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EFFECT OF POST ANTHESIS DROUGHT ON CERTAIN AGRONOMICAL CHARACTERISTICS OF WHEAT UNDER TWO DIFFERENT NITROGEN APPLICATION CONDITIONS

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ABSTRACT

A field experiment was conducted to evaluate effect of drought stress at the post anthesis stage on a bread wheat cultivar, Gönen, during the 2009-10 and 2010-11 growing seasons. Plants were covered with a rainout shelter after the post anthesis stage to prevent rain. Nitrogen fertilizers were applied at two different ways during the plant growth. The experiment was arranged in split block with three replications. Grain yield was 2445 kg/ha under the control condition whereas 1755 kg/ha under the drought condition. High amount of early application of nitrogen fertilizer resulted in 21.6 % increase in grain yield. Drought after flowering stage caused 5.2 % and 20.7 % reduction in thousand kernel weight and kernel number respectively. But there were no significant effects of nitrogen treatments on these traits. Plant height, tiller number, spike number, spikelet and kernel number, single plant yield, spike and stem weight decreased as a result of drought stress after post anthesis while only tiller number and spike number interacted with nitrogen treatments under the stress condition. The results suggested that early application of nitrogen leads to sufficient plant growth and root development resulting in a better adaptation to the post anthesis drought conditions.

Key words: wheat, post anthesis drought, nitrogen, yield

INTRODUCTION

Drought affected areas have been increasing with the global warming all around the world (Isendahl and Schmidt, 2006). The negative effects of drought have also became more pronounced in the Mediterranean basin such as the Aegean Region (Acevedo et al., 1999). Skovmand et al. (2001) stated that cereal production increases every year so the water need will also increase correspondingly. Modern wheat cultivars have generally been bred for optimal conditions so they have limited tolerance to water stress (Richards et al., 2001). Effects of drought depend on the phenological stage of the wheat plants. Spikelet and kernel number are affected by water stress occurs during the stem elongation stage (Shpiler and Blum, 1991). Translocation of dry matter to grain is negatively affected by the drought after the flowering stage (Garcia del Moral et al., 2003; Ilker et al., 2011).

Mediterranean type climate is characterized with insufficient and variable rainfall and humid winter period but dry and warm summer seasons (Acevado et al., 1999). Therefore Vapor Pressure Deficit (VPD) is low and the soil moisture content is high during the vegetative growth stages of wheat. Beside wheat plants are faced with high temperature, light intensity and water stress during the grain filling period. Therefore drought is one of the top stress factors affecting wheat which is a cool climate crop. (Ozturk, 1999).

Shahryari et al. (2008) reported that reduction in the grain weight of wheat as a result of drought fallowing flowering stage was mostly related with grain weight and number of tillers. On the other hand the grain number and the grain weight have been previously proposed as the selection criteria for higher yield potential under the post anthesis drought conditions (Motzo et al., 1996). Blum et al. (1989) studied 68 wild wheat genotypes and reported that the tolerance level of wheat plant to the post anthesis drought was mostly regulated by the translocation capacity of dry matter to grain.

Nitrogen is the main factor limiting yield if the water is sufficient in the soil (Jensen et al., 1990). Passioura (2002) stated that negative relationship between these two entries prevents the further yield increase (Cabrera-Bosquet et al., 2007). Sugiharto et al. (1990) reported a positive relationship between leaf nitrogen and photosynthetic capacity of wheat.

The aim of this research was to study the effects post anthesis drought stress and nitrogen application on the agronomical characteristics of the bread wheat cultivar, Gönen.

MATERIALS AND METHOD

A two years of field trial was conducted in the experimental field of the Department of Field Crops of the Agricultural Faculty of the Ege University, Bornova during the 2009-10 and 2010-2011 growing seasons. A bread wheat (*Triticum aestivum* L.) cultivar Gönen was used as plant material. The trial was run in a Randomized Complete Block Design in the split plot arrangement with 3 replications in the two consecutive growing seasons.

The seeds were sown in November 21, 2009 and November 28, 2010. A rain-out shelter was used to prevent rain after the post anthesis stage to represent "drought stress", whereas plants were grown in the open field as "control". Drought treatments were started in April 2, 2010 in the first year and April 6, 2011 in the second year. The stress was imposed on the drought treated plants until harvesting at the first week of June in two trial years 2010 and 2011. Nitrogen was given in three times: 30 kg/ha as top dressing, 30 kg/ha at the beginning of stem elongation stage and 30 kg/ha before flowering stage in treatment "N1". In the "N2" treatment, Nitrogen was applied two times: 60 kg/ha as top dressing and 30 kg/ha at the beginning of stem elongation stage. The Ammonium Sulfate was used as top dressing and Ammonium Nitrate was used in other applications. All treatments received same amount of P_2O_5 (50 kg/ha) as triple Super Phosphate. There was sufficient level of potassium in the soil of experimental site, so any potassium contained fertilizer was not applied. The soil of the experimental site can be characterized as clay and loamy with 0.118 % total nitrogen, 3.5 ppm available phosphorus and 407 ppm potassium content. The experimental plots consisted of 6 rows of 3 m length. Spacings between rows were 20 cm and the seeding density was 500 seed/m^2. Meteorological conditions of the growing season and stress application period were given in Table 1.

Table 1. Rainfall, temperature and relative humidity of the experimental site during the 2009-10 and 2010-11 growing seasons.

Months	2009-10 growing season			2010-11 growing season		
	Total Rain Amount[1] (mm)	Mean Temperature (ºC)	Relative Humidity (%)	Total Rain Amount (mm)	Mean Temperature (ºC)	Relative Humidity (%)
November	160,3	14,6	70,8	32,4	18,1	75,4
December	151,8	13,1	70,2	155,7	13,3	76,9
January	142,3	10,6	66,7	100,9	9,0	69,8
February	301,3	12,6	67,8	107,3	10,3	63,1
March	16,1	13,3	61,6	18,8	12,0	57,6
April	20,4	17,4	55,7	65,3	14,5	62,1
May	27,1	21,8	49,8	29,4	20,1	55,7
June	76,3	25,5	51,4	0,6	25,4	48,2

1.Rainfall was 0 in the Drought stress plots in April, May and June in two growing years.

After physiological maturity, border lines of the plots were removed and 10 individual plants were randomly sampled. The samples were separated into stems and generative parts. Thousand kernel weight (TKW) was determined as the mean of samples of 100 seeds. Other parts of plants were dried in an oven at 105 ºC for 24 hours and dry weights were determined. Plant height, tiller numbers, spike number, spike length, spikelet number, kernel number, spike weight, stem weight, kernel per spike, thousand kernel weight and plant yield were determined by using the measurements of 10 single plants. Grain yield and hectoliter weight were determined by the plant samples obtained from the middle four rows of plots.

All data were analyzed by using standard ANOVA techniques of the computer program TARİST. The means were compared by using the LSD test described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Variation for stress conditions was significant for all parameters except spike length and hectoliter weight (Table 2 and 3) whereas variation for nitrogen application was non significant. The interaction between the stress condition and nitrogen application was significant only in tiller number and spike number. Grain yield of the plants subjected to drought stress during the post anthesis stage had also lower grain yield than that of the control (Figure 1). In addition, the N2 type nitrogen application regime resulted in higher grain yield under the two conditions; stress and control. Highest grain yield was found for control and in the N2 type treatment as 2.653 kg/ha (Figure 1).

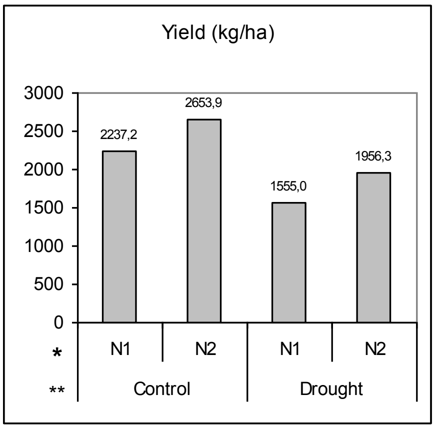

Figure 1. Effect of post anthesis drought stress and different nitrogen applications on yield of wheat (cv. Gönen). N1 and N2 refer two different nitrogen application (Stress treatment LSD: 346.2, Nitrogen treatment LSD: 466.5).

These results showed that nitrogen application is more efficient if total amount of the fertilizer is given two times as in the N1 instead of three times as in the N2 treatment when post-anthesis drought may occur. Negative effect of drought on wheat yield has been presented in several studies (Shah and Paulsen, 2003; Ilker et al., 2011; Wardlaw, 2002). Thousand kernel weights decreased as a result of drought stress in the post anthesis stage (Table 3). Thousand kernel weight was 34.0 g in the control whereas 32.2 g in the drought treatment. Eskandari and Kasemi (2010) also found negative effect of water stress on thousand kernel weight after the flowering stage in wheat. However nitrogen applications had no significant effects on thousand grain weight although grain weight slightly decreased with N2 application in drought stress treatment. Ercoli et al. (2008) also recorded that higher nitrogen application under drought stress resulted in lower grain weight in wheat. Kernel number per spike decreased by 20.8 % as a result of drought effect after post anthesis (Table 3). The mean kernel number in

Table 2. Means of plant height, tiller number, spike number, spike length and spikelet number for the treatments

Condition	Nitrogen[1]	Plant Height (cm)	Tiller Number	Spike Number (plant)	Spike Length (cm)	Spikelet Number (spike)
Control	N1	84,6	2,8	2,4	8,3	17,7
	N2	88,2	2,9	2,6	8,4	17,7
	Mean	**86,4**	**2,8**	**2,5**	**8,4**	**17,7**
Drought	N1	76,3	2,9	2,3	7,2	16,3
	N2	76,2	2,0	1,6	7,4	15,9
	Mean	**76,2**	**2,4**	**2,0**	**7,3**	**16,1**
The significance of F values						
Drought		**	*	*	NS	*
Nitrogen		NS	NS	NS	NS	NS
Stress x Nitrogen interaction		NS	**	**	NS	NS
LSD (0.05)		6,02	0,39	0,41	-	1,57

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level
NS Non significant
1. N1: Nitrogen was given in three times: 30 kg/ha as top dressing, 30 kg/ha at the beginning of stem elongation and 30 kg/ha before flowering stage.
N2: Nitrogen was given in two times: 60 kg/ha as top dressing, 30 kg/ha at the beginning of stem elongation.

Table 3. Means of kernel number, single plant yield, spike weight, stem weight and hectoliter weight number for the treatments

Condition	Nitrogen[1]	Yield (kg/ha)	Thousand Kernel Weight (g)	Kernel Number (spike)	Single Plant Yield (g)	Spike Weight (g)	Stem Weight (g)	Hectoliter Weight (100 ml/g)
Control	N1	2237,2	34,0	30,3	3,2	4,5	8,5	204,0
	N2	2653,9	33,9	34,1	3,1	4,4	9,2	203,4
	Mean	**2445,5**	**34,0**	**32,2**	**3,2**	**4,5**	**8,8**	**203,7**
Drought	N1	1555,0	32,8	23,2	2,4	3,4	5,9	203,7
	N2	1956,3	31,7	27,8	2,3	3,2	4,9	203,8
	Mean	**1755,6**	**32,2**	**25,5**	**2,4**	**3,3**	**5,4**	**203,7**
The significance of F values								
Drought		*	*	*	*	*	*	NS
Nitrogen		NS	NS	NS	NS	NS	NS	NS
Stress x Nitrogen		NS	NS	NS	NS	NS	NS	NS
LSD (0.05)		466,5	1,00	4,86	0,69	0,99	2,78	-

* Significant at the 0.05 probability level
** Significant at the 0.01 probability level
NS Non significant
1. N1: Nitrogen was given in three times: 30 kg/ha as top dressing, 30 kg/ha at the beginning of stem elongation and 30 kg/ha before flowering stage.
N2: Nitrogen was given in two times: 60 kg/ha as top dressing, 30 kg/ha at the beginning of stem elongation.

the control treatment was 32.2 per spike while 25.5 in the drought treatment. However nitrogen application had no statistically significant effect on kernel number per spike in two conditions. Fisher (2008) also reported that water stress causes a decrease in kernel number per spike in wheat after the flowering stage. TKW, kernel number per spike (KNS) and spike number per plant (SNP) are the yield components in wheat. Therefore reduction in grain yield under the drought conditions could be attributed to decreases in the TKW and KNS. However variable responses were observed in these two parameters as a result of different nitrogen treatment. Late nitrogen application (N1) contributed TKW while early application on (N2) to KNS.

Plant height significantly decreased as a response to the drought applied after post-anthesis stage in the study (Table 2). Mean plant height was 86.4 cm under the control condition whereas 76.2 cm under the drought stress. Different nitrogen application did not affected plant height. Ozturk (1999) has also reported that plant height decreased as a result of the water stress. Tiller number of plants decreased under the drought stress (Table 2). Mean tiller number was 2.8 in the control and 2.4 in the drought stress. However plants had different response to nitrogen treatments in the control and drought stress conditions. The N1 treatment caused higher tiller number (2.9) while the N2 treatment has lower (2.0). Borghi (1999) stated that higher nitrogen application during earlier stage of wheat development enhanced dry matter accumulation thus deeper root development. Therefore, plants can be more resistant to the post anthesis drought with higher nitrogen fertilization in earlier stages. Our results confirmed these findings and tiller number of plants was higher in the N1 treatment under the post anthesis drought. Parallel results were found for spike number per plant in the present study (Table 2). Average spike number of plants was 2.5 under the control condition whereas 2.0 under the drought stress. Although nitrogen treatment did not significantly affect spike number under the control condition, the N1 treatment had higher spike number (2.5) under the stress condition and the N2 had lower (2.0). Spike number as one of the main components of grain yield had a similar trend with TKW and kernel number per spike. However different nitrogen treatments might cause different result in the spike number per plant. The N1 treatment lead to higher spike number in the stress conditions whereas the N2 treatment in the control conditions. Therefore significant increase in grain yield with the N2 treatment can be explained by slight increase in both kernel number and spike number in the control conditions as a result of the N2 treatment. Spike length was not significantly affected by both nitrogen and stress treatment (Table 2). This result can be attributed that spike length mostly controlled by genetic factors rather than environmental conditions. Drought stress after post anthesis caused significant decrease in spikelet number per spike in the present study (Table 2). Average spikelet number per spike was 17.7 in control treatment while 16.1 in drought stress treatment. Sener et al. (2000) stated that spikelet number is largely affected by the environmental conditions.

Kernel number per spike also decreased under the drought stress condition (Table 3). Kernel number was 32.2 per spike under control condition while 25.5 under drought stress condition. Reduction in kernel number in wheat as a result of post anthesis drought has been previously reported (Fisher, 2008). Single plant yield decreased by drought after flowering stage (Table 3). Single plant yield was 3.2 g in the control and 2.4 g in the drought stress treatment. However nitrogen application did not significantly affected single plant yield. Spike and stem weight was also affected by the drought and decreased in the stress treatment (Table 3). Mean spike weight was 4.5 g and stem weight was 8.8 g in the control whereas 3.3 g and 5.4 g respectively under the drought stress condition. Reduction in the above ground dry matter accumulation under drought stress condition was also reported by Shirazi et al. (2010). Hectoliter weight of grains was not significantly affected by the nitrogen application and stress treatments (Table 3). Tosun et al. (2006) found slightly but not significant increase in the hectoliter weight of wheat under the drought stress.

CONCLUSION

Negative effects of drought stress during post anthesis stage on wheat in the Mediterranean type of environment have been pronounced recently. Response of wheat to post anthesis drought and the interactions with different nitrogen applications in terms of yield components were studied in the present study. Significant reduction in grain yield as a result of the drought after flowering stage was found. However this reduction was more distinct with lower nitrogen application in the earlier stages. Thousand kernel weight and kernel number per spike have also decreased by the drought stress although nitrogen application had not significant effects. In conclusion, it could be suggested that high amount of nitrogen fertilizer during the earlier stage of wheat growth might balance the negative effects of drought during the post anthesis stage.

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