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DIVERGENCE ANALYSIS BASED ON YIELD AND YIELD CONTRIBUTING TRAITS OF A COLLECTION OF SPRING WHEAT GENOTYPES (*Triticum aestivum* L.)

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ABSTRACT

Genetic diversity among 24 spring wheat genotypes (Varieties/lines) was estimated using Mahalanobis D^2-statistics and principal coordinate analysis. The genotypes fell into four clusters of different size. Of the seven different characters spike length and 1000 grain weight had the highest contribution towards the divergence. The highest inter cluster distance was observed between cluster I and III followed by cluster II and III. So, genotypes from the most divergence clusters could be used as parents in hybridization program and are expected to manifest maximum heterosis as well as broad spectrum of variability.

Key words: Spring wheat; multivariate analysis; cluster; genetic divergence

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INTRODUCTION

Wheat is the most widely known grown cereal crop in the world, occupying 17% of crop acreage world over, feeding about 36% of world population (Bhanupriya *et al*., 2014) and providing 20% of the total food calories and protein in human nutrition (Verma *et al*., 2014). Approximately one-sixth of the total arable land in the world is cultivated with wheat. Whereas paddy is mainly cultivated in Asia, wheat is grown in all the continents of the world.

The improvement program in wheat in Bangladesh first attempt was to increase grain yield and second target to confer resistance to disease and tolerance to abiotic stress like heat, salinity, drought etc. The wheat Research Centre of Bangladesh Agricultural Research Institute (BARI) has already released a good number of varieties suitable for Bangladesh condition and thereby area of cultivation has considerably increased. In Bangladesh wheat was cultivated on an area of .923 million acre during 2009-2010 with a production of 976 kg/acre and during 2010-2011 this scenario change in area under production (.885 million acre) but production increases per acreage (1124 Kg), (Year book of agricultural statistics, 2012). Thus the major objectives in wheat improvement program are to increase grain yield and to release varieties resistant to biotic and abiotic stresses.

The basic key to bring about the genetic upgrading of wheat relies on hybridization and subsequent selection. In plant breeding program choice of parent is the first step for hybridization. Genetic divergence between the parents is important for effective breeding program as the genetically diverged parents are known to produce high heterotic effect and wide segregants for developing high yielding varieties. So, estimation of genetic distance is an important factor for selection of parents in wheat breeding program. In this pathway principal coordinate analysis is a multivariate statistical algorithms aims to estimating distance for all possible combination between used parents in a breeding program. Nevertheless, non hierarchical clustering helps to grouped genotypes into different clusters. Thus, the present study was to conducted to decipher the extent of genetic diversity among wheat genotypes using cluster analysis-PCO based methods for selection of parents in hybridization program to obtain desirable segregants in advance generation.

MATERIALS AND METHODS

The experiment was laid out in a randomized complete block design (RCBD) with three replications at the field laboratory of Department of Genetic Engineering and Biotechnology, Faculty of Agriculture, University of Rajshahi on 1st December. This study was performed with 24 genotypes of spring wheat (Table 1) collected from Regional Wheat Research Center of Bangladesh Agricultural Research Institute, Shyampur, Rajshahi to assess the genetic diversity among the genotypes. Each replication was consisted of 24 plots and each of the plots was 2.0 m long with five rows. The spacing was 40 cm between rows and 5 cm between plants in a row. The space maintained between the plots was 80 cm and between the replication was one meter. Seeds were sown continuously by hand in rows and after complete emergence; 5 cm distance was maintained between plant after thinning and gap filling in a row of the plot. Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum and Cow dung were applied at the rate of 220 Kg, 180 Kg, 50 Kg, 120 Kg and 6000 Kg/ha, respectively.

Data were recorded on individual plant basis from 10 randomly selected plants of each genotype from the five rows per plot in each replication. Among the characters studied as yield contributing traits plant height (cm), number of spikes per plant, spike length (cm), number of spikelets per spike, number of grains per spike, 1000 grain weight (g) were recorded on plot basis while the grain yield was recorded in the laboratory after harvesting. Data were subjected to D^2 analysis following canonical root method of Rao (1952), which was originally developed by Mahalonobis (1936). All the statistical analysis was carried out using the GENSTAT 5.13 software in IBM computer.

Table 1. List of 24 spring wheat genotypes with their breeder institute and characteristics

Sl. No.	Varieties / lines	Breeder Institute	Characteristics
1.	Shatabdi	BARI	Plant height 90-100cm, heading days 65-70 days, maturity 105-115 days, excellent tillering capacity, broad, droopy and light green leaf , heat tolerant, more stay green, Lr 13+, 1+ gene contain, TGW 46-48 gm, grain dull color, BpLB tolerant and rust resistant , yield 3600-4500 kg/ha, good yield in optimum and late
2.	Kanchan	BARI	Plant height 100-105 cm, heading days 72-75 days, maturity 112-116 days, TGW 42-45 gm, yield 4000-4500 kg/ha, excellent tillering and high chlorophyll content., Lr 23+,13+ gene present , BpLB susceptible
3.	Kalyan Sona	IARI	Plant height 85-90 cm, heading days 70-75 days, maturity 110-115 days, TGW 30-35 gm, yield 3000-3500 kg/ha
4.	BAW-1082	BARI	Plant height 80-82 cm, heading days 57-60 days, early in maturity, 100-102 days, TGW 45-48 gm, 46-48 grain per spike, yield 3800-4000 kg/ha, BpLB tolerant

Sl. No.	Varieties / lines	Breeder Institute	Characteristics
5.	Ananda	BARI	Plant height 90-95 cm, heading days 65-70 days, maturity 102-107 days, TGW 30-35 gm, yield 2000-2500 kg/ha
6.	Akbar	BARI	Plant height 85-90 cm, heading days 65-67 days, maturity 104-110 days, TGW 32-35 gm, yield 3000-3200 kg/ha
7.	Seri-82	CIMMYT	Plant height 90-95 cm, heading days 70-75 days, maturity 105-110 days, TGW 33-35 gm, yield 3000-3500 kg/ha, Lr 23, Lr 26 gene contains, slow rusting
8.	Inia-66	CIMMYT	Plant height 95-100 cm, heading days 62-65 days, maturity 102-105 days, TGW 38-40 gm, yield 3500-4000 kg, Lr 13, Lr 17 gene present
9.	Gourab	BARI	Plant height 90-102 cm, heading days 60-65 days, maturity 102-108 days, BpLB tolerant and rust resistant, TGW 40-48 gm, 45-50 grain per spike, yield 3600-4800 kg/ha, good in late
10.	BAW-1083	BARI	Plant height 95-100 cm, heading days 55-60 days, early in maturity, 95-100 days, TGW 45-48 gm, 35-38 grains/spike, yield 4200-4400 kg/ha, BpLB tolerant
11.	Prodip	BARI	Plant height 95-100 cm, heading days 64-66 days, maturity 102-110 days, heat and BpLB tolerant, broad and deep green leaf, TGW 48-55 gm, good grain filling, grain bold, white and slender, Lr 26+, 1+ gene contain, yield 4300-5100 kg/ha, also good in late
12.	Kheri	Local	Plant height 115-120 cm, TGW 28-30 gm, heading days 75-80 days, maturity 115- 118 days, yield 2000 kg/ha, narrow leaf, more biomass and It has lodging tendency
13.	Sufi	BARI	Plant height 90-102 cm, heading days 58-62 days, maturity 100-110 days, TGW 36-42 gm, 50-55 grains per spike, excellent grain filling BpLB tolerant and rust resistant, heat tolerant, sterility resistant and yield 3600-4800 kg/ha
14.	Sonalika	IARI	Plant height 90-99 cm, heading days 60-65 days, maturity 110-115 days, TGW 30-35 gm, yield 3000-3500 kg/ha
15.	BAW-1056	BARI	Plant height 75-85 cm, heading days 57-64 days, early in maturity, 95-104 days, TGW 40-46 gm, grain good, 38-40 grain per spike, yield 3500-4000 kg/ha, good ideotype but rusty (10-20S) and high biomass
16.	Balaka	BARI	Plant height 96-99 cm, heading days 68-70 days, maturity 110-115 days, TGW 35-38 gm and yield 3500-3800 kg/ha
17.	Barkat	BARI	Plant height 90-100 cm, heading days 68-70 days, maturity 105-112 days, TGW 30-32 gm and yield 3000-3300 gm
18.	Sourav	BARI	Plant height 100-105 cm, heading days 75-80 days, maturity 112-115 days, late, heat tolerant, Lr 26+, 1+ gene presence, TGW 45-46 gm, grain pale white, bold, BpLB susceptible and yield 3800-4000 kg/ha
19.	BAW-1004	BARI	Plant height 102-107 cm, heading days 65-70 days, maturity 105-115 days, TGW 45-48 gm, grain filling good, yield 3500-4000 kg/ha, very good leaf, Lr 13 + gene contain and BpLB tolerant
20.	Pavon-76	CIMMYT	Plant height 95-105 cm, heading days 80-85 days, maturity 108-115 days, TGW 24-30 gm, yield 2800-3000 kg/ha, LrI, Lr 10, Lr 13, Lr 46, + and SR gene contains
21.	Bijoy	BARI	Plant height 95-105 cm, heading days 60-65 days, maturity 103-112 days, Heat tolerant, broad and light green leaf, water logged susceptible at seedling stages, BpLB disease tolerant and rust resistance, Yield 4300-4500 kg/ha , good yield in optimum and late, TGW 45-52 gm, good grain filling, grains are white and bold
22.	Aghrani	BARI	Plant height 90-95 cm, heading days 70-72 days, maturity days 112-115 days, TGW 40-43 gm, yield 3200-3500 kg/ha
23.	Sonara-64	CIMMYT	Plant height 88-95 cm, heading days 60-65 days, maturity 105-115 days, TGW 28-30 gm, yield 2800-3000 kg/ha, Lr1 gene containing
24.	Protiva	BARI	Plant height 100-105 cm, heading days 70-73 days, maturity days 112-115 days, TGW 42-45 gm and Yield 4200-4500 kg/ha

RESULTS AND DISCUSSION

Analysis of variance revealed that all the genotypes varied significantly for all the character studied as yield contributing traits.

Cluster analysis

By the application of non-hierarchical clustering using covariance matrix 24 wheat genotypes for yield contributing traits were grouped into four distinct clusters (Table 2). Similar clustering patterns were reported Baranwal *et al.*, (2013) and Rahman *et al.,* (2015) in wheat. In the present study, cluster I and IV was the largest group, containing eight genotypes followed by cluster II. Cluster III consisted of only one genotype, respectively.

Table 2. Distribution of 24 genotypes in four clusters.

Cluster no.	Total no. of genotypes in cluster	Genotypes included in different clusters
I	8	Kalyan Sona, Ananda, Seri-82, Inia-66, BAW-1056, Barkat, Pavon-76, Sonora-64
II	7	Shatabdi, BAW-1082, Akbar, BAW-1083, Sufi, Aghrani, Protiva
III	1	Kheri
IV	8	Kanchan, Gourab, Prodip, Sonalika, Balaka, Sourav, BAW-1004, Bijoy

Canonical variate analysis

The Intra and Inter cluster distance are presented in Table 3. It was revealed from the Table that in all cases the inter cluster distances were larger than the intra cluster distances. Cluster distance suggesting wider diversity among the genotypes of different groups. The members of cluster I and III exhibited maximum divergence, as their inter cluster distance was the highest followed between II and III. On the other hand, the minimum genetic divergence was obtained in the members of cluster I and II indicating a close relationships among the genotypes of these clusters. Verma *et al.*, (2014) reported that the inter-cluster values that indicated close relationship were to be considered that hybridization among the genotypes of these clusters would not provide good levels of segregation. It is well recognized that greater the distance between clusters, wider the genetic diversity would be between the genotypes. Therefore, highly divergent genotypes would produce a broad spectrum of segregation in the subsequent generations enabling further selection and improvement. The hybrids developed from the selected genotypes within the limit of compatibility of these clusters may produce desirable transgressive segregants of high magnitude of heterosis.

Table 3. Average intra (Bold) and inter cluster distances (D^2) for 24 wheat genotypes.

Clusters	I	II	III	IV
I	**0.289 (0.538)**	3.411 (1.846)	11.749 (3.427)	5.589 (2.364)
II		**0.396 (0.629)**	10.668 (3.266)	3.723 (1.929)
III			**0.000 (0.000)**	9.319 (3.052)
IV				**0.449 (0.670)**

[Note: The values on the diagonals (bold) are intra cluster and those on off diagonals are inter cluster distance. Figures in the parentheses are the D- values ($D = \sqrt{D^2}$)]

The intra cluster distances of cluster IV were highest (0.449) than the other clusters, suggesting cluster IV included more diverse materials. Therefore, highly divergent genotypes would produce a broad spectrum of segregation in the subsequent generations enabling further selection and improvement. In this present study, it was observed that the cluster I and III as well as II and III were highly diverse. So they were seemed to be more stable.

Cluster means for the characters

The four clusters showed considerable differences in mean values for different characters under study (Table 4).From the cluster mean values it was found that cluster II had the highest mean values for grain yield (6.32), spike length (10.14), number of spikelets per spike (20.23), number of grains per spike (49.95) with moderately high mean values for remaining characters. This indicates that presence of high yielding genotypes in the cluster II. Cluster III included a single variety named Kheri which exhibited highest mean values for plant height (137.73), number of spikes per plant (8.27) and poor performance for grain yield and other yield contributing characters.

Table 4. Cluster mean values for yield and yield contributing traits in 24 spring wheat genotypes.

Characters	**Clusters**			
	I	II	III	IV
Plant height (cm)	90.97	94.76	137.73	99.52
Number of spikes per plant	4.87	5.45	8.27	5.08
Spike length (cm)	9.11	10.14	8.43	10.11
Number of spikelets per spike	19.82	20.23	20.00	19.58
Number of grains per spike	46.06	49.95	37.27	39.33
1000 Grain weight (g)	35.49	42.93	34.19	45.35
Grain yield per plant (g)	5.04	6.32	3.12	5.64

Jamil *et al*., (2015) reported that based on cluster means, the cluster have been identified for selecting parents for future hybridization programme. The genotypes superior in the cluster may be involve in a multiple crossing programme to recover transgressive segregants with high genetic yield potential.

Contribution of characters towards divergence

The contribution of individual traits to the total divergence was studied (Table 5). The Table revealed that in vector I, the important traits responsible for genetic divergence in the major axis of differentiation were number of grains per spike (0.2220) and 1000 grain weight (0.1904). On the contrary, in vector II which is the second axis of differentiation spike length (1.2574) number of spikelets per spike (0.3948) and 1000 grain weight (0.2323) were important.

Table 5. Relative contributions of yield and yield contributing traits to the total divergence in 24 spring wheat genotypes.

Characters	**Vector – I**	**Vector -II**
Plant height (cm)	+0.1336	-0.1109

Number of spikes per plant	-0.8449	+0.0912
Spike length (cm)	+0.0582	+1.2574
Number of spikelets per spike	-0.3233	+0.3948
Number of Grains per spike	+0.2220	-0.1051
1000 Grain weight (g)	+0.1904	+0.2323
Grain yield per plant (g)	+0.1791	-0.0213

The role of spike length and 1000 grain weight for both the vectors were positive across two axes indicating the important components of genetic divergence in these materials. Hossain *et al.* (2006) found spike length and 1000 grain weight as most contributing character towards the genetic divergence.

Selection of parents

Genotypically distance parents usually able to produce higher heterosis (Falconer, 1960; Ghaderi *et al.,* 1979). Considering magnitude of genetic distance, magnitude of cluster means for different characters and *per se* performance it was suggested that the crosses between genotypes belonging to cluster I and III, and II and III would give high manifestation of heterosis as well as wide spectrum of genetic variation in F_2 generation. Genotypes included cluster I could be selected for dwarf sized plant, cluster II for longest spike, higher number of grains per spike and moderate grain size and highest grain yield, cluster III for maximum plant height and highest number of spikes per plant and cluster IV for higher spike length, moderate number of spikelets per spike, bold sized grain and higher grain yield.

REFERENCES

Baranwal, D. K., V. K. Mishra and T. Singh. 2013. Genetic diversity based on cluster and principal component analyses for yield and its contributing characters in wheat (*Triticum aestivum* L.). Madras Agric. J., 100 (4-6): 320-323.

Bhanupriya, B., N. H. Das, S. Satyanarayana, S. Mukherjee and K. K. Sarker. 2014. Genetic diversity of wheat genotypes based on principal component analysis. Journal of Crop and Weed, 10(2):104-107.

Falconer, D. S. 1960. Introduction to quantitative genetics, Oliver and Bond, London. p. 304.

Ghaderi, A., M. Shishegar, A. Regai and B. Edhaie. 1979. Multivariate analysis of genetic diversity for yield and its components in mungbean. J. American Soc. Hort. Sci. 104: 728-732.

Hossain, M. S., O. I. Joarder, M. M. Rahaman and M. M. Rahaman. 2006. Genetic diversity in some genotypes of spring wheat. Bangladesh J. Environ. Sci. 12: 146-149.

Jamil, A., S. Khan, Ubaidullah, M. Zeeshan and M. Zulfiqar Ali. 2015. Cluster analysis, genotypic and phenotypic correlation among yield contributing traits in bread wheat (*Triticum aestivum* L.) germplasm. International Journal of Modern Agriculture.4 (1).22-29.

Mahalanobis, P. C. 1936. On the generalized distance in statistics. Proc. Nat. Inst. Sci., India. 2: 49-55.

Rahman, M. S., M. S. Hossain, M. K. Akbar, M. S. Islam and L. Ali. 2015. Genetic divergence in spring wheat genotypes (*Triticum aestivum* L.). Eco-friendly Agril. J. 8(01): 01-03.

Rao, C. R. 1952. Advanced statistical methods in biometric research. John. Willey and Sons. New York.

Verma, P. N., B. N. Singh, G. Singh, M. K. Singh and T. L. Setter. 2014. Genetic diversity analysis for yield and other agronomic traits in bread wheat under water logged sodic soil condition. *Journal of Wheat Research* 6(1):51-58.

Year Book of Agricultural Statistics. 2012. Bangladesh Bureau of Statistics (BBS), Statistics and Informatics Division (SID), Ministry of Planning, Government of the People's Republic of Bangladesh.