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EFFECTS OF DROUGHT STRESS POST-ANTHESIS STAGEON MOBILIZATION OF STEM-RESERVES SUPPORTING GRAIN FILLING OF SOME TRITICALE CULTIVAR AND LINES

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Abstract

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The objectives of the study were to determine the contribution of stem reserves to grain filling in a triticale cultivar and lines under drought stress conditions created at post-anthesis stage by chemical desiccant application such as potassium chlorate (4%). The study was conducted with completely random block design replicated three times at Southern Marmara Region in 2005 and 2006. In this study, dry matter translocation (DMT- mg grain^{-1}), dry matter translocations efficiency (DMTE-%), rate of grain weight reduction (RGWR-%), mean productivity (MP- kg ha^{-1}) and seed yield tolerance (SYT- kg ha $^{-1}$) were determined.

Two-year averages indicated that the lines C9 and N x E (3) were more drought resistant than the other genotypes in respect of DMT, RGWR, MP and STY.

Key words: triticale; dry matter translocation; stem-reserve mobilization; post-anthesis drought stress; chemical desiccant

Introduction

Cereals are used directly or indirectly in human nutrition and are the basic products. In general, life styles and eating habits of countries vary with the share of cereals in total food consumption. However, in the past and still today, as well as in the future cereals will form the basic food of humanity and their importance will continue in the face of population increase (Kun, 1996). All over the world global warming and the related climate changes emerging in many countries have begun to affect crop production significantly. Especially with experienced frequent droughts, excessive and unexpected rainfalls cause problems. Drought is one of the significant stress factors of the environment. It threatens agricultural production on $10x10^8$ ha dry farming areas in the world, especially in developing countries. The effects are also becoming more prominent with time. It also impairs the balance of food production (McWilliam, 1986). Crop production problems occured on dry farming areas due to drought must be solved. To develop new varieties or use present ones on these areas are the important way for the solution of this problem. As known, hexaploid triticale is one of a few crops to be used for this purpose. Hexaploid triticale (*x Triticosecale Wittmack*) is a synthetic species. Studies have indicated that the grain production of new and improved triticale cultivars as a monocrop or as with small grain mixtures was acceptable in a wide range of environments (Pfeiffer, 1996; Juskiw et al., 2000 a,b; Barnet et al., 2006). Triticale is, in general, more tolerant to environmental stresses than Wheat and Barley (Jessop

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1996), but less tolerant than rye. However, resistance to water stress of different triticale genotypes also varies (Kutlu, 2008).

One of the methods that were approved as effective for the selection of cereal varieties resistant to drought is the chemical desiccant application. Desicant application does not simulate drought stress. It simulates the effect of stress by inhibiting current assimilation. In fact, researches have proven that the determination of varieties having stable grain yields and resistant to drought conditions was possible by the application of chemical desiccants. Many researchers obtained succesful results in different varieties of cereal by using desicant chemicals (Hossain et al., 1990; Nicolas and Turner 1993; Blum et al., 1994; Cseuz and Erdei, 1996; Djekoun et al., 1996; Cseuz et al., 2002, Budakli et al., 2007).

Blum et al. (1983a, 1983b) proposed the use of chemical desiccation on the canopy after flowering as means for inhibiting plant photosynthesis and thus determining the capacity for grain filling by stem reserves. With this method they applied a chemical desiccant (magnesium chlorate or sodium chlorate; 0.4% w/v) as a spray to the canopy, including the spikes. The treatment was applied at 14 days after anthesis, when kernel growth entered its linear phase. At maturity, kernel weight was compared between treated and non-treated (control) plants, calculating the rate of reduction in kernel weight caused by the treatment. The rate of reduction was typically between 5 and 50% in different wheat materials.

Blum et al. (1983a) reported that, in a study on four wheat cultivars, kernel weight was the least reduced by chemical desiccant in the two cultivars that showed a greater loss of stem dry matter under desiccation relative to the controls. They suggested that varieties that translocate more carbohydrate reserves to the grains are better able to maintain a stable kernel weight under desiccation conditions. In addition, in other studies conducted on the same subject, the reduction in grain weight resulting from chemical desiccation of plants correlated significantly with the reduction in grain weight due to natural drought (Blum et al., 1983b; Nicolas and Turner, 1993).

This study was conducted with a triticale cultivar and seven lines in order to determine the contribution of reserve matters to grain filling under dry conditions that had been created by a chemical desiccant (4% potassium chlorate) at post-anthesis stage and then to determine the line(s) that are tolerant to drought.

Materials and Methods

This study was carried out at the Research and Application Center of the Agricultural Faculty, Uludag University, Bursa, Turkey, as field experiments in 2005 and 2006.

The total precipitation in the second year (428.6 mm) of the experiment during the growth season was lower than the normal value (555.6 mm), but it was approximately the same as the normal value in the first year (545.6 mm). The average temperature (10.96°C) in the second year was lower than the normal temperature (11.59°C), but it was close to normal in the first year (11.18°C). Both in the first year (66.55%) and in the second year (69.14%), the relative moisture was lower than the normal value (70.98%). Soil of the experimental area was clayey textured, almost without salt, rich in K, neutral in pH and poor in organic matter (Tumsavas and Aksoy, 2008).

The experiment was set up according to the Randomized Block Design with three replications. In the study, four triticale lines developed by crossing method in Agriculture Faculty of Uludag University (Coplu et al., 2001), three line obtained from CIMMYT and a cultivar were studied in terms of yield, yield components in Southern Marmara Region (Table 1).

In experimental years, sowings were made by using an ojord-type sowing machine in November. The size of each plot was 3 × 1.2 m. Eight rows were sown in each plot, with row spacings of 15 cm. After sowing, a hand-driven roller was used to make the seeds to be exposed to the soil. Half of the nitrogen fertilizer was applied immediately after the sowing and other half of it at the jointing stage. The N fertilizer was ammonium nitrate (26% N).

4% Potassium chlorate was used as chemical desiccant to create drought stress conditions after anthesis. The desiccant was sprayed 15 days after anthesis of plants. For comparison, a 0.84 m^2 (0.7 x 1.2 m) area of each plot was used as a control. The green parts of the plants that had been exposed to desiccant completely dried in the 48 hours after the desiccant had been

Table 1
The New lines and Standard cultivar

Lines and Standard cv.	Pedigree	Source
C6	-	CIMMYT
C9	-	CIMMYT
C11	-	CIMMYT
Nörtingen x 2015 (17)	2015 (FAHAD 9-1)	NEW LINE
Nörtingen x 2003 (12)	2003 (Juanillo 98x21295-OAP)	NEW LINE
Nörtingen x Eronga (3)	-	NEW LINE
Nörtingen x Eronga (14)	-	NEW LINE
Nörtingen (Standard)	-	GERMANY

sprayed. Fifteen days after anthesis of each variety, 15 spikes from each plot were taken to determine the grain weight at that time. Cultivar and lines reached their harvesting maturity in June in each year. At the harvesting time, 15 spike samples were taken from each plot to which the chemical desiccant had been applied or not applied (control). Spike samples were dried at 68°C for 48 hours; they were then threshed with a single-spike thresher and, after weighing at a sensible balance, their dry weights were determined. After these procedures, grains of sample plants of each plot were counted, and then their average dry weights (mg grain^{-1}) were calculated. By using the values determined above, some new parameters, such as dry matter translocation (DMT; mg grain^{-1}), dry matter translocation efficiency (DMTE; %), rate of grain weight reduction (RGWR; %), mean productivity (MP; kg ha^{-1}) and seed yield tolerance (SYT; kg ha^{-1}) were calculated. The following equations were used in the calculation of these parameters:

Dry Matter Translocation (DMT; mg grain^{-1}) = (Grain dry matter of plants treated with desiccant) – (Grain dry matter of plants sampled 15 days after anthesis) (Kalayci et al., 1998; Przulj and Momcilovic, 2001).

Dry Matter Translocation Efficiency (DMTE; %) = [DMT / (Grain dry matter of plants sampled 15 days after anthesis)] × 100 (Przulj and Momcilovic, 2001).

Rate of Grain Weight Reduction (RGWR; %) = [(Grain dry weight of control plants – grain dry weight of desiccated plants) / (Grain dry weight of control plants)] × 100 (Borner et al., 2002)

Mean Productivity (MP; kg ha^{-1}) = (Yield of control + Yield of stress) / 2 (Hossain et al., 1990).

Seed Yield Tolerance (SYT; kg ha^{-1}) = Yield of control – Yield of stress (Hossain et al., 1990).

The values of the two years were combined and then subjected to statistical analysis. The values obtained from these experiments were analysed using Analaysis of Variance (ANOVA), according to the Randomized Block Design with three replications. Probability levels of 1 and 5% were used for tests of significance (Turan, 1995). Means were tested by the Least Significant Difference (LSD) at $P < 0.05$. MINITAB and MSTAT-C programmes were used for all the calculations.

Results and Discussion

According to the results of ANOVA of 2-year average values, lines indicated significant differences at the 1% level in respect of DMT, DMTE, RGWR, MP and STY. On the other hand, MP and STY were significantly different among the years at the 1% level. Mean values of all characteristics were presented on Table 2.

According to the ANOVA, the amounts of DMT of triticale variety and lines ranged from 3.23-17.16 mg grain^{-1} (Table 2). The N x E (3) and C9 lines had the highest amount of DMT, whereas the C6 line had the lowest (respectively; 17.6, 15.16 and 3.23 mg grain^{-1}). The other lines and variety were lined up between these extreme values. Different researchers reported that there were big variations among the varieties from the point of view of DMT values under stress conditions (Hossain et al., 1990; Nicolas and Turner, 1993; Fathi et al., 1997; Kalaycı et al., 1998; Khlestkina et al., 2001; Borner et al., 2002 and Cseuz et al., 2002). Our results agreed with these results.

Among the mean DMTE values of lines, significant differences were found. DMTE values ranged between 24.08% and 57.66%. The highest values were found in the N x E(3) line (57.66%) while lowest values were obtained from the varieties Nx2015(17), C6, and Nx2003(12) lines (respectively; 32.77%; 29.94%; 45.01% and 24.08%). Kalayci et al. (1998) determined that there were important variations among the wheat genotypes in respect of DMTE values under stress conditions.

Table 2
Dry Matter Translocation (DMT), Dry Matter Translocation Efficiency (DMTE), Rate of Grain Weight Reduction (RGWR), Mean Productivity (MP) and Seed Yield Tolarence (SYT) values of Triticale Lines and Standard Cultivars

Lines and Standard cv.	DMT mg grain^{-1}	DMTE %	RGWR %	MP kg ha^{-1}	SYT kg ha^{-1}
N X 2015 (7)	4.63 cd	29.94 d	28.21 bc	5890.9 a-c	1893.7 b-d
C6	3.23 d	25.15 d	26.94 b-d	5638.5 bc	1747.5 cd
C9	15.16 a	45.01 bc	19.08 d	6403.9 a	1350.1 d
C11	6.01 c	35.57 cd	29.59 b	5948.3 a-c	2066.8 bc
N X E (3)	17.16 a	57.66 a	29.03 bc	5776.0 a-c	1470.4 cd
N X 2003(12)	4.82 cd	24.08 d	35.16 ab	5875.1 a-c	2516.9 ab
NRTGN (Std.)	4.01 cd	32.77 d	20.83 cd	5990.9 ab	1858.5 b-d
N X E (14)	8.87 b	54.22 ab	43.52 a	5319.3 c	2965.7 a

[1]: Means followed by the same letter was not significantly different at 0.05 level using LSD test,
*,**;F-test significant at $p<0.05$ and $p>0.01$, respectivelly.

Conclusion

In this research, the RGWR values of triticale variety and lines ranged from 19.08 to 43.52% (Table 1). The highest value was found in the NxE (14), while the lowest value was obtained from C9 line. If DMT of a line is not high and DMTE is very high, the RGWR of this line is high. Line NxE (14) is typic example for these states. At the same time, the high proportional reduction of RGWR is effected on MP and SYT. In the same studies on wheat of Hossain et al. (1990), Nicolas and Turner (1993), Borner et al. (2002) and Cseuz et al. (2002) reported that, (after desicant application), there have been the changing rates reduction in the grain weight and that the varieties having less reduction in grain weight were more resistant against drought stress. According to the results of two years; the seed yield in stress conditions of variety and lines with mean productivity in normal conditions ranged between 5391.3-6403.9 kg ha^{-1}. The highest MP were found in the C9 line (6403.9 kg ha^{-1}), while the lowest values were obtained from N x E (14) with 5319.3 kg ha^{-1}. The variety and lines belonging to seed yield tolerances value in general have changed between 1350.1-2965.7 kg ha^{-1} and was found very important differences in the 1% level. Here a low tolerance value is required. Yield Obtained from normal conditions, with yield obtained from dry conditions, yield values close to each other how much if mentioned line would be affected less stress.

When viewed from this perspective, according to yield tolerance, the line C9 manifested in other properties and had the highest value of STY take over.

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