

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

CASE STUDY

Using bentonite clay and
composted organic matter
to manage vulnerable soils
in the Victorian Mallee





Richard McKee

Richard McKee, a fourth-generation farmer, farms with his parents Robert and Glennis McKee at Cowangie on a 2700 ha wheat, barley, legumes and canola farm. Much of the family farm is on a Mallee dune swale system consisting of very light calcareous soils which are highly susceptible to wind erosion.

The McKees 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 (30, 50, 100 and 200 kg/ha) and a composted organic

material with bentonite (50, 100 and 200 kg/ha) was direct drilled at sowing to promote crop establishment and increased ground cover on vulnerable soil. The site was one ha per treatment/control.

Rainfall totaled 289 mm in 2023 at the site which was sown to barley. This report shares insights from this demonstration site.

Key Learnings

- Direct drilling bentonite clay and composted organic material at sowing can increase the water and nutrient holding capacity of soil, improve crop emergence and ground cover protection in 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
- Lower application rates of bentonite clay and composted organic material with bentonite (50 kg/ha) managed to improve crop emergence and ground cover in late winter and post-harvest
- Bentonite and composted organic material with bentonite consistently increased crop biomass at harvest, whilst this was not the case in spring, with the bentonite treatments having reduced biomass. The benefits of bentonite were seen in the later stages of crop growth when the soil starts to dry out and the stored moisture in the bentonite can be utilised by the crop
- Higher applications of composted organic material with bentonite (100 kg/ha and 200 kg/ha) increased crop biomass in spring and at harvest, due to increasing available nutrients, but this did not translate into any significant grain yield benefits
- Direct drilling 50 kg/ha of bentonite clay at seeding is a profitable exercise with a net increase of 48.25 \$/ha. Direct drilling 30 kg/ha bentonite also showed a net positive of 32.84 \$/ha and the 200 kg/ha composted organic material with bentonite an increase of 7.7 \$/ha. These treatments demonstrated return would be seen year one of implementation. Direct drilling 50 kg/ha composted organic material with bentonite also showed a return on investment after 2.1 years.

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 it is likely to need only one application to increase field water holding capacity (WHC). A second commercial product combined composted organic material with bentonite clay was also used. 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.

Emergence, ground cover and crop biomass

Emergence rates were higher on the 100 kg/ha (125 p/m²) and 50 kg/ha (110 p/m²) bentonite treatments, and the 200 kg/ha (128 p/m²) and 50 kg/ha (124 p/m²) composted organic



Image: Bentonite clay (left) and compost organic material (right).

material with bentonite treatments compared to the control (100 p/m²). They were lower on the 30 kg/ha (97 p/m²) and 200 kg/ha (91 p/m²) bentonite treatments, and the 100 kg/ha (70 p/m²) composted organic material with bentonite treatment.

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 76%, 6% higher than the 23-year average of 70% and was the second highest yearly average recorded.

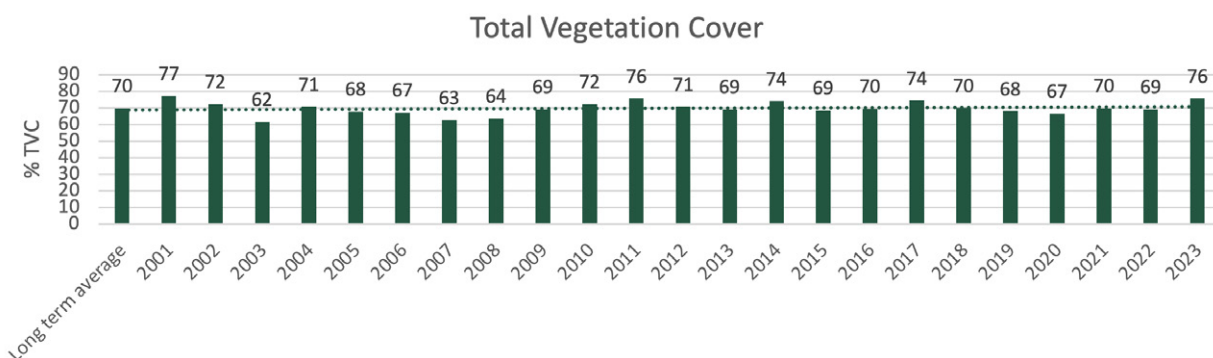


Figure 1. Total Vegetation Cover across the demonstration paddock.

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 late winter (August 2023) and summer (January 2024) (Figure 2).

In winter, ground cover was 14% denser in the 50 kg/ha bentonite treatment and 28.6% in the 50 kg/ha composted organic material with bentonite treatment. Ground cover was equally as dense in the 200 kg/ha composted organic material with bentonite treatment and 14% less dense in the 100 kg/ha, 30 kg/ha, 200 kg/ha bentonite treatments and the 100 kg/ha composted organic material with bentonite treatment.

In summer, ground cover was denser by 2.2% in the 50 kg/ha and 6.6% in the 200 kg/ha bentonite treatments and 6.7% in the 100 kg/ha and 33.3 % in the 50 kg/ha composted organic material with bentonite treatments. Ground cover was 2.2% less dense in the 100 kg/ha and 4.4% in the 30 kg/ha bentonite treatments and 15.6% in the 200 kg/ha composted organic material with bentonite.

As the season progressed, biomass cuts at harvest (summer 2023/4) indicated that only the 100 kg/ha bentonite treatment had a reduced biomass with the highest increase of 34.5% seen in the 50 kg/ha bentonite treatment, followed closely by the 200 kg/ha composted organic material with bentonite.

The mostly consistent increase in biomass later in the season indicates that the benefit of bentonite is in the later stages of the crop growth when the soil starts to dry out and the stored moisture and nutrient in the bentonite can be utilised by the crop. The increased nutrients in the composted organic with bentonite matter product assisted earlier in the growing season with the increases in biomass seen under the 100 kg/ha and 200 kg/ha treatments.

Yield and profitability

The highest yield increase of 32.14% was observed in the 50 kg/ha bentonite treatment. This was closely followed by 26.79% in the 200 kg/ha and 21.43% in the 30 kg/ha bentonite treatments. The 100 kg/ha of bentonite treatment saw a reduction in yield of 19.64% and 4.5% in the 200 kg/ha treatment of composted organic material with bentonite. The 100 kg/ha composted organic material with bentonite treatment was equal to the control.

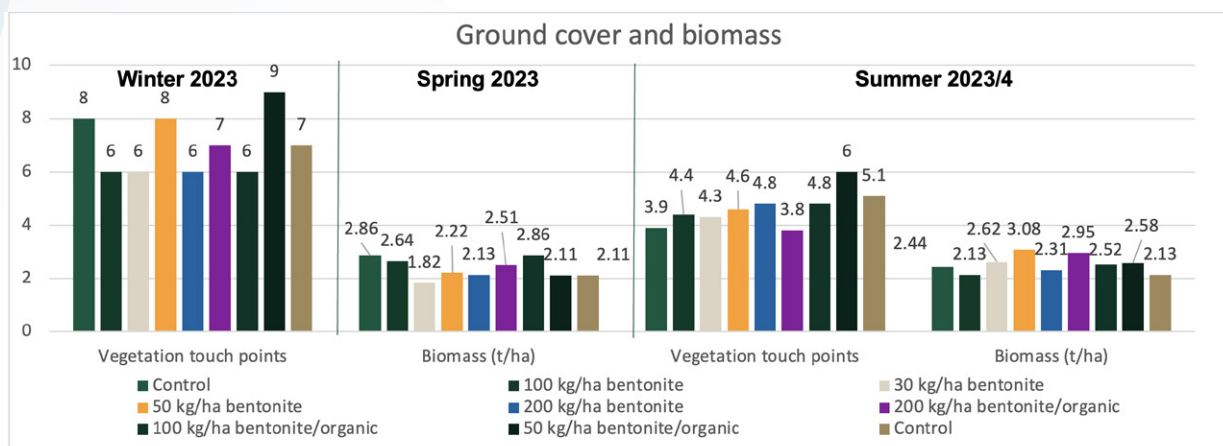


Figure 2. Ground cover and biomass assessments.

Table 1. Wheat yields and profitability

	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	0.61	\$198.25	\$0	0	\$0	\$198.25	\$0	-
100 kg/ha bentonite	0.45	\$146.25	-\$35.75	-19.64	\$20.52	\$125.73	-\$56.27	n/a
30kg/ha bentonite	0.68	\$221	\$39	21.43	\$6.16	\$214.84	\$32.84	First year
50kg/ha bentonite	0.74	\$240.5	\$58.5	32.14	\$10.25	\$230.25	\$48.25	First year
200kg/ha bentonite	0.71	\$230.75	\$48.75	26.79	\$41.05	\$189.7	\$7.7	First year
200kg/ha compost	0.54	\$175.5	-\$6.5	-3.57	\$160	\$15.5	-\$166.5	n/a
50kg/ha compost	0.60	\$195	\$13	7.14	\$40	\$155	-\$27	2.1
100kg/ha compost	0.56	\$182	\$0	0	\$88	\$94	-\$88	n/a
Control	0.51	\$165.75	\$0	0	\$0	\$165.75	\$0	-

The 50 kg/ha bentonite treatment was the most profitable of the treatments compared to the control with a net increase of 48.25 \$/ha. The 30 kg/ha bentonite treatment also showed a net positive of 32.84 \$/ha and the 200 kg/ha composted organic material with bentonite treatment an increase of 7.7 \$/ha.

Return on investment for those 3 rates/products is realized in the first year of implementation. The only other treatment that showed a positive return on investment was the 50 kg/ha composted organic material with bentonite treatment showing this ROI after 2.1 years.

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



Image: Demonstration site, 28 September 2023.

Disclaimer

Whilst all attempts were made to represent the data as accurately as possible the Department of Energy, Environment and Climate Action accepts no responsibility for any actions or decisions made associated with information presented in this case study. This document is provided to showcase learning from an unreplicated, one growing season demonstration site.

This publication may be of assistance to you but the Mallee Catchment Management Authority and the author do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purpose and therefore disclaims all liability for any error, loss or other consequence that may arise from you relying on any information in this publication.

This project is supported by the Mallee Catchment Management Authority, through funding from the Australian Government's Future Drought Fund.