THE DROUGHT EFFECT ON PRODUCTIVITY OF DIFFERENT SPRING BARLEY GENOTYPES

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ABSTRACT

Drought stress is one of the most serious environmental stresses that occur in nature and is markedly reflected in the growth and development of plants. The main purpose was to quantify reactions of spring barley (*Hordeum vulgare* L.) to soil drought during flowering period and to identify differences among four genotypes that differ in their origin. Characteristics of water atributes like relative amount of water in plant (RWC), water, osmotic and pressure potentials were measured. We quantified drought influence on four genotypes of barley. Water potential as estimation of water status, is very useful for fixing water transport in the system soil-plant-atmosphere. Gradual dehydration of the original substrate in laboratory conditions led to a gradual loss of water (RWC) from assimilatory organs and loss of turgor, which ended in plant wilting. With the gradual dehydration decreased also osmotic and water potential and loss of turgor was observed as well. Limitation of physiological processes in the case of drought during flowering period, when mechanisms of automatic compensation are broken, is the cause for a decrease in the amount of grains. We analyzed differences among genotypes in harvest reduction with statistical tools.

Key words: stress, drought, photosynthesis, harvest, spring barley

INTRODUCTION

Cereals are the most widespread crops. The economically valuable product is grain, which is used for food and feed, but also for industrial processing (Nátr, 2002). Barley (*Hordeum vulgare* L.) originates from the Eastern Mediterranean region where plants experience many abiotic stresses in the field. Its production has become more intense and complex in recent years. From this reason it is necessary to carry out experiments to estimate the response of barley plants to a variety of adverse conditions, such as low and high solar energy availability, shortage or excess of water in soil, high temperature and salinity, which affects photosynthesis and yield formation (Kalaji, 2012).

Stress is the result of complex interactions between plants and the environment. In natural conditions the effect of only one stress factor without interaction with others does not occur. Many environmental factors in isolation may not cause stress, but in different combinations they can create stress conditions for plants (Slováková, 2007). Water is a necessary factor in life and it influences the existence of plants and realization of their life cycle. One of the primary responses of plants to water deficit is stomata closure,which minimizes water loss (Carmo-Silvia, 2012). Plants wither and close stomata to limit transpiration and prevent more loss of water. Drought as abiotic stress is multidimensional in nature (Rahman, 2012).

Photosynthesis is the oldest and the most important biochemical process on the Earth. It is a unique process on the Earth and its result is the production of organic substances and oxygen. Photosynthesis is a process used by plants and other organisms to convert light energy, normally from the sun, into chemical energy and is very sensitive to drought (Brestič, 2001).

MATERIAL AND METHODS

Biological material in the experiments were four varieties of spring barley (*Hordeum vulgare* L.), that originate from four different geo-climatic conditions. Varieties used were as follows:

1) 'Nitran' – Slovak republic (*H. vulgare* conv. *distichon*),
2) 'Dobla' – Spain (*H. vulgare* conv. *hexastichon*),
3) 'Tibet White 9' – China (*H. vulgare* conv. *distichon*),
4) 'Class' – Great Britain (*H. vulgare* conv. *distichon*).

Barley plants were grown in plastic flowerpots. 81 pieces of 0.45 x 0.45m flowerpots filled with 35 kg of sieved soil substrate were used. Two weeks after germination, the plants in the 60 pieces were per flowerpot. Substrate was irrigated with water to 70% soil water capacity. Foliar fertilization of plants with Harmavit (Agrichem, Bratislava, Slovakia) in 0.2 % solution was held in a stage of two fully developed leaves. In the II. and IV. stage of organogenesis (from Kupermannova) phytosanitary spraying against fungus *Erysiphe graminis* DC systemic herbicides was performed. In IX. stage of organogenesis (from Kupermannova) flowerpots were randomly divided into two variants of the experiment: 1) well-hydrated plants (control) and 2) dehydrated plants. Gradual dehydration of plants (variant dehydrated plants) was initiated by non-watering the soil substrate. Start of the dehydration cycle was on 9. July 2012. Dehydration cycle duration was 9 days. The well-hydrated plants variant was irrigated daily with water 2.5 l per flowerpot.

Physiological parameters characterizing the source activity were measured on leaves of the barley plants. Samples for the description of the water status in the plants (relative water content, water, osmotic and pressure potential) were collected simultaneously from the leaves.

Relative water content (RWC, %) was measured by gravimetric method. Water (ψ_W; MPa) and osmotic (ψ_S; MPa) potential of leaf tissue was determined by psychrometric measurement. Pressure potential (ψ_P; MPa) was calculated as the difference between water and osmotic potentials.

Harvest parameters weight of above-ground parts of plants, weight of the main stalk, weight of cob of the main stalk and weight of grains and thousand grain weights were evaluated.

The experiment was based on the method of completely randomized arrangement (CRD). For each variety 6 flowerpots were sawn and they were divided into two groups of three flowerpots before the application of dehydration.

The results presented are mean values with standard error (SE). Number of repetitions of the measured parameters for water regime was 4 and for draught conductivity 10.

In assessing the value of genotypic differences the statistical software Statistica ver. 10 was used. Evidence supporting differences between genotypes in the water status parameters were evaluated by one-way analysis of variance and post-hoc analysis with Fisher's LSD test at the 0.05 and 0.01 level of significance. Evidence supporting differences between genotypes of plants grown in well-hydrated and dehydrated conditions in production performance was evaluated by Tukey HSD test at significance level of 0.05 and 0.01.

RESULT AND DISCUSSION

During the dehydration of the plant decrease of relative water content (RWC) occur. Water evaporates from plants by stomata (Brestič, 2001). RWC is the proportion of actual water content and water content at full saturation and is an appropriate measure of the deficit. Sinclair and Ludlow (1983) indicate that the metabolism of plants is dependent on the water content in the leaves, and RWC is an appropriate parameter for measuring water content in the plant. In our measurements of RWC we have found that the largest decline was in the variety Tibet white 9 (to 44.71 %) and least RWC decline in variety Nitran (to 53.12 %). RWC drop below 70 % significantly affects metabolic functions (Blum, 1999). Drought causes decrease in water content in the plant reducing the water potential and osmotic potential decreases also (Keyvan, 2010). The value of water potential give us information whether and how the plant is suffering from drought stress. Water potential values were equally declining in all varieties of barley. At the end of the dehydration the lowest value reached the variety Dobla (ψ_W= - 3.56 MPa) and least decreased the variety Tibet white 9 (ψ_W= -3.08 MPa). In accordance with Keyvan (2010) osmotic potential decreased simultaneously with the water potential and was lowest in the variety Dobla (ψ_S= -3.65 MPa) and highest in variety Tibet white 9 (ψ_S= -3.05 MPa). Turgor (pressure potential) exists only when the cells are well hydrated. If there is a decrease of water content in the plant, turgor decreases also. In our experiment the variety Tibet white 9 had negative values, the other three had positive values.

The plant growth development is the result of activities of physiological processes (Procházka, 1998). Drought ceases cell growth. While growth is inhibited mainly at the aboveground part, the growth of the root system is less sensitive to drought. This is caused by the fact that root system of drought stressed plants penetrates deeper into the soil horizont. The average weight of the aboveground part of the control, well watered plants of all genotypes was 1.94 ± 0.14 g and of dehydrated plants 1.59 ± 0.08g. In our experiment, the influence of drought least significantly decreased weight of the aboveground parts of the genotype Nitran (from 1.80 g for well-hydrated conditions to 1.62 g). The largest reduction of weight was recorded for the genotype Class. Water stress was statistically highly significantly present in reduction of weight of the main stalk in all genotypes, being highest in genotype Dobla (1.58 ± 0.11g) and lowest in genotype Nitran (1.26 ± 0.23g). Weight of the spike, in addition to weight of thousand grains, is considered as an essentials parameter of cereal production. The highest weight reduction of the cob due to drought was demonstrated in genotypes Tibet White 9 and Class (48.1 % and 46.4 % reduction), less significant, although highly statistically significant in genotypes Nitran (29.7 % decrease) and Dobla (30 % reduction). The highest value of weight of thousand grains reached genotype Dobla (48.04 ± 0.36g) in well hydrated conditions. Dehydration caused a reduction in weight to 46.84 ± 0.48g. Lowest value of weight of thousand grains was recorded in genotype Tibet white 9 (42.92 ± 0.54g), while dehydration caused a decline in the value to 40.73 ± 0.15g. Dehydration cause a statistically highly significant decrease in the weight of thousand grains in all genotypes. The most weight loss of grains had variety Dobla (1.09 ± 0.10g) and the lowest weight loss had variety Tibet white 9 (0.34 ± 0.04g). Drought induced reduction weight of thousand grains observed in their experiment also Vaezi et al. (2010). Reduction of weight of thousand grains is according to authors the outcome of shortening of the filling period and damage of the photosynthetic apparatus.

CONCLUSIONS

In our experiment relative water content (RWC) in the plant was monitored. With the gradual dehydration decreased water content in the leaves of spring barley. Gradual dehydration decreased water, osmotic and pressure potential (ψ_W, ψ_S, ψ_P). Statistical analysis showed that within the genotype, in good conditions of hydration and dehydration, there are significant and highly significant differences in the basic parameters of the water status. Analysis of production parameters showed that dehydration of soil substrate at the time of flowering affects the production of spring barley. As a result of drought reduced weight of above-ground parts of plants, weight of the main stalk, weight of spike of the main stalk, and weight of grains per spike and thousand grains weight especially were observed. Differences between the genotypes were statistically significant.

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