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INFLUENCE OF HYDROGEL ON GERMINATION OF LETTUCE AND ONION SEED AT DIFFERENT MOISTURE LEVELS

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Abstract

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The influence of Agrisorb (water solution 1, 3, 5 g/l) on lettuce and onion seed germination was tested in different moisture conditions (30 ml and 15 ml of water in germination box). Variants with reduced water level germinated much more slowly (MGT parameter) than standard variants, though differences in total germination at the end of the test were insignificant. Treated variants of lettuce seeds showed a statistically significant increase in germination energy (GE) on the first day (GE1, both water levels), but a significant decrease on the second day (columns GE2, 15 ml). Higher doses of Agrisorb slowed lettuce seed germination (GE2, 30 ml, dose 5 g) significantly, similarly see GE2 (15 ml, doses 1, 3, 5 g). This slowdown was apparent for GE3 (both water amount) as well. A similar but insignificant effect was evident for onions. There was an influence of cultivar and seed vigour on sensitivity to water stress. The hydrogel application influenced germination of lettuce and onion seeds. Treated lettuce seeds germinated faster than non-treated control in the beginning of germination process. This effect was not recorded in case of slowly germinated onion seed lots. Although influence of Agrisorb was positive in the beginning, higher doses of hydrogel reduced germination energy of treated seed lots (for example GE2, GE4) of both crops in comparison with non-treated control. Higher doses of hydrogel caused longer MGT of lettuce and onion as well.

Agrisorb, hydroabsorbent, water deficit, vigour

Water deficit ranks among the most important abiotic factors limiting growth and productivity of plants (Šebánek *et al.*, 1998); vegetables are a crop group with a high water requirement (Malý *et al.*, 1998).) The period after sowing can be characterized as one where a lot of water is necessary (Krug *et al.*, 2002).

Hydrophilic polymers are used in horticulture and agriculture praxis as water absorbents for better water support of plants with partial water deficiency (Rehman *et al.*, 2011; Andry *et al.*, 2009). Other authors recommend hydrophilic polymers for replanting to decrease water stress (Wroblewska *et al.*, 2012; Ruthrof *et al.*, 2010).

Kumaran *et al.* (2010) describes hydrophilic polymers as agents with the ability to absorb 100–300 times their weight in water. Kazanskii and Dubrovskii (1992) mention the ability of hydrophilic polymers to improve soil water retention. Abd El-Rehim *et al.* (2006) specify the benefits of a superabsorbent in the soil for the improvement of physical properties, better aeration, improved seed germination and root system creation in heavier soil, and for increasing water retention in lighter soils. Lošák *et al.* (2010) studied changes in the contents of N, P, K, Ca and Mg in the aboveground biomass of the respective clover-grass mixtures after Agrisorb application into soil, newertheless there were not found significant differences.

Borowski and Michalek (1998), El-Hady *et al.* (1990), El-Sayed *et al.* (1991), Graham (1991) and Koudela *et al.* (2011) also noted a stimulating effect of hydrophilic superabsorbent on plant growth and yield under impaired soil conditions.

Hydrophilic polymers are potassium salts of metacrylate prepared by copolymerizing polyethylene oxide methacrylate bis-macromonomers with small ionogenic monomers such as 2-acrylamido-2methyl-1-propansulfonic acid (Dubrovskii *et al*., 2001).

The use of hydrophilic matters could limit the negative impact of water deficit in vegetable production; this is due to more negative water potential and the ability absorb a huge amount of water, which consequently reduces the impact of environmental stress on plant physiology. A similar effect in regulating water potential is used for pre-sowing hydration treatment (priming, osmoconditioning), as reported by Olszewski *et al.* (2012).

Alexeychuk *et al.* (1999) report that seed hydration-dehydration-rehydration procedures and seed osmoconditioning in PEG solutions or polyacrylamide hydrogel stimulate proteolytic activity in seeds during germination. The authors explain that this phenomenon is most likely caused by the relationship of the stress conditions and seed swelling. Harris (1996) indicate a significant contribution of PEG seed priming to the germination rate increase and consequently to the growth of *Sorghum bicolor* (L.) Moench under semi-arid conditions; they also pointing out the significant influence of genotype on these parameters.

The aim of this experiment was to test the effect of hydrogel application on the lettuce and onion seed germination in different moisture conditions. Lettuce and onions were chosen as two model vegetables with quicker and slower germination.

MATERIAL AND METHODS

The experiment was carried out with lettuce (*Lactuca sativa* L.) and onion (*Allium cepa* L.) commercial seed lots, category "S" from SEMO Smržice, ltd. in a seed laboratory of the Faculty of Agrobiology, Food and Natural Resources, Prague. Two varieties of lettuce, Mars and Maršálus, and two varieties of onion, Všetana and Alice, were evaluated.

Seed lots were treated with hydrogel Agrisorb (potassium salt of crosslinked acrylamide/acrylic acid copolymer, Stocksorb®, Evonik Stockhausen Gmbh, Germany) in 3 doses: 1 g, 3 g and 5 g of Agrisorb per litre of water.

Hydrogel was applied using the following hydration method: seeds were mixed with hydrogel solutions for 15 minutes. Tap water without Agrisorb was used as wet control. After treatment, the seeds were dried back on filter paper (24 hours, room temperature 22 °C) to stop water intake to the seeds.

For the evaluation of dried variants and non-treated control (dry), a standard germination test (ISTA rules) was used to obtain a germination percentage (four replications per 100 seed for each sample) on filter paper (crepe, 120 $g.m^{-2}$) with 30 ml (standard) and 15 ml (dry variant) of tap water .

Seed germination was evaluated as physiological (in 24 hours intervals), and seeds with 3 mm long radical protrusions were scored as germinated to determine germination energy (Pazderu, 2009) and MGT (mean germination time, Nichols and Heydecker, 1968). Total germination was calculated as the sum of daily values.

Obtained results were statistically evaluated by the ANOVA method of analysis of variance. Arcsin $\sqrt{x}/100$ transformation was used to obtain normal distribution of germination data. Values in tables are shown after back transformation. Differences between means were evaluated by Tukey's test in the SAS system (version 9.3) at a significance level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Agrisorb is recommended for the supply of large amounts of water to plants. This experimental hypothesis was verified in the case of seeds.

The influence of Agrisorb on seed germination is evident from the results; this hypothesis was not confirmed, and variants with low levels of water (15 ml in germination box) germinated more slowly (MGT parameter) than variants with higher levels (30 ml), though only slight differences in total germination were evident at the end of the test (Tab. I and Tab. II).

A comparison of treated variants of lettuce seed lots and dry control during germination (germination energy, GE) show a statistically significant increase in germination on the first day (columns GE1, both water levels), but a statistically significant decrease on the second day (columns GE2, 15 ml). Negative influence of Agrisorb is related to its dose as well; higher doses slow lettuce seed germination (GE2, 30 ml, dose 5 g) significantly, as similarly shown with GE2 (15 ml, doses 1, 3, 5 g). This slowdown is apparent with GE3 (both water levels) as well; however, total germination values among treated variants are not statistically significant. A similar effect can be seen in onions (GE4, Tab. II), though differences are not significant. For a more detailed view, see graphs 1–4 with germination curves for each variant.

There is a noticeable effect of cultivar and seed vigour on water stress sensitivity. For lettuce, water deficiency negatively influenced the germination of the cultivar 'Mars' from day 1. However, this effect was not noted until day 3 of more vigorous cultivar 'Maršálus' germination (Tab. I). Onion cultivar 'Alice' was affected by water deficiency from day 1 of germination, but the more vigorous cultivar 'Všetana' germinated similarly in water optimal conditions as well as in water deficient conditions (Tab. II). The above mentioned results suggest that the cultivar (and its vigour) is an important factor affecting sensitivity (respectively adaptability) of seeds to the moisture deficit. The importance of

I: *Germination parameters of lettuce seeds treated with hydrogel in standard (30 ml) and dry conditions (15 ml)*

Treatment	GE1 %	GE1 %	HSD water[2]	GE2 %	GE2 %	HSD water[2]	GE3 %	GE3 %	HSD water[2]	TG %	TG %	HSD water[2]	MGT days	MGT days	HSD water[2]
	15 ml	30 ml		15 ml	30 ml		15 ml	30 ml		15 ml	30 ml		15 ml	30 ml	
Control	$0^{c,A}$	$0^{c,A}$	0.0	$93^{a,A}$	$98^{a,A}$	**5.3**	$98^{a,A}$	$100^{a,A}$	**2.2**	$100^{a,A}$	$100^{a,A}$	**0.5**	$2.1^{bc,A}$	$2.0^{b,A}$	**0.10**
Hydrated	$3^{c,B}$	$21^{b,A}$	**13.6**	$93^{ab,A}$	$99^{a,A}$	**8.1**	$95^{a,A}$	$100^{a,A}$	**4.8**	$98^{a,A}$	$100^{a,A}$	**2.3**	$2.1^{bc,A}$	$1.9^{b,A}$	**0.31**
Hydrogel 1g	$20^{b,A}$	$20^{b,A}$	**18.1**	$77^{c,B}$	$98^{a,A}$	**4.1**	$80^{b,B}$	$99^{a,A}$	**4.7**	$95^{a,B}$	$100^{a,A}$	**2.2**	$2.5^{b,A}$	$1.8^{b,B}$	**0.33**
Hydrogel 3g	$40^{a,B}$	$59^{a,A}$	**16.7**	$80^{bc,B}$	$94^{a,A}$	**12.3**	$90^{a,B}$	$98^{a,A}$	**6.0**	$96^{a,A}$	$99^{a,A}$	**3.8**	$2.0^{c,A}$	$1.7^{b,A}$	**0.51**
Hydrogel 5 g	$23^{b,A}$	$20^{b,A}$	**5.9**	$47^{d,A}$	$47^{b,A}$	**9.6**	$65^{c,A}$	$68^{b,A}$	**6.4**	$96^{a,A}$	$95^{b,A}$	**1.6**	$3.2^{a,A}$	$3.0^{a,A}$	**0.37**
HSD treatment[1]	**13.0**	**16.5**		**13.3**	**8.2**		**9.2**	**3.1**		**4.5**	**1.1**		**0.45**	**0.45**	
Maršálus	$16^{a,A}$	$14^{b,A}$	**4.5**	$82^{a,A}$	$87^{a,A}$	**5.7**	$88^{a,B}$	$97^{a,A}$	**3.2**	$97^{a,B}$	$99^{a,A}$	**1.6**	$2.3^{a,A}$	$2.2^{a,A}$	**0.23**
Mars	$14^{a,B}$	$28^{a,A}$	**7.9**	$79^{a,B}$	$86^{a,A}$	**3.4**	$86^{a,B}$	$91^{b,A}$	**2.3**	$97^{a,B}$	$99^{b,A}$	**1.1**	$2.4^{a,A}$	$2.0^{a,B}$	**0.16**
HSD cultivar[1]	**5.6**	**7.2**		**5.8**	**3.7**		**4.0**	**1.4**		**2.0**	**0.5**		**0.20**	**0.20**	

II: *Germination parameters of onion seeds treated with hydrogel in standard (30 ml) and dry conditions (15 ml)*

Treatment	GE3 %	GE3 %	HSD water[2]	GE4 %	GE4 %	HSD water[2]	GE5 %	GE5 %	HSD water[2]	TG %	TG %	HSD water[2]	MGT days	MGT days	HSD water[2]
	15 ml	30 ml		15 ml	30 ml		15 ml	30 ml		15 ml	30 ml		15 ml	30 ml	
Control	$20^{a,B}$	$43^{a,A}$	**9.4**	$43^{a,B}$	$67^{a,A}$	**10.2**	$74^{a,B}$	$82^{a,A}$	**7.2**	$89^{a,B}$	$94^{b,A}$	**3.3**	$4.4^{c,A}$	$4.1^{b,B}$	**0.29**
Hydrated	$29^{a,A}$	$24^{b,A}$	**10.1**	$47^{a,A}$	$44^{b,A}$	**10.6**	$71^{a,A}$	$73^{ab,A}$	**7.1**	$92^{a,B}$	$97^{a,A}$	**3.3**	$4.7^{bc,A}$	$4.8^{a,A}$	**0.29**
Hydrogel 1g	$16^{a,B}$	$23^{b,A}$	**7.4**	$26^{a,B}$	$41^{b,A}$	**13.6**	$66^{a,A}$	$68^{b,A}$	**12.1**	$93^{a,A}$	$96^{ab,A}$	**4.1**	$5.0^{ab,A}$	$5.0^{a,A}$	**0.44**
Hydrogel 3g	$21^{a,A}$	$22^{b,A}$	**13.6**	$35^{a,A}$	$37^{b,A}$	**18.3**	$66^{a,A}$	$69^{b,A}$	**9.2**	$92^{a,B}$	$95^{ab,A}$	**1.9**	$5.1^{ab,A}$	$5.1^{a,A}$	**0.56**
Hydrogel 5 g	$22^{a,A}$	$27^{b,A}$	**12.4**	$29^{a,B}$	$41^{b,A}$	**11.7**	$65^{a,A}$	$69^{b,A}$	**11.0**	$94^{a,A}$	$95^{ab,A}$	**3.5**	$5.0^{ab,A}$	$4.8^{a,A}$	**0.41**
HSD treatment[1]	**18.7**	**11.3**		**21.7**	**13.6**		**14.8**	**11.2**		**5.5**	**3.1**		**0.49**	**0.41**	
Alice	$8^{b,B}$	$20^{b,A}$	**3.1**	$14^{b,B}$	$34^{b,A}$	**4.7**	$53^{b,B}$	$62^{b,A}$	**5.7**	$86^{b,B}$	$92^{b,A}$	**2.5**	$5.4^{a,A}$	$5.1^{a,B}$	**0.20**
Všetana	$38^{a,A}$	$37^{a,A}$	**9.1**	$60^{a,A}$	$58^{a,A}$	**9.7**	$84^{a,A}$	$82^{a,A}$	**5.2**	$99^{a,A}$	$99^{a,A}$	**0.9**	$4.3^{b,A}$	$4.3^{b,A}$	**0.28**
HSD cultivar[1]	**8.2**	**5.0**		**9.4**	**6.0**		**6.5**	**4.5**		**2.4**	**1.4**		**0.27**	**0.19**	

GE1, 2, 3 – germination energy, TG – total germination, MGT- mean germination time
[1] means with small letters are significant in columns, [2] means with capitals are significant in rows, all values are rounded, significance corresponds with original values

cultivars with regards to drought stress tolerance is mentioned by Ghane *et al.* (2012) at *Guizota abyssinica* Cass., or Ennajeh *et al.* (2009) at *Olea europaea* L. These varieties, which are more tolerant to water deficiency, have better potential for use in extensive vegetable production systems with limited irrigation.

As it is shown from the comparison between germination curves of stressed and non stressed variants, Agrisorb influences germination negatively. The emergence reduction of cabbage seed in substrate with a hydroabsorbent is mentioned by Reis and Coelho (2007); they also describe faster subsequent growth.

These results are more likely due to lower water potential of Agrisorb than to seed water potential after imbibition period. Dry seeds have very low water potential in the first phase of germination (–100 MPa, Bewley and Black, 1994); it is lower than that of Agrisorb, and surrounding water can get into the seed. When seed water potential is increased through imbibition, both water potentials are similar, and the flow of water into the seed is made increasingly difficult. As Wack and Ulbricht (2009) determined, different hydrogels can swell water binding with pressure between 0.2–4.23 MPa. This means that the application of hydrogel on seeds can decrease the speed of seed water uptake, which can result in slower germination.

Compared to dry control, Agrisorb application appears to slow the germination process, though hydrogel plays a positive role in water absorption from the seed surroundings during the first phase of germination. Conversely, the water binding strength restricts availability of water, and seeds can germinate in water deficient conditions.

However, water binding is not totally absolute. The effect of hydrogel is lower with higher levels of water, because more free water for seed exists and due to this fact they can germinate similarly in comparison with non-treated lots (variant 30 ml; Tab. I). With lower water content in seed surroundings, the proportion of bounded water in hydrogel is higher, water availability for seeds is low, and the germination process is slower (variant 15 ml; Tab. I).

The effect of hydrogel is possible to detect only in fast germinating (lettuce) seeds, and in case only when we evaluated germination energy. Results of onions with slow germination rates are similar, but not so clearly marked (see GE4 and GE5, Tab. II). Higher doses of Agrisorb caused longer MGT of both crops as well.

CONCLUSIONS

- The hydrogel application influenced germination of lettuce and onion seeds.
- Treated lettuce seeds germinated faster than non-treated control in the beginning of germination process. This effect was not recorded in case of slowly germinated onion seed lots.
- Although influence of Agrisorb was positive in the beginning, higher doses of hydrogel reduced germination energy of treated seed lots (for example GE2, GE4) of both crops in comparison with non-treated control.
- Higher doses of hydrogel caused longer MGT of lettuce and onion as well.

SUMMARY

Water deficit is the most important abiotic factors limiting growth and productivity of plants. Hydrophilic polymers are recommended by many authors for replanting to decrease water stress. The use of hydrophilic matters could limit the negative impact of water deficit in vegetable production; this is due to more negative water potential and the ability absorb a huge amount of water, which consequently reduces the impact of environmental stress on plant physiology. A similar effect in regulating water potential is used for pre-sowing hydration treatment (priming, osmoconditioning). The aim of this experiment was to test the effect of hydrogel application on the two cultivars (Mars and Maršálus) of lettuce (*Lactuca sativa* L.) and two cultivars (Alice and Všetana) of onion (*Allium cepa* L.) seed germination in different moisture conditions. Lettuce and onions were chosen as two model vegetables with quicker and slower germination. Seed lots were treated with hydrogel Agrisorb (Evonik Stockhausen Gmbh, Germany) in 3 doses: 1 g, 3 g and 5 g of Agrisorb per litre of water. After treatment, seed germination was evaluated as physiological (in 24 hours intervals), and seeds with 3 mm long radical protrusions were scored as germinated to determine germination energy and MGT (mean germination time). Total germination was calculated as the sum of daily values. The influence of Agrisorb on seed germination is evident from the results; and variants with low levels of water (15 ml in germination box) germinated more slowly (MGT parameter) than variants with higher levels (30 ml), though only slight differences in total germination were evident at the end of the test. A comparison of treated variants of lettuce seed lots and dry control during germination (germination energy, GE) show a statistically significant increase in germination on the first day (columns GE1, both water levels), but a statistically significant decrease on the second day (columns GE2, 15 ml). Negative influence of Agrisorb is related to its dose as well; higher doses slow lettuce seed germination (GE2, 30 ml, dose 5 g) significantly, as similarly shown with GE2 (15 ml, doses 1, 3, 5 g). This slowdown is apparent with GE3 (both water levels) as well; however, total germination values among treated variants are not

statistically significant. A similar effect can be seen in onions, though differences are not significant. There is a noticeable effect of cultivar and seed vigour on water stress sensitivity. For lettuce, water deficiency negatively influenced the germination of the cultivar 'Mars' from day 1. This effect was not noted until day 3 of more vigorous cultivar 'Maršálus' germination. Onion cultivar 'Alice' was affected by water deficiency from day 1 of germination, but the more vigorous cultivar 'Všetana' germinated similarly in water optimal conditions as well as in water deficient conditions.

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