GERMINATION AND BIOMASS PRODUCTION AS AFFECTED BY SALINITY IN HYDROGEL TREATED SANDY SOIL

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ABSTRACT

Synthetic polyacrylamide polymers are water storing, gel forming soil conditioners, used to improve the water storing capacities of the drought-prone soils and to improve the supplies of plant available water, thus helping in better plant establishment and growth.

The effects of polyacrylamide co-polymers on germination and growth were investigated in this study. The polymer was mixed with dune sand at different percentage by weight and soil-hydrogel mixtures were saturated with saline solutions prepared by mixing NaCl at different proportions in deionized water after sowing seeds of three different species. Germination and growth were recorded. Both growth parameters responded positively to the addition of polymer, and negatively to the salt concentration in saturating solutions. A variation was also observed between the species.

A high level of polymer inhibited germination in rye grass.

Key words: **polyacrylamide; soil conditioning, salinity; germination; biomass.**

INTRODUCTION

Critical phases in the growth and development of any plant are those of germination and establishment. The successful establishment of agricultural crops from seed is often restricted by poor soil moisture level, especially in arid and semi-arid regions. The soils of these areas usually have a low water holding capacity and an excessive permeability. The water drain rapidly from the root zone, and even with frequent watering the water contents of the coarse textured soils are usually insufficient to support plant growth. Also the soils suffer from an excessive rate of evaporation, due to their texture and high temperatures usually encountered in these areas.

The application of hydrophilic polymers (hydrogels) as an aid to water retention in sandy soils by decreasing evaporation and deep percolation is an important development to assist plant growth in dry and arid regions of the world.

These polymers have been reported by Johnson 1984, Callaghan et. al.1988, and Woodhouse 1991, to reduce considerably evaporation in polymer treated soil. Azzam (1980, 1983); Flannery and Buscher (1982); Baasiri et. al. (1986), Salem et. al. (1991) reported the use of hydrogel to improve the water holding capacity of coarse textured soils.

James and Richard (1986), Johanson (1984), reported that water retained by hydrogels can be adversely affected by chemicals and ions present in the irrigation water. Asady et. al. (1985), Stone (1985) reported a high degree of correlation between the physical status of soil and crop production.

Amendments of plant-growing media with hydrophilic polymers often increase the water holding capacity and improve plant growth (Ghering and Lewis, 1980). Addition of hydrophilic polymers reduced the water required to almost half that of the control (Tylor and Halfcare, 1986) and increase the time to wilt and decreased water requirements (Ghering and Lewis, 1980, Willingham) and Coffey 1981).

Woodhouse and Johanson (1991) reported improvements in germination and establishment by gel-forming water storing polymers, but there are considerable variations in response of different species to polymer products.

Baxter and Waters (1986) reported that in drought prone soils moisture supplies to the seeds can be improved by coating seeds with starch co-polymers. This also enhances imbibition of prior to germination (Seong and Minor, 1982).

Inconsistencies in the effects of polymers on germination have been reported by various authors. Azzam (1985) reported an increase in germination of squash (*Cucurbita pepo*) and brassica (*Brassica oleracea*) in gel treated soil. Conversely, negative effects of high concentrations of polymer on germination of tobacco have reported by Hamilton and Lowe (1982).

Increase in rate of emergence and dry weights of seedlings of lettuce, tobacco and cotton have been reported by Wallace and Wallace (1986) in soils with different combinations of polyacrylamide as soil conditioner.

Wallace (1988) reported the interaction of hydrogel and Hoagland solution concentration and reported the decrease in shoot fresh weight of tomato with increasing Hoagland solution concentration.

A polyacrylamide material increased the growth of *Chlorophytum comosum* by 50% during summer production (Wang and Boogher 1987). However in several other studies, hydrogel material were found to have no beneficial effects on plant growth (Connver and Poole, 1976; Ingram and Yeager, 1987).

MATERIALS AND METHODS

In this study a polyacrylamide based polymer (alcosorb - A 3 extra coarse) with a particle size of 1400-4000 microns was used. It is a highly water swellable and water insoluble polymer, capable of absorbing over 400 times its own weight of pure water.

Sandy soil collected from the coastal sand dunes of Bredene (Belgium) was used during the experiment. Experiments were carried out by using mixtures of hydrogel and soil an amount of (0g, 1g, 2g and 3g of hydrogel) was used per kilogram of air dried soil on a dry weight basis respectively to prepare various soil mixtures. These soil mixtures were placed in polypropylene pots of 13 cm size with their bottom covered with filter paper. These pots were then placed in wide and deep containers filled with solutions of sodium chloride in deionized water at concentrations of 0, 10, 25 and 50 meq. 1^{-1} total soluble salts. The pots were allowed to stand for 24 hours in the solution containers for complete saturation of soil hydrogel mixture. The pots were then raised in order to let all the unbound water drain completely.

Three different crop plant species lettuce (*Lactuca sativa*) (L.) cv. Assam), trifolium (*Trifolium alexandrium* (L.) cv. Multic.) and ryegrass (*Lolium perenne* (L.) were tested in this study.

A germination test was conducted before sowing to determine the germination percentage of the seeds. Both rate of germination and the cummulative germination was recorded by counting the germinated seeds up to 12 days. The emergence of plumule and coleoptile was taken as indicator of germination.

To determine the above ground biomass production for the three species, plants were clipped at ground level when they were five weeks old. Both fresh and oven dry weights were recorded. No irrigation was given after initial saturation of pots.

RESULTS AND DISCUSSION

Germination Studies

Lettuce

Germination levels for lettuce are shown in Table 1. Hydrogel treatment had a significant effect on germination (p,0.05), while salinity level had shown no effects on germination. Also there was no strong interaction between hydrogel and slinity treatments.

Hydrogel treatment H3 (0.3%w/w) was significantly different from control, H1 (o.1%w/w) and H2 (0.2%w/w) levels. The lowest germination was observed at H3 level, suggesting that hydrogel application above H2 (0.2%w/w) inhibits germination of lettuce.

Table 1. Percentage germination of lettuce 12 days after sowing

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	95	97	98	97	97a
0.1	83	95	95	95	92a
0.2	97	100	93	92	95.5a
0.3	97	93	83	82	89
overall mean (S.Levels)	93	96	92b	91.5b	

Within a row or a column overall means followed by the same letters are not significantly different ($p<0.05$).

Although salinity treatments had shown no significant effects on germination of lettuce. However among salinity treatments, S3 treatment gave a minimum germination as compared to the other treatments.

Hydrogel level H1 and salinity level S2 gave the best overall germination.

Trifolium

Germination levels for trifolium are shown in Table 2. Hydrogel treatments had a highly significant effect on the germination of trifolium but the salinity treatment had no significant effect on germination. No significant interaction was observed between the hydrogel and salinity treatments.

Table 2. Percentage germination of Trifolium 12 days after sowing

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	75	72	77	78	75.5
0.1	72	88	85	80	81.2
0.2	88	92	88	82	87.5a
0.3	85	93	82	78	84.5a
Overall mean (S.Levels)	80	86	83	79.5	

Within a column or a row overall mean followed by the same letter is not significantly different ($p>0.05$).

Hydrogel treatments at 0.2% w/w and 0.3% w/w levels had shown significant effects as compared to the control and 0.1% w/w level. The effects of the 0.2% w/w hydrogel were more prominent than the 0.3% w/w level suggesting that higher levels of hydrogels also have some adverse effects on germination.

Salinity had no significant effect on germination of trifolium at all concentration levels under study. However the highest germination was recorded for the H2S1 level.

Rye Grass

Germination levels for rye grass are shown in Table 3. Hydrogel treatment had a significant effect on germination of rye grass ($p<0.05$).

Table 3. Percentage germination of Ryegrass 12 days after sowing

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	96	92	93	93	93.5
0.1	81	88	97	88	88.5
0.2	77	89	83	95	86a
0.3	75	87	85	87	83.5a
Overall mean (S.Levels)	82.2	89	89.5	90.7	

Within a column or a row overall means followed by the same letter are not significantly different ($p>0.05$).

Among hydrogel treatments, hydrogel levels 0.2% w/w and 0.3% w/w had shown significant differences in comparison to the control and the 0.1% w/w level. But among H2 and H3 levels there was no significant difference, indicating that the same effects can be obtained by using 0.2% w/w hydrogel instead of 0.3% w/w. Thus we can economize the expenditure on hydrogel, but germination decreased with increase in hydrogel level. This is because of swelling of soil-hydrogel mixture seeds were buried deep in soil.

Salinity levels S2 and S3 also showed significant differences in comparison to the control and S1, but no significant difference was observed among all three levels of salinity.

Biomass production Studies

Lettuce

Biomass production levels for lettuce are shown in Table 4. Both polymer treatment and salinity levels had a significant effect at ($p< 0.05$). In addition a significant interaction ($p<0.05$) was evident between polymer treatment and salinity level ($p<0.05$). Biomass production was increased significantly by all hydrogel additions compared to the control, but no significant difference was observed between the different hydrogel treatment levels.

Increase in biomass was also observed with an increase in salinity, but effects of salinity at S3 (50 meq/l) level was significantly different from other treatments (lower production). Polymer level H2 (0.2% w/w) and salinity level S3 (50 meq/l) gave the best overall biomass production.

Table 4. Oven dry weight of lettuce per plant (mg) 5 weeks after sowing.

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	40.66	57.43	56.41	63.32	54.46
0.1	44.82	59.80	74.43	76.66	63.93a
0.2	78.11	64.24	40.22	88.52	67.77a
0.3	62.34	62.25	60.76	78.50	66.04a
Overall mean (S.Levels)	56.49b	61.01b	57.96b	76.75	

Within a row or column, overall means followed by the same letter are not significantly different ($p>0.05$).

Trifolium

Biomass production levels for trifolium are shown in Table 5. Both salinity and hydrogel and salinity had a significant effect on biomass production. In addition a significant interaction between these two factors was evident at ($p<0.05$).

Hydrogel application produced highly significant differences in comparison to the control. Significant difference between hydrogel treatments and control were observed, however among the hydrogel treatments H3 gave the lowest biomass production, suggesting that at higher levels of hydrogel growth of trifolium is affected.

Table 5. Oven dry weight of trifolium per plant (mg) 5 weeks after sowing.

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	37.41	66.06	72.29	72.69	62.19
0.1	62.81	75.31	77.90	78.10	73.53a
0.2	70.56	83.14	76.19	71.40	75.33a
0.3	63.88	68.83	69.33	72.57	68.65a
Overall mean (S.Levels)	58.74	73.34b		73.69b	

Within a row or column overall means followed by the same letter are not significantly different (p>0.05).

There was a significant difference between control and other salinity treatments (p,0.05). but this difference was not significant among various salinity treatments. Hydrogel level H2 and salinity level S2 gave best overall production.

Rye Grass

Biomass production for Rye grass is shown in Table 21. Salinity treatment had a significant effect (p<0.05) while hydrogel level had shown no significant effects on plant biomass production, although a significant interaction was evident between polymer treatment and salinity level.

Both polymer level H2 (0.2% w/w) and salinity level S3 (50 meq/l) produced the highest biomass. The lowest biomass production was observed at the control and the H3S3 treatment, suggesting that higher levels of salinity and hydrogel adversely affect plant growth.

Table 6. Oven dry weight of rye grass per plant (mg) 5 weeks after sowing

Polymer level (%w/w)	Salinity levels				Overall mean (P.levels)
	S0	S1	S2	S3	
0	29.25	30.64	37.52	31.43	32.21
0.1	31.45	29.32	36.93	33.26	32.74
0.2	35.45	32.46	40.04	31.11	34.77a
0.3	36.65	35.76	32.44	24.04	33.14a
Overall mean (S.Levels)	33.20	32.05	36.74	30.71	

Within a column or a row overall means followed by the same letter are not significantly different.

CONCLUSIONS

The results of studies on germination and establishment indicated that an improvement in germination and establishment can be brought about by gel forming, water absorbing polymers.

A considerable variation was observed in the response of different species tested to the hydrogel and salinity treatments. Germination in case of both trifolium and lettuce was improved on hydrogel addition to the soil, but it dropped when the hydrogel level in the soil exceeded the H2 level. A negative effect of hydrogel addition was observed in case of rye grass, where germination decreased with an increase in hydrogel level. In all three species hydrogel level H3 depressed the germination.

Addition of hydrogel showed a prominent effect on root development in all the three species. The plants were stronger, larger with an extensive root system and there was a clear evidence of root aggregation around the expanded hydrogel granules.

Higher levels of salinity S2 and S3) depressed germination in lettuce, but no significant effect was observed on trifolium and rye grass.

Biomass production in all three species improved significantly compared to control, but among the three species the biomass production of ryegrass was least affected by the addition of hydrogel.

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