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Effects of Drought and Salinity as Abiotic Stresses on Some Qualitative Traits of Iranian Wheat Genotypes

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B. NASERIAN, M.Zamani, C. VEDADI
Nuclear Agriculture Research Group- Agricultural, Medical and Industrial Research School-Nuclear Science and Technology Research Institute, Karaj, Iran
Email: bnaserian@nrcam.org

Abstract

The objective of this study was to evaluate the effects of drought and salinity stress as two main abiotic stresses conditions in Iran on end-use quality of twenty-five wheat cultivars and mutants differing in adoption to drought and salinity stress. Flag leaf area, plant height, fertile spikelet per spike, spike length, grain number per spike, grain weight per plant, 1000 grain weight, biomass, yield, harvest index, hectoliter weight, flour protein content and sedimentation value (SDS) were evaluated across Drought and salt stress. Also Under drought condition, mutant line T-66-58-6 had high flour protein content due to the lowest reduction for yield and biomass. Under salinity stress, mutant lines T-66-58-6, T 66-58-8 and Tabassi had high flour protein content and Tabassi had highest sedimentation value and the lowest reduction in yield, biomass, 1000-grain weight and grain number and weight per plant. In drought condition, Flour protein content may be increased by selection for hectoliter weight, fertile tiller and yield and harvest index. Selecting plants with more fertile tillers grain weight per plant, less hectoliter weight and grain number per plant in salinity condition may increase the flour protein content.

Keywords: Flour Protein Content, Sedimentation Value, Mutant Wheat, Drought and Salinity Stresses,

Introduction

Improvement of grain quality is a major objective of wheat (*Triticum aestivum* L.) breeding programs. Beside for enhancement of biological and nutritive value of end-use products, the quality components of grain play an important role in the economic value of new cultivars determining (Mangova and Rachovska, 2004). Proteins are the most important components of wheat grains governing end-use quality (Weegels et al., 1996). Nearly all the nitrogen in cereals is found in protein complexes. Thus analysis of nitrogen in the grain can bring useful information about its protein content. (Holubec and Dvoracek, 2005). Francoise et al., (1986) were one of the first to determine the effects of salinity on the yield quality of durum wheat. Stone and Nicolas (1994, 1995) determined that responses of genotypes for quality characters clearly varied with growing conditions. They found that soil salinity reduced the ash content and improved the color and the protein content. Wheat has low protein content, usually ranging between 10 to 14%. Through the past twenty years, an improvement in seed protein content has been mainly achieved by increasing nitrogen fertilization. The genetic improvement of protein content has been particularly hampered, not only by the sharp environmental influence, but also by the fact that a negative correlation was found between the grain yield and seed protein content in all cereals (Cox et al., 1985; Day et al., 1985). Studies have shown that the seed protein percentage can be increased by genetic manipulation without a simultaneous reduction of productivity (Johnson et al., 1978; Day et al., 1985). Wheat quality was controlled not only by genetic factors, but also by environmental conditions, especially the supply of water and fertility in soil can change wheat quality under normal cropping conditions (Triboi et al., 2003). At biochemical level, composition of flour protein depended primarily on genotypes, but significant interaction with environment was observed (Graybosch et al., 1996). Dadashi (2002) reported that protein content increased under salinity and drought stresses. Jinyin et al., (2002) found that compare with control, the content of total protein in seeds increased by 5-13% in different water deficit treatments. The induced mutation in wheat was also widely employed to modify some protein subunits determining the grain quality (Mangova and Rachovska, 2004). The previous classifications of many crops ignored the salinity affect on the quality of harvested protein (Katerji et al., 2005).

To find the germplasm resources having the most protein content and yield stability under different environments is useful. Furthermore finding the yield component for selection of best material in different environments is beneficial in breeding program. Many researchers worked on wheat yield component (Akram et al., 2002; Musaddique et al., 2000) but a few studies had been done to investigate the yield traits and morphological characters that influence the wheat protein content. The approaches used in this study give the possibility to select new mutant lines with high quality of grain that can be used as source material in breeding programs. The aim of this investigation was to evaluate mutant and cultivation lines of wheat in term of its sedimentation value and crude protein content and determine effects of some morphological and yield traits on flour protein content.

Materials and methods

The experiments were conducted in two separate arias. The irrigated and and drought condition were placed in zafaranieh (experimental farm of Agriculture, Medicine and Industry Research School,) west of karaj(35°49′19″N 50°44′2″E). The other one, with saline soil and water, at region Aktharabad, Mahdasht in south of the karaj(35°59′17″N 50 °59′77″E). The selected. distance between two station was about 70 Km. Same experiments were conducted under normal , drought and saline conditions in above mentioned farms during the crop season 2005–2006.

Plant materials: The experiments included 9 cultivars and 16 wheat mutant. The pedigree and characteristics of these cultivars and mutants are shown in Table 1. All wheat genotypes are presented in lattice design with two replications.

Table 1. Some morphological and maturity characteristics of mutant and cultivars of wheat used in the study.

Cultivars/ Mutants	Characteristics
Bezostaia	medium height, tolerance to lodging, small awns and high vigor in cold condition
Inia	earliness, has tolerance to lodging, medium height, high backing quality
Tajan garm	largely sown in north of Iran
Tajan	largely sown in north of Iran, high yield potential
Azadi	medium height and high awns
Pishtaz	sown in drought environments
Omid	awns, complete lodging, high height and has performed well in north of Iran
Tabassi	complete lodging, high height
O-64-4: Omid	dwarf , earliness
O-64-1-1: Omid	dwarf , earliness
T-66-58-7: Tabassi	small spike, awns
T-67-60: Tabassi	show a small spike, lower lodging
T-65-9-1: Tabassi	dwarf
T-65-58-8: Tabassi	small spike, lower lodging
T-65-5-1: Tabassi	compact spike, without awns
T-65-9-1P:Tabassi	dwarf, tolerance to lodging
T-65-7-1:Tabassi	dwarf, tolerance to lodging, without awns
T-65-4:Tabassi	medium height, without awns

T-65-58-10:Tabassi	Lodging, awns
T-65-58-9:Tabassi	small spike, awns
T-65-6:Tabassi	high height, without lodging
T-66-58-6:Tabassi	Lodging
T-66-58-60:Tabassi	high height, awns, great spike
T-66-58-12:Tabassi	high height, high awns
T-65-9-II:Tabassi	high height without awns, medium lodging

O : abbreviation of Omid
T: abbreviation of Tabassi

Field evaluation: The electrical conductivity (EC) of soil in Zafarnieh region was 0.67 dS m-1 with pH 8.05 while the EC of irrigation water was 0.33 dS m-1, pH 8.2 and SAR 13. The soil consisted of 30.6% clay, 36.4% silt and 33% sand. For salinity treatment, the EC of water used was 10 dS m-1 with pH 7.7 and SAR 13.78. The soil included 8% clay, 22% silt and 70% sand. Seeding rate was 120 g seeds in plot [4 x 0.25 m (length x w)]. The distance between blocks was one meter and between replications was 3 m. Fertilizer application in the three conditions was at the rate of 50 kg NH_4NO_3 ha^{-1} and 150 kg $(NH_4)2HPO_3$ ha^{-1} at planting and 100 kg NH_4NO_3 ha^{-1} at stem elongation stage, respectively.

Sampling and measurement: The data for flag leaf area (FLA), plant height (PH), fertile spikelet per spike (FSS), spike length (SL), grain number per spike (GNP), grain weight per plant (GWP), 1000 grain weight (1000 GW), biomass (B), yield (Y), harvest index (HI) and hectoliter weight (HW) were recorded for each experimental unit. At maturity stage, one of three central rows about one square meter was harvested to record grain yield of each genotype. The data for flag leaf area was measured by leaf area meter ([Opti-Sciences portable model: AM100).Harvest index (HI) was obtained by converting of total dry matter in economic yield (grain yield). Hectoliter weight was equivalent of 200 mL seeds. SDS (sedimentation value) is a method to estimate the strength of wheat gluten. It is based on the hydration capacity and flocculation of flour in a low acidity media. SDS was determined according to a procedure by Dick and Quick (1983). The gluten strength was determined using SDS (sodium dodecyl sulphate) microsedimentation test on one g of ground whole meal. A stock solution was prepared fresh daily and contained ratio of 85% lactic acid-water (1:8, v/v) and sodium dodecyl sulphate(SDS) (2% solution). The height of the interface line between the solid and the liquid was measured in millimeters. The crude protein content (N*5.7) was determined by Kjedhal method.

Statistical analysis: Analysis of variance and means comparing for FLA, PH, FSS, SL, GNP, GWP, 1000 GW, B, Y, HI and HW. flour protein content and sedimentation value has been done and means were compared using of Duncan's multiple Rang test (Duncan, 1955). Spearman coefficient of correlation and parameters of regression were calculated using mean values of characters from three conditions. Direct and indirect effects of component characters on flour protein content were worked out using path coefficient analysis. Multiple regression analysis was used to find of important characters contributing to flour protein content variation. Statistical analysis obtained using statistical analysis system (SAS Institute Release, 6 .12, 1990) and MSTAT-C software.

Results and discussion

The analysis of variance and mean values of sedimentation value and flour protein content of the tested mutants and cultivars under the three conditions are shown in Tables 2 and 3. In normal condition, there were not significant differences between cultivars and mutants for flour protein content while for sedimentation value, differences were notable. In drought and salinity for flour protein content and sedimentation value, cultivars and mutants had significant differences.

Table 2: Analysis of variance for sedimentation test and flour protein content under normal, drought and salinity conditions

	condition	MST	MSE	CV%	LSD
Sedimentation value	Normal	0.741^{ns}	0.087	12.52	0.626
	Drought	0.625^{**}	0.271	20.3	1.1
	Salinity	1.445^{**}	0.136	13.03	0.78
Flour protein content	Normal	1.721^{**}	0.87	8.77	1.98
	Drought	9.466^{*}	0.757	7.04	1.844
	Salinity	2.641^{**}	0.445	4.34	1.41

LSD*:* Least Significant Difference in 0.05%, **CV**: Coefficient of Variation, **MSE**: Mean Square of Error, **MST**: Mean Square of Treat,

**, * and ns: significant at 0.01, 0.05 and non significant

Table 3: Mean value of wheat cultivars and mutants and statistical significance for flour protein content and sedimentation test in three condition

	Flour protein content			Sedimentation value		
	Normal	Drought	Salinity	Normal	Drought	Salinity
Bezostaia	11.04 abcdef	16.35 a	15.87 abcde	3.503 ab	3.249 abcd	3.068 defg
T-66-58-7	10.47 bcdef	14.44 abc	16.34 abcd	1.697 hi	2.166 cdef	2.179 gh
T-67-60	10.36 bcdef	15.58 a	16.08 abcd	1.85F fhi	2.041 def	2.309 fgh
T-65-9-1	9.615 def	14.63 ab	14.31 efghijk	2.747 cde	2.745 abcdef	2.614 efgh
Omid	10.5B cdef	15.8 a	17.25 a	2.202 efgh	1.863 ef	2.028 h
Inia	9.951 bcdef	11.97defg	13.85 hijk	2.214 efgh	3.474 ab	4.355 ab
T-66-58-8	9.722 def	12.16 def	16.31 abcd	1.458 i	1.891 ef	2.065 h
T-65-5-1	10.41 bcdef	9.964 ghi	14.74 defghijk	2.511 cdef	3.066 abcde	3.395 cde
Tajan Garm	10.46 bcdef	11.26defghi	16.59 abc	3.208 bc	3.07 abcde	4.65 a
T-65-9-1p	8.811 f	14.61 ab	15.06 cdefghij	1.863 fghi	2.688 abcdef	2.114 h
Tabassi	10.23 bcdef	12.48 cde	16.13 abcd	2.433 defg	2.958 abcdef	3.376 cde
T-65-7-1	9.086 ef	10.84 efghi	13.67 ijk	2.277 defgh	2.575 abcdef	3.137 cdef
T-65-4	9.886 cdef	11.27defghi	16.86 ab	2.73 cde	3.35 abc	3.967 abc
T-65_58_10	10.83 abcdef	14.42 abc	15.23 bcdefghij	2.126 efghi	2.254 bcdef	1.822 h
O-64-1-1	11.42 abcd	10.16 fghi	13.56 jk	2.081 efghi	2.572 abcdef	2.185 gh
T-66-58-9	12.16 abc	11.65 defgh	16.1 abcd	1.683 hi	1.99 def	2.069 h
Pishtaz	12.22 ab	9.472 i	15.32 bcdefgh	2.977 bcd	2.756 abcdef	3.78 bcd
T-65-6	10.59 bcdef	9.218 i	13.92 ghijk	2.93 bcd	3.031 abcde	3.71 bcd
T-66-58-6	10.62 abcdef	13.25 bcd	15.52 bcdefg	1.976 fghi	2.085 cdef	2.465 fgh
T-66-58-60	11.13 abcde	15.09 ab	15.27 bcdefgh	1.781 ghi	2.453 abcdef	2.228 gh
T-66-58-12	12.88 a	10.9 efghi	16.45 abc	1.884Fghi	2.062 def	1.925 h
Azadi	10.4 bcdef	9.551 hi	13.42 k	2.478 defg	1.828 ef	2.336 fgh
T-65-9-11	10.77 abcdef	11.18 defghi	15.55 bcdefg	2.081 efghi	1.753 f	1.966 h
O-64-4	10.86 abcdef	12.14 def	14.15 fghijk	2.278 defgh	2.507abcdef	3.071 defg
Tajan	11.4 abcd	10.69 efghi	16.78 b	3.983 a	3.625 a	3.885 abcd

O : abbreviation of Omid
T: abbreviation of Tabassi

Average flour protein content ranged from 8.811 to 12.88 for the normal condition, 9.218 to15.8 for the drought condition and 13.42 to 17.25 for salinity condition. In normal condition T- 66-58-12, Pishtaz and T-66-58-9 had the highest flour protein content, respectively, while

T-65- 9-1p had the lowest flour protein content. In drought condition Bezostaia, Omid and T-67-60 had the highest and T-65-6, Pishtaz and Azadi had the lowest flour protein content respectively. In salinity condition Omid, T-65-4, Tajan, Tajan garm and T-66-58-12 had highest, Azadi, and O-64-1-1had the lowest flour protein contents, respectively. Variation among mutants and cultivars for flour protein content was more pronounced under drought condition than those of salinity and normal conditions, with a range of >6.59 between the highest and the lowest, Omid and T-65-6 in the drought condition and range of approximately 4 and 3.83 in normal and salinity conditions, respectively. Ryan et al. (1997) determined that responses for quality characters of genotypes clearly varied with growing conditions.

Sedimentation values and gluten index are the main parameters for the pasta quality. For sedimentation value in normal condition Bezostaia, Tajan and Tajan garm had the highest values and T-66-58-7 and T-66-58-9 had the lowest values. In drought condition, Tajan, Tajan Garm, Bezostaia and Inia and in salinity condition Inia, Tajan garm, T-65-4 and Tajan had the highest values, respectively. Above mentioned results supported the view, that flour protein content and sedimentation value have been improved by mutation breeding.

Bezostaia, Tajan garm, T-65-6 and Tajam had high sedimentation value in three conditions and we can use for cultivation and pasta quality in three conditions. In drought condition, T-66-58-6 had the highest flour protein content that is attributed to its lowest reduction for yield and biomass in drought condition, that made it suitable to be used for breeding and cultivation program. In saline condition, T-66-58-6, T 66-58-8 and Tabassi had high flour protein content and Tabassi had the highest sedimentation value that is due to its lowest reduction for yield, biomass, 1000 grain weight and grain number and weight per plant under this condition that can be used for breeding and cultivation program in saline condition, too.

Data indicated a positive correlation between number of fertile tillers and flour protein content and a negative one between yield of one square of meter plot, HI and FPC with flour protein content in drought condition (Table 4). There was no correlation between flag leaf area and flour protein content in drought condition and number of fertile tiller and grain weight per plant with flour protein content in salinity condition. The FPC in normal condition has positive correlation with flour protein content (0.304) but in drought and salinity condition have negative correlation (-0.422 and -0.329). Flour protein content has not significantly correlated with sedimentation value under all conditions. Blanco and De Giovanni (1998) reported no correlation between protein content and the sedimentation value in recombinant inbred lines derived from the cross durum wheat cv. Messapia* of *T. dicoccoides*. Sedimentation value in saline condition was negatively correlated with flag

Table 4:Correlation coefficient of morphological and yield traits at three conditions

		FLA	FTN	PH	SSN	SL	GNP	GWP	1000 GW	B	Y	HI	HW	FPC
FPC	N	-0.18	0.24	0.05	0.13	-0.15	0.13	0.22	0.13	-0.19	-0.18	-0.03	0.3	
	D	0.34	0.46*	0.27	0.25	-0.04	0.1	0.04	-0.07	-0.12	-0.62**	-0.61**	-0.42*	
	S	0.14	0.34	0.26	0.3	0.71**	0.16	0.34	0.22	-0.06	-0.20	-0.14	-0.33	
SDS	N	-0.05	-0.29	-0.35	-0.15	-0.04	-0.01	-0.22	-0.45*	-0.32	-0.15	0.25	0.65**	0.08
	D	-0.41*	-0.29	-0.46*	0.16	0.13	-0.04	-0.16	-0.15	-0.14	0.15	0.38	0.29	-0.16
	S	-0.45*	-0.45*	-0.33	-0.59**	-0.32	-0.53**	-0.49**	0.23	-0.46*	-0.24	0.28	0.46*	-0.08

LA: Flag leaf area, **FTN**: Fertile tiller number **PH**: Plant height, **FSS**: Fertile spikelet per spike, **SL**: Spike length, **GNP**: Grain number per spike, **GWP**: Grain weight per plant, **1000GW**: 1000 grain weight, **B**: Biomass, **Y**: Yield, **HI**: Harvest index, **HW**: Hectoliter weight**, FPC**: Flour protein content, **SDS**: Sedimentation value
N: Normal, **D**: Drought, **S**: Salinity condition **F**

Leaf area, number of fertile tiller, spikelet number per spike, grain number and weight per plant and biomass. The FPC was more closely correlated to the sedimentation value in normal and saline condition while in drought condition this correlation was not significant. Spike productivity characters, except of 1000 grain weight and harvest index had negative correlation with crude protein content in grain. Protein percentage was negatively correlated to 1000 grain weight, indicating that high protein content could partly be due to the reduced seed size. However, some lines exhibited an increase in protein content as well as in 1000 grain weight. A negative correlation between protein content and seed weight was also found by Nevo et al. (1986), but not by Avivi (1978), Levy, and Feldman (1989).

Effects of characters on flour protein content were estimated by means of multiple regression analysis for all conditions and were less confirming than those from correlation analysis (Table 5), probably due to interactions among characters appraised in regression. Flour protein content was significantly determined by FPC under normal condition, by number of fertile tiller under drought was and by number of fertile tiller, grain number per plant and grain weight per plant under salinity. Dotlacil et al. (2003) reported that regression analysis confirmed that crude protein content was positively affected by plant height and grain weight per spike. The main commercial, technological and nutritional characteristics considered by breeders and pasta markers concern kernels (100 grain weight, hectoliter weight, seed size etc.) flour (carotenoid content, protein content, gluten quality and quantity)and pasta. Path analysis indicated that in normal condition 1000 GW, yield of one m row, hectoliter weight had positive and biomass, and harvest index had negative effect on flour protein content. In drought condition, number of fertile tiller, grain number per plant and 1000 grain weight had positive, grain weight per plant and yield of one m^2 plot had negative effect.

Table 5: Multiple regression analysis for components of flour protein content under three conditions

	Normal		Drought		Salinity	
	Parameter Estimate	Prob >T	Parameter Estimate	Prob >T	Parameter Estimate	Prob >T
Intercep	-3.7358	0.1703	-1.1651	0.7583	7.6052	0.0476
FLA	-0.0001	0.4593	0.0002	0.5089	-0.0003	.2218
FTN	0.0089	0.9108	0.4379	0.033	0.3114	0.0272
PH	0.002	0.5102	-0.0007	0.9364	-0.0119	0.3733
SSN	0.0257	0.1182	0.1179	0.111	0.0969	0.162
SL	0.0699	0.297	-0.0654	0.2081	0	0.9999
GNP	-0.0011	0.8766	0.0092	0.6124	-0.0359	0.0404
GWP	0.014	0.916	-0.6353	0.2109	0.7923	0.0758
1000GW	0.0205	0.3253	0.0528	0.455	-0.0597	0.1247
B	-2.1531	0.2742	0.6193	0.6785	-5.3056	0.2783
Y	6.9651	0.2482	-4.6709	0.5389	15.5831	0.3271
HI	-0.0535	0.418	0.0257	0.7161	-0.079	0.2349
HW	0.0707	0.0083	-0.0104	0.7591	-0.0102	0.5647

FLA: Flag leaf area, **FTN**: Fertile tiller number **PH**: Plant height, **FSS**: Fertile spikelet per spike, **SL**: Spike length, **GNP**: Grain number per spike, **GWP**: Grain weight per plant, **1000GW**: 1000 grain weight, **B**: Biomass, **Y**: Yield, **HI**: Harvest index, **HW**: Hectoliter weight**, FPC**: Flour protein content, **SDS**: Sedimentation value
N: Normal, **D**: Drought, **S**: Salinity condition
R- square in normal, drought and salinity conditions: 0.683, 0.698 and 0.629
Adj R- square in normal, drought and salinity conditions: 0.366, 0.4 and 0.29

In saline condition number of fertile tiller, grain weight per plant and yield had positive and grain number per plant, 1000-grain weight, biomass and harvest index had negative direct effects on flour protein content (Table 6). Under normal condition, biomass and harvest index via yield of one m row and 1000 GW and PH via HI had positive effect and yield had negative effect via biomass on flour protein content. Under drought condition flag leaf area, number of fertile tiller, plant height, spike number per spike, grain number per plant and 1000 GW had negative and biomass and yield (low) had positive effect via grain per plant on flour protein content. Furthermore, grain weight per plant had positive effect on flour protein content via grain number per plant. Under salinity, flag leaf area, number of fertile tiller, PH, number of spikelet per spike, spike length, grain number per plant, grain weight per plant and FPC had negative effect on flour protein content via grain number per plant and positive effect via grain weight per plant. On the other hand grain number and weight per plant had positive effect via number of fertile tiller. Bagnara et al. (1973) reported that mutant lines with higher protein content tend to have lower yields with shorter stems, delayed heading times,

Table 6:Path analysis for components of flour protein content under three conditions

		FLA	FTN	PH	SSN	SL	GNP	GWP	1000GW	B	Y	HI	HW	Corr
FLA	**N**	**(-0.178)**	-0.017	0.005	0.042	0.013	0.037	-0.014	0.127	0.249	0.12	-0.382	0.061	-0.177
	D	**(0.193)**	0.471	-0.011	0.183	-0.057	0.348	-0.879	0.009	0.036	0.181	-0.163	0.003	0.335
	S	**(-0.375)**	0.381	-0.163	0.302	0	-1.361	1.448	-0.091	-0.862	0.459	0.299	0.118	0.139
FTN	**N**	0.055	**(0.057)**	0.044	0.083	-0.078	-0.135	0.112	0.256	-0.055	-0.402	0.376	-0.338	0.236
	D	0.098	**(0.929)**	-0.01	0.094	0.032	0.402	-1.378	0.145	-0.042	0.264	-0.146	0.012	0.465
	S	-0.111	**(1.289)**	-0.026	0.292	0	-4.589	2.891	0.563	0.016	-0.276	0.213	0.066	0.344
PH	**N**	-0.005	0.011	**(0.22)**	0.06	-0.04	0.077	0.009	0.05	-0.049	-0.99	0.725	-0.459	0.05
	D	0.083	0.393	**(-0.024)**	0.058	0.005	0.039	-0.714	0.379	0.036	0.191	-0.169	0.011	0.271
	S	-0.153	0.092	**(-0.369)**	0.285	0	-0.131	1.014	-0.489	-0.868	0.404	0.464	0.102	0.259
SSN	**N**	-0.021	0.014	0.036	**(0.364)**	0.066	-0.068	0.031	-0.11	0.284	-0.231	-0.098	-0.116	0.126
	D	0.072	0.179	-0.003	**(0.487)**	-0.034	0.519	-0.913	-0.195	-0.843	0.196	-0.032	-0.008	0.251
	S	-0.196	0.653	-0.182	**(0.577)**	0	-3.346	2.712	0.048	-0.358	0.282	0	0.098	0.299
SL	**N**	-0.007	-0.013	-0.026	0.071	**(0.339)**	-0.091	0.032	-0.22	0.141	0.418	-0.416	0.058	-0.148
	D	0.039	-0.106	0	0.059	**(-0.28)**	0	0.246	-0.113	-0.058	0.143	-0.009	0.015	-0.036
	S	-0.049	0.866	-0.037	0.153	**(0)**	-3.376	1.932	0.519	0.132	-0.508	0.172	0.023	0.072
GNP	**N**	0.029	0.033	-0.073	0.107	0.133	**(-0.232)**	0.124	-0.188	0.386	0.013	-0.276	0.129	0.133
	D	0.091	0.506	-0.001	0.342	0	**(0.739)**	-1.55	-0.182	-0.115	0.17	0.014	-0.009	0.099
	S	-0.098	1.133	-0.009	0.369	0	**(-5.223)**	3.189	0.701	0.186	-0.284	0.116	0.057	0.162
GWP	**N**	0.017	0.042	0.013	0.075	0.072	-0.192	**(0.15)**	0.275	0.291	-0.464	0.115	-0.092	0.218
	D	0.09	0.681	-0.009	0.237	0.038	0.61	**(-1.878)**	0.167	-0.085	0.135	-0.011	-0.012	0.043
	S	-0.151	1.034	-0.104	0.434	0	-4.624	**(3.603)**	0.091	0.031	-0.174	0.109	0.074	0.343
1000GW	**N**	-0.028	0.018	0.136	-0.049	-0.092	0.054	0.051	**(0.815)**	-0.295	-0.551	0.569	-0.392	0.132
	D	-0.003	0.219	-0.015	-0.154	0.051	-0.219	-0.511	**(0.616)**	0.03	-0.033	-0.031	-0.003	-0.071
	S	-0.024	-0.518	-0.129	-0.019	0	2.616	-0.235	**(-1.399)**	-0.348	0.291	-0.016	-0.007	0.216
B	**N**	0.019	0.013	0.005	-0.045	-0.021	0.038	-0.019	0.104	**(-2.32)**	2.27	0.154	-0.359	-0.191
	D	0.023	-0.131	-0.003	-0.139	0.056	-0.287	0.542	0.063	**(0.294)**	-0.291	-0.113	0.003	-0.125
	S	-0.159	-0.009	-0.158	0.102	0	0.478	-0.055	-0.24	**(-2.028)**	1.479	0.412	0.045	-0.064
Y	**N**	-0.008	-0.008	-0.08	-0.031	0.052	-0.001	-0.026	-0.165	-1.94	**(2.713)**	-0.449	-0.129	-0.181
	D	-0.063	-0.446	0.009	-0.174	0.073	-0.229	0.463	0.037	0.156	**(-0.549)**	0.189	-0.027	-0.623
	S	-0.087	-0.182	-0.076	0.083	0	0.755	-0.32	-0.208	-1.548	**(1.961)**	-0.652	-0.018	-0.204
HI	**N**	-0.063	-0.019	-0.147	0.033	0.13	-0.059	-0.016	-0.428	0.329	1.122	**(-1.085)**	0.378	-0.028
	D	-0.097	-0.418	0.013	-0.047	0.008	0.032	0.063	-0.058	-0.102	-0.319	**(0.325)**	-0.035	-0.615
	S	0.07	-0.173	0.108	0	0	0.379	-0.249	-0.014	0.525	0.805	**(-1.589)**	-0.077	-0.137
HW	**N**	-0.012	-0.022	-0.115	-0.064	0.023	-0.034	-0.016	-0.363	0.947	-0.401	-0.466	**(0.878)**	0.304
	D	-0.009	-0.166	0.004	0.054	0.06	0.099	-0.313	0.266	-0.013	-0.21	0.162	**(-0.07)**	-0.422
	S	0.233	-0.451	0.199	-0.298	0	1.563	-1.404	-0.054	0.486	-.182	-0.649	**(-0.19)**	-0.33

FLA: Flag leaf area, **FTN**: Fertile tiller number **PH**: Plant height, **FSS**: Fertile spikelet per spike, **SL**: Spike length, **GNP**: Grain number per spike, **GWP**: Grain weight per plant, **1000GW**: 1000 grain weight, **B**: Biomass, **Y**: Yield, **HI**: Harvest index, **HW**: Hectoliter weight**, FPC**: Flour protein content, **Corr**: Correlation
N: Normal, **D**: Drought, **S**: Salinity condition
Data on parenthesis are related to indirect effect.

Lower test weight and lower percentage of yellow berry kernels. Sakin et al. (2005) stated that mutant lines having yield stability and high values of both yield and quality characters could be used for durum wheat improvement.

Conclusion

Responses of genotypes for quality characters clearly vary depending on the growing condition. Under drought condition, T-66-58-6 and saline condition T-66-58-6, T 66-58-8 and Tabassi had the highest(10.23%) flour protein content due to their lowest reduction for some yield components, which makes the suitable choices to be applied in breeding and cultivation programs. Some plant traits may be used to complement selection to increase flour protein content under various conditions. Flour protein content may be increased by selecting plants with increased FPC under normal condition, with more fertile tiller and fewer FPC, yield and harvest index under drought and saline conditions.

References

1. Akram, M., M. Hussain, S. Akhtar and E. Rasul, 2002.Impact of NaCl salinity on yield components of some wheat accession/varieties. Int. J. Agri. Biol.,1:156-158.
2. Asadi, A.A. and B. Naserian, 2007. Evaluation of salt tolerance based on morphological and yield traits in wheat cultivars and mutants. Inter. J. Agric. Biology. 5:
3. Avivi, L., 1978. Itilization of Triticum dicoccoides for te improvement of grain protein quantity and quality in cultivated wheat. Israeli-Italian joint meet. Genet. Breed. Crop plants, Rome. Mon. Genet. Agr., pp.27-38.
4. Bagnara, D., L. Rossi and G. Porreca, 1973. Mutagenesis in Triticum durum: mutants for protein content obtained from the cv. Capeiti. Proc. of the Symp. on Genetics and Breeding Durum Wheat, Univ. di Bari., 14-18 Maggio, 679-685.
5. Blanco, A. and C. De Giovanni, 1998. Triticum dicoccoides for qualitative improvement of durum wheat: Associations of protein loci to grain traits in recombinant inbred lines. Euphytica, 41,149-158.
6. Cox, M.C., C.O. Qualset and D.W. Rians, 1985. Genetic variation for nitrogen assimilation and translocation in wheat. 11. Nitrogen assimilation in relation on grain yield and protein. Crop Sci., 25, 430-435.
7. Dadashi, M. R., 2002. Effects of salinity and drought stresses on quality parameters bread wheat genotypes. In: Proc. 5th Int. Wheat Genet. Symp.,New Delhi, pp: 221-222.
8. Day, G.E., G.N. Paulsen and R.G. Sears, 1985. Nitrogen relations in winter wheat cultivars differing in grain protein percentage and stature. I. Plant Nutr., 8,555-566.
9. Dick, J.W. and J.S. Quick, 1983.Amodified screening test for rapid estimation of gluten strength in early generation durum wheat breeding lines. Cereal Chem. 60, 315-318.
10. Dotlacil, L., J. Hermuth, and Z. Stehno, 2003. Earliness, spike productivity and protein content in European winter wheat landraces and obsolete cultivars. Plant Soil and Environment**.**49,(2):67-74.
11. Duncan, D.B., 1955. Multiple range and multiple F-test. Biometrics, **II**: 1.
12. Francoise, L.E., E.V. Mass, T.J. Donavan and V.L. Yongs, 1986. Effect of salinity on grain yield and quality, Vegetative growth and germination of semi dwarf and durum wheat. Agron. J. 78:1053-1058.
13. Graybosch, R.A., C.J. Peterson, D.R. Shelton and P.S. Baenziger, 1996. Genotypic and environmental modification of wheat flour protein composition in relation to end use quality. Crop Sci., 36, 296-300.
14. Holubec, V. and V. Dvoracek, 2005. Protein structure variability of Aegilops species. In: Proc. 5th Int. Triticeae symposium, Prague. Pp 148-155.
15. Jinyin, L., Lun S., Junfeng, G.,2002. Effects of water deficit on contents of protein and amino acid in wheat seeds In: Proc. 5th Int. Wheat Genet. Symp.,New delhi, pp:222-223.
16. Johnson, V.A., K.D. Wilhelmi, S.L. Kuhr, P.J. Matter and J.W. Schmidt, 1978. Breeding progress for protein and lysine in wheat. In: Proc. 5th Int. Wheat Genet. Symp.,New delhi, pp.825-835.

17. Katerji, N., J.W.Van Hoorn, C.Fares, A.Hamdy, M. Mastrorilli and T. Oweis, 2005. Salinity affect on grain quality of two durum wheat varieties differing in salt tolerance. Agri. Water management, 75:2,85-91.
18. Levy, A.A., and M. Feldman, 1989. Location of genes for high grain protein content percentage and other quantitative traits in wild wheat *Triticum aestivum* var. dicoccoides. Euphytica, 41,113-122.
19. Mangova, M. and G. Rachovska, 2004. Technological characteristics of newly developed mutant common winter wheat lines. Plant Soil Environ. 50: 84-87.
20. Musaddique, M., A. Hussain, S.A. Wajid and A. Ahmad, 2000. Growth, yield and components of yield of different genotypes of wheat. Int. J. Agri. Boil. 3:242-244.
21. Naserian, B., A.A. Asadi, M. Rahimi and M.R. Ardekani, 2007. Evaluation of wheat cultivars and mutants for morphological and yield traits and comparing of yield components under irrigated and rain fed conditions. Asian J. Plant Sci. 6:214-224.
22. Nevo, E., A. Gramma, A. Belles and E.M. Golenberg, 1986. Resources of high protein genotypes in wild wheat, *Triticum dicoccoides*, in Israel: Predictive method by ecology and allozyme markers. Genet., 69,215-227.
23. Ryan, J., N. Nsarellah and M. Mergoum, 1997. Nitrogen fertilization of durum wheat cultivars in the rain fed are of Morocco: biomass, yield and quality considerations. Cereal Res. Comon., 25: 85-90.
24. Sakin, M.A., A. Yildrim, and S. Gokmen, 2005. Determining some yield and quality charecteristics of mutants induced from a durum wheat (*Triticum durum*) cultivar. Turk. J. Agric. For., 29, 61-67.
25. SAS Institute Inc. SAS Procedures Guide: Version 6.3 ed. Cary: SAS institute.1990.
26. Stone. P.J. and M.E. Nicolas, 1994. Wheat cultivars vary widely in their responses of grain yield and quality to short periods of post-anthesis heat stress. Australian J. Plant Physiol. 22,927-934.
27. Stone. P.J. and M.E. Nicolas, 1995. A survey of the effects of high temperature during grain filling on yield and quality of 75 wheat cultivars. Australian J. Plant Physiol. 46,475-492.
28. Triboi, E., P. Martre, and A.M. Triboi-Blondel, 2003. Environmentally-induced changes in protein composition in developing grains of wheat are related to changes in total protein content. J. Exp. Bot., 54: 1731-1742.Weegels, P.L., R.J. Hamer, and J.D. Schofield, 1996. Critical review: functional properties of wheat glutenin. J. Cer. Sci.. 23,1-18.