Selection indices in Bread Wheat [*Triticum aestivum* L.]

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Abstract
The discriminant-function technique was used to construct selection indices in 52 genotypes of bread wheat (*Triticum aestivum* L.).Sixty-three selection indices involving grain yield per plant and its five components were constructed using discriminant function technique. In general, the more the number of characters included in a selection index, the better was its performance.The index based on five characters *viz.*,grain yield per plant, 100-grain weight, days to maturity, harvest index and number of effective tillers per plant which had highest genetic advance and relative efficiency of 155.77g and 1867.41%, respectively followed by an index based onfive characters i.e. grain yield per plant, biological yield per plant, 100-grain weight, days to maturity, harvest index which possessed genetic gain and relative efficiency of 53.85g and1856.78% respectively. The use of both these indices is advocated for selecting high yielding genotypes ofbread wheat.

Keyword: Selection indices, discriminant function, bread wheat.

Introduction
Due to great importance of bread wheat as cereal crops, very wide research work has been done on construction of selection indices in bread wheat. It is now well recognized thatgrain 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 discriminat 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 fifty-two diverse genotypes of bread wheat during *Rabi* 2013-14 in a randomized block design with three replications atWheat Research Station, Junagadh Agricultural University, Junagadh. Each entry was sown in a single row of 4.0 m length with a spacing of 22.5 × 10 cm. Observations were recorded on five randomly plants selected for thegrain yield per plant (X_1), biological yield per plant (X_2), 100-grain weight (X_3), days to maturity (X_4), harvest index (X_5), number of effective tillers per plant (X_6).For constructing the selection indices, the characters with high and significant genetic correlation coefficients and sizable direct effects on grain yield were considered. The model suggested by Robinson*et al.* (1951) was used for the construction of selection indices and the development of required discriminant function. A total of 63 selection indices were constructed using six traits. The respective genetic advance through selection was also calculated as per the formula suggested by Robinson *et al.* (1951). 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 five characters*viz.*, ($X_1+X_3+X_4+X_5+X_6$) or ($X_1+X_2+X_3+X_4+X_5$) were considered. Thus, selection indices are more reliable and realistic for selecting desirable genotypes since they are constructed by giving proper weightage on the characters associated with the grain yield per plant.
The maximum genetic advance (GA) and relative efficiency (RI) in single character discriminant function was0.55g and448.93% respectively for 100-grin weight which, however, genetic advance (GA), relative efficiency (RI) and relative efficiency per character increased

upto8.20g,927.46% and 463.73% respectively in two character combinations (X_2+X_5) and 10.12g,837.55% and 279.18%, respectively in three characters combinations ($X_2+X_4+X_5$). Thus, there was an increase in the genetic gain as well as on relative efficiency with an increase in the character combinations. In four character combinations ($X_2+X_3+X_4+X_6$), the highest genetic advance, relative efficiency and relative efficiency per characterwere 17.10g,1267.48%,and 316.87% respectively.For character combinations i.e. $X_2+X_3+X_4+X_6$ also recorded second highest genetic advance (21.47g), relative efficiency (1242.75%) and relative efficiency per character (310.68%). Whereas the maximum genetic advance, relative efficiency and relative efficiency per character in five characters combinations ($X_1+X_2+X_4+X_5+X_6$) were 155.77g, 1867.41% and 373.48 respectively followed by $X_1+X_2+X_3+X_4+X_5$ with genetic advance of 53.84g, relative efficiency of 1856.78% and relative efficiency per character of 371.35%. All the six character combinations decline the value of relative efficiency up to 566.19%. Robinson *et al.* (1951) recorded a progressive increase in efficiency of selection indices with inclusion of every additional character in the index formula. Hazel and Lush (1943) also stated that the superiority of selection based on index increased with an increase in the number of characters under selection. In bread wheat,Ferdous*et al.* (2010) and Kemelew (2011)were also reported that an increase in characters resulted in an increase in genetic gain and that the selection indices improved the efficiency than the straight selection for grain yield alone.

Further, it was observed that the straight selection for grainyield was not that much rewarding (GA=2.83g, RI=100%) as it was through its components likebiological yield per plant (GA=5.24g, RI=192.80%), 100-grain weight (GA=0.55g, RI=448.93%), daysto maturity (GA=11.20g, RI=111.94%), harvest index (GA=2.49g, RI=107.06%), number of effective tillers per plant (GA=0.51g, RI=107.06%)and/or in their combinations. The efficiency in selection for grain yield was exhibited by a discriminant function involvinggrain yield per plant, 100-grain weight, days to maturity, harvest index and number of effective tillers per plant ($X_1+X_3+X_4+X_5+X_6$) which had a genetic advance, relative efficiency and relative efficiency per character of 155.77g,1867.41% and 373.48%, respectively. 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 also been reported by Patel (2006).

The present study showed consistent increase in the relative efficiency of the succeeding index with simultaneous inclusion of each character up to five characters. However, in practice, the plant breeders might be interested in maximum gain with minimum number of characters. With this view, relative efficiency per character (463.73%) was also worked out for each selection index. It was observed that maximum relative efficiency per character was observed in selection index comprised of biological yield per plant and harvest index (X_2+X_5) followed by 421.17% value in case of biological yield per plant and days to maturity (X_2+X_4). Therefore, due weightage should be given to days to maturity, biological yield per plant and harvest index while formulating selection index of wheat crop. Overall, selection index consisting of five traits *viz*., grain yield per plant, 100-grain weight, days to maturity, harvest index and number of effective tillers per plant could be advantageously exploited in the bread wheat breeding programmes. The present study also revealed that the discriminant function method of making selections in plants appears to be the most useful than the straight selection for grain yield alone and hence, due weightage should be given to the important selection indices while making selection for grain yield advancement in bread wheat.

Referances

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

Sr. No.	Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative efficiency per character (%)
1	X_1: Grain yield per plant	$0.501X_1$	2.830	100.000	100.000
2	X_2: Biological yield per plant	$0.595\ X_2$	5.241	192.801	192.801
3	X_3: 100-grain weight	$0.397\ X_3$	0.555	448.931	448.931
4	X_4: Days to maturity	$0.877\ X_4$	11.200	111.946	111.946
5	X_5: Harvest index	$0.213\ X_5$	2.499	107.068	107.068
6	X_6: No. of effective tillers per	$0.145\ X_6$	0.518	348.200	348.200
7	X_1+X_2	$-0.373X_1 +0.445X_2$	3.838	318.440	159.220
8	X_1+X_3	$1.766X_1 - 0.733X_3$	7.392	214.006	107.003
9	X_1+X_4	$-3.368X_1 + 2.453X_4$	17.212	302.400	151.200
10	X_1+X_5	$0.629X_1 - 0.058X_5$	4.291	506.521	253.256
11	X_1+X_6	$1.014X_1 - 0.478X_6$	4.104	101.122	50.561
12	X_2+X_3	$3.297X_2 - 1.5510X_3$	13.350	3.886	1.943
13	X_2+X_4	$-1.445X_2 + 1.508X_4$	12.209	842.358	421.179
14	X_2+X_5	$1.960X_2 - 0.812X_5$	8.204	927.465	463.732
15	X_2+X_6	$2.874X_2 - 1.403X_6$	11.593	200.209	100.104
16	X_3+X_4	$-3.856X_3 + 2.773X_4$	19.420	161.502	80.751
17	X_3+X_5	$-0.760X_3 + 0.552X_5$	3.877	400.991	200.495
18	X_3+X_6	$1.900X_3 - 0.908X_6$	0.149	206.990	103.495
19	X_4+X5	$7.998X_4 - 3.707X_5$	32.296	164.319	82.159
20	X_4+X6	$8.819\ X_4 - 4.361X_6$	35.559	387.507	193.753
21	X_5+X6	$1.900X_5 - 0.908X_6$	7.676	171.127	85.563
22	$X_1+X_2+X_3$	$1.003X_1 - 0.056X_2 - 0.261X_3$	6.192	95.592	31.864
23	$X_1+X_2+X_4$	$0.621X_1 - 0.278X_2 + 1.270X_4$	15.374	241.341	80.447
24	$X_1+X_2+X_5$	$1.145X_1 - 0.168X_2 + 0.193X_5$	7.936	202.113	67.371
25	$X_1+X_2+X_6$	$1.035X_1 - 0.068X_2 - 0.222X_6$	6.300	125.717	41.905
26	$X_1+X_3+X_4$	$0.542X_1 - 0.440X_3 + 1.286X_4$	14.857	433.333	144.444
27	$X_1+X_3+X_5$	$0.993X_1 - 0.310X_3 + 0.254X_5$	6.561	304.251	101.417

28	$X_1+X_3+X_6$	$0.714X_1 - 0.167X_3 - 0.057X_6$	3.665	249.531	83.177
29	$X_1+X_4+X_5$	$-0.215X_1 + 0.361X_4 + 0.327X_5$	9.253	264.058	88.019
30	$X_1+X_4+X_6$	$-0.057X_1 + 0.392X_4 - 0.252X_6$	7.749	242.514	80.838
31	$X_1+X_5+X_6$	$0.841X_1 - 0.089X_5 - 0.129X_6$	4.820	270.579	90.193
32	$X_2+X_3+X_4$	$1.627X_2 - 0.682X_3 + 1.121X_4$	16.614	335.316	111.772
33	$X_2+X_3+X_5$	$2.140X_2 - 0.570X_3 + 0.097X_5$	11.665	255.816	85.272
34	$X_2+X_3+X_6$	$1.876X_2 - 0.431X_3 - 0.212X_6$	9.567	55.503	18.501
35	$X_2+X_4+X_5$	$0.870X_2 + 0.110X_4 + 0.182X_5$	10.124	837.559	279.186
36	$X_2+X_4+X_6$	$1.042X_2 + 0.137X_4 - 0.396X_6$	9.298	435.159	145.053
37	$X_2+X_5+X_6$	$1.990X_2 - 0.353X_5 - 0.273X_6$	10.374	262.806	87.602
38	$X_3+X_4+X_5$	$-1.975X_3 + 0.737X_4 + 0.476X_5 0.476X_5 0.476X_5$	12.856	414.397	138.132
39	$X_3+X_4+X_6$	$-1.398X_3 + 0.647X_4 - 0.0512X_6$	9.808	544.914	181.638
40	$X_3+X_5+X_6$	$-0.290X_3 + 0.135X_5 + 0.030X_6$	2.126	369.812	123.270
41	$X_4+X_5+X_6$	$6.274X_4 - 1.276X_5 - 0.900X_4$	32.112	225.404	75.134
42	$X_1+X_2+X_3+X_4$	$1.399X_1 + 0.0052X_2 - 0.295X_3 + 1.099X_4$	16.684	515.258	128.814
43	$X_1+X_2+X_3+X_5$	$1.403X_1 - 0.053X_2 – 0.309X_3 + 0.414X_5$	10.076	397.731	99.432
44	$X_1+X_2+X_3+X_6$	$0.658X_1 - 0.255X_2 + 1.299X_3 + 0.214X_6$	15.888	188.237	47.059
45	$X_1+X_2+X_4+X_5$	$0.792X_1 - 0.244X_2 + 1.574X_4 + 0.756X_5$	20.892	265.102	66.275
46	$X_1+X_2+X_4+X_6$	$1.222X_1 + 0.766X_2 + 0.971X_4 + 0.365X_6$	17.982	560.042	140.010
47	$X_1+X_2+X_5+X_6$	$1.179X_1 - 0.156X_2 + 0.238X_5 + 0.157X_6$	8.642	446.035	111.508
48	$X_1+X_3+X_4+X_5$	$0.874X_1 - 0.504X_3 + 1.582X_4 + 0.561X_5$	19.755	319.379	79.844
49	$X_1+X_3+X_4+X_6$	$0.620X_1 - 0.447X_3 + 1.307X_4 + 0.108X_6$	15.249	287.167	71.791
50	$X_1+X_3+X_5+X_6$	$1.068X_1 - 0.328X_3 + 0.291X_5 + 0.060X_6$	7.217	356.129	89.032
51	$X_1+X_4+X_5+X_6$	$-0.1981X_1 + 0.394X_4 + 0.386X_5 + 0.290X_6$	10.164	140.497	35.124

52	$X_2+X_3+X_4+X_5$	$1.950X_2 - 0.749X_3 + 1.416X_4 + 0.530X_5$	21.472	1242.757	310.689
53	$X_2+X_3+X_4+X_6$	$1.713X_2 - 0.695X_3 + 1.138X_4 + 0.079X_6$	17.102	1267.480	316.87
54	$X_2+X_3+X_5+X_6$	$2.222X_2 - 0.593X_3 + 0.130X_5 + 0.031X_6$	12.246	463.559	115.889
55	$X_2+X_4+X_5+X_6$	$0.894X_2 + 0.137X_4 + 0.237X_5 + 0.261X_6$	11.110	406.015	101.503
56	$X_3+X_4+X_5+X_6$	$-2.063X_3 + 0.794X_4 + 0.549X_5 + 0.294X_6$	13.655	426.945	106.738
57	$X_1+X_2+X_3+X_4+X_5$	$38.867X_1 + 0.449X_2 - 3.283X_3 + 0.066X_4 - 1.327X_5$	53.848	1856.781	371.356
58	$X_1+X_2+X_3+X_4+X_6$	$35.513X_1 + 0.463X_2 - 1.034X_3 + 0.055X_4 - 2.687X_6$	47.724	465.959	93.191
59	$X_1+X_2+X_3+X_5+X_6$	$41.066X_1 + 0.253X_2 + 3.162X_3 - 2.319X_5 - 2.805X_6$	48.595	370.522	74.104
60	$X_1+X_2+X_4+X_5+X_6$	$61.647X_1 + 0.027X_2+129.151X_4 - 5.364X_5 - 9.792X_6$	177.804	565.206	113.041
61	$X_1+X_3+X_4+X_5+X_6$	$43.659X_1 - 0.691X_3 + 116.291X_4 -4.028X_5 - 7.956X_6$	155.776	1867.414	373.482
62	$X_2+X_3+X_4+X_5+X_6$	$64.627X_2 - 1.014X_3 +116.302X_4 - 5.787X_5 -9.261X_6$	163.518	481.072	96.214
63	$X_1+X_2+X_3+X_4+X_5+X_6$	$71.890X_1 + 0.3282X_2 + 1.140X_3 - 2.070X_4 - 1.566X_5 - 3.603X_6$	71.189	566.190	94.365