June 2024

Building drought resilience of vulnerable soils in low rainfall cropping and grazing systems

CASE STUDY

Using bentonite clay to manage vulnerable soils in the Victorian Mallee

Australian Government
Department of Agriculture, Fisheries and Forestry

Future Drought Fund

mallee catchment management authority

AGRICULTURE VICTORIA

Phil and Pam Vallance and son Richard farm near Ouyen on a 4200 ha property. The Vallances run a mixed cropping and opportunistic grazing system.

Image: Phil Vallance with Agriculture Victoria staff Martin Hamilton and Roger Harrower.

Much of the family farm is on a Mallee dune swale system consisting of very light calcareous soils which are very highly susceptible to wind erosion.

The Vallances have been investigating ways to stabilise these soils, increase ground cover persistence, increase agricultural productivity and profitability, and promote a faster paddock recovery in dry times.

A demonstration site was established over the 2023 season. Granular bentonite clay was broadcast (pre sowing) and incorporated (sowing) at 2 different rates, 5 t/ha and 10 t/ha, across particularly vulnerable sand dunes to promote crop establishment and increased ground cover.

The trial site was one ha per treatment/control. Rainfall totaled 283 mm in 2023 at the site and it was sown to wheat. This report shares some insights from this demonstration site.

Image: Aerial view of the trial site, Google earth.

Key Learnings

- The broadcast application of bentonite clay can increase the water and nutrient holding capacity of soil, improve crop emergence and ground cover protection of vulnerable Mallee soils, thereby increasing resilience to dry seasonal conditions
- The grade and quantity of bentonite clay used can affect the extent to which water and nutrients are retained in the soil
- High applications of bentonite clay (10 t/ha) are more effective at aiding crop emergence, increasing crop biomass later in the season and ground cover over summer, however this did not translate into yield benefits
- When broadcast at 5 t/ha, bentonite clay has the potential to increase crop biomass, water use efficiency and wheat yields by up to 123% and $154/ha
- Broadcasting bentonite clay is costly, with return on investment only seen after 5.3 years at 5 t/ha and no return at 10 t/ha (not accounting for any change in variables over time and one application of bentonite having a lasting effect).

Why Bentonite clay?

The Victorian Mallee has some of the most vulnerable soils in Australia. When managed through proven, innovative processes, these soils can be productive. Reducing erosion of these soils through increased ground cover is paramount to assist with the stabilisation of carbon in the soil and associated nutrients such as nitrogen.

Dune swale systems of the Victorian Mallee, not only have issues with poor ground cover and soil erosion but also associated waterlogging and discharge in swales when water seeps through these systems.

Bentonite clay was chosen for this site as it's a very plastic clay that shrinks (or swells) markedly in response to the removal (or addition) of water. Bentonite is a stable mineral and in agricultural production systems is likely to need only one application to increase field water holding capacity (WHC). Improving WHC should improve crop emergence and crop growth on vulnerable to erosion soils in the Mallee. Bentonite aims to therefore improve the longevity of ground cover throughout the season and reduce the impact of dry seasonal conditions on farming systems.

Image: Pelletised bentonite clay

Total Vegetation Cover (TVC) was assessed from the MODIS Fractional Cover Product. The Total Fractional/Vegetation Cover includes the sub-pixel proportion of both photosynthetic (green) vegetation and non-photosynthetic (dead/stubble) vegetation. This was assessed over the trial area (Figure 1) from 2001 through April 2024.

Across the 2023 season the average TVC across the year was 73%, 13% higher than the 23-year average of 60% and was the highest yearly average recorded.

Emergence, ground cover and crop biomass

Emergence rates (plants per 100cm) were both higher on the 5 t/ha and the 10 t/ha bentonite treatment areas compared to the control. Crop establishment was increased by 7.1% in the 5t/ha and 36.1% in the 10 t/ha treatment compared to the control.

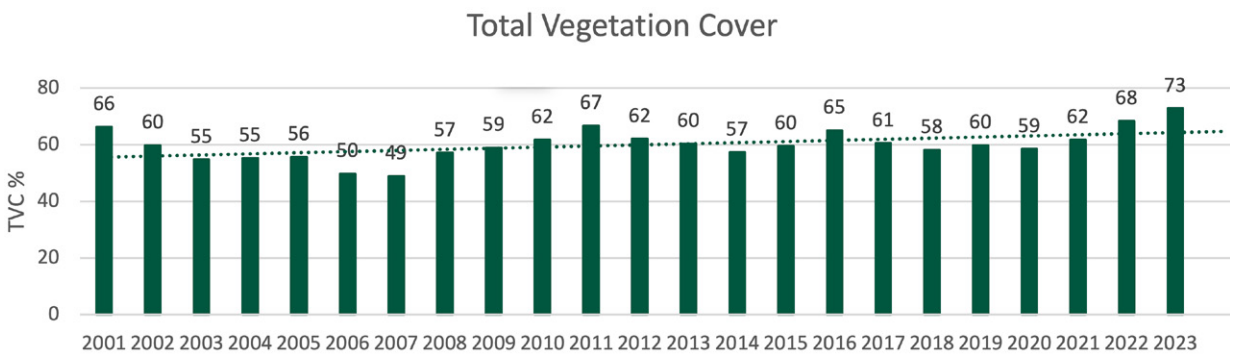

Figure 1. Average TVC across each year as a % of ground that has photosynthetic growth, across the trial site

Ground cover assessments were taken across the treatments using the Mallee Catchment Management Authority In-Paddock Ground cover Assessment Standards pre and post sowing (June 2023), in winter (August 2023) and summer (January 2024) (Figure 2). Winter ground cover was 23.6% more dense than the control for the 5 t/ha bentonite clay treatment site and 14.5% less dense in the 10 t/ha.

In summer both the treatments showed denser ground cover with the 5 t/ha site 7.4 % and the 10 t/ha 22.2% more dense than the control indicating the treatments were improving ground cover.

Vegetation was 9.4% taller in the 5 t/ha treatment and 11.6% shorter in the 10 t/ha treatment in winter and in summer 29.2% taller in the 5 t/ha treatment and 30.2% taller in the 10 t/ha treatment compared to the control. Biomass cuts that were taken in spring indicated little difference between the treatments and the control, with only the 5t/ha treatment showing an increase of 9.8%.

Summer rainfall increased stored soil moisture, aiding initial crop biomass production, with the bentonite treatments yet to affect the water holding capacity of the soil. As the season progressed, biomass cuts at harvest indicated that whilst there was only a 3.2% increase in crop biomass in the 5 t/ha treatment, the 10 t/ha treatment increased by 25.6%.

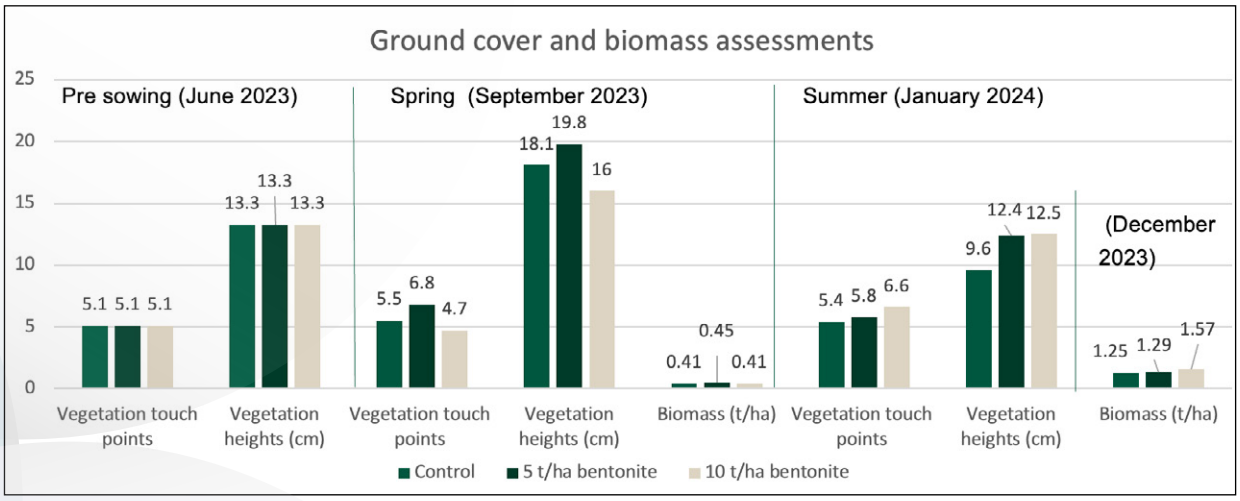

Figure 2. Ground cover and biomass assessments.

Yield and Profitability

Table 1. Wheat yields and profitability from the application of bentonite at 2 different rates.

	Yield (t/ha)	Income ($/ha)	Difference from control ($/ha)	Difference from control (%)	Cost ($/ha)	Gross return ($/ha)	Gross difference from control ($/ha)	Return on Investment (years)
Control	0.4	$126	$0	0	$0	$126	$0	
5 t/ha	0.89	$280.4	$154.4	122.5	$945	-$665	-$791	5.3
10 t/ha	0.31	$97.7	-$28.3	-22.5	$1,879	-$1,781	-$1907	n/a

Yield increased by 123% in the 5 t/ha treatment and decreased by 23% in the 10 t/ha treatment when compared to the control. As bentonite clay holds onto moisture and nutrients in the soil, it is possible that the higher amount of bentonite released the water and nutrients at a later stage of the season, promoting crop biomass growth over grain yield, as we saw a 25.6% increase in crop biomass at harvest in the 10 t/ha bentonite treatment.

As the trial site was on the top of a dune, yields were significantly lower than other areas of the paddock. The dune used in the demonstration is also positioned in line with the heavy turning areas at seeding and during harvest and due to its proximity to the neighboring forest and is impacted by kangaroos and emus.

Image: Crop growing on the site, 24 August 2023.

Broadcasting bentonite clay is costly, with return on investment only seen after 5.3 years at 5 t/ha and no return at 10 t/ha (not accounting for any change in variables over time and one application of bentonite having a lasting effect).

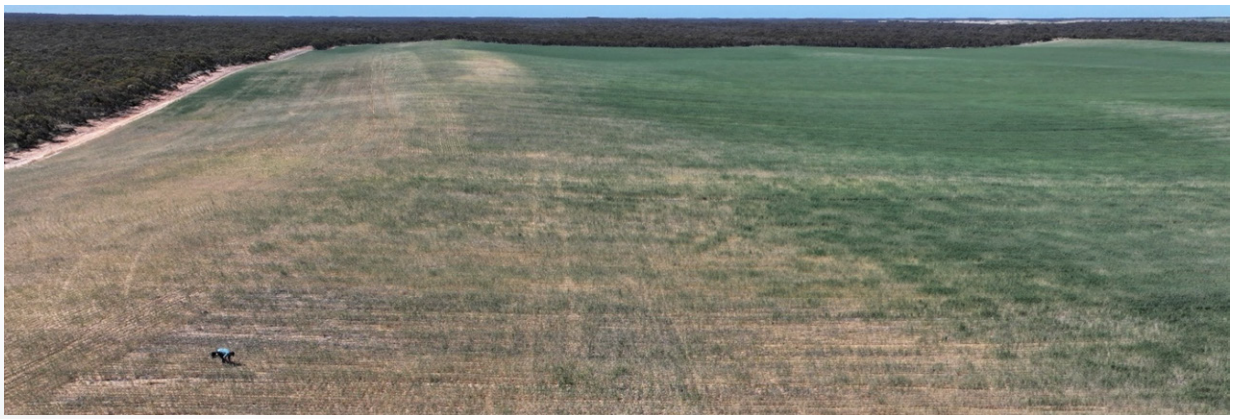

Image: Vulnerable dune trial site, 26 September 2023

This project is supported by the Mallee Catchment Management Authority, through funding from the Australian Government's Future Drought Fund. For a copy of the full technical report email **rebecca.mitchell@agriculture.vic.gov.au**

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