GROWTH REGULATORS MODERATE NEGATIVE IMPACTS OF DROUGHT ON WINTER WHEAT

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The aim of this study was to determine the impact of growth regulators on the physiological parameters, grain yield and quality of winter wheat under drought stress simulated by experimental rain-out shelters. We hypothesized that growth regulators can contribute to mitigating the negative impact of drought on physiological parameters, yield formation and grain quality of winter wheat.. The experiment was conducted in a field experimental station in Žabčice (49°00'41.3"N) on winter wheat variety Matylda in 2013/2014. The experimental station is located in a warm area with prevailing continental climate (average annual rainfall 482 mm and temperature 9.3 °C). Within this experiment following growth regulators and fungicide with growth regulation effect were used: Retacel extra R68 (chlormequat chloride 720 g.l^{-1}), Moddus (trinexapac-ethyl 250 g.l^{-1}), Cerone (ethephon 480 g.l^{-1}), Amistar (azoxystrobin 250 g.l^{-1}). These growth regulators were applied at growth stages between BBCH 31 and BBCH 59. Application of growth regulators partly eliminated negative impact of drought on CO_2 assimilation rate, chlorophyll content and grain yield particularly in azoxystrobin, chlormequat chloride and trinexapac-ethyl applications. Growth regulators also reduced the negative impact of drought on grain quality (protein content).

Keywords: winter wheat, growth regulators, water stress, drought

INTRODUCTION

Plants are often subjected to periods of soil and atmospheric water deficit during their life cycle. The frequency of such phenomena is likely to increase in the future even outside today's arid/semi-arid regions. Plant responses to water scarcity are complex, involving deleterious and/or adaptive changes, and under field conditions these responses can be synergistically or antagonistically modified by the superimposition of other stresses (Chaves, 2001). Water deficit is the most common environmental stress factor limiting plant productivity. The ability of plants to tolerate water deficit is determined by multiple biochemical pathways that facilitate retention and/or acquisition of water, protect chloroplast functions, and maintain ion homeostasis. Essential pathways include those that lead to synthesis of osmotically active metabolites and specific proteins that control ion and water flux, support scavenging of oxygen radicals, or may act as chaperones. The ability of plants to detoxify radicals under conditions of water deficit is probably the most critical requirement. Many stress-tolerant species accumulate methylated metabolites, which play a crucial dual role as osmoprotectants, and as radical scavengers. Their synthesis is correlated with stress-induced enhancement of photorespiration. However, transfer of individual genes from tolerant plants only confers marginally increased water-stress tolerance to stress-sensitive species: tolerance engineering will probably require the transfer of multiple genes (Bohnert, 1994).

The primary objective of plant growth regulators use is to prevent lodging of the canopy causing in most serious cases reduction of yield and its quality and increasing the harvest costs. Plant growth regulators (also known as plant hormones) are chemicals used to alter the growth of a plants or plant parts. Hormones are substances naturally produced by plants, substances that control normal plant functions, such as root growth, fruit deployment and fall, growth and other developmental processes. The application of growth regulators can affect the reinforcement of productive tillers and prolongation of the activity of leaf surface. Growth regulators can improve the water use efficiency by regulation of stomata opening. It also causes the increase in the root:shoot ratio.

The aim of the experiment was to evaluate positive and negative impacts of growth regulators on physiology and winter wheat yield in conditions of drought, to select suitable types of regulators and the time of applying in order to improve tolerance to drought.

Fig. 1: Rain-out shelters over the experimental area of winter wheat

MATERIALS AND METHODS

The experimental station is located in Southern Moravia (the Czech Republic) in Žabčice. Moderate soils are dominant type in this region. The location is considered to be one of the hottest areas in the Czech Republic. The sowing of variety Matylda have been done on 15th October in 2013 with sowing density 4 MGS (millions of gemineable seeds). Within this experiment following growth regulators and fungicide with growth regulation effect were used: Retacel extra R68 (chlormequat

chloride 720 g.l^{-1}) BBCH 31, Moddus (trinexapac-ethyl 250 g.l^{-1}) BBCH 32-35, Cerone (ethephon 480 g.l^{-1}) BBCH 39-49, Amistar (azoxystrobin 250 g.l^{-1}) BBCH 45-49. Measuring of physiological parameters was done in the middle of drought stress (May 26th, 2014), and at the end of drought stress effect. N fertilization using LAD 27 fertilizer at the dose of 160 kg N.ha^{-1} and DAM 390 (solution of water, Ammonium nitrate and urea) fertilizer at the dose of 30 kg N.ha^{-1}. The crop was treated using the herbicide COUGAR FORTE + fungicide HUTTON FORTE. After wheat ripening evaluation of yield and yield structure has been done.

RESULTS

Drought stress led to a general decline in chlorophyll content in both upper leaves (F and F-1; Fig. 2). All growth regulators used in the experiment reduced this decline, particularly in the flag leaf. The highest mitigating effect on drought caused decline in chlorophyll content was observed for active ingredient azoxystrobin. Active ingredient etephon reduced negative effect of drought on chlorophyll content, but also led to a decrease in chlorophyll content in lower leaf (F-1), both in the treatment well watered and drought stressed. Conversely, the flavonoid content in leaves of plants exposed to drought stress increased particularly in the lower leaf (F-1). Growth regulators generally reduced this effect, while the most significant effect was found for application of etephon where flavonoid content in drought stressed plants dropped below a level of well watered plants.

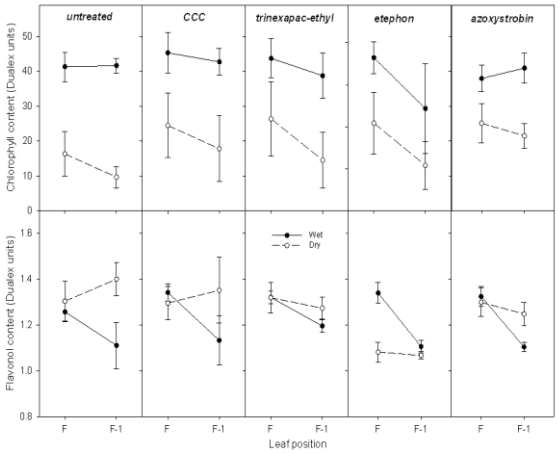

Figure 2: Changes in chlorophyll and flavonol contentin flag leaf (F) and second leaf from the top (F-1) under drought stress and the effect of growth regulator applications. The means (points) and standard deviations (error bars) are presented (n=3).

The drought stress strongly reduced light saturated CO_2 assimilation rate (Amax; Fig. 3). This negative effect was mitigated by application of all growth regulators. The positive effect of growth regulators under drought stress was most prononunced in application of CCC, trinexapac-ethyl and azoxystrobin.

The effect of drought on stomatal conductance is shown in the Fig. 4. Drought stress significantly reduced stomatal conductance. Whereas after application of trinexapac-ethyl and etephon the stomatal conductance remained almost unaffected, the application of CCC and particularly azoxystrobin increased Gs in both drought stressed and well watered treatment compare to untreated control. Drought stress generally decreased grain protein content. This effect was highest in untreated control and application of azoxystrobin. The negative effect of drought on protein content was slightly reduced by application of CCC and trinexapac ethyl. In well watered treatments was protein content enhanced particularly by application of CCC and azoxystrobin.

The negative effect of drought stress on grain protein content was mitigated particularly by application of growth regulators CCC and trinexapac-ethyl (Fig. 5).

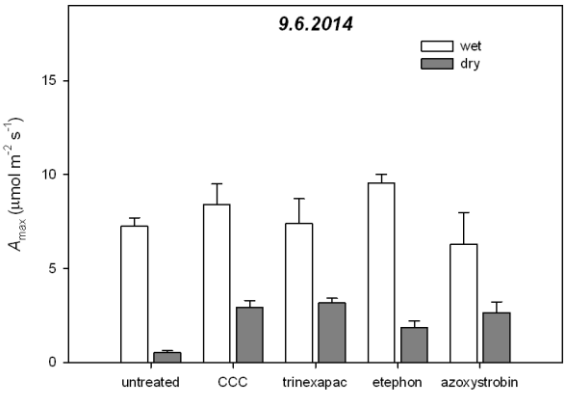

Figure 3: Effect of drought stress and applications of growth regulators on light saturated CO_2 assimilation rate (A_{max}). The means (columns) and standard deviations (error bars) are presented (n=3).

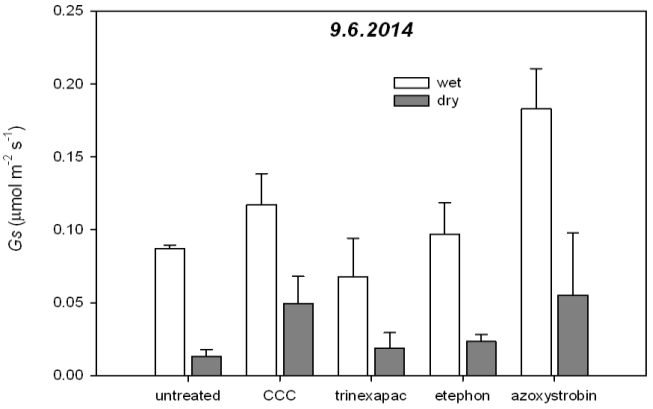

Figure 4: Effect of drought stress and applications of growth regulators on stomatal conductance (*G*s). The means (columns) and standard deviations (error bars) are presented (n=3).

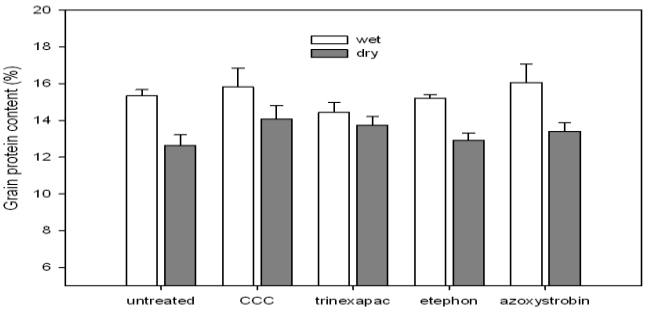

Figure 5: Effect of drought stress and applications of growth regulators on grain protein content. The means (columns) and standard deviations (error bars) are presented (n=3).

CONCLUSION

- By applying growth regulators we were able to reach a partial elimination of drought stress effect. Based on the preliminary results, it can be stated that, practically all growth regulators used in the

experiment reduced decline in chlorophyll content in both upper leaves (F and F-1). Conversely, the flavonoid content in leaves of plants exposed to drought stress increased particularly in the lower leaf (F-1).

- The drought stress strongly reduced light saturated CO_2 assimilation rate (Amax). This negative effect was mitigated by application of all growth regulators.
- Drought stress significantly reduced stomatal conductance.
- Drought stress generally decreased grain protein content and application CCC and trinexapac-ethyl partially mitigated this negative effect.

Acknowledgement

This article was written at Mendel University in Brno as a part of the project IGA AF MENDELU no. TP 7/2015 with the support of the Specific University Research Grant, provided by the Ministry of Education, Youth and Sports of the Czech Republic in the year of 2015.

LITERATURE

Bohnert, H. J. et al. (1994) in Biochemical and Cellular Mechanisms of Stress Tolerance in Plants" (Cherry, J. H., ed.), pp. 415-428, SpringerVerlag

Chaves, M. M. et al. (2001): How Plants Cope with Water Stress in the Field? Photosynthesis and Growth [online]. <http://aob.oxfordjournals.org/content/89/7/907.short>