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GENETICS OF SOME PHYSIO-MORPHIC TRAITS OF HEXAPLOID WHEAT GENOTYPES UNDER RAINFED CONDITIONS

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ABSTRACT
A study was conducted in the Department of Plant Breeding and Genetics, PMAS Arid Agriculture University, Rawalpindi, Pakistan during *rabi* season 2012-13 to estimate genetic variability using 25 different wheat varieties/genotypes. These genotypes were planted in two replications following a RCBD under rainfed conditions. Data were collected for the traits viz. leaf chlorophyll content, relative water content, plant height, number of spikelets per spike, spike length, 1000-kernel weight and grain yield. Components of variation, heritability and genetic advance were estimated for all traits. The results showed that all wheat genotypes differed significantly for all studied characters, indicating existence of sufficient genetic variability within different genotypes. High phenotypic (34.05%) and genotypic coefficients of variation (28.15%) were recorded for grain yield per meter square. High heritability with low genetic advance was recorded for leaf chlorophyll content, relative water content, spike length, 1000-kernel weight and grain yield, while plant height possessed moderate heritability (50.17%) with low genetic advance (0.73). WC-19, Shalimar-88 and Rohtas-90 genotypes performed better and produced maximum grain yields under rainfed conditions i.e. 514.5, 364.0 and 385.5 g per meter square, respectively. The study concludes good source of material for further breeding programme. So, information on the genetic parameters such as coefficient of variation, heritability and genetic advance may be helpful for plant breeders to evolve suitable cultivars within a short span of time.

KEYWORDS: *Triticum aestivum;* wheat; genotypes; genetic variability; heritability; relative water content; chlorophyll content; yield traits; Pakistan.

INTRODUCTION
Wheat (*Triticum aestivum* L.) is a food crop of global significance. It is grown in diversified environments all around the world. It provides one-third of the world's population with more than half of their calories and protein requirements (8). Wheat is ranked first among cereal crops of Pakistan and dominates in acreage and production. It is the country's most important agricultural commodity being grown by 80 percent farmers. The major production area is in Punjab followed by Sindh province. During the year 2013-14, wheat crop occupied 17054 acres of Punjab land, giving a production of 19.74 million tons (4).

In view of its significance this crop has always been subjected to extensive and ceaseless research to maximize grain production and to improve grain yield per unit area. However, there is still considerable room for improvement, especially to amplify efforts for continued genetic improvement of wheat to meet growing requirements of ever-increasing population. Genetic manipulation is the best way to boost wheat production. Therefore, it is necessary to estimate and study the genetic variation and mode of inheritance of different plant parameters to initiate productive wheat breeding programmes.

The analysis of genetic variation in breeding materials is of fundamental interest to plant breeders as it contributes to selection, monitoring of germplasm and prediction of potential genetic gain (10). Heritability, a measure of the phenotypic variance attributable to genetic causes, has predictive function of breeding crops (22). The higher the heritability estimates, the simpler are the selection procedures (12). The estimate of genetic advance is more useful as a selection tool when considered jointly with heritability estimates. Heritability estimates will be reliable if accompanied by high genetic advance (3). However, if a character or trait is controlled by non-additive gene action, it gives high heritability but low genetic advance, while if the character is ruled by additive gene action, heritability and genetic advance both would be high (16). Phenotypic and genotypic variance, heritability and genetic advance have been used to assess the magnitude of variance in wheat breeding material (6).

The present study was conducted to evaluate wheat materials for genetic variability and heritability under rainfed conditions of Rawalpindi.

MATERIALS AND METHODS

This study was conducted in the Department of Plant Breeding and Genetics, PMAS Arid Agriculture University, Rawalpindi, Pakistan during *rabi* season 2012-13. The experiment was laid out following RCBD with two replications under rainfed conditions. The research material comprised 25 wheat genotypes including local land races and commercial cultivars of Pakistan as detailed below:-

S. No.	Genotype/variety	S. No.	Genotype/variety
1.	BW1-2000	14.	Kiran-95
2.	CP	15.	Marvi-2000
3.	WC-13	16.	Noshhra-96
4.	WC-24	17.	Punjab-81
5.	WC-19	18.	Rohtas-90
6.	03FJ-26	19.	Sarsabz
7.	04FJH-08	20.	Saleem-2000
8.	99FJ-03	21.	Seher-06
9.	LLR-9	22.	Shaheen
10.	Fakhar-e-Sarhad	23.	Sindh 5 /12
11.	Faisalabad-85	24.	Sonora
12.	Inqalab-91	25.	Shalimar-88
13.	Kaghan-93	-	---

Two meter long rows of each variety were sown, maintaining an inter row spacing of 30 cm. Uniform cultural practices were performed as and when required. Data were collected for the traits, like relative water content, leaf chlorophyll content, plant height, spikelets number per spike, spike length, 1000-kernel weight and grain yield per meter quare. Leaf chlorophyll content of each entry was determined at four-leaf stage using chlorophyll meter (SPAD-502). The relative water content (RWC) of leaves was assessed using the method of Barrs and Weatherley (5). Following Steel *et al*. (23) data collected for leaf chlorophyll content, relative water content, plant height, number of spikelets per spike, spike length, 1000-kernel weight and grain yield were subjected to statistical analysis to ascertain differences among the means of various genotypes (23). Genotypic and phenotypic correlations were computed following Kwon and Torrie(15).

RESULTS AND DISCUSSION

Relative water content (%)

Analysis of variance showed that differences among genotypes were highly significant (Table 1) for the trait indicating presence of high genetic variability. Means for RWC ranged between 64-82 percent among 25 genotypes. Comparison of means (Table 2) showed that genotype WC-24 maintained higher RWC (82%), while genotypes WC-19 attained minimum RWC (64%).

The genotypic and phenotypic coefficients of variation (GCV and PCV) noted were 5.84 and 6.59 percent, respectively (Table 3). The small difference between GCV and PCV reveals that genetic factors have a greater role than growing environment in the expression of trait which provide maximum chances of fruitful selection. High heritability estimate (78.33%) was attained with low genetic advance (1.43). High estimate of broad sense heritability with low GA shows that role of non-additive gene action is predominant. Findings of the present study are in accordance with those of Jatoi *et al.,* (11) and Rad *et al.* (18) who also reported a higher estimate of heritability for RWC in wheat..

Table 1. Analysis of variance of different physio-morphic traits of wheat under rainfed conditions

SOV	RWC	LCC	PH	SPS	SL	TKW	GY
Genotypes	40.28**	18.01**	115.17**	2.89**	5.47**	34.55**	16106.71**
Reps	11.53	11.52	8.0	12.5	7.22	3.38	32665.52
Error	4.90	2.44	17.58	0.96	0.61	2.8	3025.56
CV (%)	3.07	4.06	4.39	4.68	6.4	4.49	19.15

**Highly significant, RWC = Relative water content, LCC = Leaf chlorophyll content, SPS = Spikelets per spike, SL = Spike l
Fenotypic and phenotypic correlations were computed following Kwon and Torrie (15)

Table 2. Mean values of different physio-morphic traits of wheat genotypes/varieties

Genotype/ varieties	Relative water content (%)	Leaf chlorophyll content (%)	Plant height (cm)	Spikelets/ spike	Spike length (cm)	1000-kernel weight (g)	Grain yield (g/m^2)
Sindh 5/12	65.5	39.5	95.5	19.5	12.5	33.5	264.5
99FJ-03	73.0	39.5	97.5	20.0	12.0	36.0	147.0
CP	75.0	39.0	103.0	20.5	12.0	36.5	189.0
BWL-2000	70.5	37.5	101.5	20.0	13.5	33.5	192.0
Marvi-2000	75.0	39.0	93.0	20.5	12.0	33.5	343.0
WC-13	66.5	35.5	91.5	22.0	11.5	34.5	166.5
Sonora	73.5	34.5	100.5	23.0	12.5	36.0	323.0
Rohtas-90	75.0	37.0	99.0	23.0	13.0	31.0	385.5
WC-24	82.0	38.5	86.0	21.5	12.0	39.0	302.0
Sarsabz	66.0	36.0	103.0	23.5	15.5	33.5	283.5
Shalimar-88	70.5	33.0	78.5	19.0	11.5	31.5	369.0
WC-19	64.0	33.0	112.0	21.0	11.0	41.5	514.5
Saleem-2000	78.5	39.0	82.0	20.5	10.5	34.0	304.5
Shaheen	76.0	42.0	92.5	21.0	10.5	36.5	189.0
03FJ-26	72.5	41.5	92.5	19.5	11.5	45.0	267.0
Fakhar-e-Sarhad	77.5	41.0	93	22.5	13.5	44.0	257.5
Seher-2006	71.0	38.0	104.5	20.0	12.5	43.5	211.0
Faisalabad-85	73.5	41.0	91.0	21.0	13.0	31.0	286.5
LLR-9	64.5	33.5	98.0	20.0	6.0	41.0	273.0
Punjab-81	70.5	39.5	100.5	20.0	12.0	38.5	342.0
Nowshera-96	71.0	37.0	88.0	20.5	13.0	39.0	274.5
Kiran-95	76.5	39.0	105.5	21.0	13.5	39.5	303.0
04FJH-08	72.5	44.5	94.0	20.5	12.5	43.0	273.0
Kaghan-93	71.5	42.5	96.5	21.0	11.5	38.0	494.0
Inqalab-91	70.0	40.5	91.0	22.5	12.5	38.5	227.5
Mean	72.08	38.44	95.6	20.94	12.06	37.26	287.28
CD (5%)	4.56	3.22	8.64	2.02	1.59	4.83	113.31

Table 3. Estimates of genetic parameters of different physio-morphic traits of wheat genotypes

Trait	GCV (%)	PCV (%)	h^2 (%)	GA
Relative water content	5.84	6.59	78.33	1.43
Leaf chlorophyll content	7.26	8.32	76.17	1.37
Plant height	4.69	6.62	50.17	0.73
Spikelets per spike	12.95	14.44	80.38	1.49
Spike length	7.31	8.52	73.51	1.3
1000-kernel weight	10.69	11.59	85.02	1.62
Grain yield	28.15	34.05	68.37	1.16

GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, GA = Genetic advance, h^2 = broad sense heritability.

Leaf chlorophyll content (%)

Analysis of variance indicated that differences among genotypes were highly significant for the leaf chlorophyll content (Table 1). It indicated presence of high genetic variability among genotypes and possible selection of superior entry. Means of trait ranged from 33 to 44.5 percent among genotypes with a mean value of 38.44 percent. Comparison of means (Table 2) showed that genotype 04FJH-08 maintained maximum content of leaf chlorophyll (44.5%) while genotypes WC-19 and Shalimar-94 had minimum leaf chlorophyll content (33% each).

GCV and PCV for this trait were 7.26 and 8.32 percent, respectively. The difference between GCV and PCV revealed environmental influence on the expression of trait. GCV was less than PCV. This result indicated prominent role of environment in expression of these traits (24). Heritability value for this trait was 76.17 percent with GA of 1.37 (Table 3). These results suggest the involvement of non-additive genes in inheritance mechanism of the trait.

Plant height (cm)

Analysis of variance showed highly significant differences among genotypes for plant height (Table 1). Plant height ranged between 78.5-112 cm with a mean value of 95.6 cm. Genotype WC-19 was the tallest one with a height of 112 cm while, genotype Shalimar-94 was the shortest one (78.5 cm) (Table 2).

GCV and PCV for this trait were 4.69 and 6.62 percent, respectively (Table 3). A smaller magnitude of difference between GCV and PCV confirms that genetic factors have a greater role than growing environment in the expression of trait providing a good scope of rewarding selection. High heritability estimate (50.17%) with low GA (0.73%) was observed. It shows that the role of non-additive genes is predominant in trait expression. These results agree to the findings of Gulnaz *et al.* (9) and Khan (13). However, Kotal *et al.* (14) had reported a moderate heritability for plant height. The difference in results may be due to wheat material used and /or environmental conditions.

Number of spikelets/spike

The analysis of variance for spikelets per spike revealed highly significant differences among genotypes (Table 1). The spikelets number ranged from 19.0 to 23.50 with a mean value of 20.94. Comparison of means (Table 2) showed that genotype Sarsabz attained maximum spikelets (23.5), closely followed by genotypes Sonora and Rohtas-90 (23 each). Shalimar-88 showed minimum number of spikelets (19.0).

GCV and PCV recorded were 12.95 and 14.44 percent, respectively (Table 3). This little increase in PCV depicts the influence of environment on the trait's expression, hence a careful selection is needed. Heritability value of 80.38 percent was attained with GA of 1.49. Present findings are in accordance with those of Cheema *et al.* (7) who also reported moderate heritability estimate (47.38%). However, Kotal *et al.* (14) reported high heritability estimates (71%) for the trait. The different may be due to different research material and environmental conditions.

Spike length (cm)

Analysis of variance showed highly significant differences among the genotypes for spike length (Table 1). Spike length varied from 6.0 cm to 15.5 cm among 25 genotypes with a mean value of 12.06 cm. Comparison of means (Table 2) showed that genotype Sarsabz had the largest spike (15.5 cm), against the smallest spike on genotype LLR-9 (6.0 cm).

The GCV obtained for this trait was 7.31 percent, while a little increase was observed in the magnitude of PCV (8.52%) (Table 3). A smaller difference between GCV and PCV confirms that genetic factors have a greater role than growing environment in the expression of trait, providing a good scope of rewarding selection. Heritability value of 73.51 percent with GA of 1.30 was recorded (Table 3). High estimate of broad sense heritability with low GA implies that the trait is governed by non-additive genes. Cheema *et al*. (7) have also reported similar results.

1000-kernel weight (g)

Analysis of variance showed that differences among genotypes were highly significant (Table 1) for 1000-kernel weight. The data showed 1000-kernel weight of 31 to 45 g among genotypes with a mean value of 37.26 g (Table 2). Comparison of means (Table 3) showed that, genotype Rohtas-90 and Faisalabad-85 got minimum weight (31g) while genotype 03 FJ-26 attained highest weight (45 g) closely followed by genotype Fakhar-e-Sarhad (44 g).

GCV obtained for trait was 10.69 percent, while a little increase was observed in PCV (11.59%). The recorded difference in GCV and PCV was not much high indicating a greater role of genetic factors in trait's expression as compared to environmental factors. Heritability value of 85.02 percent with GA of 1.62 was recorded (Table 3). Higher heritability magnitude with low genetic advance suggests that trait is under control of non-additive type of gene action. Riaz and Chaudhary (21) and Rashidi (19) had also reported high heritability estimates for this trait. However, Ajmal *et al*. (2) reported low heritability magnitude with same pattern of GA for 1000-Kernel weight. This deviation in results might be due to difference in research material used and environmental conditions in which experiment was conducted.

Grain yield (g/m^2)

Analysis of variance indicated highly significant differences among genotypes for grain yield (Table 1). Means for trait ranged from 147 g to 514.5 g with a mean value of 287.28 g. Comparison of means (Table 2) showed that genotype WC-19 produced maximum yield (514.5 g/m^2), against minimum yield (147 g/m^2) by genotype 99 FJ-03.

Genotypic and phenotypic coefficients of variation were 28.15 and 34.04 percent, respectively (Table 3). These differences depicted that manifested variation was not only due to the genotype of plant but an environmental influence on trait's expression also existed. Hence a great care is needed for fruitful selection as selection efficiency is low due to environmental influence. Moderately high broad sense heritability value of 68.37 with low GA of 1.16 was observed. These findings suggest a predominant role of non-additive gene action in inheritance mechanism of the trait. Kotal *et al*. (14) and Rashidi (19) also reported a moderate heritability estimates for grain yield. However, Riaz-ud-din (19), Ajmal *et al.* (2), Yaqoob (25) and Laghari *et al.,* (17) reported high heritability estimates for grain yield. These deviations in results might be due to differences in experimental material used and growing conditions under which the experiment was conducted.

CONCLUSION

The present study concluded that all tested genotypes had sufficient genetic variability for all the traits studied. Heritability estimates showed that broad sense heritability of traits such as leaf chlorophyll content, relative water content, plant height, spike length and 1000-kernel weight was high implying that these traits can be improved. Genotypes viz. WC-19, Shalimar-94 and Rohtas-90 performed better and produced maximum grain yields under rainfed conditions. The present study suggests that these genotypes might be used in future breeding programmes to develop wheat cultivars.

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CONTRIBUTION OF AUTHORS

Uzma Javed	**Conducted experiment, recorded data and prepared draft**
Ghulam Shabbir	**Planned the experiment and supervised the whole work**
Mahmood-ul-Hassan	**Extended help in improving draft**
Muhammad Ijaz Tabassum	**Helped in shaping the research article**