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ESTIMATION OF VARIETAL DIFFERENCES FOR GRAIN QUALITY TRAITS IN WHEAT UNDER TWO DIFFERENT IRRIGATION REGIMES

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ABSTRACT

The purpose of this research was to determine the differences among varieties under two irrigation conditions namely water stress and normal irrigation for wheat grain quality traits. In the years 2015 and 2016, sixteen genotypes of bread wheat were evaluated for both irrigation conditions. Split-split-plot design was used as an experimental layout. The interaction between genotypes and treatments showed significant differences for four traits viz. 1000-grain weight, test weight, starch percentage and gluten percentage. A noticeable increase in protein and gluten content of grain and reduction in 1000-grain weight, test weight and starch content were observed under water stress condition. Three lines viz. NR-423, NR-429 and DN-102, showed better results under stress for most of the traits. Hence, these lines are considered to have better response with respect to quality of grain in stressed environment.

Key words: Wheat quality; Split-split-plot design; Irrigated and stress environment

INTRODUCTION

Wheat is one of the utmost important crops cultivated under arid and semi-arid climates of the world. The most important restricting parameter of wheat production is shortage of irrigation. Like other countries of the world, Pakistan has been made efforts on large scale to develop water stress tolerant cultivars. The wheat grain quality characteristics are highly influenced by genotype, environment and their interaction. During post anthesis period undesirable environmental conditions have been identified as a main limiting factor for wheat grain quality (Barutcular *et al.*, 2016). Alghory and Yazar (2018) reported that under water stress conditions the developing grains are suffered with stress at grain filling stage which ultimately causes grain yield reduction and deterioration of grain quality. The environmental impact on dough characteristics and grain protein content within a particular location can be changed with a choice of varieties and irrigation regimes (Aslani *et al.*, 2013).

The principal environmental parameter affecting the wheat grain quality is water. Several research experimental trials have been conducted to find out the effect of water stress on wheat grain quality. Fratianni *et al.* (2013) explained that wheat yield fall that occurs under water stress environment is generally due to a rise in protein content. Gooding *et al.* (2003) led out several experimental trials under controlled environmental conditions and found out that during grain filling stage, the effect of water stress on the grain quality properties was totally dependent on the timing of stress. In particular, limiting water from the 1st to the 14th day over grain development significantly declined SDS sedimentation volume compared to water stress applied later. In difference to prior results, Ottman *et al.* (2000) found out that the effects of irrigation frequency on wheat grain quality over grain development are contrasting. The findings differences in grain quality may cause both to differences in starch characteristics and in protein content, aggregation and composition level (Prasad *et al.*, 2011).

Depending on the variability of study conditions, stress imposed, and different experimental methods there are inconsistent reports about the effect of water stress on wheat grain quality. So, the objective of this study is to evaluate the wheat genotypes for better grain quality traits under normal irrigations and water stress conditions.

MATERIALS AND METHODS

The present research was conducted at Regional Agricultural Research Institute, Bahawalpur for two growing seasons. In the years, 2014-15 and 2015-16, 16 wheat varieties (Johar-16, DN-102, NRL-1123, Anaj-17, 11C023, TW11510, DANI-1313, PR-110, PR-111, PR-112, NR-423, NR-429, NR-449, KT-338, Faisalabad 2008, Pak 13) were sown on 15th of November at the seeding rate of 450 seeds m^{-2}. Split-split plot experimental design was used. Sowing years were allocated as main plots, Sub-plots were irrigation conditions (water stress and irrigation) finally sub-sub plots put as genotypes. Each sub-sub plot comprised of 6 rows of 5 m length and 30 cm apart between the sub-plots, 1.5 m space was left to avoid edge interference between the treatments. Irrigation and water stress, two treatments were applied.

Irrigated condition: The plots were irrigated about 6 times. In both years, six irrigations of 450 m^3 ha^{-1} were necessary: three during the vegetative period and three over the grain development period.

Water stressed condition: One irrigation was applied at the time of sowing and one at grain maturity stage. In both water regimes, water was used for establishing the field capacity 0.35 m soil profile.

The recommended dose of fertilizers as source of Nitrogen, Phosphorus and Potassium were used. On the basis of soil test results, 150 kg/ha, 115 kg/ha and 60 kg/ha of Urea, DAP and MOP were added to the soil, respectively. Total amount of MOP and DAP while one-third of the urea was applied before plantation during soil preparation and mixed well with soil. At the tillering and stem elongation stage the remaining urea was applied in the form of top dressing. The weeds were eradicated manually during the growing season. No other disease or pest attack was

Separate harvesting and threshing of each subplot were conducted at maturity. One and a half kg of seeds per subplot was separated as a sample and sent to wheat grain quality testing laboratory at Wheat Research Institute, Faisalabad, to test the grain quality including gluten content, protein content and starch content. 1000-grain weight and test weight along with other above-mentioned traits were taken to evaluate the wheat lines under both water regimes.

Statistical analysis was done using Statistix-8.1 version and mean analysis was used to check the treatment*genotype interaction for both irrigation conditions.

RESULTS AND DISCUSSION

Significant differences were obtained among genotypes and treatments for the traits; 1000-grain weight, test weight, starch (%) and gluten (%). The effect of year was significant for 1000-grain weight and gluten (%). Year x treatment interaction was significant for test weight and gluten (%). Year x genotype interaction was highly significant for 1000-grain weight, starch and gluten (%). Year x treatment x genotype interaction showed non-significant results for all the measured traits. Treatment x genotype interaction was significant for gluten content (Table 1).

1000-Grain weight: Milling quality of grain is affected by grain weight of wheat and grain weight is affected by water stress. There was significant reduction under water stresses compared to irrigated condition. The reduction in 1000 grain weight was about 7.3% under stress condition (Table 2). Control conditions gave the highest grain weight. 1000-grain weight is affected differently by different genotypes of wheat as KT-338 have the highest 1000-grain weight then comes DANI-1313 and the lowest value is obtained by TW11510.

According to the previous research, the environmental conditions have significant effect on wheat grain of different genotypes (Li *et al.,* 2013; Kaya and Akcura, 2014; Bouacha *et al.,* 2014). Grain weight of winter wheat is negatively affected by increasing temperature and water deficit stress during grain filling stage (Erekul and Kohn, 2006). And reduction in this trait is also observed in the case of maize by applying water stress at grain growth stage (Sabagh *et al.,* 2015).

Test weight (Kg/hl): Water stress resulted in reduction in test weight that was recorded 75.8 kg/hL, while the maximum test weight under irrigated regime was 78.9 kg/hL (Table 2). There was 3.9 % test weight difference found between both regimes that was considered slight (Table 2). But statistical analysis showed highly significant differences among genotypes for test weight that were 80.4 kg/hL for both NR- 449 and NR- 429 than come Johar. The test weight recorded for Anaj-17 was 73.8 kg/hL which is the lowest value under water stress regime (Table 2). Hence, the results showed similarity with the findings of Pierre *et al.,* (2008) who found that test weight is reduced by water stress (Pierre *et al.,* 2008).

Table 1. Analysis of variance (MS values) for wheat quality parameters.

S.O.V	DF	1000 Grain weight	Test Weight (kg/hL)	Starch (%)	Protein (%)	Gluten (%)
Rep	2	4.785	6.193	3.997	16.295	1.210
Year	1	649.667**	4.687^{NS}	14.963^{NS}	0.0121^{NS}	173.09*
Water Treatment	1	356.212**	463.142**	139.435**	94.654**	364.928**
Year x Treatment	1	1.068^{NS}	88.292**	6.113^{NS}	5.208^{NS}	17.100**
Genotypes	15	56.699**	14.901**	9.419**	2.6501^{NS}	25.812**
Year x Genotypes	15	11.451**	2.316^{NS}	2.81**	0.9372^{NS}	9.463**
Water treat x Genotypes	15	3.961^{NS}	1.781^{NS}	1.166^{NS}	0.559^{NS}	3.531*
Year x Water treatment x Genotypes	15	2.421^{NS}	2.440^{NS}	1.118^{NS}	0.776^{NS}	2.839^{NS}
CV (%)		4.19	1.84	2.07	10.66	4.24

*=Significant at 5% level of probability **=Significant at 1% level of probability NS= non-significant

Table 2. Mean performance of 16 wheat genotypes under two different water regimes.

	1000-grain weight (g)		test weight (kg/hL)		starch (%)		Protein %		Gluten (%)	
Genotypes	Irrigated	Water stress	Irrigated	Water stress	Irrigated	Water stress	Irrigated	Water stress	Irrigated	Water stress
Johar-16	38.2	35.5	80.0	75.8	56.3	54.2	13.6	15.4	28.4	31.5
DN-102	36.2	35.0	79.3	77.6	55.7	54.0	13.6	14.5	27.4	29.0
NRL-1123	37.0	32.2	79.6	77.3	55.2	53.4	14.1	15.8	29.5	32.5
Anaj-17	35.1	32.9	77.8	73.8	54.8	53.7	13.3	15.8	27.3	31.3
11C023	37.2	35.4	77.3	75.1	54.1	52.2	14.4	15.8	30.9	32.6
TW11510	34.7	32.9	78.9	75.2	55.5	53.9	14.6	15.7	29.8	30.5
DANI-1313	41.5	38.2	79.4	76.4	53.8	52.6	14.6	15.6	29.5	31.8
PR-110	40.4	36.2	78.5	74.3	53.9	52.7	15.1	16.0	31.7	35.1
PR-111	38.2	36.4	78.3	75.8	54.0	51.7	14.9	15.9	30.0	31.8
PR-112	36.4	34.3	79.5	75.8	53.2	52.0	14.7	16.3	29.9	32.3
NR-423	41.2	36.1	79.9	76.7	55.0	52.3	14.7	16.4	32.6	35.8
NR-429	41.0	38.8	80.4	78.0	54.6	53.1	15.0	16.3	29.7	33.8
NR-449	36.3	34.5	80.4	77.5	54.4	53.5	14.9	16.1	30.0	31.8
KT-338	41.6	39.4	77.8	74.0	54.5	53.6	14.2	15.6	28.3	31.3
Faisalabad 2008	38.1	34.7	78.5	75.5	53.7	50.6	13.9	15.5	28.3	31.8
Pak 13	40.6	37.7	77.5	74.7	55.8	54.0	13.9	15.5	27.8	32.5
Mean	38.4	35.6	78.9	75.8	54.7	53.0	14.3	15.7	29.4	32.2
% reduction	7.30%		3.90%		3.10%		/		/	
% increment	/		/		/		8.90%		8.70%	

Starch weight (%): Amount of starch accumulation in wheat grain depends on genotype and their reduction also varies among genotypes under water stress. Water stress impaired the function of sucrose synthase. Low sucrose content and less efficiency of enzymatic activities of starch bio-synthetic path way As water stress effects the enzyme and sucrose synthase, which is involved in starch biosynthetic pathway under water deficit stress lowers down the starch content in wheat kernel (Bhullar and Jenner, 1985). A sustainable genotype is considered to be having a better protection mechanism against deterioration of synthesis of starch. Starch is an important component as it enhances the palatability along with a good source of energy. It also helps in increasing the extensibility of dough by maintaining the flour viscosity that is good for bakery products (Balla *et al.*, 2011).

So, a genotype having low starch content is problematic both in chapatti or bread making and other characteristics. In present experiment, results revealed Johar, Pak-13 and DN-102 as better varieties for their starch content that were 56.3%, 55.8% and 55.7%, respectively, under irrigated conditions. These genotypes also perform well for this trait under water stress conditions. Hence, it is concluded that these three lines have good chapatti making characteristics.

Protein weight (%): Grain protein contents were analyzed to evaluate quality attributes of wheat genotypes. Protein content of grains was increased significantly under water regime. The highest value (16.4%) was recorded under water stress while, the minimum protein contents in grains (13.3%) were obtained from favorable irrigation (Table 2). For grain protein content no significant variation among genotypes were found statistically. Furthermore, NR-423 followed by NR-429 and PR-112 indicated the best value for protein content in grains with mean values (16.4%, 16.3% and 16.3%, respectively) under water shortage condition (Table 2).

Pierre *et al.* (2008) reported that water stress during the growth stage of grain formation causes reduction in grain yield, 1000-grain yield and in grain thickness, but it also increases the mean values of protein percentage. Sial *et al.* (2005) reported that due to water stress, wheat 1000-grain weight was reduced which ultimately increases 4% of protein concentration under water stress condition. Eivazi *et al.* (2006) described about the reduction in the amount of some desired traits including gluten, glutenin, gliadin, kernel hardness, falling number, and also an increment in protein content indexes and the amount of water absorption under salt stress and water deficit condition.

Gluten weight (%): For gluten weight the genotypic means ranged from 29.0% to 35.8% and 27.3 to 32.6 % under water stress conditions and irrigated field conditions, respectively (Table 2). Under water stress and irrigated conditions PR-110 and NR-423 produced the highest gluten content. The gluten weight of all genotypes increased under water stress. The findings of Houshmand *et al.* (2014) are similar to our results.

CONCLUSION

A significant decrease in 1000-grain weight (g), test weight (kg/ hL) and grain starch content (%) was caused by water stress, while there was an increase in protein content (%) and gluten content (%) under such conditions. Under water stress conditions NR-423, NR-429 and DN-102 performed better in respect of most important traits of grain quality. Hence, we conclude that in the water stressed or rain-fed areas of Punjab, Pakistan above mentioned genotypes are potentially good candidates for producing good bread making quality of wheat.

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