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DIFFERENCES IN WHEAT AND TRITICALE SEED GERMINATION IN THE PRESENCE OF NATURAL AND SYNTHETIC PLANT GROWTH REGULATORS

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ABSTRACT. A simple, fast and easy-to-perform method was carried out for the quantification of the effects of plant growth regulators on wheat and triticale. The method uses seed germination, root elongation and hypocotil growth in the plants as parameters in the presence of varying concentration of giberrellic acid (GA_3), indol acetic acid (IAA), potassium nitrate (KNO_3), magnesium sulfate ($MgSO_4$) and AMO 1618. The highest germination rate was found in the seed treated with KNO_3, 90% of wheat seeds germinated at concentration 10^{-5}M, while for triticale was 77.77% at a concentration of 10^{-4}M. Longest roots were recorded in solutions of $MgSO_4$, and the greatest impact on hypocotyl had GA_3, for both wheat and triticale seeds. For both taxa retardant AMO 1618 was, at a concentration of 10^{-3}M, led to complete inhibition of germination.

Key words: Wheat, triticale, plant growth regulators.

INTRODUCTION

Wheat, the grass of the genus *Triticum* (family Poaceae), is edible and one of the oldest and most important cereal crops. Triticale (X *Triticosecale*) is a hybrid of wheat and rye, first bred in laboratories during the late 19th century. Conventional plant breeding has helped to establish triticale as a valuable crop, especially where conditions are less favorable for wheat cultivation. As a commercial crop, Triticale has much promise, as it has the potential to address specific problems within the cereal industry. As a rule, triticale combines the yield potential and grain quality of wheat with the disease and environmental tolerance (including soil conditions) of rye (LUKASZEWSKI, 2006).

Seed germination is an important event in the life of every sexually reproduced plant. Common phase of the plant life cycle is dormancy, and may be contributed with several parts of the seeds (KUCERA *et al.*, 2005). The seeds of most species are dormant at maturity and dormancy must be lost before germination can occur (BEWLY, 1997).

Wheat and triticale have dormant seeds. The dormancy and ripening are genetically traits and both are controlled by external factors. A dormant seed is unable to germinate in a specified period of time under a combination of environmental factors that are normally suitable for the germination of the non-dormant seed. Dormancy is a mechanism which prevents germination

during unsuitable ecological conditions, when the probability of seedling survival is low. Endogenous dormancy may be due to presence of germination inhibitors.

Plant growth regulators are found to play an important role in the germination process (RITCHIE and GILROY, 1998). Application of low level of growth regulators (i.e. gibberellins, cytokinins and ethylene) may break the seed dormancy. Among other chemicals, potassium nitrate (KNO_3) is widely used for breaking seed dormancy in crop seeds.

Gibberellic acid (GA_3) is one of the hormones proposed to control primary dormancy by inducing germination (NADJAFIA *et al*., 2006). It is known that gibberellins break dormancy of several types of seeds, such as seeds which require after ripening (storage at room temperature in dry conditions). GA_3 stimulates seed germination via amylase synthesis (FINCH-SAVAGE and LEUBNER-METZGER, 2006). One biochemical reaction known to be enhanced by GA_3 is the synthesis of hydrolases (especially α amylase) in the endosperm of cereal grains; breakdown is generally assumed to be an essential process of germination (KOLUMBINA *et al*., 2006).

It has been demonstrated that other plant growth substances, such as auxins, could be effective on seed dormancy breaking in some plants (THOMAS and VAN STADEN, 1995). However, the effects of auxin on seed germination have not been widely tested, particularly in crops. Also, nitrate (such as KNO_3) clearly stimulated the germination of dormant seeds (ALBORESI *et al*., 2005). The effect of KNO_3 was discovered when it was proven that the Knopp solution encourages germination of some plant species. Later was confirmed that the potassium nitrate interaction with the light and temperature.

AMO 1618 belongs to the group of growth retardants. In contrast to other inhibitors of early GA_3 synthesis, such as ancymidol (COOLBAUGH *et al*., 1976; RADEMACHER, 2000), the major site of activity of AMO 1618 is not well known.

The aim of this work was to examine effects of plant growth regulators (auxin, gibberellin, KNO_3 and $MgSO_4$) and inhibitors (AMO 1618) on seed germination and plant growth in wheat and triticale.

MATERIAL AND METHODS

The material used in this paper is the seeds of wheat (sort Vojvoda) and triticale (sort Smaragd), harvested in 2012. Seeds are obtained from the Small Grains Research Centre in Kragujevac and stored under standard conditions. The experiment was carried two months after harvesting the seeds. At the start of experiment, the seeds were surface sterilized. The seeds were soaked in 70% ethanol for the three minutes, than soaked in 1% of sodium hypochloride for 30 minutes and washed with sterile distilled water 3 times for 5 minutes.

To determine if plant hormones and growth regulators overcome dormancy in wheat and triticale, three replicates of thirty seeds were incubated in Petri dishes on filter paper moistened with 5 ml different solutions (GA_3, IAA, KNO_3, $MgSO_4$ and AMO 1618) at concentrations 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} M. One set of untreated seeds acted as control (distilled water).For germination, the Petri dishes were left at 23±2^{o}C in climate chamber at 16/8 light-dark regime. The experiment latest for 5 days and germinated seed were counted every day. The radicle and hypocotyls elongation was measured the latest days of experiment.

The germination index (GI) was calculated as described in the Association of Official Seed Analysts (1983) by the following:

$$GI = X_1/W_1 + (X_2-X_1)/W_2 + \ldots\ldots\ldots (X_n-X_{n-1})/W_n$$

The X_n is the germination percentage on the n^{th} day and X_n is the number of the day from the first day of the experiment.

RESULTS AND DISCUSSION

Seed dormancy and germination are complex physiological processes that are controlled by a range of developmental and external cues (OGAVA *et al*., 2003). Variations in percentage of seed germination are often interpreted as reflecting adaptations to specific ecological conditions (NISHITANI and MASUZAWA, 1996). If the dormancy is defined as inhibited germination of an intact viable seed to optimize the distribution of germination over time (BEWLEY and BLACK, 1983; HILHORST, 1995), it can be expected that the inhibition of germination has evolved differently across species for adaptation on the prevailing environment so that germination occurs when conditions are likely to be suitable for establishment of a new generation (FINCH-SAVAGE and LEUBNER- METZGER, 2006).

In order to compare the effects of natural and synthetic plant growth regulators and inhibitors on seed germination in winter wheat (*T. aestivum*) and triticale (X *Triticosecale*), we are investigated germination rates of seeds, root elongation and the growth of hypocotyls at different concentrations of GA_3, IAA, KNO_3, $MgSO_4$ and AMO 1618.

Results for percentage of the germinated wheat seeds is shown in Table 1. In the control group of seeds, a germination rate was 82.22%. Wheat seeds failed to germinate in the 10^{-3}M AMO 1618, while the highest percentage of seed germination (90%) was recorded in a solution of KNO_3, at concentrations of 10^{-5}M.

Table 1. Percent of germinated seeds of *T. aestivum* in different concentrations of plant growth regulators and the inhibitor AMO 1618.

PGH	10^{-3}M	10^{-4}M	10^{-5}M	10^{-6}M
GA_3	83.33	85.55	74.44	88.88
IAA	65.55	75.55	83.33	82.22
KNO_3	81.11	77.77	90	86.66
$MgSO_4$	83.33	83.33	87.77	78.88
AMO1618	/	48.88	76.66	85.55
control		82.22		

The results obtained for the germination of triticale seeds (Table 2) are similar to those obtained for wheat seed, whereby, in the case of triticale seeds, control group have 75.57% of germination. Germination was not observed in a group of seeds which have been treated with retardant AMO 1618 at a concentration of 10^{-3}M, whereas the highest germination rate was found in seeds treated with 10^{-4}M KNO_3 (77.77%).

Figures 1 and 2 summarized the results for the effect of selected natural and synthetic plant growth regulators on a wheat and triticale root elongation. It was found that the wheat, as well as triticale, showing a varied root elongation in the same concentrations of growth regulators. In the case of wheat, which seed in the control group had a root length 54.83 mm, best results are achieved by using $MgSO_4$, whereby the concentration of the 10^{-4}M had the most stimulating effect (63.18mm). Obtained results for the triticale are the similar as for the wheat; magnesium salt had the strongest effect on root elongation, with the difference that the best effects had concentration of the 10^{-6}M. Also, the length of the roots was slightly lower (control group – 45.74 mm; 10^{-6}M $MgSO_4$ – 55.43mm). AMO 1618 had the most inhibitory effect in both

wheat and triticale root elongation. The complete inhibition of root elongation was with concentration 10^{-3}M.

Table 2. Percent of germinated seeds of *Triticosecale* in different concentrations of plant growth regulators and the inhibitor AMO 1618.

PGH	10^{-3}M	10^{-4}M	10^{-5}M	10^{-6}M
GA_3	67.67	66.67	74.33	64.40
IAA	43.23	56.57	67.87	64.43
KNO_3	63.36	77.77	74.57	58.90
$MgSO_4$	57.92	67.88	65.32	68.89
AMO1618	/	17.78	63.28	67.95
control		75.57		

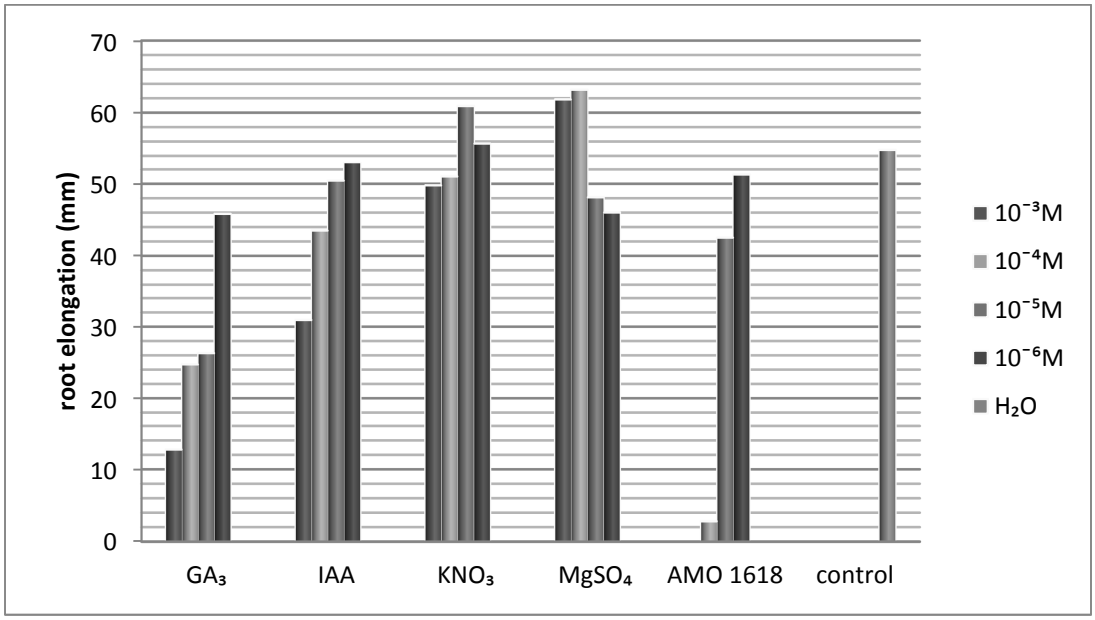

Figure 1. Effect of different plant growth regulators and inhibitor AMO 1618 on *T. aestivum* root elongation.

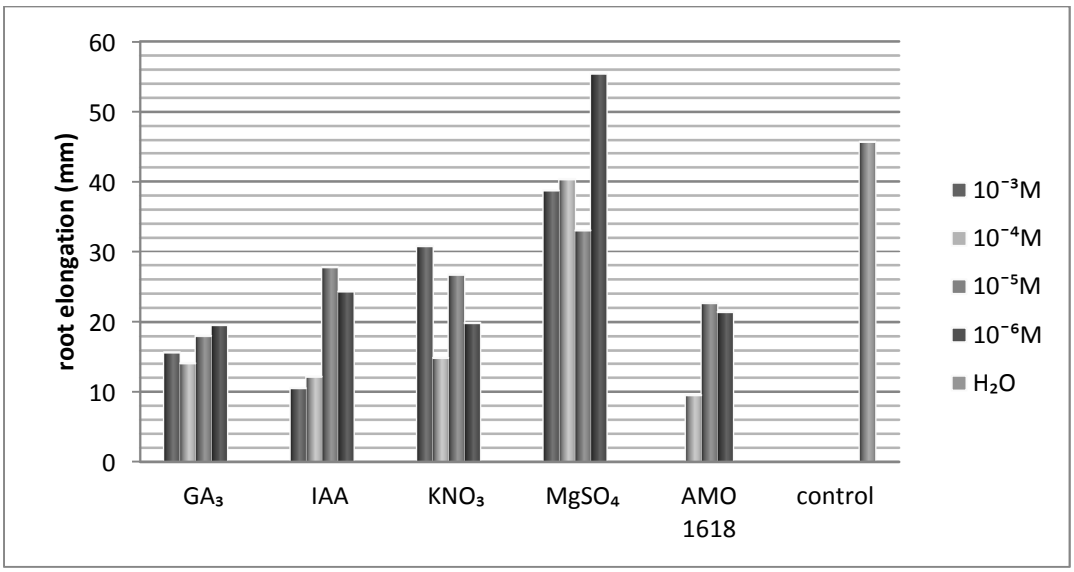

Figure 2. Effects of different plant growth regulators and inhibitor AMO 1618 on *Triticosecale* root elongation.

Result of hypocotyls growth is presented in Figures 3 and 4. According to obtained values, the greatest influence on the growth of hypocotyls had GA_3. In the case of wheat, hypocotyls are, at a concentration of 10^{-6}M GA_3, had a length of 38.61 mm, highest than the control with distilled water (32.33 mm). The seeds of triticale, when compared with wheat seed, showed a slightly greater length of the hypocotyls in the control group (32.87 mm), but the maximum length of hypocotyls was achieved in solution of greater GA_3 concentrations (36.69 mm at 10^{-5}M).

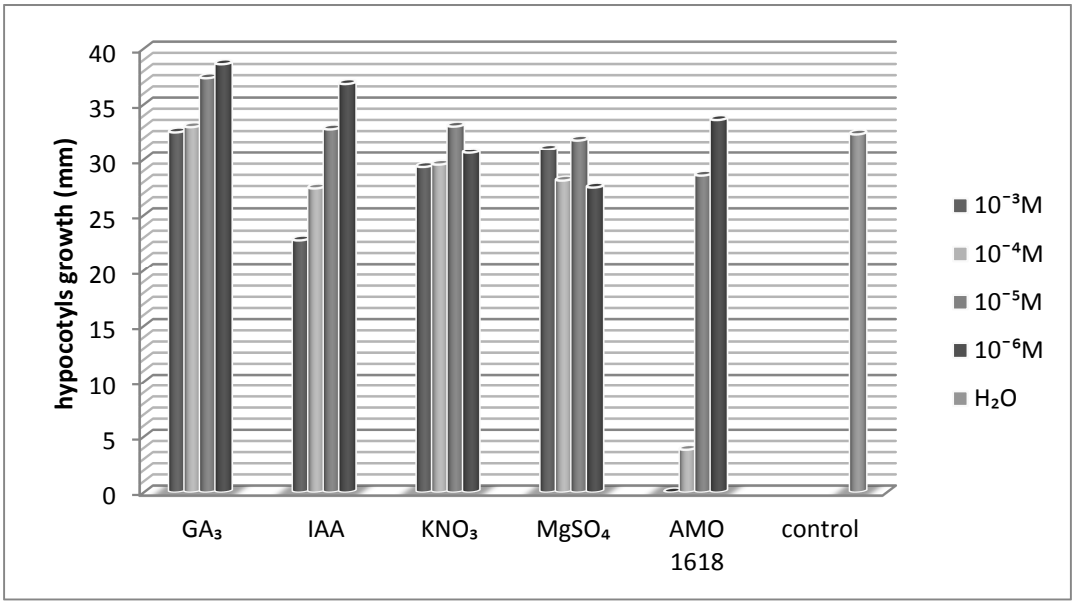

Figure 3. *T. aestivum* hypocotyls growth under the influence of plant growth regulators and inhibitor AMO 1618.

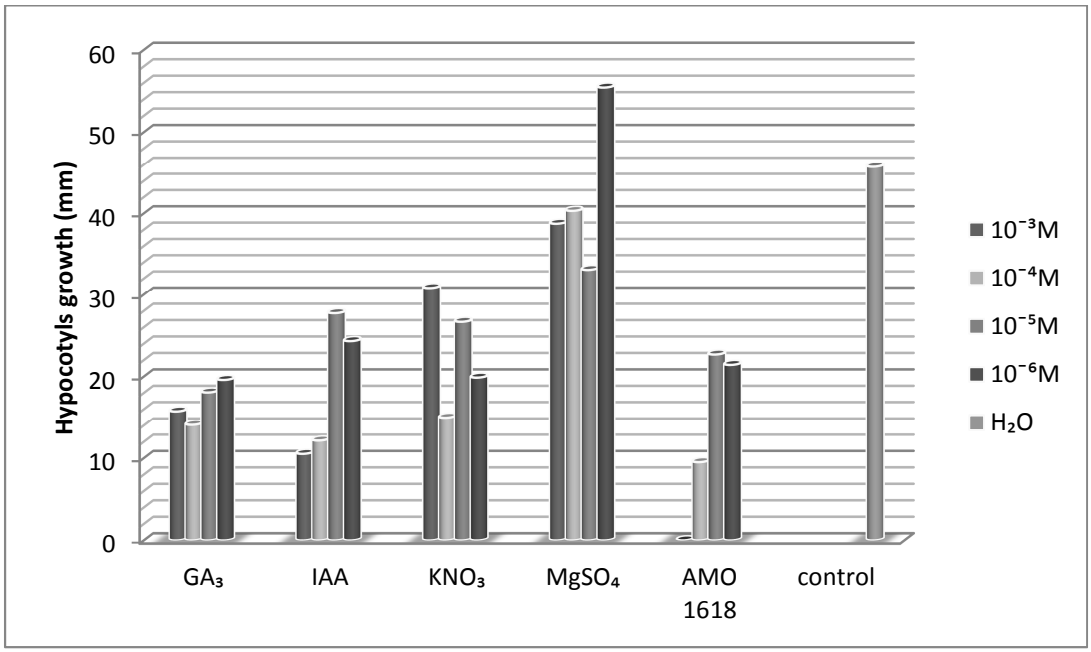

Figure 4. *Triticale* hypocotyls growth under the influence of plant growth regulators and inhibitor AMO 1618.

The different responses of plant to various growth regulators may change according to species, ecotype and even presumably the location of plants in taxonomy (KABAR, 1998). Dormancy patterns are similar for closely related taxa, but may vary within a family, even between co-occurring species with similar life histories (KARLSSON *et al*., 2006). Nitrate is an important nitrogen source for plants, but also a signal molecule that controls various aspects of plant development and has for long been known to stimulate germination in a large number of plant species (ALBORESI *et al*., 2005). According to our results, solution of KNO_3 had the best effect on the germination of seeds in both cases, but in different concentrations. These results are supported by TAJBAKHSH (1996) and BRANDEL (2005) which demonstrated that the seed germination could be enhanced by KNO_3 solute on plant seeds with seed dormancy.

The cell growth is accompanied by wall synthesis, and in advance of that, growth cells show extensive cytological activity (COWLING and HARBERD, 1999). Cell division at the root tip and cell elongation in the extension zone is two different mechanisms (ARDUINI *et al*., 1994). In our work, the best effect on root elongation had solution of $MgSO_4$ in concentration of 10^{-4}M for wheat, respectively 10^{-6}M for triticale. Some plant species appear to be able to tolerate or adjust to the salt media even though germination was initially inhibited or accelerated. The length of the incubation period is critical when seed germination is used for initial screening of plant species in relation to salt solutions. This should be considered in designing salt studies to insure proper interpretation (RIES and HOFMANN, 1983).

Hypocotyl elongation is very plastic and is influenced strongly by factors that regulate cell elongation in the adult plant such as light, plant hormones, temperature, and touch (COLLETT *et al*., 2000).The gibberellins are endogenous regulators of plant growth which regulates hypocotyl growth by altering the extent of hypocotyl cell elongation (COWLING and HARBERD, 1999). According to the results of this study, GA_3 was most effective in the case of hypocotyls elongation, with the only difference in the concentration of the solution.

In conclusion it can be noted that, when it comes to wheat and triticale, the main parameters of seed germination: the seed germination percentage, root elongation and hypocotyl growth are under the influence of both natural and synthetic plant growth regulators. If the seeds

of wheat and triticale are compared with each other, slightly better response to the applied solutions showed wheat seed.

CONCLUSION

Wheat and triticale are grains which have dormant seeds. Dormancy may be breaking by natural and synthetic plant growth regulators and their role was depended by used concentration. The highest effect on percentage of wheat germination had GA_3 and KNO_3, especially at lower concentration. Retardant AMO 1618 inhibited germination, and lethal concentration was 10^{-3} M. At triticale seeds, no solution has effect on breaking dormancy (except KNO_3 at concentration 10^{-4} M). It means that dormancy has already broken by seed ripening. Root and hypocotyl elongation was affected by used solution and their concentration. At wheat, all used growth regulators increased root and hypocotyls elongation, even AMO 1618. In contrast to this, root and hypocotyls elongation at triticale was recorded only at magnesium-sulfate.

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