Selection indices in Bread Wheat \textit{[Triticum aestivum L.]} \\

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Abstract 

The discriminant-function technique was used to construct selection indices in 52 genotypes of bread wheat \textit{(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 on five 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 and 1856.78% respectively. The use of both these indices is advocated for selecting high yielding genotypes of bread 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 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 fifty-two diverse genotypes of bread wheat during \textit{Rabi} 2013-14 in a randomized block design with three replications at Wheat 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 the grain 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 \textit{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_2+X_3+X_4+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 was 0.55g and 448.93% respectively for 100-grain weight which, however, genetic advance (GA), relative efficiency (RI) and relative efficiency per character increased

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upto 8.20g, 927.46% and 463.73% respectively in two character combinations (X₃+X₄) and 10.12g, 837.55% and 279.18%, respectively in three characters combinations (X₂+X₃+X₄). 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 (X₂+X₃+X₄+X₅), the highest genetic advance, relative efficiency and relative efficiency per character were 1710g, 1267.48% and 316.87% respectively. For character combinations i.e. X₃+X₄+X₅+X₆ also recorded second highest genetic advance (2147g), relative efficiency (1242.75%) and relative efficiency per character (310.68%). Whereas the maximum genetic advance, relative efficiency and relative efficiency per character in the five character combinations (X₁+X₂+X₃+X₄+X₅) were 155.77g, 1867.41% and 373.48 respectively followed by X₁+X₂+X₃+X₄+X₅ with genetic advance 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, Ferdouset 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 grain yield was not that much rewarding (GA=2.83g, RI=100%) as it was through its components like biological yield per plant (GA=5.24g, RI=107.06%), 100-grain weight (GA=0.55g, RI=448.93%), days to 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 involving grain yield per plant, 100-grain weight, days to maturity, harvest index and number of effective tillers per plant (X₁+X₂+X₃+X₄+X₅) 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 (X₂+X₃) followed by 421.17% value in case of biological yield per plant and days to maturity (X₁+X₂). 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.

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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 plant | $0.145 X_6$ | 0.518 | 348.200 | 348.200 |
| 7       | $X_1 + X_2$ | $1.766X_1 - 0.733X_2$ | 7.392 | 214.006 | 107.003 |
| 8       | $X_1 + X_3$ | $-3.368X_1 + 2.453X_3$ | 17.212 | 302.400 | 151.200 |
| 9       | $X_1 + X_4$ | $0.629X_1 - 0.058X_4$ | 4.291 | 506.521 | 253.256 |
| 10      | $X_1 + X_5$ | $1.014X_1 - 0.478X_5$ | 4.104 | 101.122 | 50.561 |
| 11      | $X_2 + X_3$ | $2.874X_2 - 1.403X_3$ | 11.593 | 200.209 | 100.104 |
| 12      | $X_2 + X_4$ | $-1.445X_2 + 1.508X_4$ | 12.209 | 321.502 | 160.751 |
| 13      | $X_2 + X_5$ | $1.960X_2 - 0.812X_5$ | 8.204 | 927.465 | 463.732 |
| 14      | $X_2 + X_6$ | $2.874X_2 - 1.403X_6$ | 11.593 | 200.209 | 100.104 |
| 15      | $X_3 + X_4$ | $-3.856X_3 + 2.773X_4$ | 19.420 | 321.502 | 160.751 |
| 16      | $X_3 + X_5$ | $-0.760X_3 + 0.552X_5$ | 3.877 | 400.991 | 200.495 |
| 17      | $X_3 + X_6$ | $1.900X_3 - 0.908X_6$ | 0.149 | 206.990 | 103.495 |
| 18      | $X_4 + X_5$ | $7.998X_4 - 3.707X_5$ | 32.296 | 164.319 | 82.159 |
| 19      | $X_4 + X_6$ | $8.819 X_4 - 4.361X_6$ | 35.559 | 387.507 | 193.753 |
| 20      | $X_5 + X_6$ | $1.900X_5 - 0.908X_6$ | 7.676 | 171.127 | 85.563 |
| 21      | $X_1 + X_2 + X_3$ | $1.003X_1 - 0.056X_2 - 0.261X_3$ | 6.192 | 95.592 | 31.864 |
| 22      | $X_1 + X_2 + X_4$ | $0.621X_1 - 0.278X_2 + 1.270X_4$ | 15.374 | 241.341 | 80.447 |
| 23      | $X_1 + X_3 + X_4$ | $1.145X_1 - 0.168X_2 + 0.193X_4$ | 7.936 | 202.113 | 67.371 |
| 24      | $X_1 + X_2 + X_5$ | $1.035X_1 - 0.068X_2 - 0.222X_5$ | 6.300 | 125.717 | 41.905 |
| 25      | $X_1 + X_3 + X_5$ | $0.542X_1 - 0.440X_3 + 1.286X_5$ | 14.857 | 433.333 | 144.444 |
| 26      | $X_1 + X_3 + X_6$ | $0.993X_1 - 0.310X_3 + 0.254X_6$ | 6.561 | 304.251 | 101.417 |
|   | \(X_1 + X_2 + X_3\) | \(X_1 + X_2 + X_4\) | \(X_1 + X_2 + X_5\) | \(X_1 + X_2 + X_6\) | \(X_1 + X_3 + X_4\) | \(X_1 + X_3 + X_5\) | \(X_1 + X_3 + X_6\) | \(X_1 + X_4 + X_5\) | \(X_1 + X_4 + X_6\) | \(X_1 + X_5 + X_6\) | \(X_2 + X_3 + X_4\) | \(X_2 + X_3 + X_5\) | \(X_2 + X_3 + X_6\) | \(X_2 + X_4 + X_5\) | \(X_2 + X_4 + X_6\) | \(X_2 + X_5 + X_6\) | \(X_3 + X_4 + X_5\) | \(X_3 + X_4 + X_6\) | \(X_3 + X_5 + X_6\) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | \(0.714X_1 - 0.167X_2 - 0.057X_5\) | 3.665 | 249.531 | 83.177 |
| 29 | \(-0.215X_1 + 0.361X_2 + 0.327X_4\) | 9.253 | 264.058 | 88.019 |
| 30 | \(-0.057X_1 + 0.392X_2 - 0.252X_6\) | 7.749 | 242.514 | 80.838 |
| 31 | \(0.841X_1 - 0.089X_2 - 0.129X_6\) | 4.820 | 270.579 | 90.193 |
| 32 | \(1.627X_1 + 0.682X_2 + 1.121X_4\) | 16.614 | 335.316 | 111.772 |
| 33 | \(2.140X_2 - 0.570X_3 + 0.097X_5\) | 11.665 | 255.816 | 85.272 |
| 34 | \(1.876X_2 - 0.431X_3 + 0.212X_6\) | 9.567 | 55.503 | 18.501 |
| 35 | \(0.870X_2 + 0.110X_3 + 0.182X_5\) | 10.124 | 837.559 | 279.186 |
| 36 | \(1.042X_2 + 0.137X_3 + 0.396X_6\) | 9.298 | 435.159 | 145.053 |
| 37 | \(1.990X_2 - 0.353X_3 - 0.273X_6\) | 10.374 | 262.806 | 87.602 |
| 38 | \(-1.975X_3 + 0.737X_4 + 0.476X_2 - 0.476X_5\) | 12.856 | 414.397 | 138.132 |
| 39 | \(-1.398X_3 + 0.647X_4 - 0.0512X_6\) | 9.808 | 544.914 | 181.638 |
| 40 | \(-0.290X_3 + 0.135X_4 + 0.030X_6\) | 2.126 | 369.812 | 123.270 |
| 41 | \(6.274X_4 - 1.276X_3 - 0.900X_4\) | 32.112 | 225.404 | 75.134 |
| 42 | \(1.399X_1 + 0.0052X_2 - 0.295X_3 + 1.099X_4\) | 16.684 | 515.258 | 128.814 |
| 43 | \(1.403X_1 - 0.053X_2 - 0.309X_3 + 0.414X_4\) | 10.076 | 397.731 | 99.432 |
| 44 | \(0.658X_1 - 0.255X_2 + 1.299X_3 + 0.214X_5\) | 15.888 | 188.237 | 47.059 |
| 45 | \(0.792X_1 - 0.244X_2 + 1.574X_3 + 0.756X_6\) | 20.892 | 265.102 | 66.275 |
| 46 | \(1.222X_1 + 0.766X_2 + 0.971X_3 + 0.365X_6\) | 17.982 | 560.042 | 140.010 |
| 47 | \(1.179X_1 - 0.156X_2 + 0.238X_3 + 0.157X_6\) | 8.642 | 446.035 | 111.508 |
| 48 | \(0.874X_1 - 0.504X_2 + 1.582X_3 + 0.561X_5\) | 19.755 | 319.379 | 79.844 |
| 49 | \(0.620X_1 - 0.447X_2 + 1.307X_4 + 0.108X_6\) | 15.249 | 287.167 | 71.791 |
| 50 | \(1.068X_1 - 0.328X_2 + 0.291X_4 + 0.060X_5\) | 7.217 | 356.129 | 89.032 |
| 51 | \(-0.1981X_1 + 0.394X_4 + 0.386X_2 + 0.290X_6\) | 10.164 | 140.497 | 35.124 |
|   | Expression                        | Coefficient 1 | Coefficient 2 | Coefficient 3 |
|---|-----------------------------------|---------------|---------------|---------------|
| 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| $X_2 + X_3 + X_4 + X_6$           | 2.222X_2 - 0.593X_3 + 0.130X_4 + 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| $X_1 + X_2 + X_3 + X_4 + X_6$    | 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| $X_1 + X_2 + X_4 + X_5 + X_6$    | 43.659X_1 - 0.691X_2 + 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 |