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Genetic Variability, Heritability and Diversity for Yield Contributing Traits in Reference Varieties of Wheat

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Genetic variability study in 129 wheat varieties (80 bread and 49 durum wheat) revealed high magnitude of variability and high degree of heritability for majority of yield associated traits. Difference between the PCV and GCV was high for harvest index followed by number of grains per spike and grain yield/plant indicating the influence of environment on their expression. High magnitude of genotypic coefficient of variation (≥ 17.0%) was observed for spike length, plant height, grain yield/plant and flag leaf length, which indicates high degree of genetic variability and offers great scope for selection of these characters. High to moderate heritability coupled with high to moderate genetic advance as percentage of mean was exhibited for 7 traits *viz.*, days to flowering, days to maturity, plant height, number of tillers/plant, biomass/plant, flag leaf length and 1000 grain weight, which indicated the predominance of additive gene action in the expression of these characters and very high possibility of improvement through selection for all these characters. Bread wheat varieties *viz.*, CPAN 3004, GW 322, HI 617, HI 1500, DWR 39, DWR 195, GW 89, UP 2113, NP 700 and NP 771 and durum wheat varieties *viz.*, A-28, HI 8381, MPO 215, HD 4530, HD 4672, NIDW 295, Raj 1555 and UAS 415 were found to be superior for grain yield and other traits along with being divergent from other lines, which can be utilized as donors for developing superior genotypes with high grain yield.

Key Words: Wheat, Germplasm, Variability, Diversity, Gene action

Introduction

Wheat is one of the most important staple food grains of human race grown under diverse agro-climatic conditions, occupying nearly 29.65 million ha with a record production of 95.85 million tonnes during 2013-14 in India (AICW&BP Progress report 2013-14). Besides, common wheat, durum wheat (*Triticum durum Desf*.), occupies 5% and *dicoccum* wheat occupies one percent of production in our country. To achieve surplus production with limited land available, genotypes having high productivity and quality traits should be developed through genetic improvement. For a successful breeding programme, the evaluation of germplasm (reference varieties) for assessing genetic variability using phenotypic and genotypic co-efficient of variation, heritability, genetic advance and diversity for yield and yield components is a pre-requisite. Hence, knowledge of nature and magnitude of genetic variability present in germplasm and the extent of heritability of the economic traits is of greater help in identifying the parents with novelty and diversity for planning a suitable breeding strategy.

Grain yield is the complex trait involving many yield components and influenced by genotype, agro-ecological conditions and their interactions. In any selection programme, emphasis on yield and its component characters lies solely on their heritability and genetic advance. High heritability alone is not enough to make efficient selection, unless the information is accompanied by substantial amount of genetic variation (Johnson *et al*., 1955). Success in recombination breeding depends on suitable selection of best parents, exploitation of high heterotic crosses and selection of transgressive segregants. The study was conducted with an objective to find out the extent of variability, heritability, genetic advance and diversity among the available reference varieties of wheat including both bread and durum wheat.

Materials and Methods

The experimental material comprised of 129 wheat varieties (80 bread wheat, 49 *durum* and *dicoccum* wheat), which were evaluated in a randomized block design with two replications; each plot is represented by two rows of 2.5 m long and 23 cm apart under timely

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sown conditions at Directorate of Soybean Research Farm under the supervision of ICAR-Indian Agricultural Research Institute, Regional Station. Recommended package of practices were followed for the genotypes, so as to make them to express their full potential. The data of 13 grain yield and its contributing components were recorded on 5 randomly selected plants from each replication. The mean replicated data on various biometric traits were subjected to analysis of variance as per the standard statistical procedure (Panse and Sukhatme, 1985). Phenotypic and genotypic components of variance were estimated as per the formulae suggested by Lush (1940). Estimates of phenotypic and genotypic coefficients of variation were calculated as per the standard formulae (Burton, 1952). The broad sense heritability was estimated for all the characters as the ratio of genotypic variance to total or phenotypic variance (Lush, 1940). The expected genetic gain or advance under selection for each character was estimated by following the method suggested by Johnson *et al.* (1955).

Results and Discussion

The mean sum of squares based on ANOVA of 129 wheat genotypes (bread, *durum* and *dicoccum* wheat) for 13 characters indicated the presence of high amount of variability among the genotypes. The coefficient of variation (CV) in pooled analysis ranged from 0.5 (days to maturity) to 15.9 (no. of grains/spike). The values of phenotypic coefficient of variation were higher than that of the genotypic coefficient of variation for all the characters (Table 1). The phenotypic coefficient of variation was estimated to be high for grain yield/plant (24.3) followed by number of grains per spike (22.0), biomass/plant (19.6), harvest index (19.5), number of tillers/plant (19.4) and spike length (19.4). These results were in accordance with the findings of Koksal Yagd *et al.* (2007) and Bhoite *et al.* (2008). Genotypic coefficient of variation also showed the similar trend for some of the traits and was observed to be high for spike length (19.1) followed by plant height (18.9), grain yield per plant (18.8) and flag leaf length (17.1) indicating high degree of genetic variability offering great scope for selection of these characters (Yagdi and Sozen, 2009; Riaz-Ud-Din *et al.,* 2010). Difference between the PCV and GCV was high for harvest index followed by number of grains per spike and grain yield/ plant indicating the presence of environmental influence on the expression of these traits. Significant variability for characters under study among genotypes represents availability of divergent genetic sources which will be useful in improving grain yield in wheat (Mohammed *et al.,* 2011; Mostafa *et al.,* 2012).

Heritability in broad sense was observed to be high for days to flowering (0.98) followed by days to maturity (0.98), plant height (0.98); and spike length (0.97); while, low for number of grains /spike (0.47) and harvest index (0.40). Genetic advance was found to be highest for plant height (39.5) followed by days to flowering (12.6), 1000 grain weight (11.0) and biomass yield (11.0). Whereas, genetic advance over its mean is high for number of grains per spike (60.4) followed by

Table 1. Estimates of genetic variability for various characters of wheat

Character	Bread wheat			Durum & dicoccum wheat			PCV %	GCV %	h2	GA	GA % over mean
	Mean	Min	Max	Mean	Min	Max					
Days to flowering	75	59	92	78	70	90	8.2	8.1	0.98	12.6	16.6
Days to maturity	114	105	123	115	109	123	3.6	3.4	0.98	8.4	7.3
Plant height (cm)	102	58	145	102	80	139	19.1	18.9	0.98	39.5	38.8
No. of tillers/plant	9.0	6.2	12.9	8.9	6.4	13.3	19.4	16.1	0.69	2.5	27.8
Flag leaf length (cm)	22.2	14.7	31.5	21.4	14.8	28.3	17.6	17.1	0.95	7.6	34.7
Spike length (cm)	8.8	6.3	12.2	6.5	4.4	8.5	19.4	19.1	0.97	3.1	38.8
No. of spikelet/spike	16.0	11.4	20.0	17.3	14.6	20.1	13.4	10.4	0.61	2.7	16.5
No. of grains/spike	39.7	25.1	58.9	41.5	26.3	61.1	22.0	15.1	0.47	8.7	60.4
Hectoliter weight (kg/l)	76.5	64.0	81.5	77.6	66.0	84.5	4.7	4.4	0.88	6.6	8.6
1000 grain weight (g)	42.6	30.9	53.6	49.8	37.9	58.1	13.9	12.8	0.65	11.0	24.2
Harvest index	39.4	27.3	68.0	40.9	27.7	52.0	19.5	12.4	0.40	6.4	16.0
Biomass/plant (g)	41.7	27.1	63.0	39.5	28.1	52.9	19.6	16.0	0.66	11.0	26.9
Grain yield/plant (g)	16.2	10.7	32.6	15.5	10.2	20.3	24.3	18.8	0.60	4.5	28.3

spike length (38.8) and flag leaf length (34.7) (Table 1).These results were in accordance with the findings of Payal-Saxena *et al.* (2007) and Rashidi *et al.* (2011). High to moderate heritability coupled with high to moderate genetic advance as percentage of mean was exhibited for 7 traits *viz.,* days to flowering, days to maturity, plant height, no. of tillers/plant, biomass/plant, flag leaf length and 1000 grain weight, which indicates the predominance of additive gene action in the expression of these characters and consequently greater chance of improving these traits through simple selection. Spike length, no. of spikelets/spike and grain yield per plant showed high to moderate heritability with low genetic advance, which suggested that the presence of non-additive gene action and hence, improvement of these traits could be difficult through direct selection.

On the basis of mean performance of the varieties, three varieties *viz.,* CPAN 3004, GW 322 and HI 617 showed highest grain yield/plant, while HI 1500, GW 322 and NP 846 had showed highest harvest index. Varieties CPAN 3004, HI 617 and DWR 39 showed highest biomass yield/plant, and highest 1000 grain weight was observed in PDW 274 followed by WH 896 and NP 404. Varieties HD 2270, HPW 89 and HS 207 were found to have high flag leaf length, while, K 9644, GW 89 and HPW 89 has high spike length. Varieties NIDW 15, HD 2285 and GW 89 were having highest no. of grains/spike, while, PDW 233, WL 896 and PDW 215 has highest hectoliter weight. Wheat varieties HD 1941, WH 542, WR 544, HD 2285 and NP-4 were observed to be flowered and matured early compared to all other genotypes. Varieties Lal Bahadur followed by HD 1949 and GW 173 were found to be short stature in comparison to other ones under study. Varieties with high number of tillers/plant were NIDW 295, WL 291 and UAS 145, while, high no. of spikelets/spike were seen in CPAN 3004, DDK 1001 and VL 738 (Table 2).

The quantitative assessment of genetic divergence among reference varieties based on grain yield and its contributing traits was carried out using Mahalanobis' D^2statistic. The varieties were grouped into eight clusters each, when bread and durum and *dicoccum* varieties were considered separately and into 12 groups under pooled conditions, indicating high levels of genetic variability existing among them. Plant height followed by days to flowering, no. of grains/spike, grain yield/plant and biomass/plant contributed the most towards divergence among genotypes (Gartan and Mittal 2003, and Sidharthan and Malik, 2006).

Among bread wheat varieties, the average intra-cluster distance (Table 3) varied from 5.1 to 6.8. Cluster VI contained maximum number of genotypes (15) followed by cluster I (12), cluster VII (12), while cluster V contained five genotypes (Table 5). Maximum inter-cluster distance was reported between cluster IV and V (31.6) followed by cluster I & IV (26.5) and cluster III & V (20.4) revealing wide diversity among the varieties included in these clusters. The cluster means showed that varieties with more no. of grains/spike, high harvest index, high biomass yield/plant along with high grain yield/plant were observed in cluster IV, whereas dwarf genotypes with high hectoliter weight were observed in cluster VII. Early flowering genotypes with high 1000 grain weight were present in cluster I. Based on the genetic diversity and per se performance,

Table 2. Superior wheat genotypes among the reference varieties for various characters

Characters	Genotype
Days to flowering	HD 1941, WH 542, WR 544, HS 277 and HD 2278
Days to maturity	WR 544, HD 2285, NP 4, NP 52 and NP 770
Plant height (cm)	LalBahadur , HD 1949, GW 173, HD 1940 and PBW 222
No. of tillers/plant	NIDW 295, WH 291, UAS 415, NP 152 and PBW 222
Flag leaf length (cm)	HD 2270,HPW 89, HS 207, DWL 5023 AND K 9107
Spike length (cm)	K 9644, GW 89, HPW 89, K 9006 and K 68
No. of spikelets/spike	CPAN 3004, DDK 1001, VL 738, Bijaga yellow and PBW 34
No. of grains/spike	NIDW 15, HD 2285, GW 89, CPAN 179 and DWR 1006
Hectolitre weight (kg/l)	PDW 233, WH 896, PDW 215, HD 4672 and HD 2270
1000 grain weight (g)	PDW 274, WH 896, NP 404, DWR 185 and MACS 9
Harvest index	HI 1500, GW 322, NP 846, CPAN 3004 and PDW 215,
Biomass/plant (g)	CPAN 3004, HI 617, DWR 39, HD 1941, and DL 803-2
Grain yield/plant (g)	CPAN 3004, GW 322, HI 617, HI 1500 and DWR 39

Table 3. Average intra and inter-cluster D^2 values between the clusters in bread wheat

Clusters	I	II	III	IV	V	VI	VII	VIII
Bread wheat								
I	5.8							
II	9.1	6.5						
III	11.2	12.6	5.1					
IV	26.5	17.1	12.5	6.8				
V	11.4	15.4	20.4	31.6	5.4			
VI	14.3	15.8	13.0	15.4	16.3	6.4		
VII	13.0	17.8	16.3	31.2	16.5	18.7	6.4	
VIII	10.1	11.4	10.2	14.9	11.5	14.6	15.7	5.6
Durum and dicoccum wheat								
I	6.2							
II	23.3	5.5						
III	19.3	25.9	3.6					
IV	26.3	11.4	26.8	6.4				
V	14.0	11.7	24.6	26.4	4.9			
VI	23.7	11.7	27.0	27.8	16.2	4.9		
VII	14.6	17.1	16.5	23.5	10.6	20.0	4.5	
VIII	26.9	8.1	18.5	17.6	16.5	13.0	9.6	6.0

Table 4. Average intra and inter-cluster D^2 values between the clusters in pooled genotypes

Clusters	I	II	III	IV	V	VI	VII	VIII	IX	X	**XI**	**XII**
I	6.5											
II	14.6	5.1										
III	9.9	15.4	6.2									
IV	39.1	69.8	46.7	0.0								
V	16.5	18.6	10.5	59.4	6.7							
VI	15.5	15.5	16.0	52.3	19.7	5.4						
VII	14.2	16.6	21.5	55.3	13.0	13.4	6.1					
VIII	32.8	27.9	32.8	37.4	38.4	26.8	35.2	8.1				
IX	14.7	10.0	21.2	59.5	10.2	23.1	9.2	36.3	4.7			
X	12.9	9.3	24.0	55.4	21.9	9.5	10.0	26.2	10.4	5.7		
XI	16.0	12.0	11.1	61.2	10.1	20.0	16.0	29.2	11.8	11.3	7.2	
XII	18.3	15.5	11.2	41.8	19.4	18.4	13.7	10.4	19.0	24.5	13.8	6.3

it was observed that bread wheat varieties like CPAN 3004, HI 617, DWR 39, DWR 195, GW 89 of cluster IV; and UP 2113, NP 700 and NP 771 of cluster V can be used as donors for high grain yield along with yield contributing traits.

Among *durum* and *dicoccum* wheat genotypes, the average intra-cluster distance (Table 3) varied from 3.6 to 6.4. Cluster II contained the maximum number of varieties (10) followed by clusters V and VIII (8 each), while cluster IV contained three genotypes (Table 5). Maximum inter-cluster distance was reported between cluster IV and VI (27.8) followed by cluster III & VI (27.0) and cluster I & VIII (26.9) revealing that the genotypes included in these clusters were genetically more divergent. The cluster means showed that early maturing varieties with high 1000 grain weight were observed in cluster V, whereas dwarf varieties with high no. of tillers/plant, no. of grains/spike and high biomass yield/plant were observed in cluster VI. Varieties with high flag leaf length and no. of spikelets/spike along with high grain yield/plant were present in cluster VIII. Based on the genetic diversity and per se performance, it was observed that varieties like A-28, HI 8381 and MPO 215 of cluster IV and HD 4530, HD 4672, NIDW 295, Raj 1555 and UAS 415 of cluster VI can be used as donors for high grain yield along with yield contributing traits.

In pooled analysis (bread, *durum* and *dicoccum* wheat), the average intra-cluster distance (Table 4) varied from 0.0 to 8.1. Cluster VI contained maximum number

Table 5. Grouping of wheat genotypes into different clusters

Cluster	No. of genotypes	Grouped genotypes
Bread wheat		
I	12	AKW 381, HB 208, HD1941, HD 1949, HD 2278, HD 2327, HW 2004, K 8962, K 9465, LOK 1, RIDLEY, WH 542
II	11	AKW 1071, DWR 162, HP 1493, HPW 89 HS 207, HYB 633, K 9006, K9107, K 9644, VL 421, NP 839
III	7	DL 153-2, HD 2428, HI 1500, HP 1731, K 68, K 816, VL 829
IV	7	CPAN 3004, DL 803-2, DWR 39, DWR 195, GW 89, GW 322, HI 617
V	5	NP 4, NP 52, NP 770, NP 771, UP 2113
VI	15	C 306, CPAN 1796, HD 2733, HD 2781, HD 2824, HPW 242, HUW 234, PBW 222, PBW 299, PBW 343, RAJMOLYA RODHAK , SONARA 64, VL 616, VL 738, VL 832
VII	12	DL 784-2, DL 788-2, GW 173, HD 2270, HD 2281, HD 2285, HD 2329, HD 2402, LAL BAHADUR, NP 846, WH 283, WR 544
VIII	11	HD 2236, HI 977, HP 1744, HS 277, HS 295, KALYAN SONA, PBW 373, RAJ 1482, SONALIKA, VL 404, WH 291
Durum and dicoccum wheat		
I	4	BIJAGA RED,GW 1139, HD 4502, MACS 1967,
II	10	MACS 2694, MPO 1106, NIDW 15, PBW 34, PBW 215, PBW 233, PBW 274, PBW 291, RAJ 6560,WH 896
III	4	DDK 1009, DDK 1029, HW 1095, NP 200
IV	3	A-28, HI 8381, MPO 215,
V	8	GW-2, HI 8498, JU-12, MACS-9, MACS 2846, MACS 3125, N-59, NI 5749
VI	5	HD 4530, HD 4672, NIDW 295, RAJ 1555, UAS 415,
VII	7	A-9-30-1, DWR 137, GW-1, HI 7483, JNK-4W-184, NP 404
VIII	8	AKDW 2997-1, BIJAGA YELLOW, DDK 1001, DDK 1025, DWL 5023, DWR 185, RAJ 911, WH 912

Table 6. Grouping of different wheat genotypes (pooled) into various clusters

Cluster	No. of genotypes	Grouped genotypes
I	8	HUW 234, RAJMOLYA, DDK 1001, DDK 1009, DDK 1025, DDK 1029, HW 1095, NP 200
II	7	AKW 1071, BIJAGA YELLOW, HD 4530, HD 4672, NIDW 295, RAJ 1555, UAS 415
III	16	AKW 381, HP 1493, HPW 89, HS 207, K 9006, K 9107, K 9465, NP 771, VL 421, NP 839, VL 829, A-9-30-1, BIJAGA RED, DWR 137, GW 1, HI 7483
IV	1	HI 1500
V	16	DL 784-2, DL 788-2, HB 208, HD 1941, HD 2278, HD 2281, HD 2327, HD 2329, HD 2402, K 8962, LAL BAHADUR, LOK 1, NP 846, RIDLEY, WH 283, WR 544
VI	18	A-28, AKDW 2997, DWL 5032, DWR 185, HI 8381, MACS 2694, MPO 215, MPO 1106, NIDW 15, PBW 34, PDW 215, PDW 233, PDW 274, PDW 291, RAJ 911, RAJ 6560, WH 896, WH 912
VII	13	GW 173, HD 1949, HD 2236, HD 2270, HD 2285, HD 2781, HP 1731, HS 295, HW 2004, K 816, KALYAN SONA, HD 4502, JNK-4W-184
VIII	4	CPAN 3004, DL 153-2, GW 322, HI 617
IX	12	WH 542, GW 2, GW 1139, HI 8498, JU 12, MACS -9, MACS 1967, MACS 2846, MACS 3125, N 59, NI 5749, NP 404
X	14	C 306, CPAN 1796, DWR 162, HD 2824, HPW 42, HYB 633, PBW 222, PBW 299, PBW 343, SONARA 64, VL 616, VL 738, VL 829, DWR 1006
XI	11	HP 1744, HS 277, NP 4, NP 52, NP 770, PBW 373, RAJ 1482, SONALIKA, UP 2113, VL 404, WH 291
XII	09	DL 803-2, DWR 39, DWR 195, GW 89, HD 2428, HD 2733, HI 977, K 68, K 9644

of varieties (18) followed by cluster III (16), cluster V (16), while, cluster IV contains only one variety (Table 6). Maximum inter-cluster distance was reported between cluster II and IV (69.8) followed by cluster IV and XI (61.2), and cluster IV and IX (59.5), while minimum between cluster VII and IX (9.2). Cluster means showed that earliest maturity varieties with dwarf plant types were observed in cluster V, whereas, varieties with high biomass yield/plant and high grain yield/plant were observed in cluster VIII. Varieties with high flag leaf length and high harvest index were present in cluster IV. Based on the genetic diversity and per se performance, it was observed that varieties like AKAW 1071, Bijaga Yellow, HD 4530, HD 4672, NIDW 295, Raj 1555 and UAS 415 of cluster II; WH 291, PBW 373, Raj 1482, NP 770, NP 4, NP 52 and HS 277 of cluster XI; and HI 1500 of cluster IV can be used as donors for high grain yield along with yield contributing traits.

Therefore, as a whole, bread wheat varieties *viz.*, CPAN 3004, GW 322, HI 617, HI 1500, DWR 39, DWR 195, GW 89, UP 2113, NP 700 and NP 771; and durum wheat varieties *viz.*, A-28, HI 8381, MPO 215, HD 4530, HD 4672, NIDW 295, Raj 1555 and UAS 415 can be used as donors to cross among them for developing superior genotypes with high yield in wheat breeding programmes.

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