X_2	+	0.764 X_4	+	0.038 X_6	19.547	591.88
38	$X_3.X_4.X_5$	0.718 X_3	+	0.519 X_5	+	0.487 X_6	15.316	463.79
39	$X_3.X_4.X_6$	0.780 X_3	+	0.766 X_4	+	0.646 X_5	15.898	481.39
40	$X_3.X_5.X_6$	0.783 X_3	+	0.652 X_5	+	2.262 X_6	18.497	560.10

(***Contd.***)

Table 3. (*Contd.*)

1	2	3	4	5
41	$X_4.X_5.X_6$	$0.651 X_4 + 0.494 X_5 - 0.223 X_6$	8.224	249.03
42	$X_1.X_2.X_3.X_4$	$0.892 X_1 + 0.939 X_2 + 0.667 X_3 + 0.805 X_4$	21.615	654.48
43	$X_1.X_2.X_3.X_5$	$0.624 X_1 + 1.062 X_2 + 0.783 X_3 + 0.548 X_5$	25.942	785.51
44	$X_1.X_2.X_3.X_6$	$- 6.814X_1 + 7.519 X_2 + 0.7876X_3 + 6.356 X_6$	45.746	1385.16
45	$X_1.X_2.X_4.X_5$	$2.626 X_1 + 1.005 X_2 + 0.104 X_4 - 0.273 X_5$	20.679	626.15
46	$X_1.X_2.X_4.X_6$	$4.672 X_1 + 0.919 X_2 + 0.493 X_4 - 4.638 X_6$	20.336	615.76
47	$X_1.X_2.X_5.X_6$	$0.372 X_1 + 1.053 X_2 + 0.565 X_5 + 0.788 X_6$	21.542	652.29
48	$X_1.X_3.X_4.X_5$	$3.010 X_1 + 0.772 X_3 + 0.026$ X4 - 0.340 X5	18.473	559.34
49	$X_1.X_3.X_4.X_6$	$- 6.912X_1 + 1.546 X_3 + 1.362X_4 + 10.40 X_6$	21.451	649.51
50	$X_1.X_3.X_5.X_6$	$3.168 X_1 + 0.918 X_3 - 0.180 X_5 - 1.007 X_6$	18.995	575.15
51	$X_1.X_4.X_5.X_6$	$- 0.348X_1 + 0.951 X_4 + 0.890X_5 + 1.016 X_6$	11.481	347.63
52	$X_2.X_3.X_4.X_5$	$1.006 X_2 + 0.739 X_3 + 0.758 X_4 + 0.613 X_5$	22.946	694.79
53	$X_2.X_3.X_4.X_6$	$0.866 X_2 + 0.806 X_3 + 0.692 X_4 + 1.759 X_6$	21.610	654.34
54	$X_2.X_3.X_5.X_6$	$0.943 X_2 + 0.892 X_3 + 0.615 X_5 + 2.243 X_6$	26.843	812.80
55	$X_2.X_4.X_5.X_6$	$1.072 X_2 + 0.649 X_4 + 0.447 X_5 + 0.340 X_6$	18.325	554.87
56	$X_3.X_4.X_5.X_6$	$0.886 X_3 + 0.632 X_4 + 0.553 X_5 + 1.515 X_6$	17.333	524.83
57	$X_1.X_2.X_3.X_4.X_5$	$3.052 X_1 + 1.025 X_2 + 0.793 X_3 + 0.005 X_4 - 0.395 X_5$	25.694	778.00
58	$X_1.X_2.X_3.X_4.X_6$	$- 7.701X_1 + 0.917 X_2 + 1.644 X_3 + 1.41 X_4 + 11.37 X_6$	26.803	811.59
59	$X_1.X_2.X_3.X_5.X_6$	$2.848 X_1 + 1.180 X_2 + 0.937 X_3 - 0.168 X_5 - 0.806 X_6$	27.644	837.05
60	$X_1.X_2.X_4.X_5.X_6$	$2.022 X_1 + 1.010 X_2 + 0.711 X_4 + 0.740 X_5 + 1.771 X_6$	23.387	708.14
61	$X_1.X_3.X_4.X_5.X_6$	$1.082 X_1 + 0.940 X_3 + 0.522 X_4 + 0.321 X_5 + 0.987 X_6$	20.484	620.26
62	$X_2.X_3.X_4.X_5.X_6$	$0.964 X_2 + 0.909 X_3 + 0.624 X_4 + 0.531 X_5 + 1.490 X_6$	24.810	751.23
63	$X_1.X_2.X_3.X_4.X_5.X_6$	$1.015 X_1 + 1.025 X_2 + 0.960 X_3 + 0.536 X_4 + 0316 X_5 + 0.991 X_6$	27.609	835.99