Reducing the impact of muddy water on rice crop establishment

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Abstract

High water turbidity levels affect the successful establishment of rice seedlings. A range of anionic polyacrylamides (PAM) were tested for their effect on turbidity, infiltration, germination and crop growth. Different PAM products had varying ability to reduce water turbidity. PAM at the rate of 5 kg/ha combined with gypsum at the rate of 25 kg/ha reduced turbidity below threshold levels. PAM used alone or with gypsum did not have any significant effect on infiltration through the treated soils. On the other hand, these treatments had a positive effect on the germination of soybean seeds. Plant growth rate was also improved by these treatments.

Media summary

Small amounts of polyacrylamides (PAM) in irrigation water and gypsum applied to the soil can overcome muddy water problems which seriously affect rice crop establishment in many rice growing areas.

Key Words

Polyacrylamides (PAM), turbidity, sodicity, gypsum, rice establishment.

Introduction

Turbid water in rice fields is widespread in many irrigation districts in southern NSW. It is associated with an average rice yield decrease of 1.1 t/ha, primarily through adverse effects on rice establishment and early growth. This represents a farm gate loss of several million dollars each year to rice growers. Seed burial due to dispersion also has an effect on establishment in sodic soils. Broadcast gypsum before flooding generally results in clearer water. Unfortunately, gypsum application also increases recharge of the groundwater which subsequently leads to rising watertables, salinity and waterlogging problems.

Polyacrylamides (PAM) are used in agriculture in many countries, mainly for the improvement of soil physical properties. Use of PAM as soil conditioners increased after the introduction of Krilium? in 1951 (De Boodt 1972). New generation PAM have high molecular weights, low application rates, and important environment, soil conservation and irrigation efficiency benefits for general agriculture, making the use of these products economically feasible (Sojka and Lentz 1994). In previous studies, Cay et al. (2001) showed that an application of PAM at the rate of 5 kg/ha combined with gypsum at the rate of 0.6 t/ha, was effective in reducing the dispersion of a sodic soil and reducing the turbidity of water by more than 99.7%. Deery et al. (2002) demonstrated that a low molecular weight, high density PAM, at the rate of 5 kg/ha, applied with gypsum at the rate of 25 kg/ha, could be a possible treatment for reducing rice water turbidity without increasing water infiltration rates in the rice field. This study was undertaken to assess the effect of different PAM formulations on water turbidity, soil column infiltration and establishment of a crop.

Methods

The soil and the PAM

The soil was collected from 0-0.1 m layer of a sodic Vertosol (exchangeable sodium percentage, ESP>12) near Wakool in NSW. The site had been under wheat in year 2002. Prior to this, it was under rice in the 2001-2002 season. The soil exhibited severe turbidity problems which had resulted in poor establishment of rice. Details of the soil preparation procedures were described by Cay et al. (2001). The PAM used in this study were anionic polyacrylamides (supplied by Nalco Australia Pty Ltd) in powder, liquid emulsion and liquid dispersion formulations (Table 1). Both low molecular weight (5-8 Mg/mole) and high molecular weight (15-20 Mg/mole) PAM were used in this study. Based on % active ingredients in each formulations, PAM solutions in de-ionised water were prepared to represent a PAM application rate of 5 kg/ha.

Table 1. Properties of PAM used in the study.

Product name	Form	Relative molecular weight	% anionic charge	% active ingredient
02KOR059	Powder	Low	5	~95
X0211006	Powder	Low	35	~95
X0211003	Powder	High	5	~95
X0211005	Powder	High	35	~95
X0210072	Liquid emulsion	Low	5	~42
X0211004	Liquid emulsion	Low	35	~42
X0211002	Liquid emulsion	High	5	~42
99AUS133	Liquid emulsion	High	35	~42
00LT053	Liquid dispersion	High	30	~20

Turbidity tests

A sample of 100 g soil was used in a 400 mL glass jar for this experiment. Gypsum was applied at the rate of 25, 50 and 100 kg/ha. However, gypsum at the rate of 25 kg/ha was used when it was combined with each PAM (Table 1). Rates of application were calculated based on the soil surface area in the jar. Gypsum was applied by sprinkling onto the soil surface. PAM was mixed with deionised water and the solution was applied to the soil surface at a rate of 0.15 ML/ha. After 16 hours, 0.85 ML/ha of deionised water was added to the jar. After 24 hours, the suspension was gently stirred for 2 minutes using an electric motor. After standing for 30 seconds, the turbidity of the suspension above the soil surface was determined using a *Hach*? turbidimeter. Results are reported in nephelometric turbidity units (NTU).

Infiltration tests

A set of 60 cm-long Perspex transparent tubes (internal diameter 12.5 cm) were packed with soil to a depth of 50 cm to achieve a bulk density of 1.31 Mg/m^3 of the packed soil column. The bottom of the tube was covered with cloth and placed over a plastic saucer in order to avoid soil moving downward. Only 3 PAM treatments were selected for this test based on the results from the previous turbidity tests. Gypsum at the rate of 25 kg/ha was used either alone or combined with PAM. The treatments were applied on to the soil surface and 8 cm water column was maintained over the soil surface with the help of a Mariotte bottle. Depth of wetting front advancement seen through the transparent tube was measured against time.

Germination and dry matter tests

12 cm diameter pots were filled with untreated air dried soil (<2 mm) to a bulk density of 1.31 Mg/m^3. Four soybean seeds (*Glycine max*, variety Stephens) were planted in each pot and the same treatments as for the infiltration tests were applied on to the surface of the soil. Germination was noted up until 12 days after planting and thereafter no more germination took place. Plants were thinned in order to have 2 plants in each pot. Pots were irrigated by pouring water on to a saucer placed at the bottom of the pot. Dry matter weight of aerial parts was determined 40 days after planting.

Results

High turbidity level of untreated soil was progressively reduced by increasing amounts of gypsum and gypsum at the rate of 100 kg/ha reduced the turbidity below the threshold level, 170 NTU (Humphreys and Bars 1998) required for successful rice seedling establishment (Figure 1). Reduction in average turbidity by PAM is similar to that achieved by gypsum at the rate of 25 kg/ha. However, PAM combined with gypsum reduced turbidity levels that is comparable to that achieved by gypsum at 100 kg/ha.

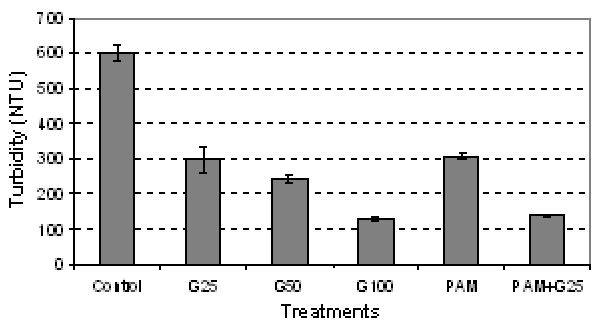

Figure 1. The effect of gypsum and PAM treatments on water turbidity (G, gypsum; PAM, polyacrylamides; numbers represent rate of application in kg/ha). Error bars are standard error of mean.

Different PAM products reduced the turbidity to varying extents as shown in Figure 2. Even though, all the 9 PAM products tested in this study significantly reduced water turbidity levels, they failed to reduce the turbidity below the threshold level. However, when these products were applied with gypsum at the rate of 25 kg/ha, six of them reduced the turbidity below 170 NTU. It should be noted that the 2 most efficient formulations, namely X0211006 and X0211005, were the powder forms with high anionic charge (35%). Products X0211006, X0211005 and 99AUS133 were identified as the most effective PAM to reduce turbidity levels when they were used with gypsum and therefore used in subsequent infiltration and germination tests.

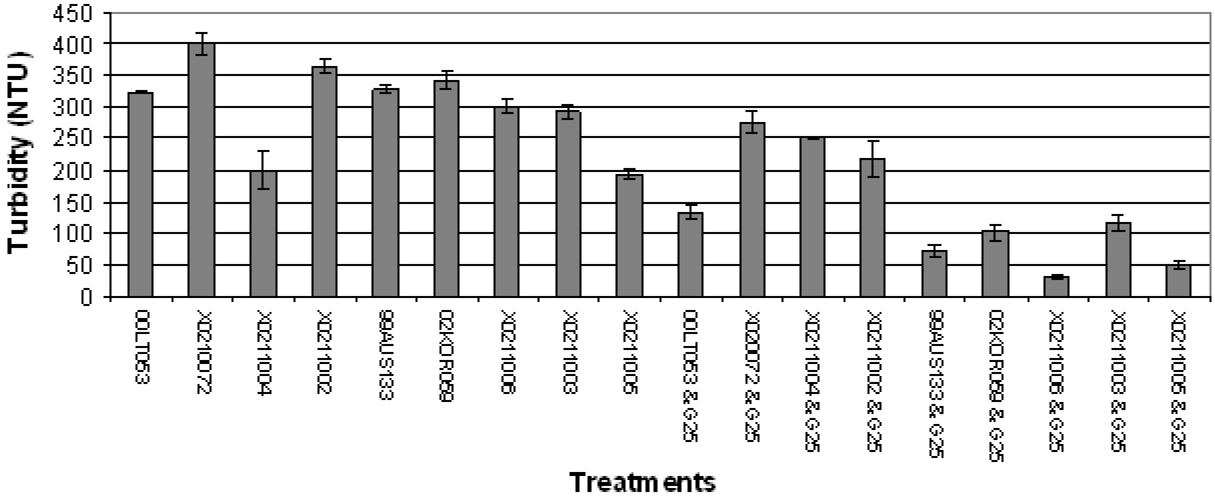

Figure 2. The effect of different PAM products used alone or combined with gypsum on water turbidity. Error bars are standard error of mean.

Results of the infiltration tests showed that the advancement of water through a column of soil was similar for the control and the soil treated with 25 kg/ha of gypsum (Figure 3). Most of the treatments where the soils were treated with PAM or PAM combined with gypsum showed initially a higher rate of water advancement through the soil. However, the rate of water advancement through the soil became almost equal after 200-300 hours of infiltration for the control and all treatments and therefore the initial difference in infiltration remained the same throughout the experiment. A statistical analysis of the data revealed no significance difference between the treatments for their final depth of infiltration. The implication of these results is that when PAM at 5 kg/ha, gypsum at 25 kg/ha or both together used to control turbidity of water would not significantly influence the rate of infiltration of water and hence the amount of water percolating towards groundwater.

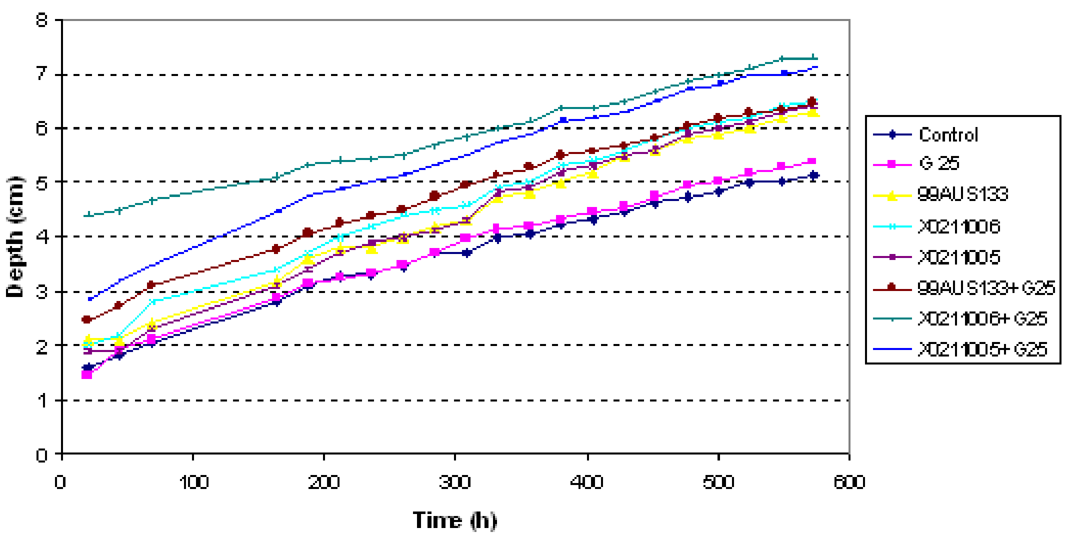

Figure 3. The effect of different treatments on advancement of wetting front through the soil column.

99AUS133 was the only PAM when used alone to treat the soil that improved the germination of soybean seeds (Figure 4). However, all PAM combined with gypsum treatments had positive effects on the germination compared with that in the control soil. In terms of dry matter production, it was observed that all PAM treatments increased the dry matter production indicating improved growth rate of soybean plants in PAM treated soils (Figure 5). Similar results were obtained when these PAM were combined with gypsum except for X0211006.

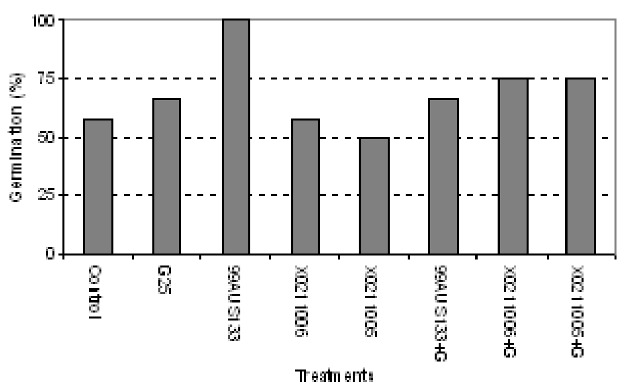

Figure 4. The effect of different treatments on germination of soybean seeds.

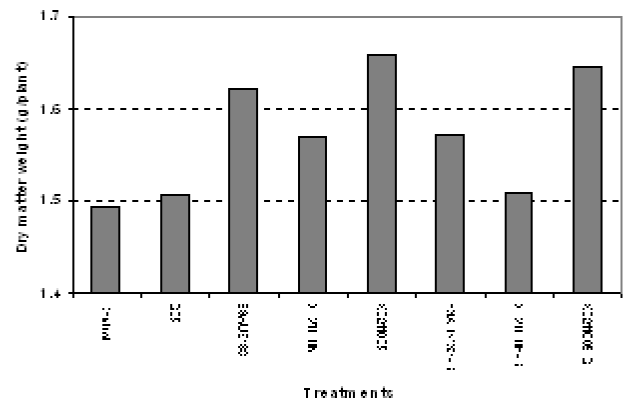

Figure 5. The effect of different treatments on dry matter production of soybean plants.

Conclusion

The potential use of PAM applied with irrigation water to control rice water turbidity problems has been demonstrated from these studies. Three PAM products have been identified as effective in achieving the above. It has been demonstrated that PAM at the rate of 5 kg/ha combined with gypsum at the rate of 25 kg/ha was an effective method to control water turbidity. While these treatments do not affect infiltration or percolation of water through the soil, they seem to improve seed germination and crop growth. These results need to be confirmed under field conditions.

Acknowledgements

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