

Effect of hydrogel on the turf grass species growing under salt stress

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Abstract: *Effect of hydrogel on the turf grass species growing under salt stress.* Hydrogels can absorb huge amount of water and so are able to decrease the drought stress in plants. They are used in horticulture and agriculture for years. It is possible that they may be applied also on the grass near – road areas. Because of water deficient and high salinity growth of plants in these conditions is however hard. Meanwhile, too high concentration of ions in soil can decrease efficacy of hydrogel, since it can absorb water and cations as well. Nevertheless there is still too less studies on such problem. From this point of view it seems that the complex assessment of hydrogels effect on urban lawn grass is needed. The aim of the study was therefore the evaluation of grasses condition after their cultivation under salt stress with and without hydrogels amendment. Experience was conducted for four months in the controlled green house conditions. The efficacy of hydrogels amendment was measured by the grass reactions (turfs height, fresh matter content and level of membranes injury) on three levels of salinity. The results allowed concluding that, concentration of the road de-icing salt was the main factor, which affected condition of all tested species. This reaction was independent on the presence of hydrogel. Nevertheless under low and medium saline conditions watersorbent weakened significantly influence of salt stress on the grass.

Key words: drought, water sorbent, salt stress, urban lawn grass.

INTRODUCTION

Hydrogels are polymer substances which are able to absorb huge amount of water (Trippei et al. 1991). Amended to soil

they increase its watercapacity, decrease evapotranspiration and allow plants to mitigate the drought stress (Leciejewski 2008; Bartnik 2008). This innovative method is known to be: easy, cheap and ecological. It lets to decrease costs of irrigation and humans work, enables to save water and energy with holding the chemical safety for the environment (Benedycka and Nowal 1998; Sroka 2004; Diener and Hey 2005; Baranowski 2006).

Nowadays, soil supersorbents are used commonly in horticulture and agriculture, where they precipitate: growth, rooting and leafing of many species, cultivated around the world (tomatos, cotton, tobacco) (Wallace and Wallace 1986; Sroka 2004; Al-Humaid 2005). It is also known that watersorbents help to recultivate the degraded areas – even there, where flora was absolutely devastated, they provide the revegetation (Paluszek and Żembrowski 2006).

Above advantages suggest therefore that using of hydrogels could be successfully broaden to the other domains, especially there, where drought problems are frequent. Such practices however have not been established well yet, because effectiveness of hydrosorbents depends often on species (Wallace and Wallace 1986; Sroka 2004; Akhter et al. 2004; Al-Humaid 2005).

For this reason Department of Environmental Protection (DEP) SGGW started evaluation of using hydrogels on the grass species present in the near – road areas. Lawn grasses are the most common green areas near the road sides and play an important role in landfill landscaping and shaping the microclimate conditions (Wysocki and Stawicka 2005; Pawluśkiewicz 2009). Unfortunately many stresses, especially drought, decrease their growth and condition (Wysocki 2008; Pawluśkiewicz 2009), what with high costs of irrigation cause that some innovative cultivation is needed.

Preliminary, greenhouse studies provided by DEP in 2009 allowed to conclude, that hydrogel influenced positively on germination, growth and dry matter content of tested grass species cultivated under simulated drought stress. It was also demonstrated that amendment of watersorbent make it possible to limit the watering frequency for tested plants from 3 to 1 per week and thanks to that to decrease costs of their irrigation for 3.5 times (Hadam 2010).

Nevertheless it should be also pointed that apart from the water hydrogels can absorb also cations (Benedycka and Nowal 1998), what in depend on species, may decrease watersorbents efficacy in the drought resistance (Akhter et al. 2004). It is therefore possible that, high concentration of sodium in the roadside soils, resulting from using salts for de-icing (Wrochna et al. 2010), may exclude the relevance for using hydrogels on the near – road grasslands. This issue however has not been investigated yet.

The aim of the study was therefore the assessment of the grass reaction on the exposure to the soil salinity during

greenhouse cultivation with and without hydrogels additive.

MATERIAL AND METHODS

The study was conducted for four months in a greenhouse of the Faculty of Horticulture and Landscape Architecture, Warsaw University of Life Sciences.

The experimental substrate, based on: sand, peat and horticultural soil (in proportion 1:1:1), was divided into two portions – with or without hydrogel amendment. The hydrogel was added in the amount required by the manufacturer (2 g /L of substrate).

Such prepared substrates were filled in the pots (12 cm diameter and volume 0.8 dm³) and then were sown with one of the species, which are known to be the most common in the near- road areas:

- red fescue (*Festuca rubra* L.) cv. Raisa (0.086 g of seeds/ pot),
- kentucky bluegrass (*Poa pratensis* L.) cv. Jarotka (0.074 g of seeds/ pot),
- perennial regrass (*Lolium perenne* L.) cv. Accent (0.123 g of seeds/ pot).

Number of seeds planted per pot depended on the: seedling emergence and seedling purity of each species, assessed by the Plant Breeding and Acclimatization Institute.

After a month plants cultivated with and without hydrogels amendment were treated with water salt solutions using the “Kłodawska” road de-icing salt (containing 97% NaCl) in concentrations of 0 g · dm⁻³ (control pots), 5 g · dm⁻³ and 10 g · dm⁻³. On the basis of the salinity curve for used substrate the electricity conductance was obtained there-

fore as medium ($5.45 \text{ mS}\cdot\text{cm}^{-1}$) or high ($9.91 \text{ mS}\cdot\text{cm}^{-1}$) (Kreeb 1979). The control pots (without salt solution) were watered only, nevertheless its electric conductivity was also measured and it appeared to be a low saline ($\text{EC} = 1.30 \text{ mS}\cdot\text{cm}^{-1}$).

Effectiveness of hydrogel under saline conditions was assessed after four months on the basis of the grass condition, characterised by the following parameters:

- turfs height [cm],
- fresh matter content of the plants above – ground [g /pot],
- increased membrane injury in compare to the control (plants not treated with the road de-icing salt) [%].

Above parameters are commonly used in assessments of plants reaction on the stressed environmental conditions (Żurek 2006; Pawluśkiewicz 2009).

Measurements were conducted in 4 replications, where replication was a single pot with each grass species planted with or without hydrogels amendment and treated with the salt solution as was written above.

Results obtained from the study were analyzed statistically using the two factorial analysis of variance (ANOVA) of the Statgraphics 4.1 Plus software. Significance of differences between the combinations was examined with t-Student test at $\alpha = 0.05$. Results show the mean values 4 replications.

During whole experiment plants were watered to the optimal level on the basis of the measurements conducted by soil moisture meter (ECHO – EC5). Grass were also mowing – once a week to 5 cm height.

The temperature and air humidity in the greenhouse were measured everyday (termo-hygrometer EPI 8703) and fluctuated from 22.9 to 35.0°C and 32.5–42.2%.

RESULTS AND DISCUSSION

Figures present effect of soil salinity in the presence and absence of hydrogels amendment on the: height (Fig. 1), fresh matter content (Fig. 2) and percentage of membrane injury (Fig. 3) in red fescue Raisa, kentucky bluegrass Jarotka and perennial regrass Accent.

The obtained results confirmed earlier observations (Wrochna et al. 2005), that soil salinity has negative effect on the growth and development of plants. Because of disturbing physiological and biochemical processes, it results, among the others, in: lower growth, decreased biomass production and increased membrane injury (Alpaslan and Gunes 2001; Morant-Manceau et al. 2004; Kacperska 2005). It was shown that concentration of the road- de-icing salt was the main factor, which affected all tested species. Independent on the water sorbents presence height and fresh matter content of red fescue Raisa, kentucky bluegrass Jarotka and perennial regrass Accent decreased significantly with increase of the salt concentration (Figs. 1–2). It was also observed that, in both cases – in pots with and without sorbents additive, the higher level of salinity was simulated, the significantly higher turfs membrane injury was indicated (Fig. 3).

It can be therefore concluded that additive of the road de-icing salt decreased also ability of the hydrogel in improving condition of the tested grass species, probably, due to disturbing its water

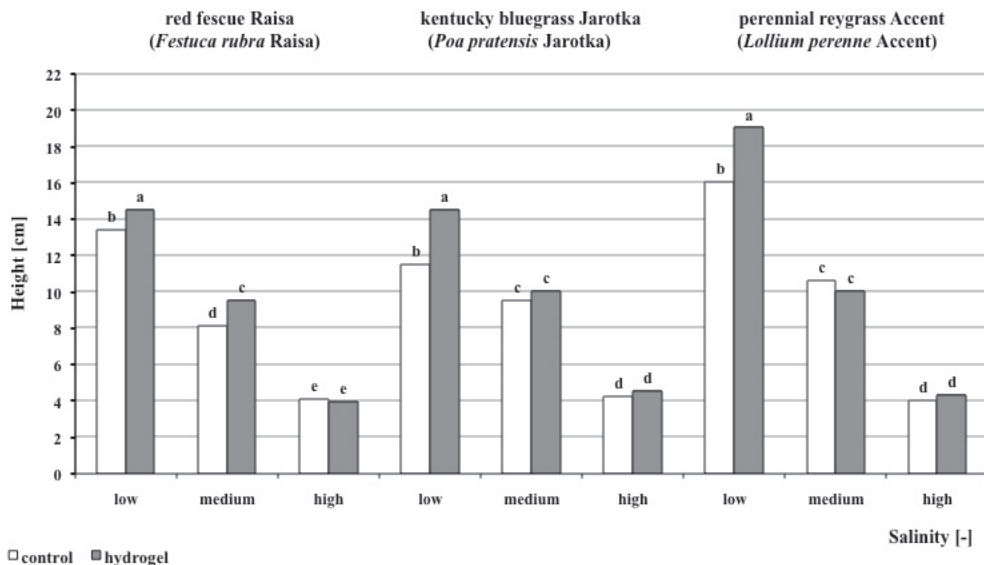


FIGURE 1. Influence of salinity on the turfs height of the grass species cultivated with and without (control) hydrogels amendment. Different letters show statistically significant differences between means within each species

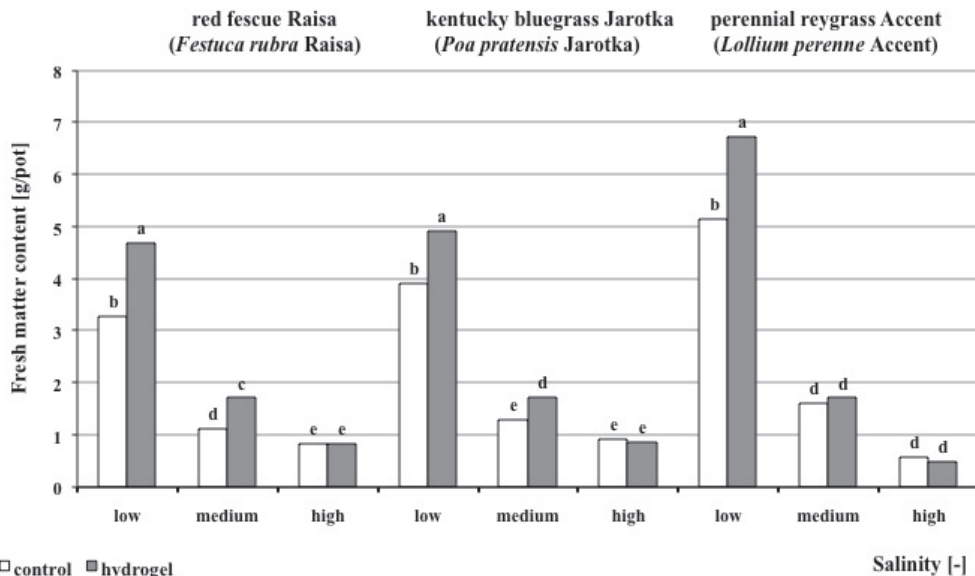


FIGURE 2. Influence of salinity on the fresh matter content of the grass species cultivated with and without (control) hydrogels amendment. Different letters show statistically significant differences between means within each species

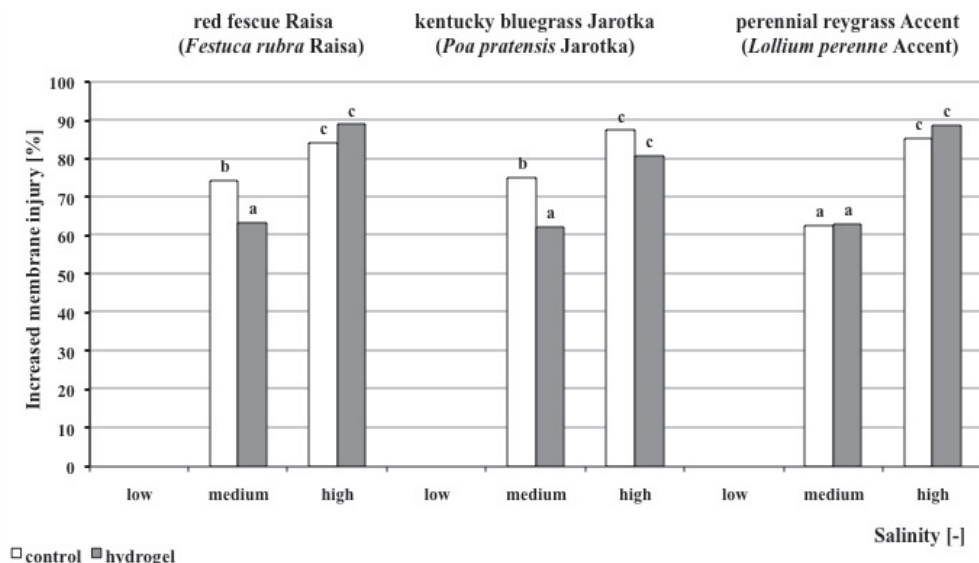


FIGURE 3. Influence of salinity on increased membrane injury of the grass species cultivated with and without (control) hydrogels amendment. Different letters show statistically significant differences between means within each species

absorbing abilities. Johnson (1984) and Asady et al. (1985) provided that chemicals and ions can adversely affect the function of hydrogels. It was also observed that its water retention was significantly lowered when the saline water was used (Akhter et al. 2004).

Nevertheless presented studies indicated also that, to the certain level of salinity, hydrogel can still enable some of the tested species to tolerate the salt stress. Under low saline conditions ($EC = 1.30 \text{ mS}\cdot\text{cm}^{-1}$) turfs height and fresh matter content of all tested species cultivated with the sorbents amendment was significantly greater than those without hydrogel. In the pots with the medium concentration of salt ($5 \text{ g}\cdot\text{dm}^{-3}$) similar reaction on the watersorbents amendment was observed in the height and fresh matter content of red fescue (Figs. 1–2) and in the fresh matter production of kentucky bluegrass (Fig. 2). In such conditions hy-

drogel decreased significantly also their membrane injury, from above 70% (in pots without hydrogel) to about 60% (Fig. 3). Similar observations have been reported by Hamed et al. (1995), who showed that under glasshouse condition incorporation of hydrogel into sand has enabled cotton and maize to be grown in the saline solutions. It was also investigated that water sorbents amendment improved salt tolerance of certain other horticultural crops, including: tomato, cucumber, lettuce and bean (Hamed et al. 1990; Kant and Turan 2010). Despite above, under the medium salt stress hydrogel did not influenced on perennial regrass. *Lolium perenne* is however known to be more tolerant to salinity than the other tested species (Alshammary et al. 2004; Wu et al. 2005). It may therefore explain why its all examined parameters were in pots with and without hydrosorbent comparable (Figs. 1–3).

Because of the vulnerability on the salt stress, grass species are usually not recommended on the highly salinated areas (Pawluśkiewicz 2009). Presented results showed that hydrogel does not support their growth in such conditions. Height and fresh matter content of all tested species cultivated with the sorbents additive was comparably low with the controls (without hydrogel). Salt concentration of $10 \text{ g} \cdot \text{dm}^{-3}$ increased also grass membrane injury – to the high level above 80% in all species, independent on the hydrogels presence. It is possible that high concentration of sodium cations could saturate hydrogels matrix to that level, in which it was unable to absorb water (Akhter et al. 2004). In such conditions water sorbent was therefore unable to provide optimal substrates humidity and it could not amend condition of cultivated species.

CONCLUSIONS

1. Presented results allowed to conclude that additive of the road de-icing salt decreased efficacy of hydrogel in improving condition of the tested grass species.
2. Independent on the hydrogels amendment concentration of the road de-icing salt was the main factor which affected the: growth, fresh matter content and level of membrane injury in all tested species (red fescue Raisa, kentucky bluegrass Jarotka and perennial regrass Accent). The higher dose of salt was added to the pots, the weaker condition of grass was observed – in both cases – with and without hydrogel.
3. Nevertheless hydrogel was able to improve condition of plants during cultivation under low and medium salt stress. Its efficacy depended however on the tested grass species and examined parameter.
4. Under low saline conditions hydrogel was the most efficacy. Growth and fresh matter content of all studied species cultivated with its amendment was higher than in the control – without hydrosorbent.
5. Under medium saline conditions efficacy of hydrogel was worse, but it lowered the growth inhibition of red fescue. It also increased the fresh matter production and decreased membranes injury of red fescue and kentucky bluegrass. Only perennial regrass was not affected by the water sorbents amendment in such conditions. However this may result from its own ability to tolerate the salinity.
6. Hydrosorbent was indicated to be inefficient in the highly salinated pots. Independent on the tested species, turfs height, fresh matter content and level of membranes injury were highly affected by the salt stress in all pots – with and without hydrogels amendment.
7. Studied hydrogel appears to be highly effective for use as a soil conditioner on the lawn grass areas, to improve its tolerance to the low and medium saline conditions. These results should be however confirmed by the field trials.

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Streszczenie: Wpływ hydrożelu na wybrane gatunki traw gazonowych uprawianych w warunkach stresu solnego. Hydrożele to substancje zdolne do gromadzenia dużej ilości wody, a wykorzystywane w praktyce mają łagodzić skutki suszy u roślin. Stosowane są od lat w ogrodniczej i rolniczej produkcji roślinnej, być może znajdują również zastosowanie w pielęgnacji zieleni przyulicznej. Obszary przyuliczne są szczególnie trudne do rozwoju roślinności – występuje tam jednak nie tylko deficyt wody, ale i zasolenie. Obecność nadmiernej ilości jonów w roztworze glebowym może tymczasem obniżyć skuteczność działania hydrożelu, który oprócz wody sorbuje również kationy. Brak jest jednak wystarczającej wiedzy na ten temat. Istnieje zatem potrzeba kompleksowej oceny skuteczności hydrożeli w warunkach przyulicznych, uwzględniającej jednocześnie kilka czynników stresowych. Opracowanie to prezentuje wstępne wyniki badań działania hydrożelu w warunkach zasolenia na przykładzie reakcji wybranych gatunków traw gazonowych (kostrzewy czerwonej odm. Raisa, wiechliny łąkowej odm. Jarotka i życicy trwałej odm. Accent), które występują powszechnie na trawnikach przyulicznych. Doświadczenie wazonowe prowadzono przez cztery miesiące w kontrolowanych warunkach szklarniowych. Miarą skuteczności działania hydrożelu była ocena: wysokości darni, produkcji świeżej masy i stopnia uszkodzenia błon komórkowych traw narażonych na trzy poziomy zasolenia podłoża, w obecności i przy braku sorbentu. Uzyskane wyniki pozwoliły stwierdzić, że głównym czynnikiem determinującym niniejsze parametry było stężenie soli w podłożu. Reakcja ta była niezależna od obecności hydrożelu w podłożu. Mimo to w warunkach małego oraz średniego zasolenia dodatek sorbentu osłabił istotnie działanie stresu solnego na badane trawy.

Słowa kluczowe: hydrosorbent, stres solny, susza, trawniki przyuliczne

MS. received May 2011

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