



Formulation of Selection Indices for Yield Enhancement in Bread Wheat (*Triticum aestivum* L.)

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Abstract: The present experiment was designed with the objective of creating selection indices within 50 different genetic varieties of bread wheat (*Triticum aestivum* L.) using the discriminant-function technique under timely sown conditions. We developed a total of thirty-one selection indices, which incorporated grain yield plant⁻¹ and four other yield components. By including a greater number of characteristics within the index, the effectiveness of the selection process was enhanced. The selection index, primarily focused on two traits, namely biological yield plant⁻¹ and harvest index, emerged as the most efficient for identifying higher-yielding strains. The findings underscored the importance of assigning maximum priority to these attributes when making selections related to yield traits in bread wheat.

Key words: Bread wheat, discriminant function, relative efficiency, genetic advance and selection indices.

Wheat stands as the world's second most crucial food crop, ranking only behind rice in terms of both its extent of cultivation and overall production. India contributes approximately 12% towards the global wheat supply. The total area sown to wheat has crossed 34 m ha in the current rabi season of the 2023-24 with production of 112 mt with an average yield of 3294 kg ha⁻¹ (Anon., 2021a). In Gujarat, a total of 1.36 mha were dedicated to wheat cultivation, resulting in a production of 4.37 mt with an average yield of 3204 kg ha⁻¹ (Anon., 2021b). States of the Indo-Gangetic Plains viz. Haryana, Punjab, Bihar and Uttar Pradesh are the main contributors to India's wheat production, collectively contributing about 85% of the country's total wheat output. [Pl give "a" or "b" marking to Anon 2021. You could also replace one of the Anon with Anon 2023]

Wheat, a member of the *Triticum* genus within the *Poaceae* family, is believed to have originated in the Middle East region of Asia (Lupton, 1987). In India, wheat cultivation encompasses various types. Throughout the wheat-growing regions of the country, bread wheat, characterized by its hexaploid nature with a chromosome count of 2n=6x=42, is extensively cultivated. Macaroni or durum wheat, which is

a tetraploid with $2n=4x=28$ chromosomes, is primarily cultivated in the northern states such as Punjab as well as in the southern states. In contrast, emmer wheat, another tetraploid with $2n=4x=28$ chromosomes, has a more limited presence, mainly confined to the southern states, particularly in Karnataka, and certain regions of Gujarat.

Wheat, a self-pollinating and cool-season crop thrives in areas with an average temperature range of 18 to 22°C and receiving rainfall between 750-1600 mm. Self-pollination is predominantly attributed to the chasmogamous condition of wheat flowers. The crop requires four-six irrigations depending on the soil type and rainfall. The duration between planting and harvest for wheat varies from 110 to 130 days, depending on factors such as climate, seed type, and soil conditions.

Wheat is acclaimed as the world's most favored staple food, providing more nourishment for humans than any other food source. The nutritional profile of 100 g of bread wheat shows that it provides approximately 326 to 335 calories. This includes 71 g carbohydrates, 14 g protein, 2.5 g fat, 2 g minerals, and significant amounts of vitamins like thiamine, folic acids, pantothenic acids, riboflavin, niacin along with essential minerals such as zinc, calcium, magnesium, and iron (Wolde *et al.*, 2016).

Grain yield in wheat is governed by a polygenic system and is highly susceptible to environmental fluctuations. Therefore, direct selection based solely on grain yield often lacks reliability. Selection based on an appropriate selection index has demonstrated greater effectiveness compared to directly selecting on the basis of grain yield. The utilization of discriminant function analysis, initially devised by Fisher in 1936 and first employed by Smith in 1936, offers valuable insights into determining the relative importance or weightage allocated to specific yield components. Consequently, selection indices assist plant breeders in distinguishing desirable genotypes based on their phenotypic performance.

Materials and Methods

The investigation into the analysis of selection indices was conducted during the Rabi season of 2018-19 at the Wheat Research

Station of Junagadh Agricultural University, Junagadh. The experimental material consisted of a diverse set of 50 wheat genotypes (*T. aestivum* L.). The pure seeds of these genotypes were procured from Wheat Research Station, Junagadh Agricultural University, Junagadh. A Randomized Complete Block Design was employed for planting these genotypes. This design included two replications, and each genotype was sown in a narrow rectangular plot measuring 2.50 m x 1.20 m with a spacing of 20 cm between rows and 10 cm between individual plants. Genotypes were randomly allocated to plots within each replication. All necessary agronomic practices and recommended plant protection measures were followed to ensure a good crop growth.

The yield characteristics being studied encompassed a range of factors such as days to 50% flowering, days to maturity, grain filling period, plant height, number of productive tillers plant⁻¹, spike length, number of grains main spike⁻¹, grain weight main spike⁻¹, grain yield plant⁻¹, biological yield plant⁻¹, harvest index, and 1000-grain weight. For statistical analysis, the mean values of five randomly selected plants within each genotype were utilized for each replication. In constructing the selection indices, priority was given to traits that exhibited highly significant correlations with grain yield plant⁻¹ and had a positive direct impact on grain yield. Consequently, grain yield plant⁻¹ (X1) was chosen along with four components, namely plant height (X2), biological yield plant⁻¹ (X3), harvest index (X4), and number of grains main spike⁻¹ (X5). The respective genetic advances through selection and the relative efficiency of different discriminant functions were also computed using the formula recommended by Robinson *et al.* (1951). To gauge the relative efficiency of various discriminant functions compared to direct selection for grain yield, the efficiency of selection for grain yield plant⁻¹ was set at 100% and subsequently analyzed and compared.

Results and Discussion

In order to choose the best genetic strains by assessing their comparative performances, we created and examined selection criteria for factors such as grain yield plant⁻¹. The outcomes pertaining to these selection criteria, discriminant functions, anticipated genetic

Table 1. Comparative evaluation of Selection Indices, Discriminant function, Anticipated Genetic Advancement in Grain Yield and Relative efficiency in Bread Wheat selection

Selection index	Discriminant function	Expected genetic advance	Relative efficiency (%)	Relative efficiency per character (%)
X ₁ Grain yield plant ⁻¹	0.864X ₁	4.73	100.00	100.00
X ₂ Plant height	0.688X ₂	7.52	158.95	158.95
X ₃ Biological yield plant ⁻¹	0.935X ₃	17.74	375.08	375.08
X ₄ Harvest index	0.536X ₄	5.09	107.67	107.67
X ₅ No. of grains main spike ⁻¹	0.937X ₅	12.71	268.72	268.72
X ₁ + X ₂	2.128X ₁ + 0.238X ₂	13.81	291.92	145.96
X ₁ + X ₃	0.838X ₁ + 0.967X ₃	22.63	478.43	239.21
X ₁ + X ₄	0.351X ₁ + 0.364X ₄	3.52	74.52	37.26
X ₁ + X ₅	0.986X ₁ + 0.943X ₅	17.57	371.51	185.76
X ₂ + X ₃	-0.106X ₂ + 1.495X ₃	27.32	577.79	288.90
X ₂ + X ₄	0.277X ₂ + 0.108X ₄	2.56	54.08	27.04
X ₂ + X ₅	0.317X ₂ + 1.365X ₅	21.34	451.25	225.63
X₃ + X₄	3.791X₃ + 7.536X₄	65.06	1375.70	687.90
X ₃ + X ₅	1.856X ₃ - 1.741X ₅	17.80	376.40	188.20
X ₄ + X ₅	0.311X ₄ + 0.688X ₅	8.14	172.18	86.09
X ₁ + X ₂ + X ₃	1.066X ₁ + 0.007X ₂ + 1.408X ₃	32.22	681.24	227.08
X ₁ + X ₂ + X ₄	2.906X ₁ - 0.763 X ₂ - 0.420X ₄	10.67	225.64	75.22
X ₁ + X ₂ + X ₅	1.988X ₁ + 0.142X ₂ + 1.140X ₅	26.61	562.72	187.58
X ₁ + X ₃ + X ₄	-2.254X ₁ + 1.887X ₃ + 1.207X ₄	18.42	389.46	129.82
X ₁ + X ₃ + X ₅	0.769X ₁ + 0.878X ₃ + 1.170X ₅	35.46	749.78	249.93
X ₁ + X ₄ + X ₅	1.110X ₁ + 0.179X ₄ + 0.601X ₅	13.04	275.63	91.88
X ₂ + X ₃ + X ₄	-0.342X ₂ + 1.485X ₃ + 0.416X ₄	22.83	482.69	160.90
X ₂ + X ₃ + X ₅	-0.170X ₂ + 1.473X ₃ + 1.086X ₅	39.97	845.16	281.72
X ₂ + X ₄ + X ₅	0.087X ₂ + 0.139X ₄ + 1.198X ₅	16.31	344.87	114.96
X ₃ + X ₄ + X ₅	0.917X ₃ + 0.509X ₄ + 0.865X ₅	25.83	546.24	182.08
X ₁ + X ₂ + X ₃ + X ₄	1.286X ₁ - 0.286X ₂ + 1.306X ₃ + 0.201X ₄	27.70	585.70	146.43
X₁ + X₂ + X₃ + X₅	0.997X₁ - 0.057X₂ + 1.361X₃ + 1.155X₅	44.88	949.06	237.27
X ₁ + X ₂ + X ₄ + X ₅	4.546X ₁ - 0.981X ₂ - 0.861X ₄ + 0.298X ₅	22.66	479.15	119.79
X ₁ + X ₃ + X ₄ + X ₅	-3.473X ₁ + 2.190X ₃ + 1.549X ₄ + 1.190X ₅	30.87	652.70	163.18
X ₂ + X ₃ + X ₄ + X ₅	-0.409X ₂ + 1.614X ₃ + 0.424X ₄ + 0.855X ₅	35.21	744.50	186.13
X ₁ + X ₂ + X ₃ + X ₄ + X ₅	1.380X ₁ - 0.359X ₂ + 1.379X ₃ + 0.185X ₄ + 0.898X ₅	40.12	848.47	169.70

improvements, and relative effectiveness are detailed in Table 1, assuming that selecting for grain yield plant⁻¹ alone is 100% effective. The findings indicated that; the efficiency of selection is greater when it is based on individual characteristics rather than a straight forward selection process. This efficiency is further enhanced when two or more characteristics are taken into account. The greatest efficiency was observed when all four characteristics were considered simultaneously.

In the role of a plant breeder, one holds specific plant characteristics in mind for particular crops, and thus, assigns varying degrees of importance to these different traits when making decisions about selecting specific genotype types. To facilitate this process, it

is essential to employ a selection index that allocates appropriate weights to each of the two or more traits under consideration. Opting for selection through two or more traits proves to be more accurate and efficient than individually selecting based on various characteristics, as attested by Hazel and Lush in 1943. The groundwork for the creation of selection indices can be attributed to the work of Smith in 1936, Hazel in 1943, and Robinson *et al.* in 1951.

Hazel and Lush (1943) noted that as you incorporate a greater number of traits into the selection process, the effectiveness of the selection also sees an improvement. McVetty and Evans (1980) as well as Eshoghi *et al.* (2011) conducted reviews which further supported the notion that using a selection index is more

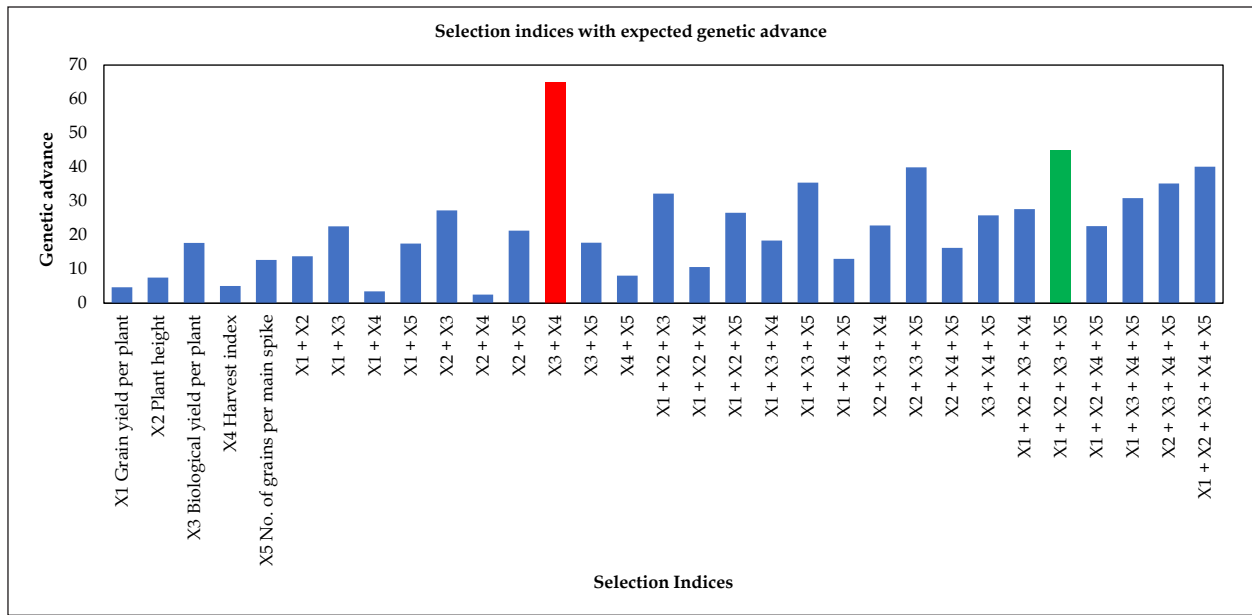


Fig. 1. Bar graph of selection indices showing expected genetic advance in bread wheat.

advantageous than opting for direct selection in the context of wheat. In our current investigation, we observed a significant enhancement in the anticipated genetic advancement and relative efficiency when selection was predicated based on two or more characteristics.

When a single character discriminant function i.e. biological yield plant⁻¹ counted, the highest level of relative efficiency (RI) of 375.08% is achieved. This efficiency surged significantly to 1375.70% when used as a combination of two characters, specifically biological yield plant⁻¹ and harvest index. In the case of three-character combinations (comprising plant height, biological yield plant⁻¹, and the number of grains main spike⁻¹), the relative efficiency stood at 845.16%. When we extended the combination to four characters, including grain yield plant⁻¹, plant height, biological yield plant⁻¹, and the number of grains main spike⁻¹, the relative efficiency soared to 949.06%. Finally, with a combination of five characters, namely grain yield plant⁻¹, plant height, biological yield plant⁻¹, harvest index, and the number of grains main spike⁻¹, the relative efficiency reached an impressive 848.47%. These findings are in accordance with the study carried out by Malav *et al.* (2023).

The peak level of relative efficiency, standing at an impressive 1375.70%, was demonstrated by a selection index comprising two specific component traits, namely biological yield

plant⁻¹ and harvest index (X3+X4). This finding aligns with the views expressed by Afrayeem *et al.* (2023) and Raiyani *et al.* (2015), who similarly emphasized that an augmentation in the number of traits leads to an elevation in genetic gains. They also concurred that utilizing selection indices proves to be more efficient than relying solely on direct selection for grain yield.

Additionally, it was noted that selecting solely for grain yield plant⁻¹ did not yield as substantial rewards (GA=4.73 g, RI=100%) compared to when the focus was on its constituent factors, such as plant height (GA=7.52 g, RI=158.95%), biological yield plant⁻¹ (GA=17.74 g, RI=375.08%), harvest index (GA=5.09 g, RI=107.67%), and the number of grains main spike⁻¹ (GA=12.71 g, RI=268.72%), either individually or in various combinations (Table 1).

As depicted in Figure 1, the highest degree of efficiency in selecting for grain yield was achieved through a discriminant function that incorporated biological yield plant⁻¹ and harvest index (X3+X4), showcasing the most substantial genetic gain and relative efficiency (65.06 g and 1375.70%) when contrasted with a straightforward grain yield selection. Another noteworthy selection index, comprised the inclusion of four distinct traits, namely grain yield plant⁻¹, plant height, biological yield plant⁻¹, and the number of grains main spike⁻¹

($X_1+X_2+X_3+X_5$), which boasted a heightened genetic gain (44.88 g) and relative efficiency (949.06%), denoted in green on the graph.

However, from a practical perspective, plant breeders consistently seek to maximize gains while minimizing the number of traits involved. In this regard, the selection index featuring biological yield plant⁻¹ and harvest index (X_3+X_4) emerges as a strategically advantageous choice for wheat breeding programs. The results aligned with the experiment conducted by Patel *et al.* (2020).

The current investigation reveals a consistent rise in the relative efficiency of each subsequent index as each character is simultaneously incorporated. Nonetheless, in practical scenarios, plant breeders often aim to maximize gains while using the fewest number of traits possible. In line with this objective, the relative efficiency per character was computed for each selection index. Notably, the selection index composed of biological yield plant⁻¹ and harvest index (X_3+X_4) displayed the highest relative efficiency per character, followed closely by plant height and biological yield plant⁻¹ (X_2+X_3).

Conclusion

Curiously, when constructing selection indices for wheat crop, biological yield plant⁻¹ was integrated into systems comprising two, three, four, or five different characters. This integration notably enhanced the relative selection efficiency. Consequently, it is advisable to assign significant importance to biological yield plant⁻¹ when devising a selection index for wheat cultivation. The current investigation highlights the advantages of employing the discriminant function method over relying solely on grain yield for plant selection. As such, it is affirmed that considerable emphasis should be placed on key selection indices when aiming to advance grain yield in bread wheat through the selection process.

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