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ARTICLE

Effects of drought and combined drought and heat stress on germination ability and seminal root growth of wheat (*Triticum aestivum* L) seedlings

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ABSTRACT Wheat plants of the drought tolerant Plainsman V and sensitive Cappelle Desprez genotypes were subjected to drought and combined drought and elevated, 34/24 °C day/night temperature at three various phases of reproductive development, at meiosis, from the 1st to the 5th day after pollination and from the 5th to the 9th day of seed development. After seed maturation, the germination frequency of the grains was calculated and the seminal root number of the seedlings was determined. Neither of the stress treatments affected the germination percentage of the genotypes significantly. Neither of the treatments reduced the number of seminal roots in the case of the tolerant genotype. However in sensitive variety the ratio of seedlings with only one root increased to 42% after drought stress, applied during the 5.-9. days after pollination. In this genotype the combined stress increased the proportion of one-rooted seedlings to 56% and 78% when applied during 1.-5. DAP and 5.-9. DAP, respectively. Histological studies revealed that the lateral root meristems were present in control and stressed embryos of both genotypes. **Acta Biol Szeged 52(1):157-159 (2008)**

KEY WORDS

drought stress
heat stress
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Among the different abiotic stresses affecting wheat, especially drought and high temperature are considered as key stress factors with high potential impact on crop yield. In the recent years simultaneous occurrence of these stresses shows increasing frequency and causes serious loss in grain yield. Drought and heat stress may occur at the time of the reproductive developmental stages of cereals (Sahnoune et al. 2004). The effects of various kinds of abiotic stress on these processes are different, but in all cases negative, and their influence always results in a decline in the yield quantity (for reviews see Saini and Westgate 2000, Mahajan and Tuteja 2005). The success of cereal reproduction as well as the realization of the yield potential of a given cultivar, however are dependent not only on the stress sensitivity of the reproductive and grain filling stages but on overall plant growth and development. Efficient photosynthesis and stem reserve accumulation during the vegetative phase has a decisive role on the formation of generative organs and thus may directly affect final yield (Blum et al. 1994). Therefore, in order to improve yield safety in cereals, the whole developmental process, from grain to grain, needs to be considered and appropriate strategies may target several developmental stages (Triboï and Triboï-Blondel 2002).

In our experiments the effects of drought and combined drought and heat stress on the germination and seminal root number were studied. One of the most important numerical parameter of seedlings is the seminal root number. To shed light on the differences between the effect of drought and heat stresses on wheat cultivars with different tolerance, Cappelle Desprez and Plainsman V were used as sensitive and tolerant genotypes.

Materials and Methods

Plant material and cultivation

Drought sensitive Cappelle Desprez (10-10) and drought tolerant Plainsman V (10-10) winter wheat genotypes were grown in phytotron chambers using a spring climatic programme T2 (Tischner et al. 1997).

Stress conditions

Wheat plant were subjected to drought stress and combined drought and heat stress at three various phases of reproductive development i.e. at the time of meiosis, from the 1st to the 5th day after pollination (1.-5. DAP) and from the 5th to the 9th day after pollination (5.-9. DAP). Combined stress involved 34/24ºC day/night temperatures and total water withdrawal in all phenophases. As for the drought stress, total withdrawal of water was applied on contrast to the control environment with a daily water supply of 150 ml. Stress conditions existed for 5 days in each experiment. During the plant cultivation, the following temperatures were applied as control conditions: 19/14ºC at the time of meiosis and 23/14ºC day/night

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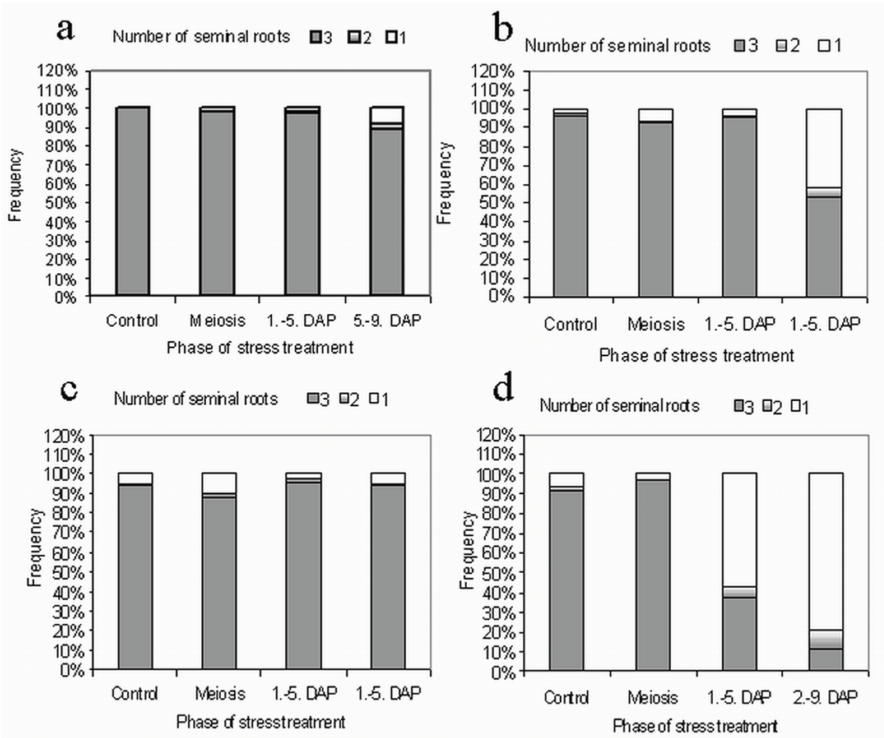

Figure 1. Effect of drought and combined drought and heat stress on the number of seminal roots. a: drought stressed Plainsman V seedlings, b: drought stressed Cappelle Desprez seedlings, c: drought and heat stressed Plainsman V seedlings, d: drought and heat stressed Cappelle Desprez seedlings. DAP: days after pollination.

temperature at the time of 1.-5. DAP and 5.-9. DAP. After the treatments plants were returned to the control environment with a temperature of 23/14°C and daily water supplies of 150 ml, as for control plants, and were grown to full maturity, with a final daily max/min temperature of 26/17°C.

Germination conditions

Kernels located in the main spikes of control and stress treated plants were surface sterilised and germinated under sterile conditions in Petri-dishes between wet filter papers at 8ºC for 7 days.

Histological studies

Kernels at full maturity were embedded in Spurr's resin using the method described by Spurr (1969). Semi-thin (1 µm) sections were prepared from the kernels using an RMC RT-7000 microtome. Sections were stained with periodic acid Schiff stain and counterstained with 0.5% toluidine blue. Observations were made using an Olympus BX51 light microscope.

Statistical analysis

All the data were pooled means from the ten replicates and statistically evaluated by the Student's *t*-test using SPSS for Windows, version 10.0.

Results

In our experiments there was no significant difference ($P<0.005$) in the germination frequency between the control grains and the grains of treated plants (data not shown). On the contrary, concerning the number of seminal roots per seedling there were significant differences between genotypes and treatments as well. Independently from the genotype, more than 90% of control seedlings developed three seminal roots. Plainsman V was proven to be more tolerant against drought as well as against combined drought and high temperature, since there was no significant difference in the number of seminal roots if compared the various stress treatments to the control. (Fig. 1a, c) In the case of the sensitive Cappelle Desprez seedlings drought stress did not cause significant change in root numbers when applied at the time of meiosis and 1.-5. DAP, but when applied at 5.-9. DAP the proportion of seedlings with only one seminal root increased to 41.84% (Fig. 1b). Combined drought and heat stress resulted in more serious reduction in the number of seminal roots at the time of 1.-5. DAP and 5.-9. DAP, increasing the ratio of one-rooted seedlings to 56.25% and 78.4%, respectively (Fig. 1d) at a $P<0,005$ level of probability.

Our histological studies verified that in the treated embryos of both genotypes, similarly to the control, the meristems responsible for lateral root formation are present, but the reduced amount of starch granules in the endosperm couldn't fuel their development.

Discussion

Our results suggest that the reduced carbohydrate content of the endosperm (unpublished data), as a consequence of applied drought and heat stress, is sufficient to provide the required nutrients for normal germination even in the case of the sensitive genotype. The number of seminal roots has a great impact on the fitness of the seedlings, because these roots supply the wheat plant with nutrients between germination and tillering. Their number determines the extent of tillering, and thus influences yield production (Klepper et al. 1998). In sensitive Cappelle Desprez the number of seminal roots significantly decreased, what indicates, that the reduced carbohydrate content of the endosperm could not fuel the development of all seminal roots in this genotype. The presence of seminal root meristems in the embryos of the sensitive genotype, developed in the kernels subjected to combined stress indicates that the decreased ratio of normal seminal root formation is very likely not the consequence of abnormal embryo development.

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