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Assessment of principal component analysis for yield and its attributing traits in bread wheat (*Triticum astivum* L) for normal and late sown conditions

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Abstract
An experiment was carried out to access principal component analysis (PCA) for yield and its attributing traits with 30 genotypes including 5 checks *viz.,* MP 3288, MP3336, MP 3382 GW322 and JW3211 sown in RBD design with three replications at JNKVV research farm during *Rabi* 2017-18. Out of 19, only seven principal components (PCs) exhibited more than 1.0 eigen value and showed 76.84% variability among the traits studied. The first principal component accounted for highest variation with trait number of tillers per plant, number of ear per plant, biological yield per plant, grain yield per plant, canopy temperature and protein percent. The result of PCA revealed that PC1 contributed highest variation 18.78% followed by 15.47% (PC2). 10.63% (PC3), 10.03% (PC4), 7.98% (PC5), 7.46% (PC6) and 6.46% (PC7) respectively. Maximum variation was found in PC1 and PC2, therefore selection of lines for characters under PC1 and PC2 may be desirable. The result of present study could be exploited in planning and execution of future breeding programme in wheat.

Keywords: PCA, eigen value, bread wheat

Introduction
Wheat is most important cereal crop to feed majority of world's population. India is one of the principal wheat producing country in the world. In year 2017—18, wheat production was estimated 97.44 MT with an average national productivity of 3172 kg/hac. The complex physiological process determine yield and there is a great role of environment, which influence the yield. Temperature and short winter growing season in central India are main factors for yield in wheat. High temperature increases threat of grain filling but, the duration of grain filling is reduced considerably and grain weight is decreased (Sofeild *et at.* 1977). It has been expected that early sowing of wheat may escape from high temperature during grain filling but high temperature at the time of sowing affects germination and early vegetative growth. As a multivariate statistical technique, the principal components analysis (PCA) has the ability to transform a number of possibly correlated variables into a smaller number of variables called principal components the principal components are linear transformations of the original variables and could be respective of a particular meaning. This approach is very helpful in deciding which agronomic traits of crop contributing most to yield, subsequently, these agronomic traits should be emphasized in the breeding program.
Principal component help researcher to distinguished significant relationship between traits. This is a multivariate analysis method that aims to explain the correction between a large set of variable in terms of a small number of underlying independent factors. The main objective of this research is to access the potential genotype by using PCA based method for selection of desirable genotype.

Material Method
This investigation was carried out at Seed Breeding Farm, Department of Plant Breeding and Genetics College of Agriculture, JNKVV, Jabalpur (M.P). Experimental material consist of 30 genotype including 5 checks viz., GW322, JW3211, MP3288, MP3336 and MP3382 obtained from Wheat Improvement Project, JNKVV Jabalpur (M.P.) during *Rabi* (2017-18). The experiment was conducted with three replication under RBD for normal and late date of sowing. Standard agronomic practices were adopted in each experiment to raise a good crop. Observations were recorded on five plants which are randomly selected from each genotype for various quantitative characters. Observations were recorded on five plants which are randomly selected from each genotype for various quantitative traits *viz.*, days to 50%

flowering, days to maturity, plant height, number of effective tillers, number of ears per plant, number of spikelet per spike, ear length, ear weight, peduncle length, biological yield per plant, grain yield per plant, 1000-grain weight, harvest index, canopy temperature, chlorophyll content, relative water content, sedimentation value, protein and starch percent.

Statistical analysis: PCA is a well-known method of dimension reduction that can be used to reduce a large set of variables to a small set that still contains most of the information in the large set (Massy, 1965; Jolliffie, 1986) [7, 4]. It is a mathematical procedure that transforms a number of (possibly) correlated variables into a (smaller) number of uncorrelated variables called principal components. The first principal component accounts for as much of the variability in the data as possible, and each succeeding component accounts for as much of the remaining variability as possible.

Result and Discussion

Principal component analysis had wide spread applications because it reveals simple underlying structures in complex data sets using analytical solution. Principal component analysis provides a means for comparing relative importance of such dimensions. Principal component analysis was performed for identification and ranking of genotypes based on combination of phenotypic traits.

In present investigation PCA was performed for yield and yield contributing traits of bread wheat genotypes. Out of nineteen only seven principal components (PCs) exhibited more than 1.0 eigen value, and showed 76.84% variability among the traits studied. So, these seven principal components were given due importance for the further explanation.

Screen plot explained the percentage of variance associated between eigen values and principal components with each PC obtained by drawing a graph. First principal component recorded the highest variation 18.78% (PC1) followed by 15.47% (PC2), 10.63% (PC3), 10.03% (PC4), 7.98% (PC5), 7.46% (PC6) and 6.46% (PC7). Total variation of seven PCs was recorded to be 76.84%. Semi curve line obtained after eight PC with little variation observed in each PC indicated that maximum variation was found in PC1 and PC2; therefore selection of lines for characters under PC1 and PC2 may be desirable.

Rotated component matrix revealed that first seven PCs are representing maximum variability (76.84%) hence, the traits falling in these six PCs may be given due importance in wheat breeding. It revealed that the first principal component (PC1) which accounted for the highest variation (27.693%) was mostly related with yield traits such number of tillers per plant, number of ear per plant, biological yield per plant, grain yield per plant, canopy temperature and protein content. The second principal component (PC2) was dominated by yield related traits viz., days to 50% heading, days to maturity, ear length, ear weight, harvest index and starch content, while PC3 consisted with traits viz., plant height and peduncle length. Fourth principal component (PC4) was related with thousand grain weight, fifth principal component (PC5) with number of spikelet per ear, sixth principal component (PC6) with chlorophyll content and seven principal component (PC7) with relative water content and sedimentation value (Table). On the basis of PCA, most of the important yields attributing traits were present in PC1, and PC2.

The PC scores of the each component (PC1, PC2, PC3, PC4 PC5 PC6 and PC7) had positive and negative values (Table). These scores can be utilized to propose precise selection indices whose intensity can be decided by variability explained by each of principal component. High PC score for a particular genotype in a particular component denotes high values for the variables in that particular genotype. In PC1, the positive scores ranged from 3.879 (MP 3497) to 1.004 (GW 322), while negative value ranged from -3.828 (MP 3510) to -0.363 (MP 3507). In PC2, the positive value of the component ranged from 3.332 (MP 3511) to 1.014 (JW 3288) and negative value ranged from -2.842 (MP-3521) to -0.066 (GS 10016). In PC3, the positive value of the components ranged from 2.440 (GS 7059) to 1.296 (MP 3510) and negative from -2.816 (MP 3508) to -0.010 (MP 3595). In PC4, the positive value of the components ranged from 2.652 (MP-3511) to 1.194 (MP 3513), while negative value ranged from -2.601 (MP 3507) to -0.009 (MP 3497). In PC5, the positive value of the components ranged from 2.349 (MP 3507) to 1.024 (Borlaug-100), while negative value ranged from -2.138 (MP 3514) to-0.029 (MP 3595). IN PC6, the positive value of the components ranged from 2.086 (MP 3510) to 1.261 (MP 3517), while negative value ranged from -2.689 (MP-3507) to -0.116 (GS 7014). IN PC7, the positive value of the components ranged from 2.128 (MP 3593) to 1.009 (JW 3211), while negative value ranged from -2.073 (MP 3516) to -0.083 (MP 3520).

On the basis of yield and yield attributing traits, out of top seven principal component the value of PC1 was highest than PC2, PC3, PC4, PC5 PC6 and PC7. Germplasm lines showing maximum positive PC scores and common in PC1, PC2 PC3 and PC4 for the traits *viz.*, number of tiller per plant, plant height, number of ear per plant, biological yield per plant, grain yield per plant, canopy temperature, protein, days to maturity, days to 50% heading, ear length, ear weight, harvest index, starch content, plant height, peduncle length and thousand grain weight are MP 3519, MP 3503, MP 3511, MP 3517, GS 10016, GS 10056 and Borlaug-100 for yield and yield attributing traits. Thus, selection of these lines can help in further development of new high yielding quality varieties.

The results found in present investigation were in agreement for projection of PC1 and PC2 showed maximum variability for traits *viz.*, number of ear per plant, days to heading days to maturity, ear length, ear weight and grain yield per plant Ali *et al.* (2015) [1], Khan *et al.* (2015) [5], Bhanupriya *et al.* (2014) [3] and Meena *et al.* (2014) contributed towards significant principal components and were highly related to the grain yield.

Table 1: Eigen values, percentage of total variation and cumulative Eigen values for corresponding 19 traits in wheat genotypes

Traits	Principal Component (PC)	Eigen value	Percentage of total variation	Cumulative Percentage
Days to 50% heading	PC1	3.569	18.784	18.784
Days to maturity	PC2	2.94	15.474	34.258
Plant height (cm)	PC3	2.02	10.631	44.889
Number of tillers per plant	PC4	1.907	10.036	54.925
Number of ear per plant	PC5	1.518	7.987	62.912

Number of spikelet per plant	PC6	1.419	7.467	70.378
Ear length (cm)	PC7	1.228	6.464	76.843
Ear weight (cm)	PC8	0.989	5.203	82.046
Peduncle length (cm)	PC9	0.753	3.963	86.01
Biological yield per plant	PC10	0.674	3.545	89.555
Grain yield per plant	PC11	0.541	2.849	92.404
1000 grain weight (g)	PC12	0.416	2.188	94.592
Harvest index%	PC13	0.32	1.686	96.278
Canopy temperature (%)	PC14	0.247	1.3	97.578
Chlorophyll content (SPAD 502)	PC15	0.166	0.875	98.453
Relative water content (%)	PC16	0.104	0.546	98.999
Sedimentation value (ml)	PC17	0.090	0.472	99.471
Protine (%)	PC18	0.055	0.290	99.761
Starch (%)	PC19	0.045	0.239	100.000

Table 2: Principle components for 19 traits of wheat genotype

Traits	**Princple Components**						
	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Days to 50% heading	-0.483	0.549	-0.290	0.131	-0.065	0.190	-0.266
Days to maturity	-0.588	0.450	0.329	-0.272	0.118	0.036	0.043
Plant height (cm)	0.023	0.063	0.680	-0.292	-0.249	-0.292	0.072
Number of tillers per plant	0.693	0.170	-0.363	-0.266	0.241	-0.112	0.034
Number of ear per plant	0.652	0.195	-0.262	-0.394	0.069	-0.141	0.360
Number of spikelet per spike	-0.091	-0.443	0.191	0.012	0.652	-0.029	-0.287
Ear length (cm)	-0.234	0.560	0.231	-0.306	0.516	0.291	0.064
Ear weight (cm)	-0.178	0.604	0.045	-0.126	0.326	0.282	0.427
Peduncle length (cm)	0.115	-0.056	0.721	-0.062	-0.373	0.168	0.169
Biological yield per plant	0.683	0.396	-0.144	-0.086	-0.223	0.375	-0.129
Grain yield per plant	0.666	0.429	0.234	0.476	0.056	-0.095	0.163
1000 grain weight (g)	0.165	0.001	0.229	0.825	0.289	-0.215	0.178
Harvest index%	0.559	0.602	0.312	0.175	-0.143	-0.085	-0.196
Canopy temperature (%)	0.583	-0.313	-0.203	-0.051	-0.002	0.394	-0.040
Chlorophyll content (SPAD 502)	0.016	-0.499	0.202	-0.126	-0.238	0.601	0.111
Relative water content (%)	-0.361	0.072	-0.360	-0.124	-0.285	-0.404	0.410
Sedimentation value (ml)	-0.139	-0.370	-0.093	0.428	0.106	0.328	0.549
Protein (%)	0.400	-0.267	0.285	-0.129	0.278	0.034	-0.381
Starch (%)	-0.279	0.472	-0.163	0.461	-0.232	0.281	-0.296

Table 3: Interpretation of rotated component matrix for the traits having highest value in each PCs

	PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**
Traits	NTPP	DH	PH	TGW	NSPP	CC	RWC
	NEPP	DM	PL				SV
	BYPP	EL					
	GYPP	EW					
	CT	HI					
	P	SC					

DH= Days to 50% heading, DM= Days to maturity, PH= Plant height (cm), NTPP= Number of tillers per plant, NEPP= Number of ear per plant, NSPP = Number of spikelet per spike, EL = Ear length (cm), EW= Ear weight, PL = Peduncle length (cm), BYPP = Biological yield per plant (g), GYPP = Grain yield per plant(g),TGW= Thousand grain weight, HI = Harvest index (%), CT = Canopy temperature (ºC), CC = Chlorophyll content (SPAD Units), RWC= Relative water content, SDS = Sedimentation value (ml) PP = Protein%, SC= Starch content%,

Table 4: Principal Component score of wheat genotypes

S. No.	**Genotype**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1.	MP3493	0.624	-0.615	-1.370	-0.875	-0.816	0.626	2.128
2.	MP3495	-0.692	0.013	-0.010	1.753	-0.029	-1.690	-1.530
3.	MP3497	3.879	0.383	-0.627	-0.009	0.610	-0.409	-1.883
4.	MP3503	3.151	0.215	-1.165	2.351	-1.601	1.346	-1.071
5.	MP3507	-0.363	0.142	-0.374	-2.601	0.561	-2.689	-0.238
6.	MP3508	0.741	0.639	-2.816	1.340	-0.450	-1.235	-1.238
7.	MP3509	1.396	-0.234	0.974	0.858	1.213	-0.414	0.711
8.	MP3510	-3.828	-0.266	1.296	0.225	-0.008	2.086	0.924
9.	MP3511	-0.996	3.332	1.531	2.652	0.047	-0.297	0.975
10.	MP3512	1.341	0.714	1.751	-1.225	-1.799	0.791	-1.298
11.	MP3513	2.202	0.174	-1.084	1.194	-0.855	-1.046	0.277
12.	MP3514	-3.053	-1.561	-1.861	1.580	-2.138	0.133	0.574
13.	MP3515	-2.071	-0.775	-1.511	0.326	-0.661	-0.492	1.489
14.	MP3516	-0.462	1.020	-0.732	-1.867	1.739	0.780	-2.073
15.	MP3517	0.320	-1.221	1.377	1.337	-0.111	1.261	-1.469

16.	MP3518	-2.487	1.835	-1.344	-0.817	-0.083	2.044	-0.285
17.	MP3519	-1.477	1.915	1.361	1.662	1.175	-0.191	-0.792
18.	MP3520	0.154	2.306	1.850	0.751	-1.120	0.107	-0.083
19.	MP3521	-0.475	-2.842	-1.116	-0.445	0.962	1.298	0.509
20.	MP3522	0.130	-0.912	0.314	-1.262	1.977	1.525	0.817
21.	GW322	1.004	2.905	-1.154	-2.606	-0.334	0.919	0.894
22.	JW3211	0.042	2.132	0.296	0.503	1.852	-1.111	1.009
23.	MP3288	-0.554	1.014	-0.033	-0.276	0.196	-1.582	2.065
24.	MP3336	2.771	-0.115	-1.681	0.395	1.303	1.322	-0.567
25.	MP3382	1.491	-3.093	-1.522	1.356	1.777	-0.978	0.301
26.	Borlaug100	2.889	-0.392	0.904	0.341	1.024	-0.319	-0.602
27.	GS-7014	-1.281	-4.721	2.160	-0.502	-0.606	-0.116	-0.438
28.	GS-7059	-0.772	-1.561	2.440	0.542	-0.182	-1.624	-0.076
29.	GS-10016	0.760	-0.066	-0.101	-1.745	-3.222	-0.893	-0.369
30	GS-10056	3.372	-0.364	2.252	-1.429	-0.421	0.846	1.337

Table 5: List of selected genotypes in each principal component

PC1	PC2	PC3	PC4	PC5	PC6	PC7
MP 3497	MP 3511	MP 3510	MP 3495	MP 3509	MP 3503	MP 3493
MP 3503	MP 3516	MP 3511	MP 3503	MP 3516	MP 3510	MP 3515
MP 3509	MP 3518	MP 3512	MP 3508	MP 3519	MP 3517	JW 3211
MP 3512	MP 3519	MP 3517	MP 3511	MP 3522	MP 3518	MP 3288
MP 3513	MP 3520	MP 3519	MP 3513	JW 3211	MP 3521	GS 10056
GW 322	GW 322	MP 3520	MP 3514	MP 3336	MP 3522	
MP-3336	JW 3211	GS 7014	MP 3517	MP 3382	MP 3336	
Borlaug-100	MP 3288	GS 7059	MP 3519	Borlaug-100		
GS 10056		GS 10056	MP 3382			

Conclusion

The present investigation provides significant information helpful in genetic improvement in bread wheat. Out of nineteen only seven principal components (PCs) exhibited more than 1.0 eigen value, and showed 76.84% variability and only eleven principal components (PCs) exhibited more than 0.5 Eigen value and showed about 92.40% variability among the traits studied. On the basis of principle component analysis twenty eight genotypes are ranked into PC1 followed by twenty four in PC2 and twenty one genotypes on PC3, which possess higher number of values for the yield and quality attributing traits. Evaluation of Principal component can be useful for the selection of the most efficient lines and hybridization programme in wheat improvement.

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