Evaluating gypsum and polyacrylamide use on irrigated pasture in northern Victoria

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Abstract
The purpose of this research was to investigate the application of varying rates of gypsum and the liquid formulation polyacrylamide (PAM) Flobond™ on a ryegrass and shaftal clover pasture to determine the effects on germination and pasture yield in northern Victoria. Eight treatments were applied post sowing and incorporated with irrigation. Three treatments of gypsum alone, Flobond™ alone and with gypsum also the untreated control. The results of this trial found that rates of 5t/ha and 10t/ha of gypsum applied alone did reduce the establishment of the Turbo cv. shaftal clover (*Trifolium resupinatum*). No other treatments reduced the establishment of either the Turbo cv. clover or the Jackpot cv. ryegrass (*Lolium Multiflorum*). Pasture yield was estimated by taking four biomass cuts during the trial which ran from March to November 2018. The treatments which had reduced clover establishment were able to compensate in yield by the first biomass cut 53 days after treatment (DAT). There was no statistical difference between treatments at either a biomass cut or cumulatively during the trial. The treatments of Flobond™ alone and with lower more economic rates of gypsum did have higher yields which show potential for further work with other formulations of PAM to reduce the costs of amending soil structure and improving water infiltration. The liquid formulation of Flobond™ was difficult to apply which may limit its potential use in this market.

Keywords
(PAM), Flobond™, gypsum, irrigation efficiency, germination, pasture yield

Introduction
Irrigation efficiency will become vital to the continued production of fodder and pasture in the northern Victorian irrigation area. Current low yielding fodder production combined with high water costs have led to high priced hay and silage. This in turn has caused many dairy farmers in this region to cease milking or to relocate to areas with less dependence on irrigated water.

One of the key factors in improving irrigation efficiency is to improve soil aggregation using gypsum to improve water infiltration and remove salts. Soil aggregation tends to decline with soils in this region partly due to the relatively high levels of magnesium and sodium in these soils (Schulte and Kelling 1993). The magnesium levels in these soils appears to be due to the natural formation of the soil and the sodium content has been exacerbated by the use of flood irrigation water containing sodium (Rengasamy et al. 2010; Six et al. 2004).

The use of flood irrigation has led to some soils becoming compacted. This compaction coupled with the fragile nature of the soil structure has led to lower pasture production. (Kelly and Lawson 2012). Gypsum is the standard treatment for improving water infiltration however the gypsum is expensive to use, owing to the cost of freight as there are no local gypsum pits closer than Kerang for the Goulburn Valley.

Flobond™ is a liquid anionic polyacrylamide made by SNF Australia based in Geelong. It has the potential to cause soil particles to aggregate and thereby create space in the soil structure through which water may flow more easily (Six et al. 2004). Flobond™ liquid is an anionic organic co-polymer encapsulated with oil. It has a high molecular weight and is soluble in water once the oil capsule is broken. It aggregates positively charged colloids when a potassium ion is released in water. Flobond™ will breakdown under UV light and microbial action to form water, CO2 and ammonium nitrate. Flobond™ is used extensively in irrigated crops in the USA where it has FDA approval and its use is subsidised in California (SNF Australia 2018).

The low rate of 3L/ha and the comparatively lower cost of using this product led to its inclusion in this trial to investigate its effect on germination and potential yield improvement through the use of Flobond™ alone and with reduced rates of gypsum.

Methods
The trial site was chosen because it was able to be managed with grazing cattle and it represented a typical Goulburn valley loam and pasture. The soil was identified as a Katamatite loam (Mikhail 1975). A randomised complete block design was used for the small plot treatments conducted in a flood irrigated ryegrass (*Lolium multiflorium*) cv. Jackpot and shaftal clover (*Trifolium resupinatum*) cv. Turbo based pasture at Katandra in the Goulburn valley.

The trial was sown dry on 23/3/18 using a Gaspardo® triple disc seeder. The sowing rate was 13kg/ha ryegrass and 17kg/ha of shaftal clover with 40kg/ha MAP fertiliser (7.2 kg/ha N, 4 kg/ha P). The row spacing was 7cm. Treatments were applied post sowing on 30/3/18 with the gypsum applied first and the Flobond™ applied separately with a modified watering can, as the Flobond™ is very viscous even after dilution (Table 1). The site was irrigated on 31/3/18 to initiate germination and incorporate the treatments.

Table 1. Treatments applied post sowing and pre-emergent incorporated by irrigation

Treatment	Product and Rate
T1	2.5t/ha gypsum
T2	5t/ha gypsum
T3	10t/ha gypsum
T4	250kg/ha gypsum + 3L/ha Flobond
T5	3L/ha Flobond
T6	500kg/ha gypsum + 3L/ha Flobond
T7	1t/ha gypsum + 3L/ha Flobond
T8	Untreated control

Each plot was 2m x 5m with a 0.5m buffer. Nine random soil samples were taken as representative of the entire trial area prior to application of the treatments and sowing. After analysis the gypsum applied was found to be Class 3 containing 15.5% calcium and 11.2% sulphur which is the lowest class of gypsum.

The site was managed by the co-operator with the objectives of grazing cattle and conserving fodder. Cattle were excluded from the site by an electric fence once grazing commenced at 52 DAT.

Weed control consisted of an application of Buttress® (2,4-DB) at 3L/ha and Strike-Out® (Chlorpryfos) at 700mL/ha for the broadleaf weeds chickweed (*Cerastium glomeratum*) and capeweed (*Arctotheca calendula*) also Red Legged Earth Mite (*Halotydeus destructor*) and Lucerne flea (*Sminthurus viridus*) on the 27/4/18. On 6/6/18 Shogun® (Propaquizafop) was applied at 300mL/ha with 150mL/ha Wetter 1000® for barley grass (*Hordeum spp.)* control.

Liquid fertiliser was applied twice using 4L/ha CS Black® (2.7% N, 7% P, 7%K, 2.7% Ca + TE) and 35L/ha liquid urea (46% N) equating to 16.1kg/ha nitrogen (N) 300g/ha phosphorus (P) and 300g/ha potassium (K). The first application was 7/6/18 and the second on the 18/7/18. These applications caused some leaf burn to the shaftal clover. A granular application of 80kg/ha of urea (37kg/ha N) was top-dressed on 28/9/18.

An establishment count was carried out on 11/4/18 using a 25cm x 10cm quadrat. There were five counts/plot for each treatment with the ryegrass and shaftal clover counted separately. Pasture yield was estimated on 23/6/18, 10/8/18, 9/10/18 and 13/11/18 by mowing the plots using a lawn mower with a 46cm cutting width and a 7cm cutting height. Three cuts were made in each plot and the wet weights were recorded and sub-samples were dried and weighed.

There were two irrigations of 0.6 to 0.8ML/ha and another four irrigations with similar volumes applied in spring. The total amount of irrigation water was approximately 4.4ML/ha of irrigation water with 150mL/ha of rain between April and November. This gives a total of approximately 5.9ML/ha during the growing period.

Results

Treatment 5, 3L/ha of Flobond™, gave the best establishment of clover with Treatments 2 and 3 with 5t/ha and 10t/ha of gypsum alone reducing the clover establishment. There was little effect on the germination of the ryegrass with any treatment although Treatment 6 appeared to reduce both ryegrass and clover (Figure 1). The only statistical difference in yield between treatments was between T5 3L/ha (Flobond® alone) and T3 (10t/ha gypsum alone) (Figure 2).

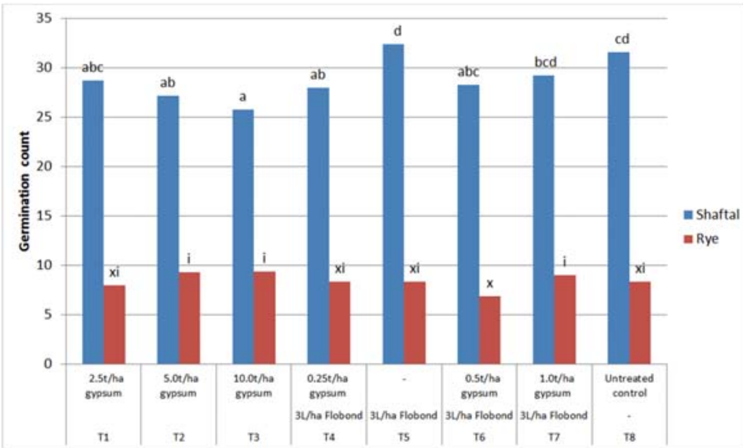

Figure 1. Seedling counts (plants/m2) for the shaftal clover and the ryegrass at eleven days after irrigation. (LSD 5%)

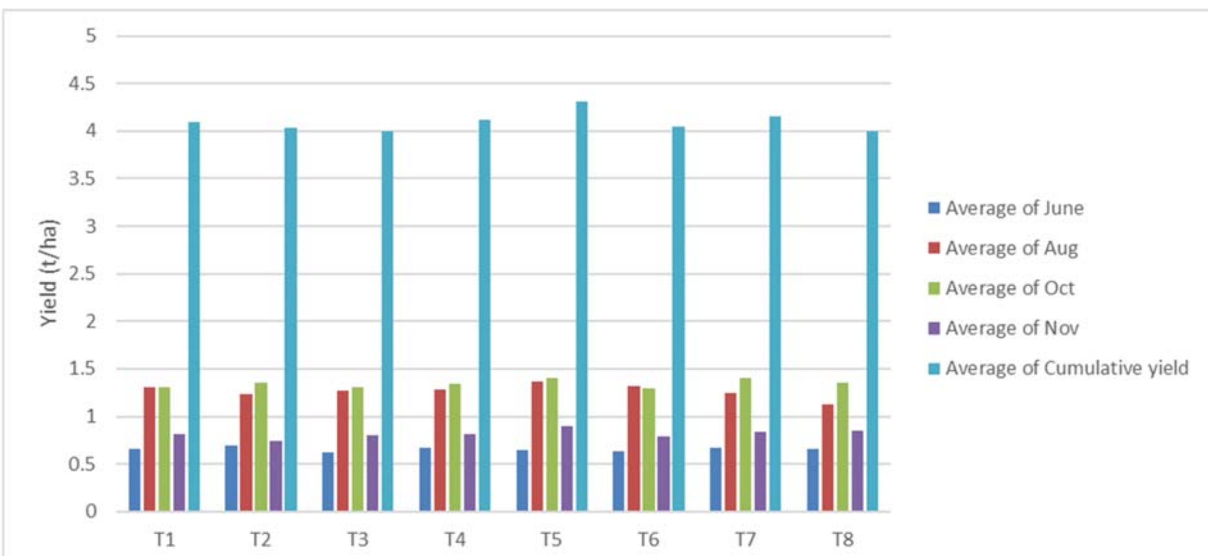

Figure 2. The cumulative average yields of the treatments and the average yields for the treatments for each of the cuts during the year. (LSD 5%)

Discussion

This trial supports Canadas et al. (2014) who state that high rates of applied gypsum do not reduce germination unless they cause an ionic imbalance in the soil. Although a reduction in the clover was observed and there was a statistical difference, the plant population was able to compensate in pasture yield for this loss within 43 days after the plant establishment count.

The trial indicated that Flobond™ alone and used in conjunction with gypsum may assist in amending soils. This soil was sufficient in all nutrients, had good (3.5%) levels of SOC and low levels of sodium and aluminium. The calcium to magnesium ratio of 2.76 was within the desirable range (Schulte and Kelling 1993). All these factors suggest that this soil would have good water infiltration properties which would in turn allow good root development which reduced the impact of the amendments applied on the pasture yield (Schulte and Kelling 1993).

Table 2. Cost/ha of gypsum at $60/t (ex GST) and Flobond™ @ $4.50/L (ex GST) and dry matter (DM) production for each treatment

Treatment	Cost/ha	Cumulative Yield DM/ha
T1 2.5t/ha gypsum	$150	4.05t
T2 5t/ha gypsum	$300	4t
T3 10t/ha gypsum	$600	3.96t
T4 250kg/ha gypsum + 3L/ha Flobond	$28.50	4.08t
T5 3L/ha Flobond	$13.50	4.18t
T6 500kg/ha gypsum + 3L/ha Flobond	$43.50	4t
T7 1t/ha gypsum + 3L/ha Flobond	$73.50	3.93t
T8 untreated control	$0	3.92t

It can be seen that Flobond™ would provide farmers with a very cost effective option to amend soil in the Goulburn valley (Table 2). Flobond™ breaks down to water, CO2 and ammonium nitrate (NH_4NO_3) within 6 to 8 weeks after application.(SNF Australia 2018) This means that it has no residual value for the soil as opposed to gypsum which may last up to five years in the soil depending on rainfall and irrigation (Cockcroft and Dillon 2004). The highly viscous nature of the liquid Flobond™ formulation makes it very difficult to apply (Misra and Hood 2007). The liquid Flobond™ is encapsulated with oil to keep it in suspension and this oily capsule needs to be broken down with turbulence. It is therefore very difficult and expensive to use it with flood irrigation, its viscosity makes it impossible to spray which leaves applying it through a centre pivot or lateral irrigator where it can be broken down and dissolved by the pump's turbulence. This requires a suction pump to feed the Flobond™ into the irrigator. This pump is expensive and it must be monitored as damage will occur if it is run dry. This research has shown that Flobond™ is economically and environmentally viable for use as a soil amendment providing that the application and residual issues could be resolved.

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