# Prediction of varietal replacement in wheat (*Triticum aestivum* L. em. Thell.)


**Abstract**

Nine wheat genotypes, *viz.*, K-508, K-17, K-818, RAJ4037, RAJ3404, K-8903, DBW-14, K-9357 and HD2967 were evaluated in a randomized block design on nine parameters *viz.*, tillering ability, plant height, grain yield per plant, peduncle length, spikelets per spike, flag leaf area, thousand grain weight, days to maturity and grains per spike at experimental farm of BRD PG College, Deoria, Uttar Pradesh, India with an objective of recommending suitable plant types to farmers of this region. Normalized cumulative ranks (NCR) were used as criteria for selecting suitable plant types. Small flag leaf and early maturity were the criteria of selection (left directional selection) and rest seven characters were selected for higher values (right directional selection). The suitability order of varieties/genotypes, as per NCR values was DBW-14, HD2967, K-508, RAJ4037, K-818, RAJ3404, K-17, K-9357 and K-8903. Top four varieties, namely DBW-14, HD2967, K-508 and RAJ4037 could be recommended for cultivation in this region. When all nine characters were selected for higher values, the suitability order came as HD2967, RAJ4037, DBW-14 and K-9357. High positive correlations were observed between peduncle length and test weight (0.831) and plant height and days to maturity (0.652). When peduncle length, test weight, plant height and days to maturity were made criteria of selection, the suitability order was DBW-14, K-818, HD2967 and RAJ3404. HD2967 is the standard check variety and popular in this region. Therefore, a few of these selected/recommended varieties would give close fight to HD2967 and might eventually replace.



**Key words**: Ideal plant types, Normalized cumulative ranks, Prediction of varietal replacement, Selection.


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## Introduction

Plant breeders' humble duty is to provide correct scientific knowledge of crop varieties to farmers so that enough food could be produced to feed humans and their pets alike. Novel improved genotypes/varieties must keep replacing established popular varieties that are used as standard check varieties in varietal trials. Therefore, promising new variants/genotypes need to be evaluated along with current standard check varieties. With this purpose in mind, we evaluated nine wheat genotypes on nine parameters and used three selection approaches/schemes to select suitable plant types for growing in this region. PBW-343 has been gradually replaced by HD2967. The present varietal trial data predict the replacement of HD2967 by novel promising variants/varieties.

## Materials and Methods

Nine wheat genotypes included in this experiment are K-508, K-17, K-818, RAJ4037, RAJ3404, K-8903, DBW-14, K-9357 and HD2967. These varieties/genotypes were evaluated in a randomized block design on nine parameters namely, tillering ability (number of tillers), plant height (cm), grain yield per plant (g), peduncle length (cm), spikelets per spike (number), flag leaf area ($cm^2$ as calculated by length into breadth into correction factor 0.75), thousand grain weight or test weight (in grams), days to maturity (days) and grains per spike (numbers). The experiment was conducted at experimental farm of BRD PG College, Deoria, Uttar Pradesh, India with standard package of practices. Normalized cumulative ranks (NCR) were used as criteria for selecting suitable plant types as discussed in a few earlier papers using formula $NCR = (\sum_{i=1}^{n} R_i)/(\sum_{i=1}^{n} R_i)min$ (Singh and Kant 2022; Singh and Tiwari 2020; Yadav et al. 2020; Singh et al. 2018; Singh 2018; Singh, S. N. 2017). Under first selection scheme, small flag leaf and early maturity were the criteria of selection (left directional selection) and rest seven characters were selected for higher values (right directional selection). In second selection scheme, all nine characters were selected for high values (only right directional selection). Observing the high positive correlations between peduncle length and test weight (0.831) and plant height and days to maturity (0.652), the third selection scheme was of feature reduction. In this scheme ideal plant types were selected on the basis of peduncle length, test weight, plant height and days to maturity. HD2967 was used as the standard check variety as it is very popular in this region after replacing PBW343. The common top few varieties and/or the unique list (of varieties under three selection schemes) are predicted to be eventually replacing today's standard check variety HD2967.

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**Results and Discussion**

The summarized data as means of five randomly selected plants, the ranks, cumulative ranks, normalized cumulative ranks and the outcome of first selection scheme are consolidated in a single table (Table 1) as advocated in earlier papers (Singh and Kant 2022; Singh and Tiwari 2020). The descriptive statistics is given in table 2 for quick reference and overall understanding of the experimental materials. The outcome of second selection scheme is given in table 3. Correlation data are given in table 4. The ranks are given in parentheses in tables 1, 3 and 5. Varieties DBW-14 and HD2967 are equally good as CR & NCR values of both are 40 & 1 respectively. Similarly, variety K-508 and RAJ4037 have equal CR & NCR values of 42 & 1.05 respectively. Therefore, these varieties (DBW-14, K-508 and RAJ4037) are likely to appeal farmers of this region and eventually replace HD2967.

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Table 1: Summarized data as means of five randomly selected plants, ranks, cumulative ranks (CR) and normalized cumulative ranks (NCR) values.

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| S.N. | Variety ↓ Sort | Tillering | Plant Height (cm) | Grain yield /Plant (g) | Peduncle length (cm) | Spikelets /spike | Flag Leaf Area | 1000 Grain Weight | Days to Maturity | Grains /Spike | CR | NCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|



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| | order→ | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DBW-14 | 5.71 (7) | 95.96 (2) | 11.05 (8) | 53.18 (2) | 17.22 (6) | 37.73 (2) | 45.11 (1) | 123.24 (6) | 44.56 (6) | 40 | 1 |
| 2 | HD2967 | 6.14 (5) | 90.13 (4) | 14.89 (1) | 44.75 (6) | 18.06 (4) | 48.48 (9) | 42.22 (4) | 119.78 (4) | 52.33 (3) | 40 | 1 |
| 3 | K-508 | 6.15 (4) | 82.03 (8) | 12.11 (5) | 45.12 (5) | 17.6 (5) | 42.5 (6) | 39.99 (7) | 110.21 (1) | 56.38 (1) | 42 | 1.05 |
| 4 | RAJ4037 | 7.17 (2) | 77.03 (9) | 13.26 (3) | 45.38 (4) | 16.78 (8) | 44.25 (8) | 42.54 (2) | 117.51 (2) | 50.52 (4) | 42 | 1.05 |
| 5 | K-818 | 6.39 (3) | 89.32 (5) | 9.98 (9) | 54.21 (1) | 16.93 (7) | 35.89 (1) | 42.27 (3) | 124.22 (7) | 43.51 (7) | 43 | 1.08 |
| 6 | RAJ3404 | 6.14 (5) | 88.88 (6) | 12.96 (4) | 48.77 (3) | 15.94 (9) | 38.21 (3) | 41.02 (5) | 119.52 (3) | 34.75 (8) | 46 | 1.15 |
| 7 | K-17 | 8.12 (1) | 90.37 (3) | 11.3 (7) | 40.37 (8) | 18.73 (2) | 44.19 (7) | 38.87 (8) | 120.22 (5) | 33.52 (9) | 50 | 1.25 |
| 8 | K-9357 | 4.32 (9) | 87.81 (7) | 14.65 (2) | 43.78 (7) | 19.34 (1) | 38.87 (4) | 40.01 (6) | 126.81 (9) | 49.19 (5) | 50 | 1.25 |
| 9 | K-8903 | 5.56 (8) | 96.89 (1) | 11.34 (6) | 37.58 (9) | 18.39 (3) | 39.03 (5) | 37.55 (9) | 126.19 (8) | 53.28 (2) | 51 | 1.28 |

Table 2: The descriptive statistics of all nine characters.

| Descriptive Statistics | Tillering | Plant Height (cm) | Grain yield/Plant (g) | Peduncle length(cm) | Spikelets/ spike | Flag Leaf Area | 1000 Grain Weight | Days to Maturity | Grains /Spike |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 6.189 | 88.713 | 12.393 | 45.904 | 17.666 | 41.017 | 41.064 | 120.856 | 46.449 |
| Standard Error | 0.351 | 2.063 | 0.558 | 1.813 | 0.356 | 1.354 | 0.752 | 1.703 | 2.688 |
| Median | 6.14 | 89.32 | 12.11 | 45.12 | 17.6 | 39.03 | 41.02 | 120.22 | 49.19 |
| Standard Deviation | 1.052 | 6.19 | 1.674 | 5.44 | 1.068 | 4.061 | 2.257 | 5.109 | 8.064 |
| Sample Variance | 1.107 | 38.313 | 2.801 | 29.599 | 1.14 | 16.493 | 5.096 | 26.098 | 65.024 |
| Kurtosis | 1.383 | 0.514 | -0.978 | -0.477 | -0.605 | -0.412 | 0.12 | 1.407 | -0.758 |
| Skewness | 0.175 | -0.65 | 0.305 | 0.223 | 0.003 | 0.659 | 0.228 | -1.004 | -0.676 |
| Range | 3.8 | 19.86 | 4.91 | 16.63 | 3.4 | 12.59 | 7.56 | 16.6 | 22.86 |
| Minimum | 4.32 | 77.03 | 9.98 | 37.58 | 15.94 | 35.89 | 37.55 | 110.21 | 33.52 |
| Maximum | 8.12 | 96.89 | 14.89 | 54.21 | 19.34 | 48.48 | 45.11 | 126.81 | 56.38 |
| Sum | 55.7 | 798.42 | 111.54 | 413.14 | 158.99 | 369.15 | 369.58 | 1087.7 | 418.04 |
| Count | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 | 9 |
| Confidence Level (95.0%) | 0.81 | 4.76 | 1.29 | 4.18 | 0.82 | 3.12 | 1.74 | 3.93 | 6.2 |

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Even if we select for large flag leaf area and late maturity (the second selection scheme), the top four selected varieties are HD2967, RAJ4037, DBW-14 and K-9357. In this selection scheme, the standard check variety HD2967 itself proves to be topper. Out of these two lists (the outcomes of first and second selection schemes), three varieties, namely HD2967, RAJ4037, and DBW-14 are common to both the lists and the total number of selected varieties under first two selection schemes is five (HD2967, RAJ4037, DBW-14 (common to both selection schemes), K-508 (exclusive to selection scheme one) and K-9357(exclusive to selection scheme two)). These five varieties could be tried further in multi-location trials at farmers' fields at large scale (demonstration trials).

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Table 3: The outcome of second selection scheme.

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| S.N. | Variety↓ Sort order→ | Tillering 0 | Plant Height (cm) 0 | Grain yield /Plant (g) 0 | Peduncle length (cm) 0 | Spikelets /spike 0 | Flag Leaf Area 0 | 1000 Grain Weight 0 | Days to Maturity 0 | Grains /Spike 0 | CR | NCR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | HD2967 | 6.14 (5) | 90.13 (4) | 14.89 (1) | 44.75 (6) | 18.06 (4) | 48.48 (1) | 42.22 (4) | 119.78 (6) | 52.33 (3) | 34 | 1 |
| 2 | RAJ4037 | 7.17 (2) | 77.03 (9) | 13.26 (3) | 45.38 (4) | 16.78 (8) | 44.25 (2) | 42.54 (2) | 117.51 (8) | 50.52 (4) | 42 | 1.24 |
| 3 | DBW-14 | 5.71 (7) | 95.96 (2) | 11.05 (8) | 53.18 (2) | 17.22 (6) | 37.73 (8) | 45.11 (1) | 123.24 (4) | 44.56 (6) | 44 | 1.29 |
| 4 | K-9357 | 4.32 (9) | 87.81 (7) | 14.65 (2) | 43.78 (7) | 19.34 (1) | 38.87 (6) | 40.01 (6) | 126.81 (1) | 49.19 (5) | 44 | 1.29 |
| 5 | K-8903 | 5.56 (8) | 96.89 (1) | 11.34 (6) | 37.58 (9) | 18.39 (3) | 39.03 (5) | 37.55 (9) | 126.19 (2) | 53.28 (2) | 45 | 1.32 |
| 6 | K-17 | 8.12 (1) | 90.37 (3) | 11.3 (7) | 40.37 (8) | 18.73 (2) | 44.19 (3) | 38.87 (8) | 120.22 (5) | 33.52 (9) | 46 | 1.35 |
| 7 | K-818 | 6.39 (3) | 89.32 (5) | 9.98 (9) | 54.21 (1) | 16.93 (7) | 35.89 (9) | 42.27 (3) | 124.22 (3) | 43.51 (7) | 47 | 1.38 |
| 8 | K-508 | 6.15 (4) | 82.03 (8) | 12.11 (5) | 45.12 (5) | 17.6 (5) | 42.5 (4) | 39.99 (7) | 110.21 (9) | 56.38 (1) | 48 | 1.41 |
| 9 | RAJ3404 | 6.14 (5) | 88.88 (6) | 12.96 (4) | 48.77 (3) | 15.94 (9) | 38.21 (7) | 41.02 (5) | 119.52 (7) | 34.75 (8) | 54 | 1.59 |

Table 4: Correlation data.

| | Tillering | Plant Height (cm) | Grain yield /Plant (g) | Peduncle length (cm) | Spikelets/ spike | Flag Leaf Area | 1000 Grain Weight | Days to Maturity | Grains /Spike |
|---|---|---|---|---|---|---|---|---|---|
| Tillering | 1 | | | | | | | | |
| Plant Height | -0.286 | 1 | | | | | | | |

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| (cm) | | | | | | | | | |
| Grain yield /Plant (g) | -0.34 | -0.341 | 1 | | | | | | |
| Peduncle length(cm) | -0.084 | -0.027 | -0.292 | 1 | | | | | |
| Spikelets/ spike | -0.252 | 0.256 | 0.244 | -0.639 | 1 | | | | |
| Flag Leaf Area | 0.434 | -0.366 | 0.552 | -0.467 | 0.242 | 1 | | | |
| 1000 Grain Weight | -0.016 | -0.088 | -0.006 | 0.831 | -0.521 | -0.072 | 1 | | |
| Days to Maturity | -0.44 | 0.652 | -0.089 | -0.003 | 0.347 | -0.49 | -0.049 | 1 | |
| Grains /Spike | -0.445 | -0.228 | 0.292 | -0.227 | 0.247 | 0.249 | -0.048 | -0.193 | 1 |

On the basis of correlation analysis, high positive correlations were observed between 1. peduncle length and test weight (0.831), 2. plant height and days to maturity (0.652) and 3. grain yield per plant and flag leaf area (0.552). Seeing the first two high correlations, characters like peduncle length, test weight, plant height and days to maturity could be considered as criteria of selection (the third selection scheme) and rest of the characters could be left for further research thoughts like feature reduction, linkage etc.

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Table 5: The outcome of third selection scheme.

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| S.N. | Variety↓ | Plant Height (cm) | Peduncle length (cm) | 1000 Grain Weight | Days to Maturity | CR | NCR |
|---|---|---|---|---|---|---|---|
| | Sort order→ | 0 | 0 | 0 | 0 | | |
| 1 | DBW-14 | 95.96 (2) | 53.18 (2) | 45.11 (1) | 123.24 (4) | 9 | 1 |
| 2 | K-818 | 89.32 (5) | 54.21 (1) | 42.27 (3) | 124.22 (3) | 12 | 1.33 |
| 3 | HD2967 | 90.13 (4) | 44.75 (6) | 42.22 (4) | 119.78 (6) | 20 | 2.22 |
| 4 | RAJ3404 | 88.88 (6) | 48.77 (3) | 41.02 (5) | 119.52 (7) | 21 | 2.33 |

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|---|---|---|---|---|---|---|---|
| 5 | K-8903 | 96.89 (1) | 37.58 (9) | 37.55 (9) | 126.19 (2) | 21 | 2.33 |
| 6 | K-9357 | 87.81 (7) | 43.78 (7) | 40.01 (6) | 126.81 (1) | 21 | 2.33 |
| 7 | RAJ4037 | 77.03 (9) | 45.38 (4) | 42.54 (2) | 117.51 (8) | 23 | 2.56 |
| 8 | K-17 | 90.37 (3) | 40.37 (8) | 38.87 (8) | 120.22 (5) | 24 | 2.67 |
| 9 | K-508 | 82.03 (8) | 45.12 (5) | 39.99 (7) | 110.21 (9) | 29 | 3.22 |

Long peduncles of tall and late varieties might be the result of high mobility of solvent (water), solutes (nutrients) and photosynthates, metabolites etc so as to facilitate grain filling and increasing test weight. That is why, early or timely sowing of late varieties is important so that crop gets enough time for biomass accumulation and resource allocation towards grains. The third selection scheme is based on this logic. Therefore, future breeding efforts should be towards tall type, non-lodging with high harvest index ideotypes. The third selection scheme is given in table 5. The top four varieties here are DBW-14, K-818, HD2967 and RAJ3404. Thus, DBW-14 is likely to give a close fight to the standard check variety HD2967. The farmers are suggested to try this on their farms.

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