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Selection indices for yield improvement in bread wheat (*Triticum aestivum* L.) under late sown condition

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Abstract
The discriminant-function technique was used to construct selection indices in 48 genotypes of bread wheat (*Triticum aestivum* L.) under late sown condition. Thirty-one selection indices involving grain yield per plant and its four components were constructed using discriminant function technique. The efficiency of selection increased with inclusion of more number of characters in the selection index. The index based on three characters *viz.*, grain yield per plant, number of productive tiller per plant and biological yield per plant recorded the highest genetic gain and relative efficiency followed by index based on four characters *viz*., grain yield per plant, number of productive tiller per plant, plant height and biological yield per plant. The use of these indices is advocated for selecting high yielding genotypes of bread wheat.

Keywords: Selection indices, discriminant function, relative efficiency and bread wheat

Introduction
Wheat is the staple food for a large part of the world population including India. It is now well recognized that grain yield is a complex polygenic character and depends upon the action and interaction of a number of factors. It is felt that progress can be accelerated if simultaneous selection for most of the economic characters contributing to grain yield is considered. For this purpose, the utilization of an appropriate multiple selection criteria based on the selection indices would be more desirable. An application of discriminant function developed by Fisher (1936) and first applied by Smith (1936) helps to identify important combination of yield components useful for selection by formulating suitable selection indices. Therefore, the object of the present study was to construct and assesses the efficiency of selection indices in bread wheat.

Materials and methods
A field trial was conducted using fourty-eight diverse genotypes of bread wheat during *Rabi* 2016-17 in a Randomized Block Design with three replications at Wheat Research Station, Junagadh Agricultural University, Junagadh. The characters studied were days to 50 % heading, days to anthesis, days to maturity, grain filling period, number of productive tillers per plant, plant height, spike length, number of spikelets per spike, number of grains per spike, 1000-grain weight, grain yield per plant, biological yield per plant, harvest index, flag leaf area, chlorophyll content and canopy temperature depression. For constructing the selection indices, the characters which had high and positive correlation with grain yield per plant and direct effects on grain yield were considered. In this context, grain yield per plant (X_1), number of productive tillers per plant (X_2), plant height (X_3), biological yield per plant (X_4) and harvest index (X_5) were identified and considered in late and very late sown conditions. The model suggested by Robinson *et al.* (1951) [8] was used for the construction of selection indices and the development of required discriminant function. A total of 31 selection indices were constructed using five traits per sowing condition. The respective genetic advance through selection was also calculated as per the formula suggested by Robinson *et al.* (1951) [8]. The relative efficiency of different discriminant functions in relation to straight selection for grain yield were assessed and compared, assuming the efficiency of selection for grain yield per plant as 100%.

Results and Discussion
Selection indices for grain yield per plant and other characters were constructed and examined to identify their relative efficiency in the selection of superior genotypes. The results on

selection indices, discriminant functions, expected genetic gain and relative efficiency are presented in Table 1. The results showed that the genetic advance and relative efficiency assessed for different indices were higher than straight selection when the selection was based on component characters which further increased considerably with the inclusion of two or more characters. The highest efficiency was noted when three or four characters were considered. Selection indices are, thus, more realistic for selecting desirable genotypes since they are constructed by giving proper weightage on the characters associated with yield. Robinson *et al.* (1951) [8] in corn recorded a progressive increase in efficiency of selection indices with inclusion of every additional character in the index formula. Hazel and Lush (1943) [4] stated that the superiority of selection based on index increases with an increase in the number of characters under selection and Mcvetty and Evans (1980) [6] and Esheghi *et al.* (2011) [1] also suggested that the selection index to be superior to direct selection in wheat.

The maximum relative efficiency in single character discriminant function was 1114.27% was exhibited by biological yield per plant. However, it increased up to 1154.63% in two character combination (grain yield per plant and biological yield per plant); 1193.31% in three character combination (grain yield per plant, number of productive tillers per plant and biological yield per plant); 1190.86 % in case of four characters (grain yield per plant, number of productive tillers per plant, plant height and biological yield per plan) and in case of five characters, it was 1134.05% (grain yield per plant, number of productive tillers per plant, plant height, biological yield per plant and harvest index). Fredous *et al.* (2010), Kemelew (2011) [5] and Shah *et al.* (2016) [9] were also with the same opinion that an increase in characters resulted in an increase in genetic gain and that the selection indices improve the efficiency than the straight selection for grain yield per plant.

Further, it was observed that the straight selection for grain yield was not that much rewarding (GA = 5.09g, RI = 100%) as it was through its components like number of productive tillers per plant, plant height, biological yield per plant and harvest index or in their combinations. The maximum efficiency in selection for grain yield was exhibited by a discriminant function involving grain yield per plant, number of productive tillers per plant and biological yield per plant, which had a genetic advance and relative efficiency of 60.70g and 1193.31%, respectively, followed by an index of four characters (grain yield per plant, number of productive tillers per plant, plant height and biological yield per plant) with 60.58g genetic advance and 1190.86% relative efficiency. High efficiency in selection based on grain yield per plant, biological yield per plant, days to maturity and number of effective tillers per plant or in combination of all these four characters has been reported by Patel (2006) [7].

The present study showed consistent increase in the relative efficiency of the succeeding index with simultaneous inclusion of each character. However, in practice the plant breeder might be interested in maximum gain with minimum number of characters. In this context, the selection index consisting grain yield per plant, number of productive tillers per plant and biological yield per plant could be advantageously exploited in the wheat breeding programmes. The present study also revealed that the discriminant function method of making selections in plants appeared to be the most useful as compared to the straight selection for grain yield alone and hence, due weightage should be given to the important selection indices while making selection for yield advancement in wheat.

Table 1: Selection index, discriminant function, expected genetic advance in grain yield and relative efficiency from the use of different selection indices in late sown condition of bread wheat

S. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)
(1)	(2)	(3)	(4)	(5)
1	X_1: Grain yield per plant	0.688 X_1	5.09	100.00
2	X2: Number of productive tillers per plant	0.884 X_2	1.88	36.86
3	X_3:Plant height	0.736 X_3	5.37	105.46
4	X_4:Biological yield per plant	0.905 X_4	56.68	1114.27
5	X_5:Harvest index	0.740 X_5	4.44	87.32
6	X_1 X_2	0.342 X_1+1.698 X_2	7.23	142.17
7	X_1 X_3	0.465 X_1+0.544 X_3	8.94	175.65
8	X_1 X_4	0.663 X_1 +0.769 X_4	58.74	1154.63
9	X_1 X_5	0.368 X_1 +0.442 X_5	8.03	157.76
10	X_2 X_3	1.141X2 +0.477 X_3	6.54	128.50
11	X_2 X_4	3.647 X_2 +0.726 X_4	58.34	1146.84
12	X_2 X_5	0.646 X_2 +0.451X_5	4.83	94.93
13	X_3 X_4	1.119 X_3 +0.781 X_4	58.22	1144.56
14	X_3 X_5	-1.434 X_3 -2.311X_5	29.63	582.42
15	X_4 X_5	0.760 X_4 +0.693 X_5	53.16	1044.99
16	X_1 X_2 X_3	0.353 X_1 +2.065 X_2 +0.524 X_3	10.98	215.74
17	X_1 X_2 X_4	0.304 X_1 +4.693 X_2 +0.727 X_4	60.70	1193.31
18	X_1 X_2 X_5	0.236 X_1 +1.811 X_2 +0.512 X_5	9.57	188.05
19	X_1 X_3 X_4	0.692X_1 + 0.472 X_3+0.763 X_4	58.32	1146.49
20	X_1 X_3 X_5	0.393 X_1-0.607 X_3-0.453 X_5	11.77	231.32
21	X_1 X_4 X_5	0.750 X_1+0.730 X_4+0.196 X_5	55.41	1089.22
22	X_2 X_3 X_4	4.419 X_2+0.276 X_3+0.708 X_4	57.98	1139.85
23	X_2 X_3 X_5	1.016 X_2+0.526 X_3-0.490 X_5	9.06	178.16
24	X_2 X_4 X_5	4.078 X_2+0.687 X_4-0.254 X_5	54.95	1080.17
25	X_3 $X_4$$X_5$	0.449 X_3+0.760 X_4-0.757 X_5	52.66	1035.09
26	X_1 X_2 X_3 X_4	0.332 X_1+5.353 X_2+0.328 X_3+0.711 X_4	60.58	1190.86
27	X_1 X_2 X_3 X_5	0.204 X_1+2.201 X_2+0.577 X_3+0.569 X_5	13.42	263.79
28	X_1 X_2 X_4 X_5	0.734 X_1+5.093 X_2+0.637 X_4-0.348 X_5	57.63	1132.98
29	X_1 X_3 X_4 X_5	0.944 X_1+0.513 X_3+0.706 X_4-0.028 X_5	55.18	1084.77
30	X_2 X_3 X_4 X_5	4.811 X_2+0.317 X_3+0.671 X_4+0.253 X_5	54.76	1076.38
31	X_1 X_2 X_3 X_4 X_5	1.029 X_1+5.793 X_2+0.341X_3+0.584 X_4-0.776 X_5	57.72	1134.56

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