

Original Research Article

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## Multivariate Approach to Identify Potential Varieties of Bread Wheat (*Triticum aestivum* L.) for Bundelkhand Region of Uttar Pradesh, India

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### ABSTRACT

The study aims to evaluate the yield potential of 60 bread wheat varieties along with three mega-varieties. The experiment was laid down in an augmented design at Banda Agriculture University, Banda, U.P. during rabi 2017-18. The data was recorded on days to 75% heading, days to maturity, plant height and grain yield. The recorded observation were analysed to identify the best performing varieties. Analysis of variance exhibited highly significant differences ( $P < 0.001$ ) among the test varieties for all traits except days to maturity indicating the presence of variability in the experimental material. The highest variance was found for grain yield followed by plant height and 75% flowering while, it was recorded lowest for days to maturity. The less significant difference were found for days to maturity among all lines. The varieties HI 1544 (5773 kg/ha), PBW 621 (5773 kg/ha), MP 1203 (5583 kg/ha), UP 2526 (5545 kg/ha) and UP 2554 (5545 kg/ha) recorded highest grain yield. UP 2382 was early matured variety (109 days) among all tested varieties. The PCA and biplot analysis was also undertaken to understand the comparative performance of genotypes in terms of their yield and contributing traits. The first two PCs contributed 79.37% of total variance with 42.03 (PC1) and 37.35 (PC2) eigenvalues. The PC1 and PC2 were significantly influenced by days to 75% heading and seed yield.

#### Keywords

Bread wheat, yield potential, genetic variability, principal components

#### Article Info

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### Introduction

Wheat is the second most important staple food crop after rice, belongs to family gramineae. It is often considered as a major source of energy and also contains valuable amounts of other important nutrients including fiber, protein. The global production of wheat is 766.4 million tons

during 2018-19, with increase of 4.8% (34.8 million tonnes) from the previous year (<http://www.fao.org/worldfoodsituation/csdb/en/>).

In India, the production is 101.20 million tons from 29.55 million ha (13.43% of global area) and highest productivity is 3424 kg/ha during 2018-19 (ICAR-IIWBR Annual Report 2018-

19). Wheat contributes 33 percent of total food grain under cereals in the country from 28 percent area (Rangare *et al.*, 2010). The major wheat producing states are Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan, Bihar, Maharashtra, Gujarat, Karnataka, West Bengal, Uttarakhand, Himachal Pradesh and Jammu & Kashmir. Uttar Pradesh stands first in terms of area 96.37 lakh ha (33.15% of the total area) and contributes about 34.53% share in total production of the country (DWR, Perspective Plan Vision 2025).

However, in terms of productivity, Punjab and Haryana were on top with 5077 and 4643 kg/ha respectively, whereas the productivity of Uttar Pradesh was 3269 kg/ha compared to the national average of 3424 kg/ha (Singh *et al.*, 2019).

Wheat is also one of the most important cereal crops in the Bundelkhand region occupying an area of 8.32 lakh hectares with a production and productivity of 23.35 lakh tonnes and 2776 kg/ha, respectively (Directorate of Economics and Statistics, Gov. of Uttar Pradesh 2018-19).

The productivity of Bundelkhand region is lower as compared to the state average productivity (3626 Kg/ha). The central and eastern regions of Bundelkhand had a wider gap between potential (40-50 q/ ha) and realized yields (<30 q/ha).

The major constraints for low productivity of the region as well as of the state are cultivation of old, low yielding, susceptible varieties, poor quality seed, untimely availability of quality seed, late sowing and also poor mechanization badly affects the wheat cultivation in the state. Due to lack of awareness among the farmers about improved agricultural technology, adoption rate of new technologies is very low in the region.

In view of the above reasons the low productivity of wheat can be improved by replacement of old varieties with improved wheat varieties recommended for this region. The newly released high yielding varieties can play a major role in improving the productivity as well as expanding the area in the target region. Adoption of improved varieties itself can enhance productivity by 20 to 25%. (Rain fed authority of India 2011). Grain yield being a polygenic trait fluctuates widely as a result of genotype x environment interaction (Akram *et al.*, 2008).

The knowledge of variability helps plant breeder in predicting the behavior of the succeeding generation and making desirable selections in a diverse set of germplasm lines. The estimation of variability, understanding the genetic distance between parents which are directly proportional to the extent of heterosis. The variability is essential for genetic improvement of any crop (Ramya and Senthil Kumar, 2009). Because, the yield is not only affected directly by environmental components but also affected indirectly by other yield components in negative or positive manner.

For increasing wheat production prime importance should be given to widely adapted high yielding varieties. Generating information about the yield potential and genetic variability among yield contributing factors is the key task in genetic improvement of any crop plant (Naik *et al.*, 2015).

The most challenging task for wheat breeders is not only to increase yield potential but also enriching the trait diversity in the populations with which breeders work. Keeping in view the above facts the present experiment was undertaken to evaluate the performance of released varieties with respect to grain yield and also to identify material suitable for Bundelkhand region.

## Materials and Methods

### Plant materials

A set of 63 bread wheat varieties comprising recently released varieties, local and obsolete cultivars were evaluated with three checks Lok-1, HD 2967 and WH 142 during rabi 2017-18 at experimental farm of Banda University of Agriculture and Technology, Banda, UP. The Lok-1 and WH 147 are heat tolerant and are widely preferred varieties for cultivation in the region. HD 2967, a ruling variety recommended for cultivation in North Western and Eastern Plane Zones (NWPZ & NEPZ) of the country also the choice of the farmers in this region. The weather conditions of this region are warm and dry which force wheat crop to mature early. The experiment was laid out in an augmented design with repeated checks in each block (Federer, 1956). The total 10 test varieties were planted in a block along with three randomly repeated checks to control local error thus making total six blocks (Stringer and Cullis, 2002). Each test variety was planted in a 6 rows plot of 4 m length with a spacing of 18.5 cm between rows. Recommended package of practices were followed to raise healthy wheat crop during season.

### Measured traits

The varieties were evaluated for agromorphological traits namely; days to 75% heading (DTH), days to maturity (DTM), plant height (PH) and grain yield per ha (GY) for all the test varieties and checks. For measuring days to 75% heading (days counted from date of sowing to the days of heading in 75% plants completed); for days to maturity (days counted from date of sowing to the days of physiological maturity completed); for plant height (height was taken from base of soil surface to terminal of spike excluding awns on five randomly selected

plants from each plot); grain yield per plot were taken from net plot six-rows of 4m length for each genotype. The data thus recorded were subjected to statistical analysis.

### Statistical analysis

The data of test varieties was analyzed as per the statistical procedure suggested by Johnson *et al.*, (1955), along with repeated checks to estimate adjusted mean of each entry and analysis of variance (ANOVA) with the help of Statistical software GenStat 14th edition (Payne *et al.*, 2011). The recorded observations were analyzed identify the best performing variety in the region and to estimate the genetic parameters with SPAD software and SPAR 2.0.

### Results and Discussion

The analysis of variance (ANOVA) for each character indicated significant differences except days to maturity among test varieties (Table 1). The contrast analyses revealed among test lines are significant for all traits except DTM while among check differences are significant. Similarly, the test vs check was also non-significant for DTH, which indicating that the test varieties were not different from check for traits under studies except DTH. The less significant variance was found for DTM among all lines. This result revealed the greater genetic variability in genotypes for all traits except DTM which will be used for selection of these traits. The adjusted variety and check means for each trait is presented in Table 2.

### Varietal performance with respect to measured traits

The trait mean values for DTH (81 days), PH (95 cm), DTM (115 days) and GY (4328 kg/ha) are presented in Table 3. The highest co-efficient of variation (CV) was found for

GY (21 %) followed by DTH (6.45%) and PH (6.038%) while, DTM (2.41%) had lowest C.V. value. The box plots depicting variability for all the traits are shown in Fig-1. The DTH among varieties ranged from 67 days (GW 173) to 90 days (Surya Jayoti). Rapid plant development in early vegetative growth stage with early flowering is the most important trait to avoid terminal heat stress (Shavrukov *et al.*, 2017).

Basic statistics data of DTM revealed that maturity duration ranged from 109 days (UP2382) to 121 days (HI 8498). Variety C 306 took 120 days from seed to seed. The KW-51 variety was noted dwarf with 78 cm height among taken lines followed by check variety Lok 1 with 83 cm.

The variety BHU 409 recorded highest plant height of 103cm. The varieties HI 1544 (5773 kg/ha), PBW 621(5773 kg/ha), MP 1203 (5583 kg/ha), UP 2526 (5545 kg/ha) and UP 2554 (5545 kg/ha) had highest GY (Table 3).

Yield is the most important among all components traits of a variety which largely depends on four factors such as spike length, spikelets per spike, grains per spike and seed index (Nizamani *et al.*, 2020). The varieties Super 231 (2567 kg/ha), KW-51(2376 kg/ha) were poor performer at this site. The three varieties i.e. Kundan, WR544 and PBW550 showed high yield performance in the Indo-gangetic plains of India and was also reported by Pandey *et al.*, 2019.

### **Cluster and principal component analysis**

PCA and cluster analysis allowed a natural grouping of the wheat genotypes. The cluster analysis was performed using euclidean distance matrix which sequestered 63 genotypes into four clusters (Fig.2, Table 4). Cluster I consisted of 8 genotypes whereas Cluster II consisted of 17 genotypes, cluster

III of 20 genotypes and cluster IV with 18 genotypes. Similarly, thirty two genotypes were clustered into 6 clusters reported by Santosh *et al.*, 2019.

The cophenetic correlation coefficient of the clusters is  $r = 0.578$ , which indicates agreement of graphical representation of the distance and correlation matrix, supporting the visual inference in the form of dendrogram (Fig. 2). Evaluation of genetic diversity can be useful for the selection of the most efficient genotypes.

The principal component analysis (PCA) transforms the large complex data into smaller correlated number of variables (PCs) with contribution to the total variance. The maximum percent contribution towards total divergence was also reported from grain yield per plot followed by canopy temperature, biological yield per plant and minimum by harvest index (Santosh *et al.*, 2019). These variables are less than or equal to original variables. In the present study, the recorded data for four traits was subjected to principal component analysis to understand the performance of genotypes in terms of their yield and contributed traits.

The analysis had transformed whole data into four PCs, which indicate that the first two PCs had the major proportion of the total variance. The first two PCs, eigen values  $>1$  accounted for 79.38 % of total variance for grain yield. The PC1 accounted 42.03 % variation into grain yield followed by PC2 (37.35%), PC3 (12.72%) and PC4 (7.91%) variance (Table 5). Saba *et al.*, 2017 also transformed recorded data into eight PCs, in which, first three components accounted 68.8% of the total variation. The first two principal components contributing more than half of the variance were plotted to observe relationships between the grouping of varieties (Fig. 3a).

**Table.1** ANOVA result of grain yield and yield components in 63 bread wheat lines

Sources	Df	DTH <sub>Mss</sub>	PH <sub>Mss</sub>	DTM <sub>Mss</sub>	GY <sub>Mss</sub>
Lines	62	29.27***	39.78***	8.59	512624.43**
Block	5	1.97	18.49*	5.20	35927.29
Error	10	3.03	3.72	6.37	93966.32
<b>Contrast analysis</b>					
Among check	2	260.17***	100.06***	103.17***	425043.57*
Among test lines	59	21.94***	22.02**	4.79	490821.83**
Test lines vs checks	1	0.02	967.43***	43.21*	1974117.48**

M<sub>ss</sub> Mean sum of squire, \* Indicates significance at P=.05, \* Indicates significance at P=.01, \*\*\* Indicates significance at P=.001, Days to 75% heading (DTH), Plant height (PH), Days to maturity (DTM), Seed Yield Kg/ha (GY)

**Table.2** Means of agro-morphological traits on evaluated varieties

S. No.	Variety	DTF	PH	DTM	GY	S. No.	Variety	DTF	PH	DTM	SY
1	Raj 3765	75	89	112	3672	34	HI 8498	87	89	121	4059
2	Super 20-51	78	96	116	3291	35	MP 1203	88	94	118	5583
3	G K Pradhan	76	93	113	3252	36	MP 4110	86	89	115	4287
4	PBW 234	78	88	117	3729	37	BHU 408	86	99	116	4973
5	Ajeet-349	78	83	115	2795	38	UP 2628	86	99	117	5164
6	Kaweri KW-11	83	93	115	3043	39	PBW 621	87	99	118	5754
7	Super 231	82	88	118	2567	40	DBW 17	89	89	118	4954
8	KW-51	78	78	115	2376	41	UP 2565	80	97	115	4415
9	MW-72	78	96	114	2910	42	PBW 343	85	97	117	3520
10	Ajeet 102	69	88	113	2681	43	WR 544	72	87	114	3386
11	Nath Wonder	84	91	114	3355	44	PBW 16	86	100	117	5539
12	Surya Jayoti	90	101	115	4669	45	UP 2425	82	100	116	4243
13	Ankur Kedar	81	99	113	5050	46	JK Vijay	87	102	115	5101
14	UdaySCW 105	80	101	113	4840	47	VL 892	80	102	113	4815
15	NL 266	76	96	112	2878	48	HD 2864	81	102	114	5253
16	Sri Ram 152	81	101	114	5221	49	PBW 550	85	100	115	4643
17	Balram 011	74	101	112	3069	50	BHU 5	87	97	119	4053
18	Super 303	68	91	118	3736	51	UP 2338	75	93	116	4402
19	BHU-1	78	101	113	4116	52	PBW 226	82	101	115	4555
20	AnkurManglesh	77	99	113	5259	53	BHU 409	88	103	117	4878
21	Mahyco Gold	81	97	111	5449	54	GW 173	67	103	110	3793
22	UP 2526	78	97	112	5545	55	PBW 373	86	98	116	3697
23	HI 1544	73	97	110	5773	56	HD 3086	82	88	118	2783
24	BHU-6	78	97	111	4764	57	RWV 4106	82	88	119	3736
25	Sonalika C/S	81	97	112	5240	58	HD 3117	84	93	119	3526
26	HD 2329	84	97	112	4745	59	HD CSW 18	82	103	117	4288
27	HD 2733	85	97	115	4668	60	HD 3171	82	101	117	4936
28	UP 2554	84	97	115	5545	61	<b>Lok-1 (Ch)</b>	<b>73</b>	<b>83</b>	<b>112</b>	<b>4857</b>
29	BHU 3	82	97	110	4649	62	<b>HD 2967 (Ch)</b>	<b>86</b>	<b>91</b>	<b>120</b>	<b>4825</b>
30	UP 2382	80	97	109	4516	63	<b>WH 142(Ch)</b>	<b>84</b>	<b>87</b>	<b>118</b>	<b>4381</b>
31	PBW 154	78	89	113	4783						
32	UP 2572	78	94	117	5373						
33	C 306	88	89	120	4706						

**Table.3** Mean, range, reduction percent, CV for grain yield and yield components in 63 bread wheat released varieties

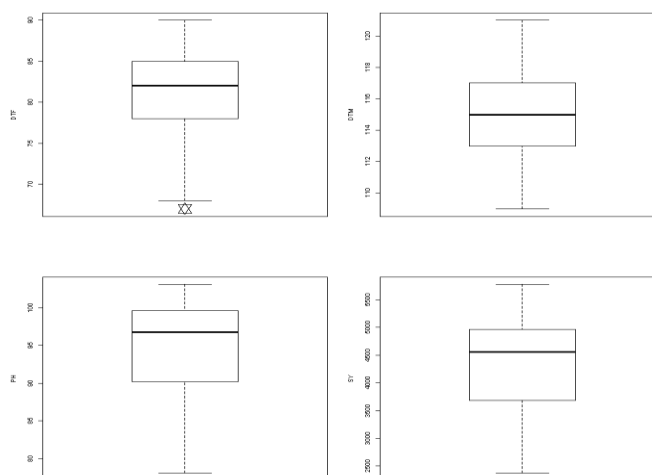
Variable	Min	Max	Mean	Range	Variance	StdDev	SEMean	CV
DTH	67.00	90.00	80.97	23.00	27.26	5.22	0.66	6.45
DTM	109.00	121.00	114.98	12.00	7.69	2.77	0.35	2.41
PH	78.110	103.110	95.072	25.000	32.951	5.740	0.723	6.038
GY	2376	5773	4328	3397	820247	906	114	21

**Table.4** Four cluster grouping wheat genotypes based on quantitative traits

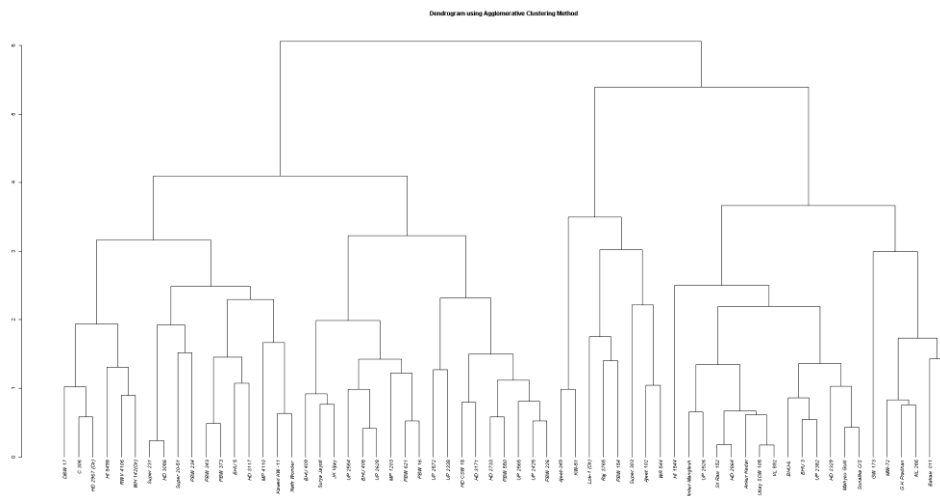
Cluster No	Cluster Size	varieties in cluster
1	8	Raj 3765 Ajeet-349 KW-51 Ajeet 102 Super 303 PBW 154 WR 544 Lok-1 (Ch)
2	17	Super 20-51 PBW 234 Kaweri KW -11 Super 231 Nath Wonder C 306 HI 8498 MP 4110 DBW 17 PBW 343 BHU 5 PBW 373 HD 3086 RWV 4106 HD 3117 HD 2967 (Ch) WH 142(Ch)
3	20	G K Pradhan MW-72 Ankur Kedar Uday SCW 105 NL 266 Sri Ram 152 Balram 011 BHU-1 Ankur Manglesh Mahyco Gold UP 2526 HI 1544 BHU-6 Sonalika C/S HD 2329 BHU 3 UP 2382 VL 892 HD 2864 GW 173
4	18	Surya Jayoti HD 2733 UP 2554 UP 2572 MP 1203 BHU 408 UP 2628 PBW 621 UP 2565 PBW 16 UP 2425 JK Vijay PBW 550 UP 2338 PBW 226 BHU 409 HD CSW 18 HD 3171

**Table.5** Principal Component analysis of 63 wheat varieties

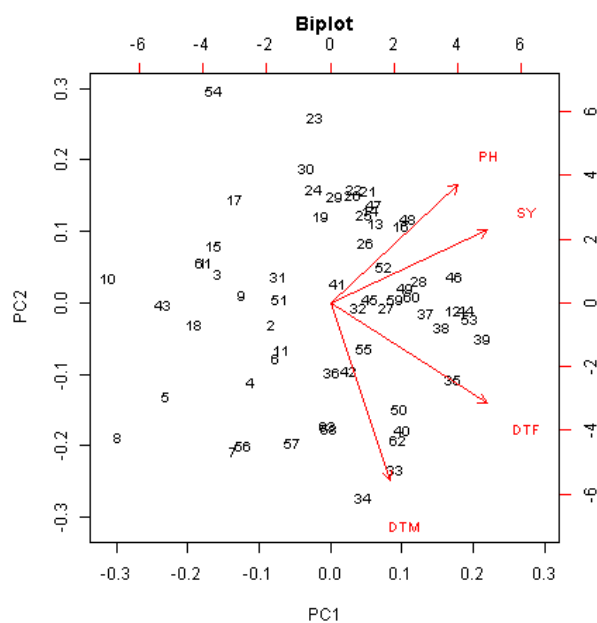
Principle component	Statistics of PC				Eigenvectors of the four variables			
	Standard deviation	Proportion of Variance	Cumulative Proportion	Eigen Values	DTF	PH	DTM	SY
PC1	1.2965	0.4203	0.4203	1.681	0.5971	0.484	0.2281	0.5977
PC2	1.2222	0.3735	0.7937	1.4939	-0.4077	0.4795	-0.7195	0.2935
PC3	0.7134	0.1272	0.9209	0.5089	0.0892	0.6959	0.1272	-0.7011
PC4	0.5623	0.0791	1	0.3162	0.6851	-0.2271	-0.6435	-0.2549



**Fig.1** Box plots depicting variation for days to 75% heading (DTH), plant height (PH), days to maturity (DTM), seed yield Kg/ha (GY)



**Fig.2** Cluster diagram of 63 wheat genotypes based on morphoagronomic traits



**Fig.3** Biplot representing association of traits with grain yield

The PC1 was positively influenced by days to 75% heading (0.5971), plant height (0.484) and seed yield per ha (0.5977) while, PC2 by plant height (0.4795), and seed yield per ha (0.2935). PC3 was influenced positively by DTH, PH and DTM while seed yield per ha had negative influence (0.7011). The PC4 was negatively influenced by all quantitative traits except DTF (Table 5). A biplot configuration of 63 wheat genotypes has been

presented in Fig. 3b represented association among traits which showed that plant height and days to 75% heading had positive influences on seed yield whereas, days to maturity showed negative influences.

In the present study 63 wheat varieties were evaluated for yield and related components traits. Significant genetic variations were observed among the wheat varieties for all the

studied parameters except DTM. HI 1544 (5773 kg/ha), PBW 621(5773 kg/ha), MP 1203 (5583 kg/ha), UP 2526 (5545 kg/ha) and UP 2554 (5545 kg/ha) had highest productivity as compared to checks. As these varieties excelled in performance for yield and yield components, thus, could be recognized for commercial cultivation in Bundelkhand region. UP 2382 was identified to be an early maturing variety among all tested varieties could be used as parent in hybridization to create variability for early maturing breeding material for this region. Based on these key traits, the genetic potential of these wheat varieties can also be exploited in wheat breeding programs.

### Author contributions

Conceptualization, HK, Data curation, and AK, Methodology, HK and AK, Software, VG, Writing-original draft, HK, and AK, Writing-review & editing, VG. All authors have read and agreed to the published version of the manuscript.

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