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DOSE-RESPONSE BEHAVIOUR OF WATER SCARCITY TOWARDS GENETICAL AND MORPHOLOGICAL TRAITS IN SPRING WHEAT (*TRICTICUM AESTIVUM* L.)

IJAZ RASOOL NOORKA*AND SABA TABASUM

Department of plant breeding & Genetics, University College of Agriculture, University of Sargodha, Pakistan
**Corresponding author e-mail: ijazphd@yahoo.com*

Abstract

Combining ability was studied in a Line × Tester mating fashion in wheat (*Tricticum aestivum* L.). Significant differences were observed for all the yield and yield contributing traits. GCA and SCA components of variation were found significant for most of the traits. Under water stressed conditions among lines the genotype Kohistan-97 revealed significant GCA effects for all the traits except spike length. Among testers, the genotype V08172 showed significant effects for the traits spike length, 1000-grain weight and flag leaf area. Based on desirable SCA effects and mean performance the cross combinations Kohistan-97 × V08172, Chakwal-86 × Punjab-81, Fsd-2008 × Punjab-81, Sehar-2006 × V08172 and Chakwal-86 × V08172 behaved best combiner to tolerate the water stress. Results of genetic analysis offered over dominance type of gene action that remained unchanged with the change in water provision for the traits like 1000 grain weight and economic yield. Similarly additive gene action was observed for the trait plant height under both normal irrigation and water stress conditions. However the cumulative genetic effects to control the expression of yield and yield components was shifted due to the changed environments. The study was concluded that due to presence of additive variance, selection could be practiced in early generation whereas in the presence of recessiveness the selection may be delayed up to the later generations. Plant traits associated with water stress tolerance having high heritability and with additive gene action may be used as indirect selection criteria for early selection of water stress tolerant genotypes. The information generated as a result of this study on genetic analysis of important economic traits of wheat under contrasting water availability positions will be of great value to the wheat breeders to design future breeding programmes.

Key words: Association, Wheat breeding, Crop production, Economic yield, Water stress.

Introduction

Wheat plant having versatility in its cultivation and behaviour surely a food and source of protein for a large segment of the society. It is true that the shaking food security situation is prevailing in the world particularly in the developing countries mainly due to sever or mild drought as well as biotic stresses that remained a constant and vibrant quandary to limit the food production process (Noorka *et al.,* 2013a). Water stress is one of the most important abiotic stresses, which generally are an adjunct to heat particularly in prolonged dry season (Dash & Mohanty 2001; Noorka & Tabasum, 2013). This is a worldwide problem and it is not specific to any region, that hits gravely in widening the gap in wheat demand and supply (HongBo *et al.,* 2006; Akhter *et al.,* 2008, Noorka *et al.,* 2013b). In continuous declining water availability situation, the water stress tolerance breeding programmes have been proved the best strategy to improve the water stress tolerance of plants however before successful genetic manipulation it is pertinent to characterize the parameters of known water stress tolerant or sensitive cultivars (Bray, 1997; Kramer, 1983; Mary *et al.,* 2001). Water stress is an inevitable and persistent feature of global agriculture in prevailing situation. About one-third of the world's potentially arable land experienced deficiently water dearth in the initiation process of proper growth. Agriculture is measured as the largest sector of Pakistan's economy consuming maximum labour force and giving output. During the year 2010-2011, area under wheat crop in Pakistan was 9.06 million hectares, out of which 7.334 million hectares were irrigated and the rest, 1.243 million hectares, were planted under rainfed conditions. Resultantly total production was estimated 23.4 million tonnes of wheat grains. Average per hectare yield was 2916 kg from irrigated areas and 1532 kg from rainfed areas (Anon., 2011). A big yield gap between irrigated and barani areas demands the water stress tolerant varieties. Under the changing climatic conditions the country is facing a serious threat of water shrinkage for daily use as well as less water for crop production. Gap in world food production and demand is generally because of biotic (Ahmed *et al.,* 2010) and abiotic stresses such as drought, high temperature and frost etc. with water stress being a major constraint.

Due to dry season the water stress effects has been increased and listed as the one of the most important abiotic stresses, generally accompanied by heat stress (Dash & Mohanty 2001; Siddiqui *et al.,* 2008). Being a worldwide problem, water stress has been reported that it seriously influences the crop productivity (HongBo *et al.,* 2006; Akhter *et al.,* 2008, Noorka & Schwarzacher, 2013). Under the prevailing conditions the development of high yielding, water stress tolerant and good quality wheat varieties are the persistent option to cope up the threatening situation of water shortage. The morphological and physiological parameters are rapidly quantifiable, heritable, selection responsive, best associated to crop growth and yield are the way to attain the desired results (Richads, 1978, Hao *et al.,* 2011, Batool *et al.,* 2013). To overcome the aridity of nearly one-fourth portion of the country, an effective wheat breeding program is needed to develop the high yielding and well adapted hybrids/varieties under limited water availability. The knowledge of genetic mechanism governing heritable parameters leads to the development and helpful to a plant breeder to develop a clear understanding of inheritance pattern to transform yield contributing traits in to final grain yield (Guttieri *et al.,* 2001, Noorka *et al.,* 2013c). The genetic and agronomical practices including infrastructure development and soil management have potential to minimise the yield gap up to 30% between potential and actual yield under water stress (Edmeades *et al.,* 2004; Negash *et al.,* 2005). Therefore development of water stress tolerant cultivars seems to be the best attitude to cope up with the water stress. Water stress also alters the plant and its thermal environment so that plants become more susceptible as its poorer defences (Mattson & Haack, 1987). Although the new methodologies are beneficial tool to pick up a rich genetic diversity to develop water stress tolerant varieties but still the conventional plant breeding have a big momentum. The hybrids showing more diverse yield potential (Troyer *et al.,* 1998) may be used in succeeding generation. The present study of line × tester analysis of the genetic traits would certainly be a valuable aid in selection and breeding for better water stress tolerance in wheat genotypes. It is expected that it will provide the yield stability to penetrate in the panic situation of food security. Keeping in view the need of the persistent scarce water situation the present study was conducted to observe the lines, testers and their crosses under both normal and water stress environment, to determine the genetic mechanism of water stress tolerance and relationship between water stress tolerant attributes and crop yield. The derived information may be helpful in developing selection criterion for the further future breeding programs to develop wheat water stress tolerant genotypes.

Materials and Methods

The study was conducted in the research area, the Department of Plant Breeding and Genetics, University College of Agriculture, University of Sargodha, Pakistan. The female parent plants were hand emasculated. The water stress tolerant wheat genotypes were crossed with the drought susceptible lines by using line × tester mating design as described by Kempthorne, 1957 during the cropping year 2009-10. In next crop season nine parents along with eighteen hybrids were planted in the field in two sets of experiment, one under normal irrigation condition, while other under water stress condition, using randomized complete block design (RCBD) with three replications. At the beginning and end of each replication, non-experimental lines were raised to minimize the edge border effects. All the other cultural practices were kept uniform to both normal and water stress conditions. The soil of selected site was analysed and found loamy with pH 7.70. To avoid the contamination of the genetic material, the hybridization was preceded carefully. At maturity, crop was harvested manually and data was recorded for the determination of the main quantitative parameters like Plant height (cm), Number of tillers per plant, Flag leaf area per plant (cm2), 1000-grain weight (g), Spike length (cm), and Economic yield per plant (g). The data was than submitted to the analysis of variance, Steel *et al.* (1997). The characters presenting significant differences were analysed Kempthorne, 1957 method of "Line × tester" to get genetic information. Heritability was calculated by using the formula given by (Falconer & Mackay, 1996).

Results

The study revealed that ordinary analysis of variance of absolute data including parents and their hybrids for quantitative traits (Table 1). All of the traits and interaction (G × S) showed highly significant differences indicative of differential genotypic response with the change in water availability condition. Than the analysis of variance of the absolute treatments the data was partitioned in to the parents, crosses, parents vs. crosses and parents were further partitioned into lines, tester and line × tester (Table 2). The interaction among the parents' vs crosses were found significant for all the traits except spike length in normal irrigation, while it was significant for all the traits under water stress condition. Variance of lines and testers revealed significant differences for number of tillers per plant, spike length, 1000-grain weight, flag leaf area, plant height and economic yield per plant under water stress condition. Interaction between lines × tester appeared to be a significant factor for all of the traits in normal irrigation and water stress condition, except number of tillers per plant which is non-significant at the water stress level. Analysis of variance of the relative values also showed significant differences among parents, crosses and parents vs. crosses (Table 2) except the interaction between parents vs. crosses, under water stress condition. Similarly the interaction line × tester gave significant results except for the trait number of tillers per plant, and flag leaf area under water stress condition.

General combining ability effects (GCA): General combining ability effects of lines and testers using absolute data (Table 3) specified that the line Kohistan-97 exhibited maximum GCA effects for the trait 1000-grain weight, flag leaf area, and economic yield per plant. Similarly the line Faisalabad-2008 presented maximum and significant GCA effects for number of tillers per plant and spike length. In GCA of tester, the genotype V08172 showed the significant effects for the trait spike length, 1000-grain weight, and flag leaf area. The significant GCA effects were also indicated by the tester genotype MH-97 for the trait economic yield per plant. Under water stress condition the line genotype Kohistan-97 showed significant GCA effects for all the traits except, spike length. Among testers, the genotype V08172 showed significant effects for spike length, 1000-grain weight and flag leaf area. While the tester genotype MH-97 showed highest and significant GCA effects for economic yield per plant. The estimates of GCA effects using data on relative values (Table 3) quantified that under water stress, the line Kohistan-97 and tester MH-97 exhibited the significant GCA effects for most of the traits under study.

Table 1. Mean squares of Absolute and Relative values for various morphological traits of F1 generation along with 9 parents under control and stress conditions.

SOV	DF	AB	RV	AB	RV	AB	RV	AB	RV	AB	RV	AB	RV
		FLA	FLA	PH	PH	NTP	NTP	SL	SL	TGW	TGW	EY	EY
Genotypes	26	3.26**	1279.45**	38.06**	825.34**	6.71**	618.85**	22.80**	858.51**	7.8**	770.65**	765.77**	277.25**
Treatment	1	20.41**	9940.22**	2310.68**	7557.80**	698.88**	6347.22**	71.68**	4135.29**	2.8**	5891.9**	163796.6**	114413.9**
G × Treat.	26	0.063**	19.81ns	4.67**	12.21**	1.36**	16.67**	1.8**	40.36**	1.72**	35.90**	141.24**	70.05**
Error	108	0.010	17.23	0.16	4.74	0.05	5.17	0.06	0.78	0.09	15.66	0.012**	0.011

AB= Absolute value, RL= Relative value, SOV= Source of variation, DF= Degree of freedom, FLA= Flag leaf area, PH= Plant height, NTP= No. of tillers/plant, SL= Spike length, TGW= 1000 grain weight, EY= Economic yield

Table 2. Mean squares of absolute and relative values of F_1 generation of 9 wheat varieties grown in normal and water stress conditions.

SOV	DF	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL
		FLA	FLA	FLA	PH	PH	PH	NTP	NTP	NTP	SL	SL	SL	T GW	T GW	T GW	EY	EY	EY
Treatments	26	1.02**	0.96**	1.02**	3.99**	19.90**	3.99**	1.13**	4.19**	1.13**	4.18**	23.51**	4.18**	3.29**	8.29**	3.29**	322.17**	131.93**	322.17**
Parents	8	1.54**	1.51**	1.54**	6.68**	43.18**	6.68**	2.01**	8.70**	2.01**	1.53**	52.93**	1.53**	3.97**	6.97**	3.97**	338.39**	261.92**	338.39**
P v C	1	0.71**	1.14**	0.71**	2.29**	80.86**	2.29**	0.54**	22.40**	0.54**	4.94**	50.18**	4.94**	1.97**	1.97**	1.97**	55.69**	391.63**	55.69**
Crosses	17	0.80**	0.70**	0.80**	2.82**	5.37**	2.82**	0.75**	0.9936**	0.75**	21.88**	8.09**	21.88**	15.42**	15.42**	15.42**	330.22**	55.47**	330.22**
Lines	5	2.43**	2.16**	2.43**	6.86**	10.41**	6.86**	2.43**	2.95**	2.43**	1.80**	12.86**	1.80**	7.57**	7.57**	7.57**	1043.21**	147.96**	1043.21**
Testers	2	0.43**	0.23**	0.43**	4.96**	9.10**	4.96**	0.13**	0.1985ns	0.13**	2.24**	23.51**	2.24**	1.94**	1.94**	1.94**	77.18**	26.49**	77.18**
L × T	10	0.06**	0.06**	0.06**	0.37**	2.10**	0.37**	0.04**	0.1764ns	0.04**	8.25**	2.63**	8.25**	18.79**	18.79**	18.79**	24.33**	15.03**	24.33**
Error	54	0.01	0.009	0.01	0.06	0.140	0.06	0.004	0.1294	0.004	0.99	0.26	0.99	1.54	1.54	1.54	0.01	0.01	0.01

Table 3. General combining ability estimates (Absolute and relative) of various morphological traits in normal and water stress conditions.

Lines and testers	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL
	FLA	FLA	FLA	PH	PH	PH	NTP	NTP	NTP	SL	SL	SL	T GW	T GW	T GW	EY	EY	EY
Sehar-06	-0.168	-0.56	2.27	-4.73	-1.53	-0.63	0.17	0.84	0.73	-0.50	0.08	0.42	1.86	2.86	2.86	-3.37	1.33	-0.22
Chakwal-86	0.571	1.58	6.59	4.63	6.77	2.25	-0.16	0.87	-0.80	0.56	0.21	-2.33	3.46	3.46	6.46	-2.73	3.13	0.75
Shafaq-2006	-0.212	-0.22	-2.82	-1.06	-1.62	-5.45	-0.58	-0.90	-5.85	-0.42	-0.49	1.26	-1.40	-1.50	-4.40	0.56	-0.44	-2.07
Kohistan-97	0.727	-1.60	8.15	0.59	1.43	6.39	0.04	0.70	6.41	0.47	0.19	0.29	-1.54	-0.54	-2.54	-2.26	0.49	3.06
Fsd-2008	-0.488	-1.94	-3.78	1.07	0.28	-1.29	0.95	0.48	0.01	-0.38	-0.61	-2.94	2.09	2.09	3.09	-2.44	-0.19	-1.07
Inqlab-91	0.428	0.428	-9.42	-0.50	-0.33	-0.34	-0.28	-0.19	-0.40	-0.18	0.06	3.33	-3.21	-3.21	-3.21	-1.78	-2.68	-0.46
V08172	0.177	0.177	0.79	0.03	0.04	0.15	-0.01	-0.08	-0.37	0.01	0.56	1.69	0.66	0.66	3.66	-0.47	0.47	-0.09
MH-97	-0.093	-0.093	1.28	0.51	0.06	2.09	0.05	0.18	0.89	-0.19	0.11	3.58	-2.21	-2.21	-4.21	-1.83	0.90	0.87
Punjab-81	-0.083	-0.083	-1.96	-0.54	-0.73	-2.24	0.05	-0.34	-0.53	-0.45	-0.17	-5.28	-2.40	-2.40	-3.40	3.60	-1.37	-0.68

Specific combining ability effects (SCA): The estimates of SCA effects using the data on absolute values (Table 4) showed that in under normal irrigation conditions, the cross combination Kohistan-97 × V08172 exhibited maximum significant SCA effects for spike length. Whereas for the trait, number of tillers per plant, spike length, 1000-grain weight, flag leaf area and economic yield per plant the hybrids Chakwal-86× Punjab-81 exhibited maximum SCA effects respectively. Under water stress condition, maximum SCA effects were observed, for 1000-grain weight, spike length. For number of tillers per plant, spike length, flag leaf area and economic yield per plant, highest SCA effects were found in hybrids Kohistan-97 × V08172, Chakwal-86 × Punjab-81, Fsd-2008 × Punjab-81, Sehar-2006 × V08172 and Chakwal-86 × V08172 respectively. The estimates of SCA effects using data on relative values (Table 4) indicated that maximum SCA effect were observed, in cross combination Chakwal-86 × MH-97 and under water stress condition the hybrid Fsd-2008 × MH-97 had maximum SCA effects for 1000-grain weight under water stress. For the spike length and economic yield per plant the maximum SCA effects were found under water stress conditions in hybrids Inqlab-91 × MH-97, Sehar-2006 × Punjab-81, Kohistan-97 ×V08172 and Chakwal-86 × V08172.

Gene action: The dominance and additive variance for various traits in wheat were found, by using absolute and relative data that are presented in (Table 5). In normal conditions the traits spike length, 1000-grain weight and spike length depicted over dominant type of gene action. While the other traits i.e. number of tillers per plant, flag leaf area and economic yield per plant showed partial dominance type of gene action. Under water stress condition all the traits showed over dominance type of gene action except flag leaf area, which exhibited partial dominance type of gene action.

Discussion

It remained an important goal of the plant breeder to investigate the genetics of plants to get maximum genetic insights to pave the path to break up the yield barriers. Early researchers used combining ability technique as given by (Griffing, 1956). Diallel crossing method (Hayman, 1954, Jinks, 1954) and Triple test cross (Kearsey & Jinks, 1968) as well as (Kempthorne, 1957) Line × Tester mating fashion in the process of crop breeding. The time has proved Line × tester analysis as a potential biometrical method to get maximum insights in the inheritance of different plant traits. It is a fact that yield and yield components of the plant under water stress are reduced even in tolerant genotypes. In crops yield the paradigm shift in grain yield mainly depends on the traits like number of tillers surviving up to maturity, spike length and grain size (1000-grain weight) that is why we generally called them yield contributing traits. In the present study, water deficit was induced at different growth stages that has reduced the number of tillers initiation and surviving up to maturity, both (Sharif, 1999; Musaddique *et al.,* 2000) reported that greater tillers/m^2 were obtained in wheat in under normal irrigation treatment that water stress conditions. Similarly (Mc Donald *et al.,* 1984) found that maximum number of tillers were associated with greater number of irrigations. The importance of tillers is evident from the fact that it affects directly the final grain yield. Many researchers have reported similar effect of irrigation on spike length in wheat (Swati *et al.,* 1985; Ahmad, 1994). Similar effects of water stress on 1000-grain weight were also reported by (Qadir *et al.,* 1999). The grain yield is very sensitive to drought and its severity of stress which caused reduction at tillering and anthesis stages and ultimately the grain yield. Similar results have been depicted in the present study in agreement with the earlier findings of (Kang *et al.,* 2002; Pirdashti *et al.,* 2004). The estimates of general combining ability (GCA) and Specific Combining ability (SCA) revealed that low GCA estimate specified that the average performance of a parent in crosses does not fluctuate from the general trend of the crosses. The high GCA results depicted that the genotype seems more related with the intrinsic genetical architecture irrespective to means (Kanga *et al.,* 2004; Nasim & Farhatullah, 2013). The lines showing high GCA exhibited additive type of gene action an early selection can be fruitful in early generation similar findings were revealed by (Roy *et al.,* 2002). However (Malano, 2008) reported that SCA alone will not be sufficient for the selection of the parent or development of the hybrids. The cross combination with high SCA estimates but low GCA exhibited the non-additive type of gene action. It seems true that the best general combiners did not mean that it always produce best hybrids (Kanga *et al.,* 2004). The present study revealed that three types of gene actions are present for the genetic insight of the traits under water stress and non-stress conditions e.g. additive, dominance and epistasis. Under water stress conditions the traits showed non-additive type of gene action except number of tillers/plant and flag leaf area, which demonstrated additive type of gene action. The results showed that significant additive and dominance effects made the water stress tolerance genetics in wheat highly complicated. It is therefore concluded that water stress has radical effects on morphological traits under the umbrella of genetic control. The traits flag leaf area, number of tillers can be used as selection benchmarks for the recognition of water stress tolerant genotypes. Moreover the genetic studies advocated that the selection for the traits showing additive type of gene action should be made in early generation. In contrast the traits having non-additive type of gene action, the heterosis breeding or delayed selection would be more beneficial to fix the trait in wheat. The material generated may be used in future breeding programme for the development of wheat cultivars best suited for water stress areas of Pakistan. This will ultimately boost up the overall wheat productivity in the country to feed the burgeoning population.

Table 4. Specific combining ability estimates (Absolute and relative) of various morphological traits in normal and water stress condition.

Crosses	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL	NL AB	WS AB	WS RL
	FLA	FLA	FLA	PH	PH	PH	NTP	NTP	NTP	SL	SL	SL	TGW	TGW	TGW	EY	EY	EY
Sehar06xV08172	0.28	1.22	2.53	-0.41	-0.49	-1.45	0.04	-0.18	-1.65	0.15	-0.44	-3.50	4.50	3.88	4.50	1.28	-1.09	-1.29
Sehar-06x MH-97	-0.13	-0.17	-3.45	0.08	-0.21	-1.23	-0.11	-0.05	0.03	-0.15	-0.23	-1.20	-1.90	-2.90	-1.90	0.57	1.26	1.13
Sehar-06x Punjab-81	-0.11	-0.05	1.11	0.32	0.7	2.68	0.16	0.24	1.62	-0.02	0.67	5.80	3.18	1.18	3.18	-1.84	-0.17	0.16
Chakwal-86xV08172	-0.08	-0.02	0.45	0.16	-0.31	-1.81	-0.09	-0.25	-1.97	0.07	0.05	0.30	3.68	1.68	3.68	-0.06	2.63	2.98
Chakwal-86x MH-97	0.14	0.15	2.22	-0.05	0.26	1.19	-0.10	0.38	2.93	0.09	0.42	2.49	-5.60	3.60	-5.60	-1.77	-0.79	-0.29
Chakwal-86x Punjab-81	-0.05	-0.13	-2.66	-0.11	0.06	0.62	0.20	-0.07	-1.56	-0.16	-0.47	-2.80	-5.46	-4.46	-5.46	1.82	-1.83	-2.04
Shafaq-06xV08172	0.008	0.05	1.87	-0.22	-0.31	-1.07	0.08	-0.05	-0.62	0.11	0.03	-0.22	0.78	4.78	0.78	1.79	-1.18	-1.17
Shafaq-06x MH-97	-0.13	-0.11	-1.53	-0.04	-0.51	-2.28	0.13	-0.20	-2.37	-0.09	-0.14	-0.38	2.58	1.58	2.58	0.35	-0.82	-0.84
Shafaq-06x PUNJAB-81	0.12	0.06	-0.35	0.26	0.83	3.35	-0.13	0.25	2.99	-0.02	0.11	0.60	-2.28	-3.28	-2.28	-2.14	1.99	2.02
Kohistan-97xV08172	-0.14	-0.18	-3.18	1.68	1.56	6.67	0.08	0.31	2.81	-0.03	-0.35	-1.42	0.51	0.51	0.51	1.77	2.25	1.35
Kohistan-97x MH-97	0.10	0.12	1.69	-0.38	-0.15	0.26	-0.01	-0.17	-1.49	-0.03	-0.15	-0.36	8.60	1.60	8.60	1.06	0.15	-0.22
Kohistan-97x Punjab-81	0.040	0.06	1.49	-0.22	-1.36	-5.93	-0.01	-0.15	-1.31	0.65	0.60	1.78	1.03	1.03	1.03	-2.82	-2.41	-1.13
Fsd-08xV08172	-0.044	-0.03	0.01	-0.27	-0.45	-1.43	0.08	0.09	0.63	-0.23	0.23	2.52	-1.66	-1.66	-1.66	0.28	0.75	0.63
Fsd-08x MH-97	-0.003	0.03	2.29	0.33	0.15	-0.22	0.08	-0.04	-0.48	0.44	0.21	0.31	-1.18	-1.18	-1.18	-2.43	-1.24	-0.58
Fsd-08x Punjab-81	0.047	-0.003	-2.30	-0.06	0.31	1.64	-0.12	-0.08	-0.15	-0.21	-0.44	-2.83	0.28	0.28	0.28	2.16	0.49	-0.05
Inqlab-91xV08172	0.015	-0.05	-1.51	0.13	0.05	0.08	0.01	0.08	0.81	0.21	0.48	2.32	8.00	4.91	6.31	-5.06	-3.37	-1.84
Inqlab-91x MH-97	0.0272	-0.01	-1.21	0.06	0.47	2.279	0.06	0.10	0.79	0.06	-0.12	-0.87	-1.19	-1.19	-1.19	2.23	1.44	0.79
Inqlab-91x Punjab-81	-0.042	0.06	3.72	-0.19	-0.53	-2.36	-0.07	-0.19	-1.60	-0.27	-0.36	-1.45	-0.07	-0.07	-0.07	2.82	1.92	1.05

Table 5. Estimates of V_D, V_A and potence ratio for absolute values under Normal and water stress condition in wheat.

Traits	NL(AB)	WS(AB)	WS(RV)	NL(AB)	WS(AB)	WS(RV)	NL(AB)	WS(AB)	WS(RV)
	DV	DV	DV	AV	AV	AV	V_D/V_A	V_D/V_A	V_D/V_A
FLA	0.061	0.076	5.96	0.091	0.078	13.25	0.66	0.86	0.42
PH	0.4104	2.6114	43.21	0.2936	0.3919	4.64	1.40	6.66	13.32
NTP	0.0493	0.0628	8.65	0.0853	0.098	4.12	0.58	0.64	2.10
SL	0.0045	0.042	36.05	0.016	0.067	6.09	0.43	1.30	6.10
TGW	0.289	0.1657	5.57	0.78	1.0766	10.76	1.66	5.86	5.86
EY	32.42	20.03	11.10	36.69	4.85	0.72	0.88	4.13	15.42

NL(AB)= Normal irrigation absolute value, WS(AB)= Water stress absolute value, WS(RV)= Water stress relative value, DV= Dominance variance, AV= Additive variance, FLA= Flag leaf area, PH= Plant height, NTP= No. of tillers/plant, SL= Spike length, TGW= 1000 grain weight, EY= Economic yield

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