EFFECT OF POLYACRYLAMIDES ON REDUCING THE DISPERSIVE PROPERTIES OF SODIC SOILS WHEN FLOOD IRRIGATED

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ABSTRACT

High turbidity in water in sodic soils has been found to contribute to poor seedling establishment for rice crops within the Western Murray Valley (WMV) of New South Wales, Australia. Polyacrylamides (PAM) were tested for their effectiveness in reducing the turbidity as an alternative to, and in conjunction with gypsum. Six high molecular weight PAM products representing anionic, cationic and non-ionic charges were tested in the laboratory both individually and in combination with analytical grade gypsum to determine their ability to reduce dispersion of a highly sodic soil (ESP>15) collected from the Wakool area in the WMV. The rates of application of PAM were 5 and 10 kg.ha^{-1} while the rates of gypsum represented 0.6, 1.25, 2.5 and 5 t.ha^{-1} of natural gypsum. 100 g of soil was placed in a 400 ml jar and flooded with solution using two different application methods. Dispersion was determined using a turbidimeter and measured in nephelometric turbidity units (NTU). Turbidity reduction was most effective in anionic PAM followed by cationic and non-ionic. A split application of 10 kg.ha^{-1} for the high density anionic charge PAM was the most successful straight treatment, reducing turbidity by 82.6% relative to its control. All PAM/gypsum combinations reduced turbidity by more than 99.7% relative to the control.

INTRODUCTION

It has been found that the average rice yields in the WMV of NSW were lower than that of the Eastern Murray Valley (Humphreys and Barrs, 1998). Humphreys and Barrs (1998) looked into the possible reasons for this phenomenon and recognised that turbidity caused by the dispersion of sodic soils was a possible contributor. In their study, Humphreys and Barrs (1998) investigated the effect of turbid water on rice seedling establishment and the possible ground water recharge ramifications from the use of gypsum.

Turbid water at the time of seed germination can have a number of different effects on rice seedling establishment. Reduced light penetration (thus reduced temperature at the soil surface), lack of soil stability for anchorage and seed burial are all believed to be contributors to low crop establishment.

It was estimated that sodicity accounts for a greater loss of production than acidity or salinity (Watson et al, 2000) in sections of Australia’s rice growing area, particularly in the WMV. This was the driving factor for investigating PAM as they have shown to increase the infiltration rates of highly sodic soils far less than gypsum (Zahow and Amrhein, 1992).

MATERIALS AND METHODS

Soil samples were collected from a rice paddock 30 km North West of Wakool in the WMV of NSW, an area known to have dispersive sodic soils (ESP>15). The soil belongs to the Great Soil Group Grey and Brown Soils with heavy texture (up to 80% clay). The paddock from which the samples were taken was in the pasture phase of a rice/pasture rotation and had no prior history of gypsum application. Samples were collected from 5-10 cm depth so as to avoid roots and organic matter from the dense population of barley grass (*Hordeum leporinum*) found at the time of sampling. Clods were primarily broken into smaller aggregates by crushing then mechanically rolled through a 2 mm sieve. The soil was thoroughly mixed and then placed in trays and dried at 50°C for approximately 3 days. 100 g of soil was then placed in a 400 ml glass jar with a plastic straw positioned vertically from the bottom to the top to let air out of the jar as the soil was being saturated. This minimised soil disturbance from escaping air bubbles and made the soil almost saturated without any air trapped.

Six high molecular weight (15-20 million) PAM (Table 1) supplied by SNF (Australia) Pty Ltd and analytical grade gypsum were used in this study. Three rates (0, 5 and 10 $kg.ha^{-1}$) of PAM, 4 rates (0, 1.25, 2.5 and 5 $t.ha^{-1}$) of gypsum, and combinations of 5 $kg.ha^{-1}$ of PAM with 0.6 or 1.25 $t.ha^{-1}$ of gypsum constituted for treatments which were trialed under two different application methods on the prepared soil samples. The analytical grade gypsum was used to represent gypsum treatments based on an average content of 85% of $CaSO_4.2H_2O$ in natural gypsum. Rates for both PAM and gypsum treatments were calculated on area basis based on the soil surface area in the jar. Turbidity was measured in NTU using a *Hach*© turbidimeter.

Table 1. Nature and density of charge on PAM used in this study

Name of PAM* used	Nature of charge on PAM	Density of charge on PAM
AN-L	Anionic	Low
AN-M	Anionic	Medium
AN-H	Anionic	High
CA-L	Cationic	Low
CA-M	Cationic	Medium
NON	Non-ionic	Zero

* codes are not trade names and used for identification purposes only

As the first method of application (split application), 50 ml of solution (containing PAM at the required rate in deionised water) was added to the soil sample and then left to stand for 16 hours. A further 280 ml of deionised water was then added to the soil sample. This produced a solution of 8.5 cm deep over the soil surface. After a period of 24 hours, turbidity of the solution was determined. As the second method of application (single application), 330 ml of solution (containing PAM at the required rate in deionised water) was added to the soil sample in the jar at a steady rate over 3 minutes and left to stand for 24 hours before turbidity readings were taken.

Gypsum was applied by sprinkling the required amount onto the soil surface within the jar to simulate conventional field application. PAM crystals were agitated in deionised water using a magnetised stirrer until fully dissolved in solution. These PAM solutions were then added to the soil by the methods as described above. After standing for 24hours, the dispersed clay formed at the soil surface of each jar was then gently stirred by an electric motor for 4 minutes. This incorporated the dispersed clay in an uniform manner throughout the suspension but without disturbing the soil surface. The jars were allowed to stand for 30 seconds after the completion of the stirring and 25 ml of aliquot was taken from the uniform suspension for turbidity measurement.

RESULTS AND DISCUSSION

A comparison of split application method with the single application method for all treatments by a two-factor analysis of variance of combined data set indicated significant differences between the two methods of application ($P=0.015$) and between the treatments ($P<0.001$). Since the effect of gypsum alone and PAM/gypsum combinations on turbidity was much greater than that of PAM alone, further analysis of data was carried out separately on two data sets representing treatments of PAM alone or gypsum and PAM/gypsum combinations.

Turbidity readings for different PAM treatments under the split and single application methods are shown in Figure 1. Two-factor analysis of variance of this data set indicated significant differences between the two application methods ($P=0.011$) and between the treatments of PAM ($P=0.038$). Mean turbidity readings for the split and single application methods were about 255 and 355 NTU, respectively. Therefore, a split application strategy similar to the one used in this study would result in more effective control of turbidity than a single application of PAM. Further analysis of data was concentrated on data from the split application method only.

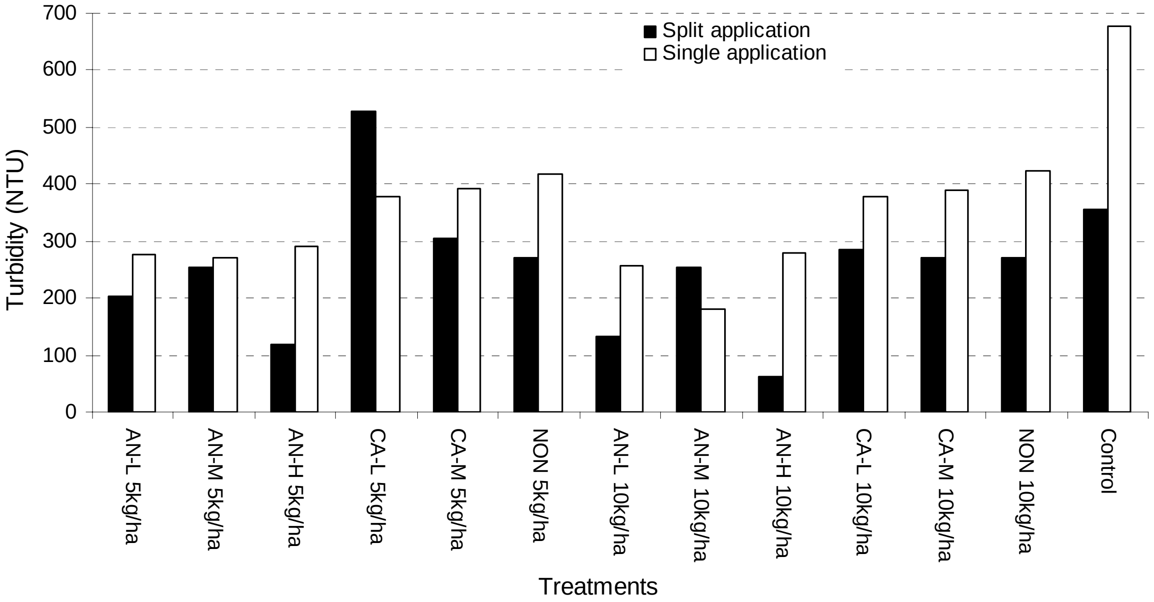

Figure 1. Turbidity of suspensions subjected to different PAM treatments by split and single application methods

A comparison of PAM with different charges indicated a significant difference (P=0.040) between them. PAM with anionic charge was more effective than that with cationic or non-ionic charges. High density anionic charge PAM (AN-H) at the rate of 10 kg.ha^{-1} reduced the turbidity of water by 82.6% compared with the control. However, a comparison of the two different rates of PAM indicated that the rate of 5 kg.ha^{-1} PAM was not significantly different than the rate of 10 kg.ha^{-1} to reduce turbidity.

Turbidity readings for different rates of gypsum and PAM/gypsum combination treatments under the split and single application methods are shown in Figure 2. The turbidity values for these treatments were much lower compared with that of PAM alone (Figure 1). Two-factor analysis of variance of this data set indicated a significant difference (P=0.046) between the treatments. However, the difference between the two application methods was not significant.

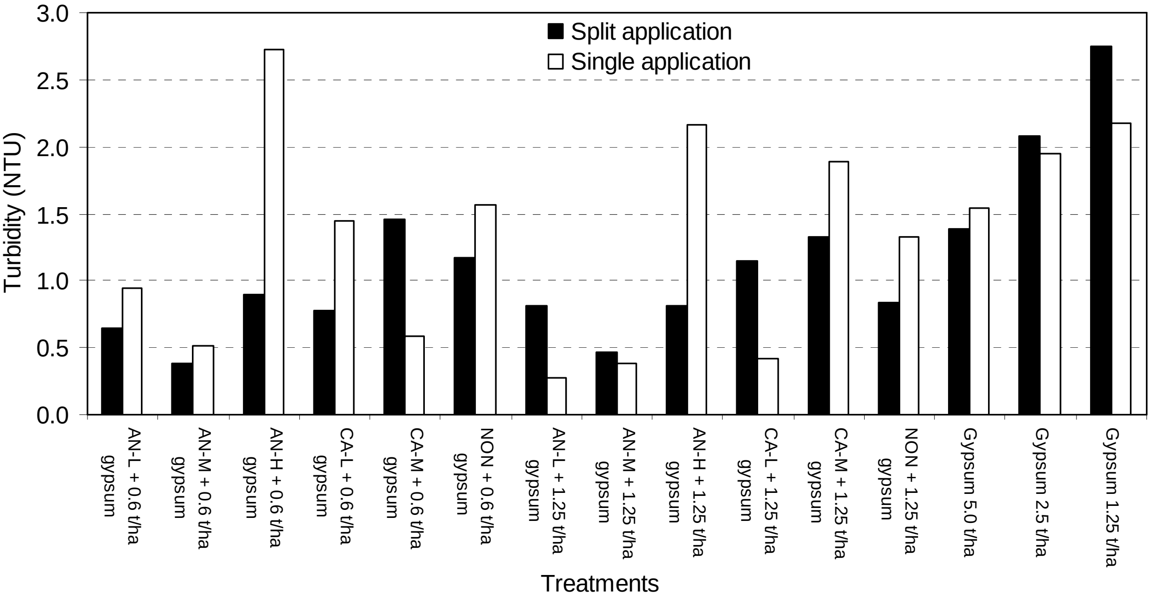

Figure 2. Turbidity of suspensions subjected to different PAM/gypsum treatments by split and single application methods

Higher application rates of gypsum will increase infiltration rates of water and in turn contribute to greater groundwater accessions (Humphreys and Barrs, 1998). Therefore it is preferable to reduce the amount of gypsum used on rice soils. The results of this study indicated that a rate of 0.6 t.ha^{-1} of gypsum coupled with 5 kg.ha^{-1} of low or medium density anionic PAM could achieve turbidity levels lower than that of resulting by higher application rates of gypsum. All PAM/gypsum combinations reduced the turbidity by 99.7% compared with the control. Further analysis of data for the split application method indicated a significant difference (P=0.027) between the PAM used. Anionic PAM were more effective that cationic or non-ionic PAM to control turbidity. Low and medium charge anionic PAM were more effective than high density anionic PAM when combined with gypsum in controlling turbidity. However, analysis of data indicated that the difference in turbidity for 0.6 and 1.25 t.ha^{-1} of gypsum combined with PAM was not significant.

The relationship between calcium and PAM has been found to be very important in flocculation of colloidal substances. The calcium has a bridging effect between PAM molecules and has been proven to be vital to the success of the PAM as a flocculating agent, particularly in floodwater of low Electrical Conductivity (Aly and Latey, 1988). Calcium will electrostatically bind the negatively charged co-monomers within the PAM (Wallace and Wallace, 1996) and may account for the relatively high flocculation in PAM and deionised water treatments.

Humphreys and Barrs (1998) found that on grey clays, a reading of 170 NTU corresponds to a 4-cm depth of visibility. They also concluded that turbid water with a visibility depth of 0-3 cm was considered as high risk for rice establishment while that of >5cm was considered as low risk if water levels were managed properly. Three PAM alone (AN-L, AN-M and AN-H) treatments produced NTU readings of less than 170 (Figure 1) while all PAM/gypsum combinations produced NTU readings of less than 2.75 (figure 2). Even though significant differences were found between the PAM, there was no value of one over the other when they were used with gypsum in reducing the turbidity to a safe level for rice establishment.

Lack of success of PAM remediation was observed in transferring the technique from the laboratory to the field (Humphreys and Barrs, 1998). It could be hypothesised that a combination of PAM and gypsum treatments could be more effective than straight PAM treatments in a field situation.

CONCLUSIONS

The high turbidity of water (>350 NTU) in control treatments showed the highly dispersive nature of the soil. Most of the PAM treatments did not reach the required minimum turbidity levels in water for rice seedling establishment. However, low density anionic charge PAM (AN-L) at the rate of 10 kg.ha^{-1} and high density anionic charge PAM (AN-H) at the rate of 5 and 10 kg.ha^{-1} were found to reduce turbidity of water less than the critical level under split application strategy. Overall turbidity readings under the split application strategy were lower that that under the single application strategy. This was true even with the control treatment. Under split application method, after the first phase of the application, soil particles would settle down with the infiltrating water or in the case of PAM, most of the PAM would be in the soil among the soil particles causing flocculation. During the second phase of application, there would be little chance for the clay particles to move back into the standing water. However, there was little opportunity for this to happen under the single application method.

All of the PAM and gypsum combinations reduced the turbidity of water by more than 99.7%. Therefore PAM combined with gypsum were highly successful methods of reducing the turbidity of water lower than critical levels required for safe rice seedling establishment. In these treatments, gypsum was applied first to the soil before adding PAM solutions and the two application strategies failed to show any significant effect on the turbidity of water. It would be interesting to test the application of gypsum and PAM together in a solution to reduce turbidity of water.

Different rates (5 and 10 kg.ha^{-1}) of application of PAM alone and different rates (0.6 and 1.25 t.ha^{-1}) of gypsum combined with PAM failed to show a significant effect on controlling the turbidity of water. It seems possible that the concentrations of PAM used in this study would be adequate to reduce the turbidity of water to levels required for better rice seedling establishment. Further research is required to find out the optimal proportion of PAM and gypsum in reducing turbidity of water especially under field conditions. A range of alternative PAM should also be evaluated for their performance. PAM combined with gypsum seems to have potential implications for the amelioration of sodic soils and recharge management under the rice cultivation.

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REFERENCES

Aly, S. M., and Letey, J. (1988) Polymer and water quality effects on flocculation of montmorillonite. Soil Science Soc. Am. J., **52**, 1453-1458.

Humphreys, E. and Barrs, H. D. (1998) Constraints to rice establishment and yield in the Western Murray Valley. Rural Industries Research and Development Corporation. RIRDC Report No 99/32, Final Report.

Wallace, A. and Wallace, G. A. (1996) Need for solution or exchangeable calcium and/or critical EC level for flocculation of clay by polyacrylamides. In Managing irrigation-induced erosion and infiltration with polyacrylamides. (Sojka, R. E. and Lentz, R. D eds.) University of Idaho Misc. Publ. No. 101-96, p 59-63.

Watson, W. D., Hall, N. H. and Hamblin, A. (2000) Economic aspects of sodic, acid and saline soils in Australia. Proc. Sodicity Conference 28 Feb-1 Mar 2000, Institute of Sustainable Irrigated Agriculture (ISIA) Tatura, Victoria, Australia.

Zahow, M. F. and Amrhein, C. (1992) Reclamation of a saline sodic soil using synthetic polymers and gypsum. Soil Science Soc. Am. J., **56**, 1257-1260.