Effect of Polymer on Soil Water Holding Capacity and Plant Water Use Efficiency

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Abstract

The amount of water retained by a sandy soil against a 0.01 MPa pressure increased by 23 and 95% by adding small amounts (0.03 and 0.07% by weight, respectively) of a polymer to the soil. However, the polymer did not significantly increase the quantity of water released from the soil by increasing the pressure from 0.01 to 1.5 MPa. The additional amount of water retained by the soil due to the presence of polymer was completely available to soybean plants grown in pots. Consequently there were substantial increases in water use efficiency of soybean plants grown in soils treated with 0.03 (12?) and 0.07% (19?) polymers.

Keywords

Polymer, sandy soil, water retention, water availability, soybeans, water use efficiency.

Introduction

The productivity of coarse textured soils is mostly limited by their low water holding capacity and excessive deep percolation losses, which reduce the efficiency of water and fertiliser use by plants. The use of gel-forming hydrophilic polymers has increased the water holding capacity of sandy soils (1, 2, 3). However, the information on the effects of rate of polymer on the availability of water for plant growth and water use efficiency is lacking in the literature.

Materials and methods

A synthetic anionic acrylic copolymer (ALCOSORB$^{?}$ 400) was mixed at three rates (0, 0.03 and 0.07 % by weight) with a Siliceous sand containing 86% sand and 6% clay in the upper 27 cm layer with negligible amount of organic matter. The soil water holding capacity of treated soils was studied using a pressure plate apparatus at 0.01 and 1.5 MPa pressures. A pot experiment with soybean (*Glycine max*; cv Stephens) was conducted in the glass-house using the above treated soils in a randomised complete block design with 3 replicates. An irrigation interval of 5 days was imposed and the pots were weighed before and after the addition of water. The weight of oven dried grain was determined for each pot at harvest. Water use efficiency was calculated from the weight of grain and the evapotranspiration from planting to harvest.

RESULTS AND DISCUSSION

The amount of water retained at 0.01 MPa pressure by the soil was significantly (P=0.001) increased by 23 and 95% with the addition of 0.03 and 0.07% polymer, respectively (Figure 1). This increase in water retention can reduce the amount of water otherwise lost by deep percolation. When the pressure was increased from 0.01 to 1.5 MPa, the polymer enabled the soil to retain more water, but the amount of water released from the soil was not significantly (P=0.05) increased.

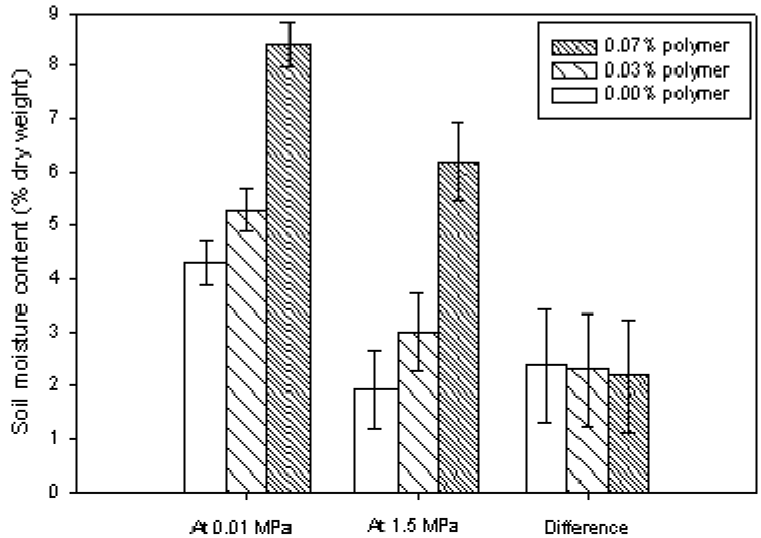

Figure 1. Soil moisture content at 0.01 and 1.5 MPa pressures and their difference for soils treated with 0, 0.03 and 0.07% polymer. Error bars are shown for l.s.d (P=0.05).

The results from the pot experiment showed that, up to 35 days after planting (DAP), more water was lost from the control than from the polymer treated soils (Figure 2). During early stages of the experiment, when much of the water was lost by evaporation from the soil due to lack of ground cover, the polymers in the soil reduced the amount of water lost from the pots. This trend was reversed after 40 DAP when the excess water retained by the polymer was utilised by plants. Due to insufficient available water in the control soil, plants suffered from moisture stress after 45 DAP. On the other hand, the plants in soils treated with polymer at the rate of 0.07% showed better growth than plants with 0.0 or 0.03% polymer in soil. The additional water stored in soils treated with 0.07% polymer enabled the plants at full canopy to survive without suffering any moisture stress for 5 days until the next irrigation. This indicated that the difference between the moisture contents at 0.01 and 1.5 MPa (Figure 1) is not representative of the available water to the soybean crop grown in the polymer treated soils.

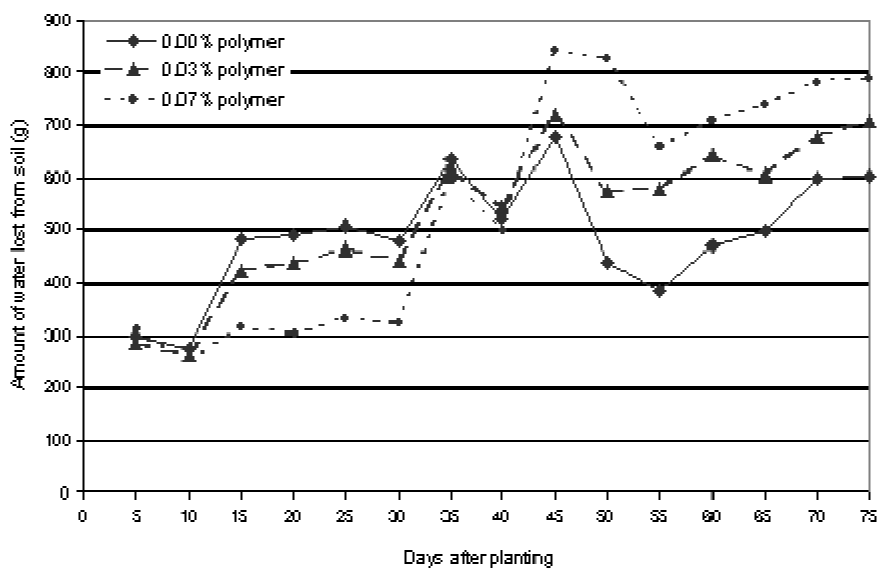

Figure 2. Amount of water lost from soil after each irrigation.

In terms of the cumulative amount of water lost during 75 days, more water was lost from the soils treated with polymer than from the control (Table 1). However, more grain was produced by plants grown in soils treated with polymer than by plants grown in untreated soil. This resulted in a significant (P=0.001) increase in water use efficiency for plants grown in soils treated with polymer. Soil treated with 0.03 and 0.07% polymer increased the water use efficiency of soybeans by about 12 and 19 times, respectively.

Table 1. Amount of water used, weight of grain harvested and calculated water use efficiency of soybean plants grown in soils treated with polymer.

Polymer in soil (%)	Amount of water used (g/pot)	Weight of grain harvested (g/pot)	Water use efficiency (grain/water)
0.00	7350a	0.14a	1.94×10^{-5}a
0.03	7987b	1.91b	23.85×10^{-5}b
0.07	8269b	3.04c	36.78×10^{-5}c
l.s.d. (P=0.05)	311	1.01	0.13×10^{-5}

Values in column followed by the same letter are not significantly different at P=0.05

Conclusion

The results from this pot study indicated that the addition of a cross-linked polymer (ALCOSORB[?] 400) in small quantities to a sandy soil can increase the retention of water against evaporation losses. The water retained by the polymer was used by the plants and this addition enhanced plant growth and improved water use efficiency. More water in the soil could save time, money and energy spent on frequently irrigating garden plants, pot plants, glasshouse plants and general horticulture.

Acknowledgements

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References

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