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The effect of polyacrylamide application and pre-wetting exposure period on infiltration and erosion from disturbed lands

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1. INTRODUCTION

One of the major problems limiting the rehabilitation of disturbed land is the establishment of an initial vegetative cover on the replaced topsoil. This is primarily influenced by the stability of the surface soil aggregates as aggregate breakdown largely determines the development of surface seals, the effectiveness of rainfall and the severity of erosional processes. Polyacrylamides (PAM) have been used in irrigated agriculture to reduce sealing, increase flocculation and reduce erosion. However, limited work has been conducted to evaluate the potential of surface applied polyacrylamides to stabilise disturbed lands. Earlier research (DeJersey *et al.*, 1996) investigated the influence of two PAMs on infiltration and erosion under simulated rainfall of topsoil from Goonyella Mine in central Queensland. This paper reports on a follow-up research program using another commercial polyacrylamide, comparing the effectiveness of PAM appliucations to a traditional straw mulch treatment, and investigating the effect of pre-wetting exposure period on PAM performance.

2. MATERIALS AND METHODS

Pre-strip topsoil from the Goonyella-Riverside Mine in central Queensland which had been uniformly mixed and sieved to remove aggregates >50 mm was packed into freely draining 0.16 m^2 trays to a depth of 100 mm. A low molecular weight, highly anionic liquid polymer "Aerotil" (Cytec Industries, Sydney) was applied to the plots using a hand sprayer at rates equivalent to 15, 30 and 60 L/ha. A comparison with traditional erosion control practices was conducted by applying a dense covering of straw to the plots at a depth of 20 mm (equivalent to ~2.75 t/ha). A combined 60 L/ha Aerotil and straw treatment was also conducted to identify any combined effect of the treatments. Plots were placed on a 10% slope and rainfall applied using a simulator based on a design by Bubenzer and Meyer (1965) at an intensity of 100 mm/h for 30 minutes. Infiltration was measured during rainfall by the change in plot mass and run-off was collected to enable total sediment loss determination. The plots were subsequently placed under glasshouse conditions and the surface soil moisture content and penetrometer resistance of the plots measured 15 days after rainfall.

To investigate the effect of pre-wetting period on the effectiveness of the PAM, Aerotil was applied at 60 L/ha to the soil trays as above and left for up to 3 weeks prior to the application of the rainfall. The persistence of the PAM treatment was also investigated by applying multiply rainfall events to the same plots over a period of 6 weeks.

3. RESULTS AND DISCUSSION

The application of the Aerotil significantly (P<0.05) increased total infiltration on the bare soil from 4.5 mm to 13.5 mm at the 60 L/ha application rate (Table 1). However, covering the soil with straw increased infiltration to 32.1 mm ande applying both straw and Aerotil resulted in a further small increase. While the total infiltration was significantly increased at low rates

Table 1. Effect of polyacrylamide and straw treatments on selected soil physical properties of Goonyella topsoil

Within columns, means followed by the same letter are not significantly difference at P =0.05

Treatment	Total Infiltration (mm)	Sediment Loss (t/ha)	θ_g Post-rainfall (%)	Surface Hardness Day 15 (kg/cm^3)	θ_g Day 15 (%)
Control	4.5 [a]	16.2 [a]	11.4 [c]	2.9 [a]	0.7 [a]
Aerotil (15 L/ha)	9.0 [b]	15.0 [a]	10.2 [bc]	4.0 [b]	-
Aerotil (30 L/ha)	9.5 [b]	14.3 [a]	9.8 [b]	4.1 [b]	-
Aerotil (60 L/ha)	13.5 [c]	9.2 [b]	7.8 [a]	5.1 [c]	0.6 [a]
Straw (2.5 t/ha)	32.1 [d]	0.7 [c]	12.8 [d]	1.5 [d]	5.5 [b]
Straw + Aerotil (60 L/ha)	33.3 [d]	0.4 [c]	11.6 [c]	1.4 [d]	6.2 [c]

of Aerotil application, sediment loss was not significantly reduced at rates below 60 L/ha with sediment loss being reduce at this rate of application by 44% (Table 1). However, application of the straw mulch was found to reduce sediment loss by 96%. A further small but non-significant improvement in both infiltration and reduction in sediment loss was found where both the straw and high rate of Aerotil were used.

The steady state final infiltration rate of the untreated bare soil (4.5 mm/h) was reached after only 5 minutes of rainfall (Fig. 1). This rate was significantly less than the final infiltration rate of the Aerotil treatments (7.8-9.4 mm/h) which were reached after approximately 10 minutes of rainfall. The straw applied treatments failed to reach steady state within the 30 minute rainfall period. These results confirm that PAM does enhance the stability of aggregates under the impact of rainfall energy resulting in increased infiltration capacity. However, the PAM treatment was less effectove than the 2.5 t/ha mulch treatment which maintained substantially higher infiltration rates throughout the rainfall event presumably due to a reduction in waterdrop impact energy.

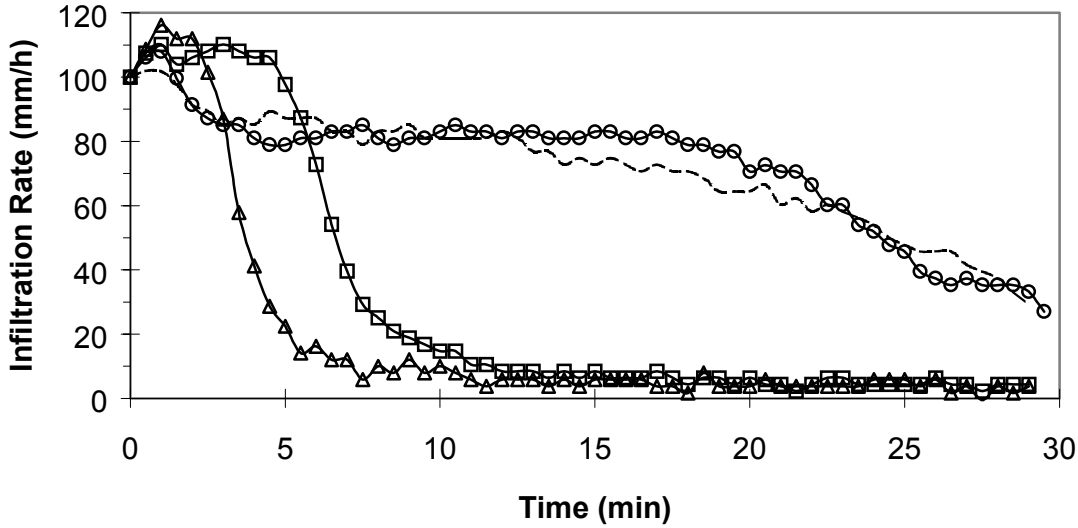

Figure 1. Typical infiltration functions for (a) bare (▲), (b) 60 L/ha Aerotil (□), (c) 2.5 t/ha straw (—), and (d) 2.5 t/ha straw + 60 L/ha Aerotil treatments (o) applied to topsoil from Goonyella and subjected to 100 mm/h simulated rainfall.

Post-rainfall surface moisture content was found to decrease with increasing rates of Aerotil application but increase with the addition of straw (Table 1). As the total infiltration was greater in the Aerotil treatments, the lower surface moisture content is presumably due to the improved surface structure in the Aerotil treatments facilitating more rapid internal drainage. The higher surface moisture content in the straw treatment is most likely associated with the increased moisture holding capacity provided by the organic matter. After 15 days drying, there was no difference in the surface moisture contents of the 60 L/ha Aerotil and control treatments (Table 1). However, the application of Aerotil was found to increase the surface hardness on drying. The straw treatments were found to have significantly higher moisture contents and lower penetrometer resistance than the other treatments after 15 days drying, presumably due to the reduction in evaporative drying.

Increasing the pre-wetting exposure period from 1 to 2 weeks after the application of the Aerotil produced no significant difference in total infiltration (Table 2). However, increasing the period to 3 weeks provided a small by significant increase in total infiltration. Total infiltration of the second rainfall event applied to the Aerotil plots were found to be significantly lower than the first rainfall infiltration (Fig 2). Where the period between the

Table 2. Effect of pre-wetting exposure period on infiltration under 100 mm/h rainfall for Goonyella topsoil

Within columns, means followed by the same letter are not significantly difference at P =0.05

Pre-wetting exposure period (weeks)	Total Infiltration (mm)
1	14.6 [a]
2	15.2 [a]
3	17.5 [b]

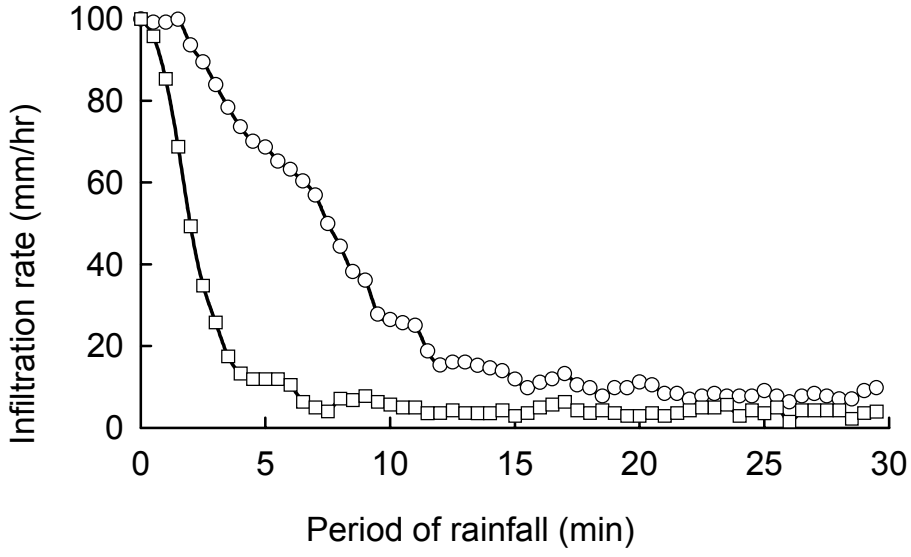

Figure 2. Infiltration rate into Goonyella topsoil treated two weeks previously with 60 L/ha of Aerotil for (a) first rainfall (o) and (b) second rainfall (□) event (100 mm/h).

rainfall events was only one week, the total infiltration decreased to 6.7 mm where as when the interval between the two rainfall events was either 3 or 4 weeks, the total infiltration was significantly higher at 10.3 mm. One explanation for this response is the likely differences in the initial soil moisture due to the variation in drying period. However, the total infiltration produced by the third and fourth rainfall simulation (with both one and three week inter-rainfall intervals, respectively) on the same plot were also higher at 9.9 and 10.0 mm, respectively. In all cases, the steady state infiltration rate was also higher than the untreated bare soil during the first rainfall event. This suggests that while the benefit of the Aerotil application is significantly reduced after the first wetting, there is a significant residual effect throughout up to four rainfall events over a six week period.

4. CONCLUSIONS

Polyacrylamides do reduce sediment loss and increase infiltration under high intensity rainfall events on disturbed lands. Increasing the application of Aerotil at rates up to 60 L/ha was found to increase infiltration and reduce sediment loss. However, the benefits of these applications were not as great as the application of a 2.5 t/ha straw mulch layer. The effectiveness of the Aerotil was improved slightly by increasing the pre-wetting exposure period but was greatly reduced after the initial rainfall irrespective of pre-wetting history.

5. REFERENCES

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