Asian Journal of Plant Sciences

ISSN 1682-3974

Asian Journal of Plant Sciences 6 (2): 214-224, 2007
ISSN 1682-3974

Evaluation of Wheat Cultivars and Mutants for Morphological and Yield Traits and Comparing of Yield Components under Irrigated and Rain Fed Conditions

Behnam Naserian, Ali Akbar Asadi, Masood Rahimi and Mohammad Reza Ardakani
Nuclear Science and Technology Research Institute, (NSTRI),
Agriculture, Medicine and Industry Research School, Karaj, Iran

Abstract: Eight improved wheat cultivars and seventeen mutants of them were compared for morphological and yield traits in two conditions, irrigated and rain fed conditions during 2005-2006 using a 5×5 partially balanced lattice design, with two replications at the Nuclear Science and Technology Research Institute (NSTRI) Agriculture, Medicine and Industry research school of Karaj, Iran. Significant differences in irrigated condition were observed in flag leaf length, plant height, flag leaf node until spike distance, grain length, 1000 grain weight, harvest index and hectoliter weight and in rain fed condition significant differences were observed in flag leaf area, flag leaf length, plant heigh to number of node, flag leaf nod until spike distance, stem diameter number of grain per spike, grain length, 1000 grain weight, biomass, harvest, index and hectoliter weight. Tabassi and its mutants showed yield stability across rain fed condition. In irrigated condition biomass and harvest index had positive direct effect and plant height had the negative direct effect but in rain fed condition biomass. Harvest index and grain per plant weight had positive direct effect and plant height and number of grain per plant had the negative direct effect on yield of 1 m row

Key words: Path analysis, stepwise regression, multiple regression, irrigated, rain fed

INTRODUCTION

About 6.5 million hectares are grown to wheat in Iran, 2.5 million hectares are irrigated and 4 million hectares grown under rain fed condition. In 2003-2004 cropping season, the total production reached 14.6 million tones, 67% was produced in irrigated condition, average 3,827 kg ha^{-1} and 33% was produced in dry land condition, average 1/187 kg ha^{-1} (Jalal Kamali and Dveiller, 2006). Average grain yield remains low, because of drought, excessive cold in mountains area and high temperature during late spring in other areas and because of disease and insect pests (Roustai *et al*., 2005). Wheat is a widely adapted crop, it is grown from temperate irrigated to dry and high rainfall areas and from warm humid to dry cold environments (Acevedo *et al*., 2002; Zarea-fizabady and Ghodsi, 2004; Falconer and Mackay, 1996).

Abiotic stresses are the most limiting factors in wheat production. Improvement of yield under stress conditions therefore must combine the high yield potential and specific factors, which are able to protect the crop against reductions due to different stresses. (Cseuz *et al*., 2002; Zarea-Fizabady and Ghodsi, 2004).

Drought is probably most important factor controlling crop yield world wide. But yield reduction is mediated through reduced leaf growth (Ashraf and Nagavi, 1994; Ashraf 1998; Ephrath and Hesketh, 1991) and consequential lower photosynthetic productivity (Chen *et al*., 1993). Effect of rain fed on the plant growth process has been extensively reported. (Hsiao, 1973; Schulze, 1989; Brar *et al*., 1990; Iqbal *et al*., 1999; Siddique *et al*., 1999).

Wheat species and cultivars within species show substantial difference in their response to soil moisture (Rascio *et al*., 1992; Iqbal *et al*., 1999). Crop drought resistance is a major factor in the stabilization of crop performance in drought prone environments. Drought resistant is now considered by both breeders and molecular biologists as a valid breeding target. However, success in breeding for tolerance has been limited, because tolerance to stress is controlled by many genes and their simultaneous selection is difficult (Zhang *et al*., 2005) but increasing wheat production under abiotic stress conditions (salinity, drought and etc.,) has become important during recent years. Development of high yield wheat cultivars is the major objective of breeding programs. Influence of environment on genetic

Corresponding Author: Behnam Naserian, Nuclear Science and Technology Research Institute, Agriculture, Medicine and Industry Research School, Karaj, Iran

architecture of the plant become evident as its phenotypic appearance. Thus expression of plant traits depend upon the action of governing genes under prevailing environment (Alam *et al*., 1991). It has been widely evidenced that different genotypes respond differently to water shortage and hence based on this concept and genetic make of the plant varieties, variability in response to drought could be an appropriate criteria for plant selection under drought condition, therefore proper investigation on the recognition of yield criteria associated with drought tolerance is a priority issue in experiments under water shortage (Donaldson, 1996; Ehdaie, 1993; Hurd, 1996; Reynolds *et al*., 2002; Sarmadnia, 1993). Thus breeding for specific, suboptimal environments a deeper understanding of the yield determining process (Blum, 1996). This is where knowledge of crop responses to water deficits maybe best to use. The aim of the present study were to comparing performance of twenty five wheat cultivar and mutants regarding their yield components for obtaining maximum grain yield in two conditions and determine the direct and indirect effects of morphological and yield components on grain yield of 1 m rows in two conditions using path and regression analysis.

MATERIALS AND METHODS

The experiments were conducted in Nuclear Science and Technology Research Institute (NSTRI) Agriculture, Medicine and Industry Research School of Karaj, Iran, during the crop season 2005-2006. Twenty five wheat mutants and cultivars, such as Bezostaia, Inia, Tajan, Tajan Garm, Azadi, Pishtaz, Omid and its mutants (O-64-4 and O-64-1-1) and Tabassi and its mutants (T-66-58-7, T-67-60, T-65-9-1, T-66-58-8, T-65- 5-1, T-65-9-1P, T-65-7-1, T-65-4, T-65-58-10, T-66-58-9, T-65-6, T-66-58-6, T-66-58-60, T-66-58-12 and T-65-9-II) were sown in simple lattice design with two replications in two conditions, irrigated and rain fed condition. Each plot consisted of 4 row, with 3 m length and 60 cm rows distance. The distance between blocks and between replication was 1 and 3 m, respectively. The electrical conductivity of the soil was 67% ds m^{-2} with pH 8.2 and SAR (Sodium Absorption Ratio) 1.3. The soil was consisted of 30.6% clay, 36.4% silt and 33% sand. The data for Flag Leaf Area (FLA), Flag Leaf Length (FLL), Flag Leaf Width (FLW), Number of Fertile Tiller (NFT), Plant Height (PH), Fertile Spikelete per Spike (FSS), Spike Length (SL), Number of Node (NN), Flag Leaf Node until Spike Distance (FLNSD), Stem Diameter (SD), Grain Number per Main Spike (GNS), Grain Weight per Main Spike (GWS), Grain Number per Plant (GNP), Grain Weight per Plant (GWP), Grain Length (GL), 1000 Grain Weight (1000 GW), Biomass (B), yield of I m row (1MY), Harvest Index (HI) and Hectoliter Weight (HW), were recorded. Evaluation of grain yield and biomass by harvesting 1 m of 2 or 3 rows were executed. For each morphological and yield traits, 5 plants were measured. After planting the experiments one surface of irrigation was applied to maintain drought condition and eight time irrigation was applied to irrigated condition.

Analysis of variance was done and observation were compared by using Duncans multiple range test (Duncan, 1955). Spearman coefficient of correlation and parameters of linear regression as well as stepwise regression were calculated using mean values of characters from two conditions. Direct and indirect effects of component characters (morphological and yield traits) on yield of 1 m row were worked out using path coefficient analysis (Dewey and Lu, 1959). Analysis of variance, correlation, path analysis, multiple regression and stepwise regression obtained using of statistical analysis system (SAS institute, Release 6/12) and MSTATC (1990) programs. For evaluation of drought tolerance SSI or stress susceptibility index was calculated as follows:

SSI = [1 - (Ydi / Ypi) / SI] SI = YD/YP

SSI = Stress Susceptibility Index
SI = Stress Intensity
YD = Yield average under stress
YP = Yield average under irrigated condition
Ydi = Yield of each genotype under stress
Ypi = Yield of each genotype under irrigated condition

RESULTS AND DISCUSSION

Analysis of variance: The analysis of variance separately conducted for each environment, indicated significant differences among the cultivars and mutants for flag leaf length, plant height, flag leaf node until spike distance, grain length,100 grain weight, harvest index and hectoliter weight in irrigated condition and flag leaf area and length, plant height, number of fertile spikelete per spike, number of node, flag leaf node until spike distance, stem diameter, number of grain per main spike, grain length, 1000 grain weight, biomass, harvest index and hectoliter weight in rain fed condition (Table 1). Eshghi and Khalilzadeh (2006) reported that under rain fed conditions, plant height, peduncle length, spike number per unit row, seed number per main spike, harvest index and number of tillers was significantly different but seed yield, fertile spike number, seed number, seed weight per plant and biomass did not show significant difference. In the other word under irrigated condition, plant height, peduncle length and seed number per main spike had significant differences but harvest index, biomass, seed yield, total number of tillers, fertile tillers, number and seed weight per main spike did not show significant differences.

Table 1: Analysis of variance for morphological and yield treats under irrigated and rain fed conditions

	MST		$\bar{X}$ ±SD		MSE		CV (%)		LSD 50%	
Parameters	Irrigated	Rain fed	Irrigated	Rain fed	Irrigated	Rain fed	Irrigated	Rain fed	Irrigated	Rain fed
FLA	165131.06^{ns}	250669.63**	1973±118.61	2209.57±146.18	121579.52	107630.33	17.67	14.85	739.17	695.47
FLL	56.67*	94.37**	17.64±0.695	19.96±8.97	20.49	26.42	8.12	8.47	30.34	34.45
FLW	2.79^{ns}	1.34^{ns}	1.376±0.49	1.39±0.34	1.66	1.23	1.18	7.93	2.73	2.35
NFT	1.99^{ns}	1.33^{ns}	5.2±0.41	4.78±0.34	2.46	1.15	30.15	22.47	3.24	2.28
PH	604.3**	335.72**	113.8±7.18	103.086±5.35	40.54	108.49	5.60	10.10	13.49	21.49
FSS	10.01^{ns}	5.04*	15.82±0.92	5.62±0.656	7.73	2.14	17.57	9.37	5.73	3.10
SL	1.18^{ns}	5.39^{ns}	8.89±0.32	9.35±0.68	0.94	5.795	10.90	25.75	2.055	4.97
NN	0/1^{ns}	0.14*	4.52±.09	4.34±0.11	0.09	0.05	6.52	5.29	0.62	0.49
FLNSD	61.87*	39.93**	40.78±2.3	34.52±1.84	12.69	11.51	8.73	9.83	7.55	7.19
SD	0.56^{ns}	0.18**	3.06±0.22	2.64±0.13	0.45	0.07	22.01	10.01	1.39	0.54
GNS	91.71^{ns}	117.37**	33.96±2.79	32.52±3.16	60.25	41.82	22.85	19.89	16.45	13.35
GWS	0.15^{ns}	0.33^{ns}	1.76±0.11	1.35±0.17	0.15	0.41	21.86	37.68	0.81	1.32
GNP	2104.33^{ns}	1920.44^{ns}	143.56±13.39	120.45±12.79	3301.81	1208.07	40.02	28.85	118.59	73.68
GWP	5.71^{ns}	2.58^{ns}	7.37±0.7	4.58±0.47	8.51	2.42	39.54	33.97	6.02	3.29
GL	0.52**	0.5**	7.11±0.21	6.81±0.21	0.09	0.12	4.25	5.01	0.62	0.72
1000GW	79.25**	40.2**	51.24±2.6	38.22±1.85	6.83	9.52	5.10	8.07	5.39	6.37
B	0.06^{ns}	0.07**	1.13±0.07	0.87±0.07	0.04	0.01	18.11	12.33	0.43	0.23
1MY	0.01^{ns}	0.004^{ns}	0.35±0.03	0.24±.0002	0.005	0.002	20.71	18.17	0.15	0.09
HI	20.61*	47.18**	31.58±1.32	28.49±2.01	9.302	12.36	9.66	12.34	6.46	7.45
HW	7.73*	13.76**	72.75±0.81	69.7±1.08	3.39	3.22	2.53	2.58	3.799	3.81

Flag Leaf Area: FLA; Flag Leaf Length: FLL; Flag Leaf Width: FLW; Number of Fertile Tiller: NFT; Plant Height: PH; Fertile Spikelete per Spike: FSS; Spike Length: SL; Number of Node: NN; Flag Leaf Node Until Spike Distance: FLNSD; Stem Diameter: SD; Grain Number per Main Spike: GNS; Grain Weight per Main Spike:GWS; Grain Number per Plant: GNP; Grain Weight per Plant: GWP; Grain Length: GL; 1000 Grain Weight:1000GW; Biomass: B; Yield of 1 m Row: 1MY; Harvest Index: HI; Hectoliter weight: HW; **, * and ns significant at 0.01; 0.05 and non significant

Flag leaf area, length and width: In irrigated condition the maximum flag leaf area, length and width was observed in Bezostaia, T-65-7-1, T-66-58-60 and Azadi whereas in rain fed condition the maximum flag leaf area, length and width was observed in Bezostaia, T -67-60, omid, T-65-58-10, T66-58-9 and T-65-6. Bezostaia in two condition have the highest flag leaf area and length and differed significantly from other cultivars and mutants.

Number of fertile tiller: In irrigated condition maximum number of fertile tiller was produced by T-67-60, T-65-4 and T-65-6 but in rain fed condition Omid, T-65-9-2, T-65-58-6 and T-65-5-1 was produced maximum fertile tiller, respectively.

Height and flag leaf node until spike distance: Maximum plant height was recorded for Omid in irrigated that taller than other cultivars and mutants whereas in rain fed condition T-65-58-10 was taller than other cultivars and mutants. Flag leaf node until spike distance in Tabassi and T-65-60 in both conditions was higher than other genotypes. In stress condition T-65-5-1 had no significant difference with Tabassi and T-65-60.

Spike length and number of fertile spikelete per spike: In irrigated condition maximum spike length was observed in Omid, O-64-1-1, O-64-4, T-66-58-12, Azadi and T-65-9-II whereas in rain fed condition was observed in Omid, T- 65-4, O-64-4, O-64-1-1 and Azadi. Maximum number of fertile spikelete per spike in irrigated condition was produced by O-64-1-1, T-65-4, T-66-58-12 and Azadi whereas in rain fed was produced by Omid, Bezostaia, T-65-5-1 and O-64-4.

Number and weight of grain per main spike: The results pertaining to number of grains per spike and weight in spike revealed that in irrigated condition Azadi, O-64-4, O-64-1-1 and Pishtaz produced maximum number of grains per main spike, moreover this genotype had the greatest grain weight per main spike, but in rain fed condition Omid O-64-1-1, T-65-5-1, O-64-4-1 and Azadi produced maximum number of grain per main spike and also produced the greatest grain weight per spike.

Number of grain per plant and grain weight per plant: The results pertaining to number of grain per plant and grain per plant weight revealed that O-64-4-1, T-65-6, T-66-58-9 and T-65-4 produced the maximum number grain per plant and had greatest grain per plant weight in irrigated condition. But in rain fed condition Omid, T-65-5-1, Tajan Garm and O-64-4 produced the maximum of grain number per plant and had greatest grain weight per plant.

1000 grain weight: In irrigated condition maximum 1000 grain weight was observed in T-66-58-9, T-66-58-12, T-66-58-8, T-65-7-1 and T-65-58-10. But in rain fed condition maximum 1000 grain weight was observed in T-65- 6, T-65-7-1, T-66-58-60 and Tajan. Seed size had not any differentiation on germination but affects growth, development and yield. Bigger seeds have several advantages when compared to smaller seeds, such as faster seedling growth, higher number of fertile tillers per plant and higher grain yield (Spilde, 1989). The advantage of bigger seeds particularly is shown when the crop is grown under environmental stresses (Mian and Nazfiger, 1994).

Biomass: It is evident from the data that in irrigated condition no significant differences were found among different cultivars and mutants. For their biomass the maximum average biomass was produced by T-65-7-1, Inia and T-65-58-10. But in rain fed condition significantly different were found among different mutants and cultivars. The maximum average of biomass was produced by Tabassi, T-65-7-1 and T-66-58-9. Razzaq *et al.* (1986) observed non significant differences in the biomass among various cultivars in irrigated condition.

Harvest index: the ability of variety to convert the total dry matter in to economic yield is indicated by its harvest index value (Akhtar *et al*., 2001). In irrigated condition the maximum harvest index value was obtained by Azadi, Tajan, O-64-4, O-64-1-1 and Tajan Garm whereas in rain fed condition was obtained by Tajan, Tajan Garm, 0-64-1-1 and 0-64-4.

Hectoliter weight: Phishtaz, Tajan, O-64-4 and Tajan Garm in irrigated condition and Tajan, Pishtaz, Tajan Garm, Bezostaia and Tabassi in rain fed condition had highest hectoliter weight.

Yield of 1 m row: No significant differences were found among different cultivars and mutants in irrigated condition. However, The maximum average of yield of 1m row produced by O-64-1-1, T-65-9-1P, Inia and T-65-58-10 whereas significantly differences were found among cultivar and mutants in rain fed condition. Tajan, Azadi and T-65-7-1 was produced the highest average of grain yield of 1 m row.

Rain fed condition reduced number of fertile tiller, height, number of spikelete per spike, number of node, flag leaf node until spike distance, stem diameter, number of grain per main spike, grain weight per main spike, number of grain per plant, grain weight per plant, grain length, 1000 grain weight, biomass, yield of 1 m row, harvest index and hectolitre weight. Whereas flag leaf area, length and width and spike length were not affected significantly. Dastfal and Ramazanpoor (2000) and Zarea and Ghodsi (1998) have concluded that water deficit reduced almost all yield components of wheat including 1000 kernel weight, number of seeds per spike, number of spike per m^2 and harvest index. Villareal *et al.* (1998) reported that variation in water regimes causes different responses in the genotypes harvest index. Reduction in grain yield depends on the genotype cultivated and the physiological stage of the plants during water stress. Under water stress condition, most tillers abort or linger to form green, immature, nuisance heads at harvest stage, thus plant traits of the main tiller may play Important role in determining the grain yield. Arnau and Monnevoux, (1995) reported that taller plants under non limiting water conditions normally have lower grain yield potential caused by higher loading, lower number of spikes per m^{-2} and inferior harvest index. Long necker *et al.* (1993) suggested that tillering is controlled by genetic and environmental factors. Peterson *et al.* (1984) and Rickman and Klepper (1991) concluded that tillering is very sensitive to water stress. As a result, leaf are a index development is the most affected physiological process during this stage.

The difference in plant height among various cultivars and mutants lines were in general, due to their genetic constitution (Akhtar *et al*., 2001). The decrease in plant height in response to water may be due to decrease in relative turgidity and dehydration of protoplasm, which is associated with a loss of turgor and reduced expansion of cell and cell division (Arnon, 1972). The decrease in stem height and ear length due to rain fed has been reported by Guinta *et al.* (1993) and Iqbal *et al.* (1999). Acevedo *et al.* (2002) reported that the number of kernels per components floret in environmental stress such as sever water stress may induce sterility and reduce grain seed. Clarke *et al.* (1991) and Ashraf *et al.* (1996) reported that Plant reduce their maximum biomass under adequate water supply, whereas moisture stress causes a marked decrease in plant biomass production. Hence in addition to other factors, dry matter production can be used as selection criteria for drought tolerance. Drought tolerance was evaluated for cultivar and mutant lines by method proposed by Fisher and Maurer (1978). Stress intensity was 0/698. In other words average yield of cultivars and mutants reduced about 30/79%. T-65-5-1, Pishtaz, T- 65-6 and Tajan were more flexible under raifed condition. There is unanimous agreement and no denying for the fact that yield of the plant in drying soil is reduced even in tolerant genotypes (Leinhos and Bergman. 1995; EL-Far and Allam, 1995).

Correlation analysis: Regardless of correlation coefficient (Table 2), yield of 1 m row had positive correlation with biomass and harvest index in two conditions. Other positive and significant correlation were observed between number of tiller with number of grain per plant and grain per plant weight, between height with

Table 2: Phenotypic correlation coefficient of morphological and yield traits in wheat cultivars and mutants under irrigated and rain fed condition

Parameters	Condition	FLA	FLL	FLW	NFT	PH	FSS	SL	NN	FLNSD	SD
FLA	Irrigated	1.00									
	Rain fed	1.00									
FLL	Irrigated	0.11	1.00								
	Rain fed	**0.74****	1.00								
FLW	Irrigated	**0.65****	-0.19	1.00							
	Rain fed	**0.63****	**0.40***	1.00							
NFT	Irrigated	-0.31	-0.43	-0.14	1.00						
	Rain fed	**0.51****	0.20	0.31	1.00						
PH	Irrigated	0.03	0.27	-0.20	0.20	1.00					
	Rain fed	**0.43****	0.36	-0.06	**0.42***	1.00					
FSS	Irrigated	0.17	-0.07	0.16	0.23	0.17	1.00				
	Rain fed	0.37	**0.47***	0.24	0.19	0.12	1.00				
SL	Irrigated	0.31	0.07	-0.30	-0.23	-0.12	0.19	1.00			
	Rain fed	0.20	0.15	-0.09	-0.11	-0.02	0.12	1.00			
NN	Irrigated	-0.13	-0.28	0.12	**0.44***	0.37	0.00	-0.12	1.00		
	Rain fed	0.90	-0.01	-0.18	0.30	0.33	0.13	0.06	1.00		
FLNSD	Irrigated	0.10	0.23	-0.25	0.10	**0.83****	0.07	-0.01	0.04	1.00	
	Rain fed	0.35	0.33	0.04	0.18	**0.82****	0.12	0.00	-0.04	1.00	
SD	Irrigated	0.14	0.06	0.06	0.10	0.18	-0.02	0.02	0.15	0.31	1.00
	Rain fed	0.38	**0.49***	0.30	0.13	**0.49***	**0.55****	0.01	-0.02	**0.55****	1.00
GNS	Irrigated	0.18	0.16	-0.18	-0.21	**-0.41***	0.25	**0.78****	-0.31	-0.14	-0.02
	Irrigated	0.24	0.28	0.31	-0.10	0.11	**0.74****	0.17	-0.12	0.16	**0.45***
GWS	Rain fed	0.11	-0.19	-0.18	0.00	0.04	0.22	**0.72****	-0.12	0.33	0.30
	Irrigated	0.01	0.18	0.04	0.30	0.15	0.10	-0.13	-0.05	0.27	0.21
GNP	Rain fed	0.11	**-0.53****	-0.15	**0.59****	-0.33	0.29	0.39	0.06	-0.19	0.06
	Irrigated	**0.47***	0.32	**0.56****	**0.54****	0.05	**0.70****	0.00	-0.04	0.17	0.36
GWP	Rain fed	-0.09	**-0.54****	-0.10	**0.74****	0.06	0.20	0.21	0.22	0.19	0.33
	Irrigated	0.47*	0.18	**0.44***	**0.73****	0.38	**0.49***	-0.14	0.07	**0.46***	**0.42***
GL	Rain fed	0.06	-0.06	-0.09	0.33	**0.63****	-0.14	-0.25	0.31	**0.58****	0.32
	Irrigated	0.09	0.08	-0.22	0.27	**0.75****	-0.34	-0.02	0.27	**0.59****	0.21
1000GW	Rain fed	0.16	0.00	0.13	0.31	**0.62****	-0.13	-0.27	0.27	**0.64****	**0.48***
	Irrigated	-0.01	-0.24	-0.22	0.24	**0.62****	-0.31	-0.18	0.16	**0.57****	0.17
B	Rain fed	-0.11	0.22	0.00	0.02	0.02	-0.12	-0.06	0.26	-0.02	0.11
	Irrigated	0.12	0.35	-0.12	-0.14	0.12	-0.29	-0.20	0.23	0.13	-0.05
1MY	Rain fed	0.04	0.28	0.05	-0.15	-0.37	-0.08	0.15	0.02	-0.33	0.14
	Irrigated	-0.33	-0.26	-0.03	**-0.48***	-0.35	-0.36	-0.26	0.01	-0.04	-0.08
HI	Rain fed	0.35	0.12	0.16	-0.35	**-0.67****	0.09	0.38	-0.32	**-0.53****	0.06
	Irrigated	**-0.50****	**-0.57****	0.04	**-0.45***	**-0.52****	-0.10	-0.03	-0.30	-0.19	-0.05
HW	Rain fed	0.07	0.02	-0.02	-0.39	**-0.52****	-0.13	0.07	**-0.59****	-0.30	-0.21
	Irrigated	-0.04	0.03	0.20	-0.17	-0.15	0.11	-0.21	**-0.42****	0.11	0.21

Parameters	Condition	GNS	GWS	GNP	GWP	GL	1000GW	B	1MY	HI	HW
GNS	Irrigated	1.00									
	Irrigated	1.00									
GWS	Rain fed	**0.76****	1.00								
	Irrigated	0.33	1.00								
GNP	Rain fed	**0.61****	**0.51****	1.00							
	Irrigated	**0.70****	0.36	1.00							
GWP	Rain fed	0.29	**0.58****	**0.83****	1.00						
	Irrigated	0.40	**0.52****	**0.83****	1.00						
GL	Rain fed	**-0.41***	0.11	-0.21	0.27	1.00					
	Irrigated	**-0.47***	-0.04	-0.33	0.05	1.00					
1000GW	Rain fed	**-0.47***	0.17	-0.23	0.34	**0.82****	1.00				
	Irrigated	**-0.44***	0.23	-0.30	0.27	**0.72****	1.00				
B	Rain fed	-0.27	-0.26	-0.17	-0.13	0.15	0.13	1.00			
	Irrigated	-0.26	**-0.42***	-0.39	-0.29	0.22	0.10	1.00			
1MY	Rain fed	0.09	-0.14	0.01	-0.17	-0.16	-0.20	**0.84****	1.00		
	Irrigated	-0.01	-0.21	-0.31	-0.25	-0.12	-0.06	**0.53****	1.00		
HI	Rain fed	**0.60****	0.20	0.25	-0.11	-0.53	**-0.53****	-0.14	**0.41***	1.00	
	Irrigated	0.29	0.14	0.04	-0.03	-0.38	-0.09	-0.37	**0.58***	1.00	
HW	Rain fed	**0.43***	0.14	0.15	-0.10	-0.61	-0.47*	-0.41*	-0.15	0.43	1.00
	Irrigated	0.29	0.22	0.13	0.17	-0.32	0.04	-0.04	0.38	**0.5***	1.00

Flag Leaf Area: FLA; Flag Leaf Length: FLL; Flag Leaf Width: FLW; Number of Fertile Tiller: NFT; Plant Height: PH; Fertile Spikelete per Spike: FSS; Spike Length: SL; Number of Node: NN; Flag Leaf Node Until Spike Distance: FLNSD; Stem Diameter: SD; Grain Number per Main Spike: GNS; Grain Weight per Main Spike:GWS; Grain Number per Plant: GNP; Grain Weight per Plant:GWP; Grain Length: GL; 1000 Grain Weight:1000GW; Biomass: B; Yield of 1 m Row: 1MY; Harvest Index: HI; Hectoliter weight: HW. **; * and ns significant at 0.01; 0.05 and non significant grain length and 1000 grain weight and between harvest index with hectoliter weight in two conditions. Negative and significant correlation were observed between harvest index with height, number of grains per spike with 1000 grain weight and grain length in two conditions. No association was found between flag leaf area, length and width with yield of 1m row in two conditions. Regarding the effect of flag leaf on grain yield contradictory results are reported in the literature. Okuyama *et al.* (2004) reported that significant and negative correlation was observed between flag leaf length and spike length. Hsu and Walton (1971) indicated that no significant correlation was found between flag leaf blade length and grain yield or components of yield in parental, F1 and F2 populations in field spaced plants. On the other hand Monyo and Whittington (1973) reported that positive correlation was found between flag leaf area and grain yield in wheat plants under greenhouse condition. In rain fed condition grain per plant weight had a positive and significant correlation with stem diameter. A thicker tiller might reduce lodging and allow greater water and nutrient material flow in the plant. In irrigated condition spike length was significantly correlated with number of grain per main spike and grain per main spike whereas in rain fed condition there was not significantly correlation between spike length with other characters. The correlation studies of the present paper showed that to increase grain per main spike weight in irrigated condition the most important traits are spike length and number of grain per main spike. For increasing grains per plant weight in irrigated condition the most important traits are number of tiller, grain per main spike weight, number of grain per plant and flag leaf length and in rain fed condition the most important traits are number of tiller, number of grains per plant, grain per main spike weight, stem diameter and flag leaf area. To increasing yield of 1 m row in irrigated condition the most important traits are number of tiller, grain per main spike weight, number of grain per plant and flag leaf length and in rain fed condition the important traits are number of tiller, number of grain per plant, grain per main spike weight, stem diameter and flag leaf area. To increase yield of lm row in irrigated condition the most important trait is biomass but in rain fed condition the most important traits are biomass and number of tiller. Moghaddam *et al.* (1997) reported that among morphological characters, there is a lower positive correlation between plant height and spike length. Spike length has low positive influence on 1000 grain weight and grain weight per spike whereas increased plant height results in lower HI. Our results confirmed this reports.

Path analysis: Yield components and plant traits contribution on grain yield may be important for breeding strategies. Simple correlation analysis that relates grain yield to a single variable may not provide a complete understanding of the importance of each component in determining grain yield. Path coefficient analysis allows an effective means of partitioning correlation coefficients into unidirectional pathway and alternate pathway. This analysis permits a critical examination of specific factors that produce a given correlation and can be successfully employed in formulating an effective selection strategy (Okuyama *et al.*, 2004). Path coefficient analysis for morphological traits (Table 3) under irrigated condition revealed that flag leaf length and number of node had positive direct effect and plant height had negative direct effect on yield of 1 m row. Under stress conditions distance of flag leaf node until spike had positive direct effect and plant height had negative direct effect on yield of 1 m row, but due to indirect effect through other plant traits, the total correlation was very low. In irrigated condition flag leaf length and width had a positive indirect effect and number of node and distance of flag leaf node until spike had negative indirect effect through plant height on yield of 1 m row. But in rain fed condition flag leaf area and length, number of tiller, number of node, flag leaf node until spike distance and stem diameter had negative indirect effect through plant height on yield. Under both conditions height were associated with yield. For the yield component traits path analysis revealed that in irrigated condition biomass and harvest index had positive direct effect on yield and under rain fed condition grain per plant weight, harvest index and biomass had positive direct effect and number of grain per plant had negative direct effect on yield (Table 4). In irrigated condition number of grain per main spike, grain per spike weight and hectoliter weight had negative indirect effect through biomass and number of grain per plant and hectoliter weight had positive indirect effect and grain length and 1000 grain weight had negative indirect effect through harvest index on yield. In rain fed condition, number of grain per main spike, grain per spike weight and grain per plant weight had negative indirect effect and grain length and biomass had positive indirect effect on yield. Number of grain per main spike, number of grain per plant and grain per main spike weight through grain per plant weight and hectoliter weight through harvest index had positive indirect effects and grain length through 1000 grain weight, grain per spike weight through biomass and grain length and biomass through harvest index had negative indirect effect on yield. Slaffer and Andrade (1991) explained that genetic improvement

Table 3: Path analysis based on phenotypic correlation coefficient for morphological traits under irrigated and rain fed condition

Parameters	Condition	FLA	FLL	FLW	NFT	PH	FSS	SL	NN	FLNSD	SD	Corr.
FLA	Irrigated	**(0.09)**	0.072	-0.025	-0.036	-0.027	-0.007	0.003	-0.071	0.029	0.013	0.044
	Rain fed	**(0.298)**	0.001	-0.135	-0.122	-0.589	-0.203	-0.072	-0.033	0.31	0.147	-0.329
FLL	Irrigated	0.059	**(0.651)**	0.007	-0.051	0.271	-0.003	0.006	-0.148	0.068	0.005	0.277
	Rain fed	0.221	**(0.001)**	-0.085	-0.048	-0.488	-0.255	-0.054	0.002	0.289	0.192	-0.22
FLW	Irrigated	0.058	-0.123	**(-0.038)**	-0.016	0.224	-0.007	-0.025	0.063	-0.074	0.005	0.048
	Rain fed	0.189	0.00	**(-0.214)**	-0.076	0.081	-0.131	0.03	0.066	0.036	0.117	-0.03
NFT	Irrigated	-0.028	-0.282	0.005	**(0.118)**	-0.205	-0.01	-0.019	0.232	0.03	0.0097	-0.147
	Rain fed	0.151	0.00	-0.067	**(-0.241)**	-0.582	-0.104	0.04	-0.113	0.158	0.049	-0.48
PH	Irrigated	0.0024	0.176	0.008	0.026	**(-1.017)**	-0.008	0.005	0.032	0.245	0.017	-.365
	Rain fed	0.128	0.00	0.013	-0.102	**(-1.375)**	-0.064	0.006	-0.124	0.728	0.19	-0.347
FSS	Irrigated	0.01	0.046	-0.006	0.027	-0.169	**(-0.045)**	0.017	0.109	0.022	-0.002	-0.084
	Rain fed	0.111	0.00	-0.052	-0.047	-0.164	**(-0.542)**	-0.042	-0.049	0.109	0.214	-0.357
SL	Irrigated	0.003	0.046	0.112	-0.027	0.12	-0.009	**(0.085)**	-0.062	0.00	0.002	0.154
	Rain fed	0.06	0.00	0.018	0.0275	0.0234	-0.065	**(-0.353)**	-0.022	0.009	0.003	-0.26
NN	Irrigated	-0.012	0.182	-0.005	0.051	-0.38	-0.009	0.01	**(0.533)**	0.011	0.013	0.01
	Rain fed	0.026	0.00	0.038	-0.073	-0.456	-0.0715	-0.021	**(-0.375)**	-0.031	-0.009	-0.224
FLNSD	Irrigated	0.009	0.151	0.01	0.012	-0.845	-0.003	0.00	0.019	**(0.295)**	0.029	-0.325
	Rain fed	0.104	0.00	-0.008	-0.043	-1.125	-0.067	0.00	0.013	**(0.89)**	0.213	-0.044
SD	Irrigated	0.013	0.036	-0.002	0.012	-0.186	0.001	0.002	0.078	0.092	**(0.093)**	0.139
	Rain fed	0.113	0.00	-0.064	-0.031	-0.671	-0.297	-0.003	0.009	-0.487	**(0.39)**	-0.044

Flag Leaf Area: FLA; Flag Leaf Length: FLL; Flag Leaf Width: FLW; Number of Fertile Tiller: NFT; Plant Height: PH; Fertile Spikelete per Spike: FSS; Spike Length: SL; Number of Node: NN; Flag Leaf Node Until Spike Distance: FLNSD; Stem Diameter: SD. Data on parenthesis are related to indirect effect; Residual effect on irrigated condition = 0.476; Residual effect on rain fed condition = 0.632. Corr.: correlation coefficient

Table 4: Path analysis based on phenotypic correlation coefficient yield traits under irrigated and rain fed condition

Parameters	Condition	GNS	GWS	GNP	GWP	GL	1000GW	B	HI	HW	Corr.
GNS	Irrigated	**(-0.128)**	0.066	0.044	0.021	0.018	-0.017	-0.244	0.326	-0.004	0.084
	Rain fed	**(0.112)**	-0.026	-0.762	0.377	-0.006	0.184	-0.196	0.251	-0.011	-0.006
GWS	Irrigated	-0.097	**(0.087)**	0.036	-0.025	0.004	-0.019	-0.235	0.109	-0.001	-0.142
	Rain fed	0.037	**(-0.077)**	-0.36	0.477	0	-0.096	-0.312	0.122	-0.009	-0.211
GNP	Irrigated	-0.078	0.044	**(0.072)**	-0.036	-0.008	0.026	-0.152	0.138	-0.002	0.004
	Rain fed	0.086	-0.028	**(-0.989)**	0.769	-0.004	0.125	-0.292	0.038	-0.005	-0.309
GWP	Irrigated	-0.037	0.05	0.059	**(-0.044)**	0.01	-0.037	-0.115	-0.097	0.057	-0.171
	Rain fed	0.045	-0.039	-0.816	**(0.933)**	0.001	-0.115	-0.216	-0.029	-0.006	-0.246
GL	Irrigated	0.053	0.01	-0.016	-0.012	**(0.036)**	-0.092	0.14	-0.286	0.005	-0.161
	Rain fed	-0.053	0.003	0.329	0.0485	**(0.012)**	-0.303	0.162	-0.336	0.012	-0.124
1000GW	Irrigated	0.061	0.015	-0.017	-0.015	0.03	**(-0.111)**	0.116	-0.286	0.004	-0.203
	Rain fed	-0.049	-0.017	0.293	0.254	0.009	**(-0.423)**	0.077	-0.083	-0.002	0.059
B	Irrigated	0.034	-0.022	-0.012	0.006	0.007	-0.014	**(0.934)**	-0.077	0.004	0.837
	Rain fed	-0.029	0.032	0.385	-0.269	0.003	-0.044	**(0.751)**	-0.304	0.002	0.529
HI	Irrigated	-0.077	0.017	0.018	0.005	-0.019	-0.006	-0.129	**(0.544)**	-0.004	0.414
	Rain fed	0.032	-0.011	-0.043	-0.031	0.005	0.039	-0.26	**(0.879)**	-0.019	0.581
HW	Irrigated	-0.055	0.012	0.011	0.005	-0.022	0.049	-0.373	0.234	**(-0.001)**	-0.148
	Rain fed	0.032	-0.017	-0.133	0.155	-0.004	-0.017	-0.034	0.395	**(-0.039)**	0.383

Grain Number per Main Spike: GNS; Grain Weight per Main Spike: GWS; Grain Number per Plant: GNP; Grain Weight per Plant: GWP; Grain Length: GL; 1000 Grain Weight:1000GW; Biomass: B; Yield of I m Row: 1MY; Harvest Index: HI; Hectoliter weight: HW. Data on parenthesis are related to indirect effect Residual effect on irrigated condition = 0..99; Residual effect on rain fed condition = 0.94. Corr.: correlation coefficient

of grain yield in winter wheat has been closely associated with increase in harvest index, but not with increases in total biomass. Wallace *et al*. (1993) warned that the trend of achieving higher grain yield by increasing harvest index is not sustainable and recommended total biomass be considered in breeding programs to assure long-term yield improvement. The three grain yield components, spike per unit, kernel per spike and kernel weight, spike per unit and kernel per spike generally are the most important determinants of grain yield (Knapp and Knapp, 1978; Shah *et al*., 1994). The positive direct effects of number of heads per plant, number of grain per head, grain weight and harvest index on grain yield has been reported in wheat (Ehdaie and Waines, 1989). Golabadi *et al*. (2005) reported that path analysis revealed that biological yield and number of spike per m^2 had the greatest positive and negative direct effect on yield, under non stress environment and one thousand grain weight also had a high direct effect on yield. In stress environment, path analysis revealed that 1000 grain weight and number of grain per spike had the greatest positive direct effect on yield, but there were high indirect effects. Ehdaie and Waines (1989) reported that plant height, number of heads per plant, number of grains per head, 1000 grain weight and harvest index each had a positive direct effect on grain yield. But plant height exhibited the lowest direct effect. The positive direct effects of plant height and number of head plant, however were partially or completely counter-balanced by their strong negative indirect effects through number of grains per head, 1000 grain weight and harvest index. Zaheer (1991) suggested that selection for high yield might be effective by simultaneous improvement of yield determinants like plant height, number of tillers per plant and number of grains per spike and yield could be increased through the selection of plant with more spikelets per spike. Paroda and Joshi (1970) reported that high positive correlation of 1000 grain weight and grain per spike with grain yield per plant was the result of high positive indirect effect of grain weight per spike. Okuyama *et al.* (2004) reported that yield per spike correlated positively with spike length and stem diameter. Path coefficient analysis indicated that, under irrigated condition yield per spike had a positive direct effect and a positive correlation with spike length and stem diameter, under non irrigated condition yield per spike showed a positive direct effect and a positive correlation with culm diameter, spike length and plant height. Van Ginkel *et al.* (1998) stated that for each pattern of rain fed, a particular and often different plant trait contributed to specific adaptation to the distinct rain fed condition. Rane (2001) indicated that in India, the ear: stem ratio was not as efficient as harvest index in selecting for drought susceptible and tolerant wheat genotypes. Okuyama and Federizzi (2005) reported that under irrigated condition, flag leaf length, peduncle extrusion length and sheath length had a high direct positive effect on yield per spike, but due to the negative effect through other plant traits, the total correlation was very low. Kumar and Hunshal (1998) observed in durum wheat that harvest index, total dry matter, effective tiller, number of grain per spike and weight per spike were the most important components of grain yield.

Regression analysis: In the next step the effects of morphological and yield traits on yield of 1 m row were estimated by means of multiple regression and stepwise regression analysis, the results are complied in Table 5 and 6. Results of stepwise regression analysis indicated that in irrigated condition for morphological traits, yield of 1 m row was determined by plant height, flag leaf length and number of node (coefficient of determination R^2 = 13, 28 and 41%) and for yield traits yield of 1 m row was determined by biomass, harvest index and 1000 grain yield (coefficient of determination R^2 = 70, 98 and 99%) whereas in drought stress condition yield of 1 m row was determined by number of tiller and spike length (R^2 = 23 and 33%, respectively) and for yield traits yield of 1 m row was determined by harvest index and biomass (R^2 = 34 and 94%). Results of multiple regression analysis indicated that in irrigated condition for morphological traits, yield of 1 m row was determined by flag leaf length and plant height and for yield traits was determined by biomass and harvest index. Under rain fed condition for morphological traits, yield of 1 m row was determined by plant height, number of tiller and distance of flag leaf node until spike and for yield traits was determined by number of grains per plant, grain per plant weight, biomass and harvest index. Results of path analysis were confirming than from multiple regression analysis but were less confirming than from stepwise regression analysis, probably due to interactions among characters appraised in regression. Vishwakarma *et al.* (2002) reported that multiple regression analysis serves an effective solution for improvement of wheat yield through some adequate models. Four adequate were selected and most important character affecting the biological yield per plant was spike height per plant.

Water stress in wheat changes patterns of plant growth and developed. Depressed water potential suppresses cell division, organ growth, net

Table 5: Stepwise and multiple regression of morphologic traits (independent variables) on the yield (dependent variables) under irrigated and rain fed condition

	Stepwise regression						Multiple regression			
	Irrigated			Rain fed			Irrigated		Rain fed	
Parameters	Step	R^2	Cr	Step	R^2	Cr	Cr	Prob>F	Cr	Prob>F
FLA	-	-	-	-	-	-	0	0.77	0	0.48
FLL	2	0.28	0.021	-	-	-	0.024	0.03	0	0.99
FLW	-	-	-	-	-	-	-0.002	0.92	-0.011	0.48
NFT	-	-	-	1	0.2306	-.0286	0.007	0.67	-0.013	0.32
PH	1	0.133	-0.0024	-	-	-	-0.004	0.08	-0.004	0.01
FSS	-	-	-	-	-	-	-0.001	0.84	-0.015	0.03
SL	-	-	-	2	0.33	-0.0088	0.007	0.74	-0.009	0.08
NN	3	0.41	0.117	-	-	-	0.147	0.12	0.065	0.11
FLNSD	-	-	-	-	-	-	0.003	0.55	0.009	0.03
SD	-	-	-	-	-	-	0.011	0.68	0.059	0.17

Flag Leaf Area: FLA; Flag Leaf Length: FLL; Flag Leaf Width: FLW; Number of Fertile Tiller: NFT; Plant Height: PH; Fertile Spikelete per Spike: FSS; Spike Length: SL; Number of Node: NN; Flag Leaf Node Until Spike Distance: FLNSD; Stem Diameter: SD. Data on parenthesis are related to indirect effect. R _ cumulative values of R^2 (Coefficient of Determination) particular steps (independent variables involved); Cr _ coefficient of regression; in stepwise regression only those coefficient of regression are given where p>0.05

Table 6: Stepwise and multiple regression of component traits (independent variables) on the yield (dependent variables) under irrigated and rain fed condition

	Stepwise regression						Multiple regression			
	Irrigated			Rain fed			Irrigated		Rain fed	
Parameters	Step	R^2	Cr	Step	R^2	Cr	Cr	Prob>F	Cr	Prob>F
GNS	-	-	-	-	-	-	-0.001	0.49	0.0006	0.32
GWS	-	-	-	-	-	-	0.019	0.57	-0.008	0.34
GNP	-	-	-	-	-	-	0.0001	0.77	-0.001	0.05
GWP	-	-	-	-	-	-	-0.0016	0.86	0.037	0.06
GL	-	-	-	-	-	-	0.004	0.48	0.001	0.89
1000GW	3	0.9914	-0.0004	-	-	-	-0.0011	0.31	-0.004	0.11
B	1	0.7	0.3307	2	0.944	0.008	0.3297	0.0001	0.186	0.001
HI	2	0.9898	0.0099	1	0.3379	0.205	0.0104	0.0001	0.008	0.001
HW	-	-	-	-	-	-	-0.0003	0.81	-0.0006	0.57

Grain Number per Main Spike: GNS; Grain Weight per Main Spike:GWS; Grain Number per Plant: GNP; Grain eight per Plant:GWP; Grain Length: GL; 1000 Grain Weight:1000GW; Biomass: B; Yield of I m Row: 1MY; Harvest Index: HI; Hectoliter weight: HW: Data on parenthesis are related to indirect effect. R _ cumulative values of R^2 (Coefficient of Determination) particular steps (independent variables involved); Cr _ coefficient of regression; in stepwise regression only those coefficient of regression are given where p>0.05

photosynthesis, protein synthesis and alters hormonal balance of major plant tissues (Gusta and Chen, 1987). In selecting improved cultivars, plant breeders attempt to incorporate tolerance to moderate levels of water stress. This study provides evidence that some plant traits may be used to complement selection based on yield and morphological components in wheat. Under irrigated condition yield may be increased by selecting plants with greatest biomass, high harvest index value and lower plant height whereas in rain fed condition, yield will be increasing by selecting plants with great biomass, high harvest index value, high grain per plant weight, lower plant height and lower number of grain per plant. Rain fed reduced most of the morphological traits and all of the yield traits. T-66-58-8, T-65-7-1, T-66-58-9, T-66-58-6, Tabassi, Azadi, T-65-5-1, T-65-6 and Pishtaz showed yield stability across rain fed condition. In present study, reduction in dry matter accumulation was noted in all the cultivars and mutants. Tabassi and its mutants showed comparatively less reduction in biomass production than other cultivars and mutants. According to above analysis, we can select suitable characters in practice of breeding. In irrigated condition, short varieties and varieties with great biomass and high harvest index are good and in rain fed condition the plants with short plant height, great biomass and harvest index, greatest grain per plant weight and lower number of grain per plant are suitable.

REFERENCES

Acevedo, E., P. Silva and H. Silva, 2002. Growth and Wheat Physiology. In: Bread Wheat Improvement and Production. Curtis, B.C., S. Rajaram and H. Gomez Macpherson (Eds). FAO, Rome, pp: 39-70.

Akhtar, M.Z., M.A. Khan, K. Ahmad and M. Alam, 2001. Evaluation of wheat (*Triticum aestivum* L.) varieties for their potential grain yield under the agroecological conditions of D.I. Khan. Online J. Biol. Sci., 1: 568-570.

Alam, K., M.A. Chowdhry and M.M. Asad, 1991. The inheritance of protein content, grain yield and its components in bread wheat (*Triticom aestivum* L.). Gomal Univ. J. Res., 11: 45-52.

Arnau, G. and P. Monneveux, 1995. Physiology and genetics of terminal water stress tolerance in barley. J. Genet. Breed, 49: 327-331.

Arnon, I., 1972. Crop Production in Dry Regions, Palunin. Leonard, N. (Ed.), Hill Book, London, pp: 203-211.

Ashraf, M.Y. and S.S.M. Nagavi, 1994. Studies on water uptake, germination and seeding growth of wheat genotypes under PEG-6000 induced water stress. Pak. J. Sci. Ind. Res., 38: 130-133.

Ashraf, M.Y., M.H. Naqvi and A.H. Khan, 1996. Evaluation of four screening techniques for drought tolerance in wheat (*Triticum aestivum* L.). Acta Agron. Hung., 44: 213-220.

Blum, A., 1996. Yield Potential and Drought Resistance: Are They Mutually Exclusive. In: Increasing yield potential in wheat. Breaking the Barriers. Reynolds, M.P., S. Rajaram and A. Mcnab (Eds.), CIMMYT. Mexico, D.F., pp: 90-100.

Brar, G.S., S. Kar and N.T. Singh, 1990. photosynthetic response of wheat to soil water deficits in the tropics. J. Agron. Crop Sci., 164: 343-348.

Chen, X.M., G.B. Begonia, D.M. Alm and J.D. Hesketh, 1993. Response of soybeen leaf photosynthesis to CO_2 and drought. Photosynthetica, 29: 447-454.

Clarke, J.M., R.A. Richards and A.L. Condon, 1991. Effect of drought stress on residual transpiration and its relationship with water use of wheat. Can. J. Pi. Sci., 71: 695-699.

Cseuz, L., J. Pauk, Z. Kertesz, J. Matuz, P. Fonad, I. Tari, and L. Erdei, 2002. Wheat breeding for tolerance to drought stress at the cereal research non_profit company. Acta Biologica Szegediensis, 46: 25-26.

Dastfal, M. and M. Ramaznpoor, 2000. Assessment of drought tolerance of wheat cultivar in climatic condition of Darab. Collection Article Abstract of Iranian Agronomy and Plant Breeding Conference, Babolsar, Mazandaran, Iran, pp: 250.

Dewey, D.R. and K.H. Lu, 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J. Madison, 541: 515-518.

Donaldson, E., 1996. Crop traits for water stress tolerance. Am. J. Alternative Agric., 11: 89-94.

Duncan, D.B., 1955. Multiple range and multiple F-test. Biometrics, II:1.

Ehdaie, B. and J.G. Waines, 1989. Genetic variation, heritability and path analysis in landraces of bread wheat from south western, Iran. Euphytica, 41: 183-190.

Ehdaie, B., 1993. Selection for drought tolerance of wheat. Keynotes Article Collection, First Iranian Agronomy and Plant Breeding Conference. Karaj, Iran, pp: 62-63.

El-Far, I.A. and A.Y. Allam, 1995. Responses of some wheat cultivars to sowing methods and drought at different stage of growth. Aussiut J. Agric. Sci., 26: 267-272.

Ephrath, J.E. and J.D. Hesketh, 1991. The effects of drought stress on leaf elongation, photosynthetic and transpiration rates in maize leaves. Photosynthetica, 25: 607-619.

Eshghi, A.G. and G. Khalilzadeh, 2006. Selection of durum wheat lines for drought resistance. 1st International conference of the theory and practices in biological water saving (ICTPB), Beijing, China, pp: 63-64.

Falconer, D.S. and T.F.C. Mackay, 1996. Introduction to Quantitative Genetics. Longman, Harlow. U.K.

Fisher, R.A. and R. Maurer, 1978. Drought resistance in spring wheat cultivars. Grain yield responses. Aust. J. Agric. Res., 29: 897-912.

Golabadi, M., A. Arzani and S.M.M. Maibody, 2005. Evaluation of variation among durum wheat F3 families for grain yield and its components under normal and water stress field conditions. Czech. J. Genet. Plant Breed., 41: 263-267.

Guinta, F.R., R. Motzo and R. Deidda, 1993. Effect of drought on yield and yield components of durum wheat and triticale in a Mediterranean environment. Field Crop Res., 33: 399-409.

Gusta, L.V. and T.H.H. Chen, 1987. The Physiology of Water and Temperature Stress. In: Wheat and Wheat Improvement. Heyne, E.G. (Ed.). Agron. Mongor. 13, 2nd Edn., ASA. CSSA. And SSSA, Madison. WI.

Hsiao, T.C., 1973. Plant response to water stress. Ann. Rev. Plant Physiol., 24: 519-570.

Hsu, P. and P.D. Walton, 1971. Relationships between yield and its components and structures above the flag leaf node in spring wheat. Crop Sci., 11: 190-193.

Hurd, E.A., 1976. Breeding for Drought Resistance in Water Deficit and Plant Growth. In: Soil Water Management and Plant Responses. Kozlowzki, T.T. (Ed.). Academic press.

Iqbal, M., K. Ahmad, I. Ahmad, M. Sadiq and M.Y. Ashraf, 1999. Yield and yield components of durum wheat as influenced by water stress at varius growth stages. Pak. J. Biol. Sci., 2: 11-14.

Jalal Kamali, M.R. and E. Duveiller, 2006. Wheat production and research in Iran: A success story. International Symposium on Wheat Yield Potential: Challenges to International Wheat Breeding, Sonora, Mexico, pp: 62-63.

Knapp, W.R. and J.S. Knapp, 1978. Response of winter wheat to date of planting and fall fertilization. Agron. J., 70: 1048-1051.

Kumar, A.B.N. and C.S. Hunshal, 1998. Correlation and path coefficient analysis in durum wheats (*Triticum durum Desf.*) under different planting dates. Crop Res. Hisar., 16: 358-361.

Leinhos, V. and H. Bergman, 1995. Changes in the yield, lignin content and protein patterns of barley (*Hordeum vulgare CV. Alexis*) induced by drought stress. Angewandie Botanik, 69: 206-210.

Long Necker, N., E.J.M. Kirby and A. Robson, 1993. Leaf emergence, tiller growth and apical development of nitrogen_deficient spring wheat. Crop Sci., 33: 154-160.

Mian, M.A.R. and E.D. Nazfiger, 1994. Seed size and water potential effects on germination and seedling growth of winter wheat. Crop Sci., 34: 169-171.

Moghaddam, M., B. Ehdaie and J.G. waines, 1997. Genetic variation and interrelationships of agronomic characters in landraces of bread wheat from southeastern Iran. Euphytica, 95: 361-369.

Monyo, J.H. and W.J. Whittington, 1973. Genotypic Differences in flag leaf area and their contribution to grain yield in wheat. Euphytica, 22: 600-606.

Okuyama, L.A. and L.C. Federizzi, 2005. Plant traits to complement selection based on yield components in wheat. Ciencia Rural, 35: 1010-1018.

Okuyama, L.A., L.C. Federizzi and J.F. Barbosa Neto, 2004. Correlation and path analysis of yield and its components and plant traits in wheat. Ciencia Rural, 34: 1710-1758.

Paroda, R.S. and A.B. Joshi, 1970. Correlation, path coefficient and their implication in discriminate function for selection in wheat (*Triticum aestivum* L.). Heredity, 25: 383-392.

Peterson, C.M., B. Klepper, F.B. Pumphrey and R.W. Rickman, 1984. Restricted rooting decreases tillering and growth of winter wheat. Agron. J., 76: 861-863.

Rane, J., 2001. Evaluation of ear: Stem weight ratio as a criterion for selection of drought tolerance wheat (*Triticum aestivum*) genotypes. Indian J. Agric. Sci., 71: 505-509.

Rascio, A., C. Platani, N. Difonza and G. Wittemer, 1992. Bound water in durum wheat under drought stress. Plant Physiol., 98: 908-912.

Razzaq, A., B.R. Khan, P.R. Hobbs and N.I. Hashmi, 1986. Comparison of morphological and physiological parameters of wheat cultivars under rain fed condition. J. Agric. Res., 24: 34-36.

Reynolds, M.P., B. S kowmand, R.M. Trethowan, R.P. Singh and M. van Ginkel, 2002. Applying physiological strategies to wheat breeding. Anonymous: Research high lights of the CIMMYT wheat Program. International Wheat Improvement Center, pp: 49-56.

Rickman, R.W. and E.L. Klepper, 1991. Tillering in Wheat. In: Predicting Crop Phenology. Hodghes, T. (Ed.), Boca Raton, Florida, pp: 73-83.

Roustai, M., E. ZadHasan and H. Ketta, 2005. Adaptability and stability analysis of grain yield in advanced bread wheat lines in cold and moderate dryland areas of Iran. 2nd International Conference on Integrated Approaches Sustain and Improve Plant Production Under Drought Stress. Italy.

Sarmadnia, G., 1993. The importance of environmental stress in agronomy Keynotes Article Collection. 1st Iranian Agronomy and Plant Breeding Conference Karaj, Iran, pp: 152-172.

SAS INSTITUTE Inc., 1990. SAS Procedures Guide: Version 6.3 . Cary Ed.: SAS institute.

Schulze, E.D., 1989. Carbon dioxide and water vapor exchange in response to drought in the atmosphere and in the soil. Ann. Rev. Plant Physiol., 34: 247-274.

Shah, S.A., S.A. Harison, D.J. Boquet, P.D. Colyer and S.H. Moore, 1994. Management effects on yield and yield components of leaf_planted wheat. Crop Sci., 34: 1298-1303.

Siddique, M.R.B., A. Hamid and M.S. Islam, 1999. Drought stress effects on photosynthetic rate and leaf gas exchange of wheat. Bot. Bull. Acad. Sci. 40: 141-145.

Slafer, G.A. and F.H. Andrade, 1991. Changes in physiological attributes of the dry matter economy of bread wheat (*Triticum aestivum*) through genetic improvement of grain yield potential at different regions of the world. Euphytica, 58: 37-49.

Spilde, L.A., 1989. Influence of seed size and test weight on several agronomic traits of barley and hard red spring wheat. J. Prod. Agric., 2: 169-172.

Van Ginkel, M., D.S. Calhound, G. Gebey Eho, A. Miranda, C. Tian_you, R. Paragas Lara, R.M. Trethown, K. Sayre, J. Crossa, S. Ragaram and S. Nagarajan, 1998. Plant traits related to yield of wheat in early, late or continuous drought condition. Euphytica, 100: 109-121.

Villareal, R.L., O. Banvelos, A. Mujeeb-Kazi and S. Rajaram, 1998. Agronomic performance of chromosomes 1B and T1BL.1RS near-isolines in the spring bread wheat seri. M82. Euphytica, 103: 195-202.

Vishwakarma, G., H.L. Sharma and P. Kumar, 2002. Multiple regression analysis for yield improvement in wheat. 9th Int. Conf. Forum for Interdisciplinary Mathematics on Statistics Combinatorics and Related Areas.

Wallace, D.H., J.P. Baudoin, J. Beaver, D.P. Coyne and D.E. Halseth *et al.*, 1993. Improving efficiency of Breeding for higher crop yield. Theor. Applied Genet., 86: 27-40.

Zhang, X., X. Chen, Z. Wu, X. Zhang, C. Huang and M. Cao, 2005. A dwarf wheat mutant is associated with increased drought resistance and altered responses to gravity, 4: 1054-1057.

Zaheer, A., 1991. Coheritability among yield and yield components in wheat. Sarhad. J. Agric., 7: 65-67.

Zarea-fizabadi, A. and M. Ghodsi, 1998. Assessing of Drought Tolerance Reaction to New Line and Cultivar of Winter and Facultative Wheat. Collection Articale Abstract of 5th Iranian Agronomy and Plant breeding Conference, Karaj, Iran, pp: 290.

Zarea-Fizabady and M. Ghodsi, 2004. Evaluation of yield and yield components of facultative and winter bread wheat genotypes (*Triticum Aestivum* L.) under different irrigation regimes in Khorasan province in Iran, 3: 184-187.