Use of PAM in Australian irrigated agriculture

By Siva Sivapalan, Charles Sturt University, Wagga Wagga, NSW

PAM IN AUSTRALIA

- An estimated 456 million hectares is used for agricultural activity in Australia;
- Of this amount, around 2.4 million hectares is irrigated;
- Poor irrigation practices can lead to serious and costly environmental problems such as acidity, sodicity and salinity;
- Polyacrylamides (PAM) have been used successfully to control soil erosion in large scale irrigated farms in the US;
- In Australian cotton fields, PAM has been identified as a potentially useful tool in preventing soil erosion and reducing off-farm movement of chemicals during irrigation; and,
- Improved irrigation efficiency of flood irrigated cropping under PAM treatment in northern Australia has also been reported.

In many countries using polyacrylamides PAM as a soil conditioner has increased in recent years, particularly since the introduction of new generation, more cost effective products. Using these products on-farm has become more economically feasible because of their low application rates. They also have important environment, soil conservation and irrigation efficiency benefits.

This article summarises the important findings from a series of experiments conducted over a five year period.

Hardsetting soils and seed germination

Hardsetting, structurally unstable soils are common in Australia. These soils are very difficult to farm because after becoming wet, they set hard and often have surface crusting. This leads to poor soil water infiltration. To overcome these problems growers often irrigate and cultivate more frequently leading to further deterioration in soil structure.

PAM was used to treat a hardsetting soil from the Trangie district of central west NSW. It was applied at four application rates: 0, 0.001, 0.005 and 0.01 per cent by soil weight to cotton seeds in pots. At the end of the experiment, the strength of the surface soil was measured to gauge the effect of the PAM on surface crusting.

There was no germination of cotton in the soil not treated with PAM. The surface soil in these pots had the highest penetration resistance of all treatments.

Soil penetration resistance decreased with higher PAM application rate. This was accompanied by increasing cotton seed germination rates.

The maximum germination in the trial was 84 per cent. This came from a PAM application rate of 0.005 per cent.

Once degraded, hardsetting soils are hard to repair because it is difficult to re-establish vegetation on them. But the results from this experiment showed that PAM could be used to promote re-establishment of a green manure crop or pasture on the degraded hardsetting soils as the first step in an amelioration process. In addition, the results show that only a shallow layer of surface soil needs to be treated with PAM to improve seed germination.

This improvement can be achieved at fairly low rates of PAM (seven kg per hectare at a rate of 0.005 per cent to a depth of one cm).

Improving water retention

Productivity of coarse textured (sandy) soils is mostly limited by the fact that they can only hold a small amount of water. They also generally have excessive deep drainage losses. These problems lead to poor efficiency of water and fertiliser use by crops growing on these soils.

'Cross-linked' PAM can absorb water and swell up to hundreds of times its dry weight. So a cross-linked PAM was applied to sandy soils with a topsoil containing 86 per cent sand and negligible amounts of organic matter to see if the soil's water holding capacity could be improved.

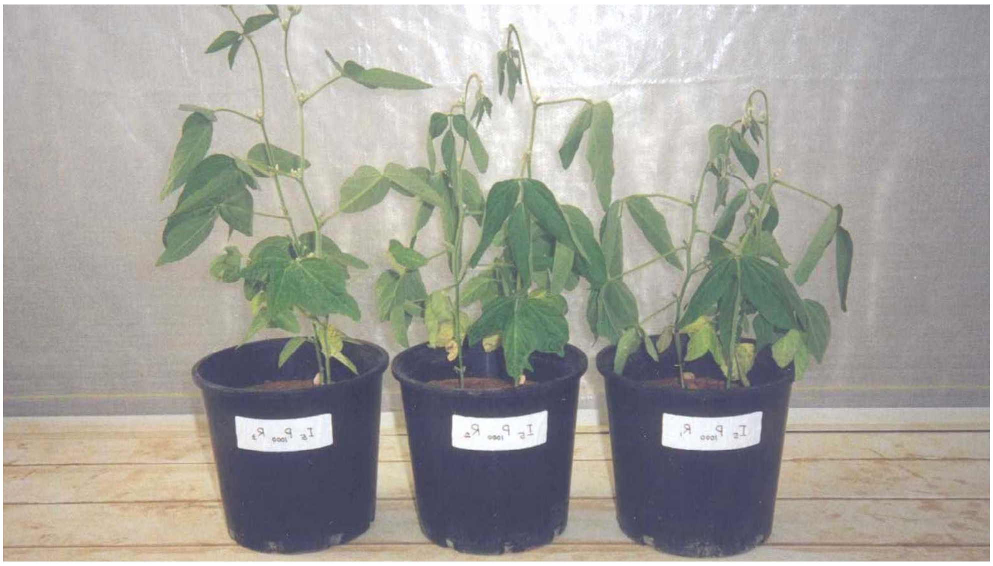
Three rates of PAM were used (0, 0.03 and 0.07 per cent by weight) and the soil water holding capacity of treated soils was measured for each treatment.

Water retained by the sandy soil increased by 23 and 95 per cent by adding just 0.03 and 0.07 per cent respectively of PAM.

The large quantity of water retained by the PAM would allow better plant growth and reduce deep drainage losses.

Soybean trial

The same sandy soils, which had been treated with PAM were used to grow soybeans in pots.



Soybeans in soil treated with 0.07 per cent PAM and irrigated once in five days. There is no sign of moisture stress.

Plant water use efficiency was calculated by weighing the harvested soybean grain and dividing this by evapotranspiration from planting to harvest. There was a 12 and 18 fold increase in water use efficiency of soybean plants grown in sandy soils treated with 0.03 and 0.07 per cent PAM respectively (Table 1).

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

PAM 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

In another experiment, grain production of soybean plants watered every three days was progressively increased by about six, nine and 14 times by incorporation of 0.05, 0.1 and 0.2 per cent PAM respectively.

In addition, the same amount of grain produced by soybean plants grown in a soil with no added PAM under a three day irrigation interval was achieved by soybeans grown in soil with 0.05 per cent PAM and irrigated every four days.

Likewise, the same amount of grain was produced from soybeans grown in soil treated with 0.1 per cent PAM but irrigated every five days.

This not only shows that crops grown in coarse-textured soils treated with PAM can produce more grain, but may do so with less frequent irrigation. This could provide savings of water, time, money and energy.

REDUCING WATER TURBIDITY

Rice yields in the western Murray Valley of New South Wales are generally lower than those in the eastern parts of the valley. A major reason for the lower yields is high turbidity (cloudy) water. This is caused by ‘dispersion’ of clay particles from sodic soils, which are common in the region.

Turbid water can have detrimental effects on rice seedling establishment. In particular, less light reaches the soil surface reducing the temperature and causes germination problems. The unstable sodic soils also provide poor conditions for seed burial and seedling anchorage.

Trials were conducted with PAM by itself and in combination with gypsum to see if water turbidity could be reduced.

Soil was collected from the Wakool area of the western Murray Valley and treated with two rates of PAM (five and 10 kg per hectare) and four rates of gypsum (0.6, 1.25, 2.5 and five tonnes per hectare) using a split and a single application method.

At the rate of 10 kg per hectare, PAM reduced the turbidity of water by about 83 per cent compared with the control. The split application strategy was significantly more effective than the single application.

The same reduction in turbidity was achieved when PAM was applied at five kg per hectare.

All PAM/gypsum combinations reduced turbidity by more than 99 per cent compared to the control. In addition, PAM combined with gypsum was more effective at controlling turbidity than PAM used alone.

The results also showed that gypsum at 0.6 tonnes per hectare coupled with five kg per hectare of PAM could achieve lower turbidity levels compared with higher application rates of gypsum.

This is a good result because high rates of gypsum on rice country can increase soil water infiltration rates, which can lead to increased groundwater accession.

At these rates of PAM and gypsum there was no effect on how fast the water moved through the soil profile.

This suggests that the use of PAM with rates of gypsum at or less than 0.6 tonnes per hectare will reduce the water turbidity without increasing the amount of water going past the root zone to the watertable.

PROMISING FUTURE

Many Australian soils have structural problems that limit crop production. And given the results from these trials, the future of PAM products in Australia looks very promising.

Although the quantity of new generation PAM products required to treat soils is relatively small, the price of the products is becoming cheaper. The current price varies from $5 to $30 per kg of PAM with cross-linked and imported product on the higher side of this range. So using them in commercial agricultural situations may well be economically attractive.

The contribution of Yin Chan (Wagga Wagga Agricultural Institute), Edward Cay (University of Sydney) and David Deery (University of Melbourne) through their collaborative involvement in various research projects is gratefully acknowledged. Financial support from Charles Sturt University and CRC for Sustainable Rice Production is also gratefully acknowledged. Allied Colloids (Australia) Pty Ltd and SNF (Australia) Pty Ltd provided samples of polyacrylamides.

Further information contact Siva Sivapalan on Ph: 02 6933 2839; Fax: 02 6933 2812;
Email: ssivapalan@csu.edu.au

Published as:

Sivapalan, Siva (2002) Use of PAM in Australian irrigated agriculture. *Australian Grain* 12(3):pp. 24-25.