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GENETIC ANALYSIS FOR FIVE IMPORTANT MORPHOLOGICAL ATTRIBUTES IN WHEAT (*Triticum aestivum* L.)

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ABSTRACT

Six wheat genotypes and their F_1 diallel hybrids were evaluated for gene action of yield and related attributes. Highly significant differences were detected amongst the genotypes for all the traits under study. Components of genetic variation highlighted the importance of both additive and non-additive gene effects for the inheritance of studied traits. Graphical representation displayed additive gene action with partial dominance for tillers per plant, grain yield per plant, 1000-grain weight and plant height and over dominance for flag leaf area. Selection in early generation and later generations was considered feasible for traits governed by additive and dominant genes, respectively. High narrow sense heritability was observed for majority traits except flag leaf area. Grain yield had strong correlation with tillers per plant.

Key words: Hayman's graphical approach, diallel cross, gene action, heritability, correlation.

INTRODUCTION

Wheat *(Triticum aestivum* L.) is the most widely cultivated crop of the world. Its contribution to value added in agriculture is 10.3% and share to GDP is 2.2% in Pakistan (Anonymous, 2014). Ever growing population demands increase in wheat production with available resources. Pakistan has made an impressive improvement in wheat production in the past few years and has attained an important position in wheat producing countries of the world. However, this position is still lower than developed countries and still needs improvement in yields.

Diallel analysis has been widely utilized for investigating genetic structure of crop plants for various traits. Information about inheritance patterns involved helps scientists to propose future breeding strategies for specific objectives. Information about inheritance of plant traits in wheat has widely been published. Additive with partial dominance type of gene action was observed for plant height, tillers per plant and grain yield per plant (Ullah *et al*., 2010; Amna *et al*., 2014), 1000-grain weight (Riaz and Chowdhry, 2003). While over-dominance type of gene action was observed for plant height (Kaukab *et al*., 2013), flag leaf area (Inamullah *et al*., 2005), tillers per plant, 1000-grain weight and grain yield per plant (Nazeer *et al*., 2013).

Heritability is an important tool to assess the magnitude of genetic variation transferred to the progenies and also provides a better estimate of selection efficiency. Narrow sense heritability assesses the extent of additive genotypic variation which is primarily responsible for modifying the genetic makeup of a population. It also assists as a guide to the reliability of phenotypic variability in a breeding program.

Correlation coefficient analysis may be utilized as a vital tool to gather the information about right reason and effective association between yield and related components (Khan *et al*., 2003). Yağd and Sözen (2009) reported significant positive correlation of grain yield with 1000-grain weight and tillers per plant, and suggested these traits as selection criteria in wheat. Therefore, the present study was carried out to investigate inheritance patterns by determining gene action, heritability and correlation using 6 × 6 diallel cross in wheat.

MATERIALS AND METHODS

The studies were conducted during crop season 2010-11 at the University of Agriculture, Faisalabad, Pakistan. Six wheat genotypes viz., five cultivars Faisalabad-08, Lasani-08, Sehar-06, Chakwal-50, Chakwal-86 (local varieties) and one line 6302 (CIMMYT) were crossed in a complete diallel fashion. All the F_1s along with six parents were space planted using a triplicated randomized complete block design. Each entry consisted of three rows of two meter length each. Row to row and plant to plant distance were kept at 23 and 15 cm, respectively. All agronomic practices were applied uniformly. After sowing, four canal irrigations were applied during whole crop season. At maturity data were recorded for plant height, flag leaf area, tillers per plant, 1000-grain weight and grain yield per plant.

Data were subjected to analysis of variance to sort out significant differences among genotypes (Steel *et al*., 1997). Scaling tests were employed to test the adequacy of additive-dominance modal following Mather and Jinks (1982). Diallel analysis and components of genetic variance were estimated following Hayman (1954) and Mather and Jinks (1982). Heritability in narrow sense was estimated following Johnson *et al*., (1955). Simple correlation was also calculated to study nature of relationships among various traits following Pearson (1920).

RESULTS

Differences were significant among genotypes for the studied traits. The scaling tests employed for adequacy of additive-dominance modal displayed full adequacy of the modal for tillers per plant while it was found partially adequate for grain yield per plant, 1000-grain weight, flag leaf area and plant height (Table 1). Various past studies revealed partial adequacy in various crop traits i.e. in barley (Johnson and Askel, 1964), sorghum (Azhar and McNeilly, 1988) and in wheat (Mahmood, 1998; Mahmood and Chowdhry, 1999; Khaliq, 2000).

Gene Action

Plant height: Components of genetic variance revealed that both D and H components were significant displaying importance of both additive and non-additive genes effects (Table 2). However, the value of H_1 and H_2 were unequal and smaller than D, indicating predominance of additive effects and unequal distribution of genes among parents. This was also supported by the $H_2/4H_1$ ratio which was lesser than 0.25 and also pointed out unequal distribution of genes amongst the parents. Negative F value signified the lower frequency of dominant genes which was supported by low value of KD/KR. The degree of dominance was less than one suggesting presence of partial dominance. Environmental effects were found significant. The estimates of narrow sense heritability signified that most of the variation inherited was of additive nature. This was also confirmed by graphical representation which displayed that plant height was controlled by partial dominance with additive type of gene action as regression line incepted the Y-axis (Wr) above the origin (Fig. 1). The graphical representation further showed that genotype Faisalabad-08 carried maximum dominant genes as being closest to the origin, closely followed by line 6302 and Chakwal-50 (Fig.1). However, the genotype Chakwal-86 contained maximum recessive genes as being farthest from the origin. The genotypes Sehar-06 and Lasani-08 possessed intermediate gene distribution.

Flag leaf area: The value of D component of genetic variance was less than H_1 more than H_2 representing the absence of additive type genetic effects. Higher value of H_1 than H_2 pointed out contribution of dominant genes for the inheritance of flag leaf area. The value of F was positive but non-significant. However, KD/KR ratio indicated the important role of dominant genes. The $H_2/4H_1$ ratio was less than 0.25 indicating unequal distribution of genes amongst the parents. The estimates of heritability in narrow sense were low (30%) with a significant Environmental variance. Over dominance for the expression of the trait was indicated by degree of dominance and graphical representation where regression line cut the Wr-axis below the origin (Fig. 2). Graph further displayed that the genotype 6302 contained maximum dominant genes being closest to the origin while the genotype Faisalabad-08 had maximum recessive genes being away from the origin. Rest of the parents had different constitution of dominant and recessive genes.

Tillers per plant: The component D was significant and greater than H components indicating preponderance of additive genetic effects controlling number of tillers per plant (Table 2). Unequal values of H_1 and H_2 evidenced unequal distribution of dominant genes among parents which was further substantiated by the ratio of $H_2/4H_1$ which was greater than 0.25. Negative and significant value of F showed greater frequency of negative genes which was supported by negative and low value of KD/KR. Heritability in narrow sense was high (70%) with significant environmental variation. Average degree of dominance was less than 1 showing involvement of partial dominance for the inheritance of the trait. The graphical representation also depicted the same with a positive intercept of regression line (Fig. 3). The graph further showed that Faisalabad-08 contained maximum dominant genes being nearest to the origin. Whereas, maximum recessive genes were contained in Chakwal-50 followed by Chakwal-86 being furthermost from the origin.

Thousand grain weight: Significant and greater value of D as compared to H_1 (0.25) and H_2 (0.32) components of genetic variance indicated the importance of additive effects for the control of this trait (Table 2). Unequal values of H_1 and H_2 signified the unequal distribution of genes among parents supported by the ratio of H_2 / $4H_1$ (0.25). Positive and significant F value suggested that dominant genes were more frequent sustained by KD/KR ratio. The estimate of narrow sense heritability was much higher (97%) but with a significant environmental influence. The value of degree of dominance was smaller than 1, suggesting the presence of partial dominance. The graphical representation of this parameter also supported the results (Fig. 4). It was further revealed that Chakwal-86 contained maximum number of dominant genes for this parameter while Faisalabad-08 had maximum recessive genes for controlling 1000-grain weight.

Grain yield per plant: Significant and greater value of D than H components of genetic variance and unequal values of H_1 and H_2unveiled additive genetic control and unequal distribution of dominant genes for inheritance of grain yield per plant (Table 2). Negative and non-significant value of F was detected. However, the value of KD/KR (0.75) showed the dominant and recessive loci are not in equal frequency. Heritability in narrow sense was high (74%) with a non-significant influence of environment. The degree of dominance and the graphical representation indicated partial dominance with additive type of gene action for the grain yield per plant (Fig. 5). Moreover, it was displayed that Faisalabad-08 contained maximum dominant genes and Chakwal-50 possessed maximum recessive genes.

Correlation analysis: Grain yield per plant was significantly and positively correlated with flag leaf area (0.58), number of tillers per plant (0.74) and 1000-grain weight (0.28) (Table 3). However, it was negatively and significantly correlated with plant height (-0.45). Flag leaf area was significantly and positively correlated with tillers per plant (0.60) and plant height (0.35) while negatively associated with 1000-grain weight (-0.40). Tillers per plant were significantly positively correlated with plant height (0.50) and non-significantly associated with 1000-grain weight (0.07). Plant height was positively and non-significantly correlated with 1000-grain weight (0.16).

Table 1. Mean squares from analysis of variance and scaling tests for adequacy of additive-dominance model for five traits in wheat

S.No.	Traits	Mean Squares (ANOVA)	Regression slope		Mean squares		Remarks
			b=0	b=1	Wr+Vr	Wr-Vr	
1	Plant height	28.19^{**}	19.67^{**}	2.76^{NS}	807.35^{*}	7.32^{NS}	Model is PA
2	Flag leaf area	39.09^{**}	3.12^{*}	0.56^{NS}	2538.78^{*}	159.28^{NS}	Model is PA
3	Tillers per plant	5.46^{**}	23.88^{**}	-2.67^{NS}	37.10^{NS}	8.33^{NS}	Model is FA
4	1000-grain weight	27.42^{**}	47.81^{**}	2.56^{NS}	139.66^{NS}	2.42^{NS}	Model is PA
5	Grain yield per plant	7.42^{**}	4.90^{**}	0.41^{NS}	143.52^{**}	6.25^{NS}	Model is PA

ANOVA = Analysis of Variance; **= P ≤ 0.01; * =P ≤ 0.05; NS=Non-significant
PA = partially adequate; FA = fully adequate

Table 2. Components of variation for studied traits of wheat.

Component of variance	Plant height	Flag leaf area	Tillers per plant	1000-grain weight	Grain yield per plant
D	$16.52^{*} \pm 0.24$	$14.79^{*} \pm 1.54$	$2.15^{*} \pm 0.05$	$22.20^{*} \pm 0.04$	$2.96^{*} \pm 0.27$
H_1	$2.19^{*} \pm 0.54$	$23.82^{*} \pm 3.91$	$0.19^{NS} \pm 0.13$	$0.25^{*} \pm 0.11$	$2.73^{*} \pm 0.65$
H_2	$2.33^{*} \pm 0.58$	$14.17^{*} \pm 3.49$	$0.50^{*} \pm 0.11$	$0.32^{*} \pm 0.10$	$2.41^{*} \pm 0.58$
F	$-3.41^{*} \pm 0.60$	$2.77^{NS} \pm 3.76$	$-1.31^{*} \pm 0.12$	$1.29^{*} \pm 0.11$	$-0.83^{NS} \pm 0.63$
E	$0.45^{*} \pm 0.09$	$1.16^{*} \pm 0.59$	$0.56^{*} \pm 0.02$	$0.25^{*} \pm 0.02$	$0.13^{NS} \pm 0.10$
$H_2/4H_1$	0.16	0.15	0.67	0.33	0.22
KD/KR	0.73	1.16	-0.02	1.76	0.75
h^2 (n.s)	91 %	30 %	70 %	97 %	74 %
$(H_1/D)^{1/2}$	0.45	1.27	0.29	0.11	0.96

KD/KR= $(4DH_1+ F)^{1/2} / (4DH_1 - F)^{1/2}$; * =P ≤ 0.05; NS=Non-significant

Table 3. Simple correlation matrix.

Traits	Grain yield per plant	Flag leaf area	Tillers per plant	1000-grain weight
Grain yield per plant	1			
Flag leaf area	0.58^{**}	1		
Tillers per plant	0.74^{**}	0.60^{**}	1	
1000-grain weight	0.28^{**}	-0.40^{**}	0.07^{NS}	1
Plant height	-0.45^{**}	0.35^{**}	0.50^{**}	0.16^{NS}

** = P ≤ 0.01, NS = Non-significant

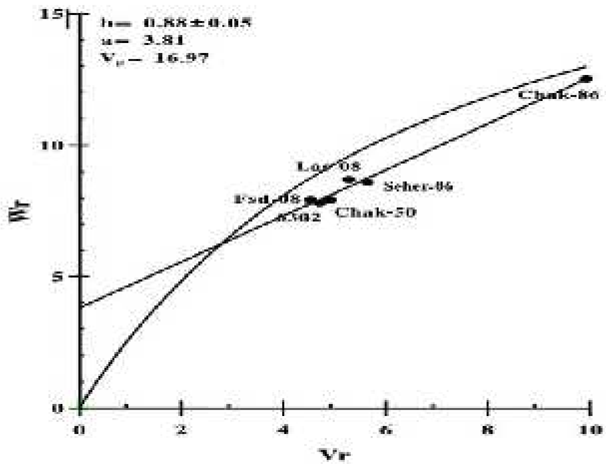

Fig.1 : Wr/Vr graph for plant height

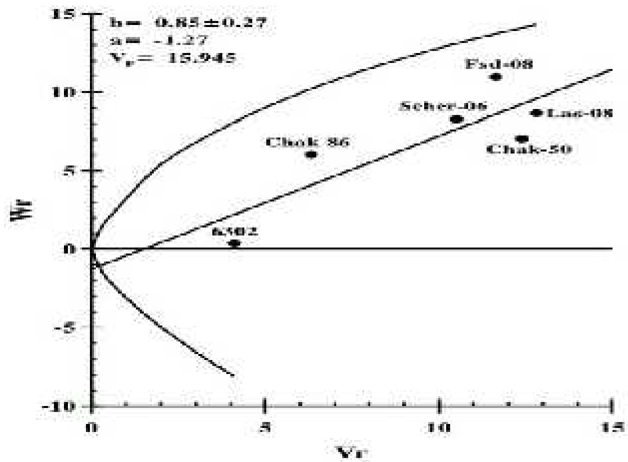

Fig.2 : Wr/Vr graph for flag leaf area

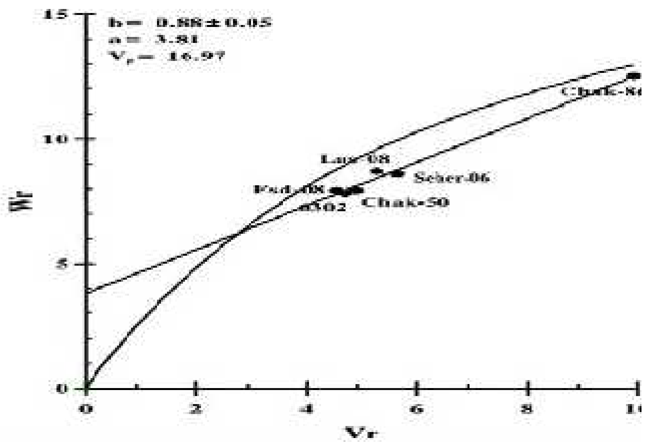

Fig. 3 : Wr/Vr graph for tillers plant

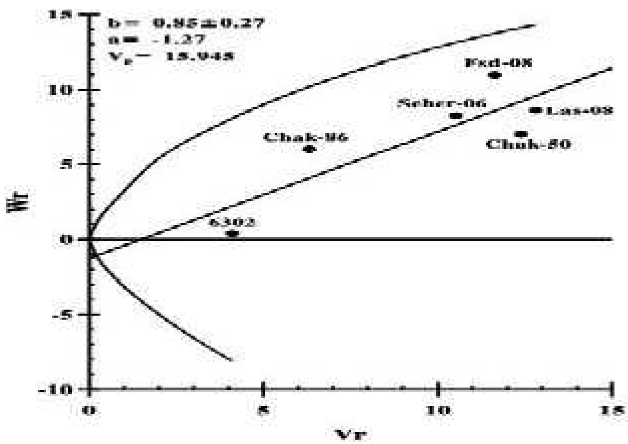

Fig. 4 : Wr/Vr graph for 1000-grain weight

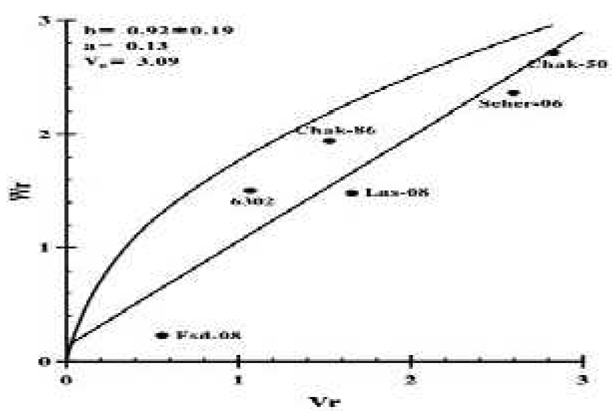

Fig. 5 : Wr/Vr graph for grain yield per plant

DISCUSSION

Significant additive and non-additive components of genetic variance illustrated the involvement of both additive and non-additive genetic effects for all the studied traits. However, additive genetic variation was significant and greater than non-additive for plant height, tillers per plant, 1000-grain weight and grain yield per plant signifying the preponderance of additive gene effects. In case of flag leaf area, however, preponderance of non-additive effects was indicated. These results were also confirmed by graphical analysis where over dominance for flag leaf area and partial dominance with additive gene action was indicated for plant height, tillers per plant, 1000-grain weight and grain yield per plant. Additive gene action with partial dominance for these traits has also been reported in past studies i.e. Inamullah *et al.* (2005) for flag leaf area; Ullah *et al.* (2010) for plant height, tillers per plant and grain yield; Golparvar *et al*. (2004) for 10000-grain weight. However, over dominance for these traits have also been reported e.g. Ajmal *et al.* (2011) and Kaukab *et al*. (2013) for plant height; Gurmani *et al.* (2007) and Nazeer *et al*. (2013) for flag leaf area, tillers per plant,1000-grain weight and for -grain yield per plant.

It was further illustrated that parents differed for dominant and recessive gene constitution for each trait. Faisalabd-08 contained the most dominant genes for plant height, tillers per plant and grain yield per plant while it contained the most recessive genes for flag leaf area and 1000-grain weight. Sehar-06 had almost intermediate gene constitution in all the traits studied. Rest of the genotypes represented variable gene constitution for the studied traits.

Thousand grain weight expressed highest narrow sense heritability followed by plant height, grain yield per plant and number of tillers per plant. Narrow sense heritability estimates the portion of genotypic variation which is actually transferred to offspring and is accountable for modifying the genetic composition of the breeding material via selection. It is directly proportional to the additive genetic variance and is higher in traits governed additively and lower in non-additively controlled traits. Thus, selection of 1000-grain weight, number of tillers per plant and plant height is viable in early generations. High heritability for these traits was also reported by Mahmood and Chowdhry (2002), Ullah *et al.* (2010), Hussain *et al*. (2013) and Nazeer *et al*. (2013).

Lowest value of heritability for flag leaf area indicated preponderance of dominance variation in the inheritance of this trait, therefore, selection of flag leaf area may be delayed till later generations. Low heritability for flag leaf area has also been reported by Riaz and Chowdhry (2003) and Inamullah *et al.* (2005). Grain yield per plant had positive and significant correlation with number of tillers per plant, flag leaf area and 1000-grain weight. Increase in number of tillers per plant will ultimately enhance the grain yield per plant. Similar results were observed by Narwal *et al*. (1999) and Kalimullah *et al*. (2012). Negative correlation of grain yield per plant with plant height illustrated that the increase in plant height had negative effect on grain yield per plant. Therefore, short statured varieties may have greater potential for increase in grain yield. Positive and significant relationship between number of tillers per plant and flag leaf area signified that increase in flag leaf area will have positive effect on grain yield enhancements.

Conclusions: The present study illustrated the existence of wide ranges of variations for most of the traits among wheat genotypes and opportunities of the genetic gain through selection or hybridization. Partial dominance with additive type of gene action with high heritability for plant height, number of tillers per plant, 1000-grain weight and grain yield per plant suggested effective selection for these traits in early generation while over dominance for flag leaf area suggested that heterosis breeding may be effective for improvement in this trait.

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