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QUANTITATIVE INHERITANCE OF SOME PHYSIOLOGICAL TRAITS FOR SPRING WHEAT UNDER TWO DIFFERENT POPULATION DENSITIES

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Abstract

A seven parent diallel involving spring wheat varieties/lines, Faisalabad-85, Pujab-96, MH-97, Uqab-2000, 6500, 6142 and 7086-1 were evaluated to study gene action for traits like flag leaf area, stomatal frequency, stomatal size, epidermal cell size and leaf venation. All these attributes were conditioned by over dominance type of genetic effects at both population density regimes. The heritability in narrow sense was highest (61%) for stomatal size at both plantings while lowest (12%) for leaf venation at high population density, whereas, heritability in broad sense was maximum for epidermal cell size 97% followed by 94% at high and low population densities, respectively.

Introduction

Cereal crops belong to the family *Gramineae* which is a large family and constituted by outstanding group of food plants, wherefrom, a majority of humanity meets its dietetic needs; amounting to an estimated 60% of calories and 50% of protein. Among this group, by all accounts, wheat *Triticum aestivum* L. em Thell, a member of the family *Poaceae,* tribe *Hordeae* and the genus *Triticum* is the most acknowledged and an important staple food crop with the largest cropped area of the world devoted to its cultivation, yielding also a matching return of food grain, far in excess of any other field crop. It is an annual, long-day and self-pollinated plant and is the world's most important food crop, covers more cultivated land at the global level than any other crop. It occupies 70% of Rabi (winter season) and 37% of total crop area in Pakistan (Ihsan *et al*., 2003). It is, being a staple food crop plays a remarkable role in meeting the diversified food requirements of both urban and rural population of Pakistan. Production of wheat is not sufficient to meet the needs of this country. Among many other causes of low yield, the plant density is one of the most important factors affecting the growth (Azher, 1969), development and grain productivity per unit area in all most all agricultural crops including wheat. Yield potential is attributed to plant density (Mian & Ahsan, 1969), especially in the field crops as plant density is one of the major factors determining the ability of the crop to capture resources. It is of particular importance because it is under fairly close control by the farmer.

The developments of improved varieties of wheat have always remained a focal point for wheat breeders all over the world. For the improvement purpose, breeders have to rely upon the selection of suitable parents and crosses. Therefore, estimation of available genetic variance in the early generation of crosses could be very helpful for a plant breeder. The knowledge about inheritance of quantitative traits is also important for every plant improvement programme. Diallel cross technique is the one used most commonly to estimate inheritance and behaviour of quantitative characters. Application of Hayman (1954) and Jinks (1954) models in F_1 generation provides information regarding nature and magnitude of the gene-action involved in the inheritance of a character. This information would be useful to plant breeders for two reasons viz. types of genetic variations in the traits for which selection is intended and rapid evaluation of yielding capacity by identifying crosses which will produce superior genotypes.

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The present research work was conducted to gain a proper understanding of the genetic basis of development and expression of certain physiological traits of spring wheat under conditions created by two different plant densities. The information so derived may be exploited effectively to further streamline the wheat improvement efforts in the country.

Materials and Methods

Plant material: Seven wheat varieties/strains viz., Faisalabad-85, Punjab-96, MH-97, Uqab-2000, 6500, 6142 and 7086-1 were crossed in a diallel fashion during March, 2005.

Experimental design: The F_1's including the reciprocals and parents were sown in a triplicated randomized complete block design at the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during 2nd fortnight of November, 2005.The entries were assigned at random to experimental unit in each block and each row contained 20 plants. Two experiments were carried out using two different plant densities (high at three inches/7.5 cm and low at six inches/15 cm inter plant distances) while inter row distance of 30 cm was kept uniform for both experiments. All agronomic and plant protection treatments were kept normal and equal for the entire experiment.

Measurement of physiological attributes: At physiological maturity 10 guarded plants were randomly selected from each replication of every genotype. Data were recorded on flag leaf area (cm^2), stomatal frequency, size of stomata (μ^2), epidermal cell (μ^2) and leaf venation.

Statistical analysis: Analysis of variance was performed as suggested by Steel *et al.,* 1997) with MSTAT-C software to evaluate the genetic differences among the wheat genotypes. Statistical significance was assumed at 5 and 1% levels of probability where the mean squares were significant; data were further subjected to diallel analysis technique advocated by Mather & Jinks (1982).

Results and Discussion

The analysis of variance showed highly significant ($p \leq 0.01$) differences among genotypes at both high and low population densities for all the physiological attributes (Table 1). This indicated the presence of adequate genetic variability which could be exploited in different crossing programmes.

Data regarding Diallel analysis presented in Table 2 revealed that values for additive variance (a) were highly significant for all the traits under investigation at both population densities except for flag leaf area and leaf venation at narrow inter plant spacings where it was significant ($p \leq 0.05$) and non-significant, respectively. The overall dominance (b) indicated statistically highly significant results for flag leaf area, size of stomata and epidermal cell at both plant densities regimes, whereas stomatal frequency was also significant for displaying the importance of both additive and dominant gene effects for the expression of characters. However, highly significant and non-significant estimates were found for physiological attribute and leaf venation at high and low population densities, respectively. For flag leaf area the component b_1 was significant in both the situation of the plant populations whereas, b_2 components were significant at

narrow interplant spacing (planted at 3 inches) and highly significant at wider interplant spacing (planted at 6 inches), depicting the symmetry of the gene distribution among the parents. Moreover, the component b_3 was highly significant at both the plant densities displaying specific gene interaction. The maternal effects (c) were highly significant in both the experiments, while the reciprocal effects other than (c) denoted by (d) were non-significant and significant at thick (3 inches) and thin (6 inches) plant populations, respectively. For stomatal frequency however, both directional dominance (b_1) and asymmetrical gene distribution (b_2) were non-significant in both the experiments, whereas, values for b_3 (specific gene interaction) were significant for both the experiments. The maternal or reciprocal effects (c) and the reciprocal effects other than c that is (d) were non-significant for both the experiments. The directional dominance b_1 was absent for stomata size under both plant spacings, however, highly significant b_2 and b_3 items indicated different distribution of dominant and recessive genes among parents and specific gene interaction or specific combining ability under both dense and wider interplant spacings. Asymmetrical gene distribution (b_2), specific gene interaction (b_3), maternal effects (c) and reciprocal effects other than (c) that is (d) were highly significant at both thick and thin plant population densities for epidermal cell size. However, directional dominance (b_1) was non-significant at 3 inches spacing and significant at 6 inches plant population. The effects due to parents, contributing varying degree of dominant alleles (b_1) were non-significant and significant, asymmetrical gene distribution (b_2) were highly significant and non-significant and specific gene interaction (specific combining ability) b_3 were significant and non-significant as revealed from Table 3 for these population densities, respectively. Similarly on perusal of this data significant and non-significant maternal effects (c), highly significant and non-significant reciprocal effects other than maternal effects (d) were noted at these two altered narrow and wide interplant distances, respectively.

The additive component of variance (D) was significant ($p \leq 0.05$) depicting the importance of additive effects for the expression of traits like flag leaf area, stomata size, epidermal cell size and leaf venation at both narrow and wider interplant spacings, whereas for stomatal frequency it was non-significant but significant at these spacings, respectively (Table 3). The dominance effects or variation due to dominance effects of genes (H_1 & H_2) were significant for all the traits at both the population densities except for stomatal frequency at these plantings, whereas these were non-significant at both high and low population densities. These estimates measure the proportion of dominance variance due to positive and negative gene effects. It was non-significant for importance of additive gene effects for this physiological trait at both plantings, whereas, non-additive gene effects were important for other traits under discussion at narrow & wide inter plant spacings. The estimates of F which indicated the relative frequency of dominant and recessive alleles in the parent were non-significant for flag leaf area, stomatal frequency and stomata size at high population density, whereas significant for epidermal cell size and leaf venation at both densities. At low population density, these estimates were significant, negative and non-significant for plant attributes like flag leaf area, stomatal frequency and stomata size, respectively. The non-significant values of F suggested the equal distribution of dominant and recessive genes in the parent, whereas, the negative values of F indicated excess of recessive alleles governing the plant characteristics. Net dominance effects expressed as the algebraic sum of overall loci in heterozygous phase in all crosses (h^2) were significant and positive in leaf venation and flag leaf area at low and at both low and high densities, respectively. Whereas these component were non-significant and positive for stomata and epidermal cell sizes at both

Table1. Mean squares from the analysis of variance of 7 ×7 diallel cross planted at high (3 inches) and low (6 inches) population densities.

Source of variation	d.f	Flag leaf area (cm^2)		Stomatal frequency		Stomata size (μ^2)		Epidermal cell size (μ^2)		Leaf venation	
		3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches
Replications	2	1.39	6.46	87.33	541.20**	3923.60	4009.05	2004.60	1450.30	0.119	0.578
Genotypes	48	3.94**	22.50**	76.21**	197.60**	27768.50**	27927.61**	48432.86**	49789.5**	0.445**	1.111**
Error	96	0.92	2.54	35.09	94.20	1589.80	1579.10	911.99	2019.40	0.113	0.582

** = Significant at 1% level.

Table 2. Estimates of genetic components of variation for flag leaf area, stomatal frequency, size of stomata and epidermal and leaf venation of spring wheat sown at high (3 inches) and low (3 inches) population densities.

Source of variation	d.f	Flag leaf area (cm^2)		Stomatal frequency		Stomata size (μ^2)		Epidermal cell size (μ^2)		Leaf venation	
		3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches
a	6	4.02*	5.81**	5.24**	5.52**	62.20**	59.88**	99.91**	48.23**	2.91	11.86**
b	21	5.85**	21.83**	2.27*	1.88*	7.23**	7.46**	36.14**	20.31**	4.62**	1.77
b_1	1	51.94*	68.43*	9.01	1.01	5.15	4.64	9.61	31.36*	3.12	25.07*
b_2	6	3.92*	51.36**	1.80	0.18	4.96**	5.08**	13.75**	7.21**	10.89**	1.76
b_3	14	4.08**	2.95**	2.28*	2.76*	8.21**	8.46**	58.07**	31.84**	2.37*	1.54
c	6	11.76**	5.00**	0.14	0.37	9.12**	9.15**	61.07**	15.45**	3.09*	1.70
d	15	1.87	2.46*	1.67	1.63	21.30**	21.17**	62.10**	24.52**	3.75**	0.40

* Value is significant when it exceeds 1.96 after dividing it with its standard error, * = Significant at ≤P0.05 and ** = Significant at ≤P0.01

Table 3. Estimates of genetic components of variation for flag leaf area, stomatal frequency, stomata size, epidermal cell size and leaf venation of spring wheat sown at high (3 inches) and low (3 inches) population densities.

Components	Flag leaf area (cm^2)		Stomatal frequency		Stomata size (μ^2)		Epidermal cell size (μ^2)		Leaf venation	
	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches	3 inches	6 inches
D	1.58*±0.25	18.81*±2.39	19.54±5.71	23.18*±12.82	7546.75*±438.63	7613.47*±426.35	16541.55*±2392.62	18511.89*±1774.86	0.23*±0.03	0.64*±0.10
H_1	2.49*±0.59	34.56*±5.75	39.88±13.75	27.09±30.87	9036.16*±1055.99	8990.56*±1026.43	30976.61*±5760.16	29519.32*±4272.92	0.54*±0.08	0.70*±0.24
H_2	2.21*±0.52	20.70*±5.07	36.29±12.12	47.25±27.20	7391.73*±930.48	7419.89*±904.43	25652.13*±5075.51	24609.31*±3765.04	0.29*±0.07	0.46*±0.21
F	1.12±0.59	30.08*±5.73	9.20±13.70	-34.52±30.76	1678.38±1052.27	1556.90±1022.81	13339.37*±5739.84	13454.58*±4257.85	0.45*±0.08	0.65*±0.24
h^2	4.72*±0.35	45.25*±3.40	10.43±8.14	-7.39±18.27	392.54±624.95	394.21±607.46	1525.93±3408.95	1885.30±2528.78	0.06±0.05	0.31*±0.14
E	0.31*±0.09	0.87±0.84	12.05±2.00	34.45*±4.49	545.82*±153.52	542.90*±149.22	311.43±837.42	669.27±621.20	0.04*±0.01	0.19*±0.03
$\sqrt{H_1/D}$	1.26	1.36	1.43	1.08	1.09	1.09	1.37	1.26	1.53	1.05
$H_2/4H_1$	0.22	0.15	0.23	0.44	0.20	0.21	0.21	0.21	0.13	0.16
$\frac{\sqrt{4DH_1}+F}{\sqrt{4DH_1}-F}$	1.79	3.88	1.39	0.18	1.23	1.21	1.84	1.81	4.52	2.91
Heritability (ns)	0.30	0.18	0.25	0.29	0.61	0.61	0.39	0.42	0.12	0.26
Heritability (bs)	0.75	0.88	0.57	0.47	0.91	0.91	0.97	0.94	0.70	0.54

* Value is significant when it exceeds 1.96 after dividing it with its standard error

densities except for stomatal frequency at wider inter plant spacing where it was non-significant and negative. The non-significant and positive values of all heterozygote (h^2) indicated the mean direction of dominance for these traits. The environmental component of variance (E) were significant for stomata size and leaf venation at both densities and for flag leaf area and stomatal frequency at high and low population densities, respectively indicating the importance of environmental influence for their varied density regimes. The estimates of dominance degree $(H_1/D)^{0.05}$ were higher than unity, indicating dominance for the characters under discussion. The ratio $(H_2/4H_1)$ depicting the negative and positive homozygote's, were less than 0.25 along with unequal H_1 and H_2 components revealed the unequal distribution of dominant and recessive genes among the parents for all plants attributes ant both plantings except for stomatal frequency at wider interplant spacings similarly the dominant to recessive ratios were very close (1.23 & 1.21) for stomata size (1.84 & 1.81) for epidermal cell size, respectively suggesting that dominant and recessive genes has almost similar effects on these varied inter plant distances. Due to the presence of over-dominance type of gene action selection of these traits in early generation will be difficult. Over-dominance was also reported earlier by Chowdhry *et al*., (1992) and Zaka & Khurram (1998). The heritability in narrow sense was highest (61%) for stomata size at both plantings while lowest (12%) for leaf venation at high population density, whereas, heritability in broad sense was maximum for epidermal cell size 97% followed by 94% at high and low population densities, respectively. These results got support by various scientists like Sharma and Srivastava *et al*., (1981), Alam *et al*., (1990), Iqbal *et al*., (1991), Srivastava & Nema (1993), Chaudhry *et al*., (1994), Ahmad (1996), Kashif & Khaliq (2003), Baksh *et al.*, (2004), Nazeer *et al.,* (2004), Chowdhry *et al*., (2005), Inamullah *et al*., (2005) and Shahid *et al*., (2005).

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