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Response of Qualitative Characteristics of Spring Bread Wheat (*Triticum aestivum* L.) to Terminal Heat and Determine Correlation Between Traits

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RESEARCH ARTICLE

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ABSTRACT

BACKGROUND: Terminal heat stress affected on qualitative characters. Identification of relation between heat tolerance and baking quality is more important. Many quality characteristics are important for the utilization of wheat, particularly flour protein concentration and bread-making properties.

OBJECTIVES: This study was performed to evaluate the tolerance of bread wheat genotypes qualitative traits to extreme heat stress (above 40 C°). Genotypes were evaluated in two separate experiments in 2 years.

METHODS: The experiment was laid out in split- split- plot design with 3 replications at field of Safi Abad Dezful (Khuzestan province of Iran) Agricultural Research Station in 2014-2016. To study qualitative traits and seed protein, 4 genotypes (Chamran, Baj, Chamran2 and ER-92-19), 3 cultivation methods (stripe, 2 line on bed and 3 line on bed) and 3 seed rate (400, 600 and 800 seed.m^{-2}) are selected.

RESULT: Seven qualitative traits involve bread value (BV), hardening index (HI), Moisture%, Protein%, WA% (water absorbance), Zeleny and Wet gluten was measured. Correlation coefficient results seed protein% had negative with HI, BV and Zeleny. BV had positive correlation with HI and positive with flour moisture and wet gluten. Results showed that cultivation method influence on BV and seed protein. Only BV influenced by seed rate. In 600 seed.m^{-2} BV was the least (513.21) and in 800 seed.m^{-2} was the most (519.28). Genotypes in BV, HI, protein and Zeleny had significant differences. These results are so useful for preparing gluten free breads. But more research require.

CONCLUSION: In hot climate such as north of Khuzestan province of Iran that spring has above temperature and multiple cropping system is usual, cultivation of tolerant and early mature genotypes had economical. In Addition with good management, seed quality is better than forecasting. So researchers can promote this project and farmers can use these results surely.

KEYWORDS: *Bread value, Hardening index, Protein, Seed, Zeleny.*

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1. BACKGROUND

Wheat is the most important cereal crop in the world and is a major source of nourishment. The total area of Iran is around 164.8 million hectares, of which about 18.5 million hectares are used for agriculture. The country's climate is generally semi-arid or arid, except in the Caspian Sea region. Warm areas of Iran are characterized by a Mediterranean climate, winter rainfall pattern, mild winters, short springs and warm-to-hot summer temperatures. This agro-climatic zone includes Khuzestan, Boushehre, Golestan, parts of Kermanshah, Ilam, Lorstan, Kohgilouieh and Boyrahmad, and Fars Province. Optimum time for sowing of wheat in Iran Qualitative characters affected by temperature. Heat and drought are the major abiotic constraints that determine wheat yield and quality in the warm areas of Iran. Terminal heat stress caused by high temperatures during wheat grain development is an important constraint to wheat production (Rane *et al*., 2000; Sharma *et al*., 2007). In most wheat growing regions and especially in Mediterranean environments, plants are subjected to several physical and biotic stresses during grain-filling. In late sowing condition, wheat crop faces high temperature stress. Heat stress lowers the grain yield and quality significantly. Terminal heat stress affected on qualitative characters. Identification of relation between heat tolerance and baking quality is more important. Many quality characteristics are important for the utilization of wheat, particularly flour protein concentration and bread-making properties. These characteristics usually are influenced by genotype and environment. Generally, it is believed that cultivar traits are the most important in determining wheat quality (Blumenthal *et al*., 1995; Geleta *et al*., 2002; Souza *et al*., 2004). Some studies reported that the role and effect of environment, such as temperature on wheat quality can be large (Blumenthal *et al*., 1991; Guttieri *et al*., 2001; Souza *et al*., 2004). Most studies on the effects of heat shocks during grain filling and maturation have focused on grain yield and yield components (Stone and Nicolas, 1998; Gibson and Paulsen, 1999; Yang *et al*., 2002; Viswanathan and Khanna-Chopra, 2001). A few studies concentrated on effects of heat stress on quality traits particularly on the content of a very high molecular weight fraction of gluten protein that is widely accepted as being one of the keys to cereal end-use quality. The quality of wheat-based foods and the processing properties of wheat flour dough are strongly related to the presence and properties of very high glutenin protein aggregates (Don *et al*., 2003). At interesting research done by Eiyvazi *et al* (2009) in Miandoab Iran of common wheat cultivars showed that genotypes had significant differences in many traits. Heat stress decreased gluten index and glutenin and increased protein, gliadin, HI, falling number and WA. In this research Arvand and Khazar cultivars had the most seed yield (416, 418 $gr.m^{-2}$) and the least gluten index. In addition Kavir and Roshan cultivars had the least and the most gluten in hot climate respectively. Genotypes with lower TWS had more

seed protein. Gluten index in Falat and Roshan was more than local cultivars. Arvand had soft texture so starch damaged and need low water for flour making. Shahsavand Hassani *et al* (2005) studied 9 genotypes of Iranian wheat had the most, average and the least salt tolerate stresses). Result showed that salt increased baking bread and valurimetery. There wasn't significant correlation between making bread value in salt stress and salt less condition. Otherwise there was positive and significant correlation between zeleny and valurimetery rate but don't refer to salt tolerance. Sayal *et al* (2006) studied effect of heat stress (over 35C°) on qualitative and quantitative characters in seed formation stages of wheat. They refer to hundred weight seed and seed yield decreased in filling seed period and increased protein (4%) in hot climate. Pierson *et al* (1998) reported that heat stress(over 35c◦) had positive effect on bread volume(BV) and SDS in filling seed period but if this time is over 90 hour, it has negative effect on bread making. Blumenal *et al* (1991) reported that heat stress (over 32C°) in filling seed period had significant positive correlation with seed protein and there was significant negative correlation between seed yield and dough firmness. Pier *et al* (2007) said that water stress in 9 bread wheat genotypes in filling seed stage decreased yield, TWS and seed size but increased seed protein (11.64 to 12.83). They said that in area with terminal water stress early maturity genotypes with stable seed quality is probability. Huwi *et al* (2007) applied 3 level of heat stress (high, average and low) increased seed protein but the gluten quality decreased because gliadin/glutenin had increased.

OBJECTIVES

This study was performed to evaluate the tolerance of bread wheat genotypes qualitative traits to extreme heat stress (above 40C°). Genotypes were evaluated in two separate experiments in 2 years.

3. MATERIALS AND METHODS

3.1. Field and Treatments Information

The experiment carried out during at the Agricultural Research Station of Safi Abad Dezful (Khuzestan province of Iran) during 2014-2016 cropping season in 32 16'N and 48 25'E and is located at 82 m of surface. The experiment was laid out in split- split- plot design with 3 replications. The research was carried out as split – split plot base on randomized complete block design with three replications that the main factor was cultivation method in three levels of A: 1- strip 2- two line on bed, and 3-three line on bed and the sub factor B was in three levels of seed rate (b_1: 400, b_2: 600, b_3: 800 seed m^{-2}) and 4 genotypes C (C_1: Chamran, C_2: Baj, C_3: Chamran2, C_4: ER-19-92).

3.2. Farm Management

Soil sampling was carried out from the farm, soil texture was loam- clay and its pH was 7.75. Other results of soil analysis are presented in Table 1. This study done in (45-50 C◦) in extreme heat stress.

Table 1. Chemical soil analysis results

Characters	0-15 (cm)	15-30 (cm)	30-60 (cm)	60-90 (cm)
Soil Texture	Silt Clay	Silt Clay	Clay	Sand Clay loam
Sand (%)	17	5	12	57
Silt (%)	43	42	35	27
Clay (%)	30	53	53	27
O.C (%)	1.4	1.2	1.2	1.5
pH	7.2	8	8.2	8.3
EC (ds.m^{-1})	4.5	3.5	2.3	2

3.3. Measured Traits

Qualitative traits evaluated including HI, BV%, WA%, Moisture%, Zeleny and Wet gluten. 50 gr seed of each genotype selected and made flour by grinder mill (about 20 gr flour obtained). This flour measured by inframatic1800 applicator (work base on infrared ray). To extract glutenin used step by step way. The first each sample add to 1000 µl Alcohol 70% and an hour stayed in hot water (60 C°). After vortex centrifuged by 5 minute in 13000 time minute. Liquid slop and added 1 ml propanol (50%). Reminder material stayed in 60 C° for 30 minute. Then vortex centrifuged and excessive liquid slop. This process replied twice again. Then added 0-5 ml propanol (50%) to each sample and centrifuged for 5 minute. Then added DTT (1%) with buffer (Tries HCl + Propanol) for 3 minute in 60 C°. After that centrifuged 13000 time/minute for 2 min. and separated buffer (1 ml) and added 4-Vp2 (0.14 M) for 15 min. in 60 C°. Then centrifuged for 2 minute and transferred top liquid to micro tubes.

3.4. Statistical Analysis

Data analysis was performed using statistical software SPSS 20 and comparison of means was done with Duncan test at 5% probability level.

RESULTS AND DISCUSSIONS

Results Summary of the analysis of variance shown in Table 2. In Combine analysis Cultivated types (A factor) had significant differences. Compare means of main plot with Duncan test showed that stripe had the least BV (509.93) and seed protein (13.943) and two line on bed had the most BV (520.18) and seed protein (14.53).

Table 2. Analysis of variance (mean square) treatments on qualitative traits

S.O.V	df	BV%	HI%	Zeleny	Flour Moisture%	WA%	Wet Gluten%
Year	1	181.683^{ns}	0.154^{ns}	1.088^{ns}	0.114^{ns}	0.169^{ns}	1.482^{ns}
Cultivation method (a)	2	2472.256*	0.59^{ns}	0.548^{ns}	0.037^{ns}	0.12^{ns}	0.924^{ns}
Error a	8	452.947	1.904	0.577	0.029	0.129	0.711
Seed rate (b)	2	545.641*	0.286^{ns}	2.644^{ns}	0.11^{ns}	0.143^{ns}	0.666^{ns}
a×b	4	787.357*	1.428^{ns}	3.29^{ns}	0.031^{ns}	0.226*	1.003^{ns}
Error b	24	425.529	2.513	2.947	0.096	0.147	2.387
Genotype (c)	3	72652.1*	66.956**	30284**	0.131^{ns}	0.087^{ns}	27.83**
a×c	6	1290.1**	1.1^{ns}	0.777^{ns}	0.1^{ns}	0.078^{ns}	3.894**
b×c	6	658.719*	1.1^{ns}	0.673^{ns}	0.105^{ns}	0.096^{ns}	1.813*
a×b×c	12	355.203^{ns}	1.25^{ns}	1.711^{ns}	0.064^{ns}	0.156^{ns}	1.111^{ns}
Error	106	212.728	1.173	0.913	0.097	0.064	0.848

$^{ns, *}$ and **: no significant, significant at 5% and 1% of probability level, respectively. BV: bread volume, HI: hardening index, WA: water absorbance.

Subplot (B factor) had significant differences in seed rate. 600 seed/m^2 had the least (513.21) and 800 seedm^{-2} had the most BV (519.82). Cultivation type × seed rate (a×b) had significant differences. Genotypes(C factor) had significant differences. Chamran had the least HI (51.59) and Baj had the most (54.13). Chamran had the least Zeleny (37.722) and ER-92-19 had the most (39.444). Baj had the least Wet gluten (37.67) and ER-92-19 had the most (39.19). Study of correlation between qualitative traits showed that BV had positive correlation with HI and WA and negative with Zeleny, wet gluten and protein percent, so bread volume in harder seeds and more WA is more than others and this is suitable for French breads but protein% is low. Knowing the relationship among these processes and investigating other quantitative traits make breeding programs and their success more optimistic and secure (Mijic *et al*., 2006). Seed yield is a quantitative trait, which expression is the result of genotype, environmental effect and the genotype environment interaction (Gunasekera *et al*., 2006). Correlation coefficient analyses help researchers to distinguish significant relationship between traits. Step-wise regression can reduce effect of non-important traits in regression model, in this way traits accounted for considerable variations of dependent variable are determined (Agrama, 1996). Assessment of relationship using correlation coefficient analyses help breeders to distinguish significant relation between traits. Determination of correlation coefficients is an important statistical procedure to evaluate breeding programs for high yield, as well as to examine direct and indirect contributions to yield variables (Semahegn Belete, 2011). Knowing the relationship among these processes and investigating other quantitative traits make breeding programs and their success more optimistic and secure (Diepenbrock, 2000). In table 3 correlations between traits has showed. Unfortunately, excessive heat decreased protein% and flour moisture%. In table 4 was showed the means of studied traits in different genotypes. Baj was the best genotype for bread making (in hot climate and late sowing) but had low protein. Therefore researchers advised Baj seeds was mixed with other genotypes for editing flour characters and good bread. Due to higher seed yield in Baj, protein that negative correlation with the yield or crop production, was low.

Table 3. Correlation between traits

Traits	BV	Zeleny	HI	WA	Moisture%	WGluten	Protein%
BV		-0.288**	0.5**	0.15*	-0.35	-0.142*	-0.366**
Zeleny			0.193**	-0.72	-0.189**	0.106	-0.166*
HI				0.86	-0.80	-0.153	-0.220**
WA					-0.94	0.026	-0.12
Moisture%						0.106	0.066
WGluten							0.111

ns, * and **: no significant, significant at 5% and 1% of probability level, respectively.

BV: bread volume, HI: hardening index, WA: water absorbance.

Table 4. The means of qualitative traits in genotypes

No.	Name	Protein%	BV	Zeleny	HI%	WA%	Moisture%	Wet gluten
1	Chamran	14.085	483.78	51.59	11.71	39.59	66.35	38.04
2	Baj	13.92	565.04	54.13	11.66	39.09	66.44	37.67
3	Chamran2	14.075	492.19	52.65	11.60	38.96	66.42	39
4	ER-92-19	13.52	524.72	52.02	11.65	39.44	66.36	39.19

BV: bread volume, HI: hardening index, WA: water absorbance

CONCLUSIONS

In hot climate such as north of Khuzestan province of Iran that spring has above temperature and multiple cropping system is usual, cultivation of tolerant and early mature genotypes had economical. In Addition with good management, seed quality is better than forecasting. So researchers can promote this project and farmers can use these results surely.

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This research is the first study in hot climate in world due to cultivation done 16 March and was obtained economical yield with acceptable quality. I think results can use in similar area.

AUTHORS' CONTRIBUTION: All authors are equally involved.

CONFLICT OF INTEREST: Authors declared no conflict of interest.

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