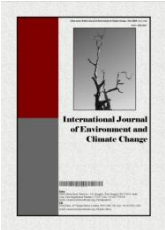

International Journal of Environment and Climate Change

12(9): 264-271, 2022; Article no.IJECC.85899
ISSN: 2581-8627
(Past name: British Journal of Environment & Climate Change, Past ISSN: 2231–4784)

Prediction of Varietal Replacement in Wheat (*Triticum aestivum* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2022/v12i930763

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/85899

Original Research Article

Received 09 February 2022
Accepted 16 April 2022
Published 25 April 2022

ABSTRACT

Nine wheat genotypes, *viz.*, K-508, K-17, K-818, RAJ4037, RAJ3404, K-8903, DBW-14, K-9357 and HD-2967 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 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 remaining seven characters were selected for higher values (right directional selection). The suitability order of varieties/genotypes, as per NCR values was DBW-14, HD-2967, K-508, RAJ-4037, K-818, RAJ-3404, K-17, K-9357 and K-8903. The top four varieties, namely DBW-14, HD-2967, K-508 and RAJ-4037 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, HD-2967 and RAJ-3404. HD-2967 is the standard check variety and popular in this region. Therefore, a few of these selected/recommended varieties would give close fight to HD-2967 and might replace it eventually.

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Keywords: Ideal plant types; normalized cumulative ranks; prediction of varietal replacement; selection.

1. INTRODUCTION

Plant breeders' humble duty is to provide correct scientific knowledge of crop varieties to farmers so that enough food can 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/ or genotypes need to be evaluated along with the 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 HD-2967. The present varietal trial data predicts the replacement of HD2967 by novel and promising variants/varieties.

2. 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 the experimental farm of BRD PG College, Deoria, Uttar Pradesh, India with a 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:

$$NCR = (\sum_{i=1}^{n} R_i) / (\sum_{i=1}^{n} R_i)min$$

[1,2,3,4,5,6] where NCR stands for normalized cumulative ranks and R for ranks. This single line formula can be broken into a set of two formulae for ease of understanding and applying the method like this:

1. $CR = (\sum_{i=1}^{n} R_i)$ and

2. $NCR = CR / CR_{min}$

Here, CR is cumulative rank. This NCR analysis method of selecting suitable plant types has been used by at least 16-20 post-graduate students in their theses [7-22] that are available in the departmental library of the college. Three selection schemes were applied in the present paper. Under the first selection scheme, small flag leaf and early maturity were the criteria of selection (left directional selection) and remaining seven characters were selected for higher values (right directional selection). In the 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 between plant height and days to maturity (0.652), the third selection scheme was for feature reduction. In this scheme, ideal plant types were selected on the basis of peduncle length, test weight, plant height and days to maturity. HD-2967 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 eventually replace today's standard check variety HD-2967.

3. RESULTS AND DISCUSSION

The summarized data as means of five randomly selected plants, the ranks, cumulative ranks, normalized cumulative ranks and the outcome of the first selection scheme are consolidated into a single table (Table 1) as advocated in earlier papers 3, 5. The descriptive statistics are given in table 2 for quick reference and overall understanding of the experimental materials. The outcome of the second selection scheme is given in table 3. Correlation data is given in table 4. The ranks are given in parentheses in tables 1, 3 and 5. Varieties DBW-14 and HD-2967 are equally good as their CR and NCR values of both are 40 and 1, respectively. Similarly, varieties K-508 and RAJ-4037 have equal CR and NCR values of 42 and 1.05, respectively. Therefore, these varieties (DBW-14, K-508 and RAJ4037) are likely to appeal to farmers in this region and eventually replace HD-2967.

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

S.N.	Variety↓ Sort order→	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
		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	HD-2967	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	RAJ-4037	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	RAJ-3404	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 (g)	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

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

Table 3. The outcome of second selection scheme

S.N.	Variety↓ Sort order→	Tillering	Plant Height (cm)	Grain yield /Plant (g)	Peduncle length (cm)	Spikelets /spike	Flag Leaf Area	1000 Grain Weight (g)	Days to Maturity	Number of Grains /Spike	CR	NCR
		0	0	0	0	0	0	0	0	0		
1	HD-2967	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	RAJ-4037	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	RAJ-3404	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 coefficients

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

Table 5. The outcome of the third selection scheme

S.N.	Variety↓	Plant Height (cm)	Peduncle length (cm)	1000 Grain Weight (g)	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	HD-2967	90.13 (4)	44.75 (6)	42.22 (4)	119.78 (6)	20	2.22
4	RAJ-3404	88.88 (6)	48.77 (3)	41.02 (5)	119.52 (7)	21	2.33
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	RAJ-4037	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

Table 6. Common top performing varieties under three selection schemes

Selection scheme↓	Selected varieties				
1	DBW-14	HD-2967	K-508	RAJ-4037	K-818
2	HD-2967	RAJ-4037	DBW-14	K-9357	K-8903
3	DBW-14	K-818	HD-2967	RAJ-3404	K-8903

Even if we select for large flag leaf area and late maturity (the second selection scheme), the top four selected varieties are HD-2967, RAJ-4037, DBW-14 and K-9357. In this selection scheme, the standard check variety HD-2967 itself proved to be the topper. Out of these two lists (the outcomes of the first and second selection schemes), three varieties, namely HD-2967, RAJ4037, and DBW-14 are common to both the lists and the total number of selected varieties under the 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)). Therefore, these five varieties could be tried further in multi-location trials at farmers' fields on a large scale (demonstration trials).

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 the remaining characters could be left for further research thoughts like feature reduction, linkage etc.

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 increase in test weight. That is why, early or timely sowing of late varieties is important so that the 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, non-lodging ideotypes with high harvest index. The third selection scheme is given in table 5. The top four varieties here are DBW-14, K-818, HD-2967 and RAJ-3404. As a result, DBW-14 is likely to compete with the standard check variety HD2967. The farmers are suggested to try this on their farms. Researchers are highly likely to be attracted towards simplicity of NCR analysis and find it as a powerful tool in drawing important inferences. Researchers might also compare it with selection indices developed by others [23,24].

4. SUMMARY AND CONCLUSIONS

The top five selected varieties under three selection schemes could be summarized in the form of Table 6.

It is clear from table 6 that farmers should go for varieties in sequence DBW-14, HD-2967, RAJ-4037, K-818, K-508 and K-9357 so on. Thus, improved varieties would keep on replacing older ones. However, there is a need to develop robust, tall, non-lodging, long duration crop ideotypes with high biological yield and high harvest index. The success of a variety does reduce varietal or crop diversity but the solution of the virtual problem lies in varietal success itself as it would free some land for other land uses. Plant diversity is conserved by various institutions like forest departments, NBPGR and so on, and the main purpose of the present paper was to demonstrate a method to select right plant type to suit farmer's field conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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