INVESTIGATING SOIL AMELIORATION TECHNIQUES IN SANDY GRAVEL SOILS IN THE SOUTHERN WIMMERA

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TAKE HOME MESSAGES

- While there is no 'one-size fits all' soil amelioration technique, applying chicken manure significantly increased yields in both years of this trial.
- It is vital to understand the soil constraint you are attempting to ameliorate, and to test a small area first.
- Establishing a crop on ripped or clayed soil can be difficult due to variable seeding depth however crop type and seeder set up can be used to improve establishment.

BACKGROUND

While yields increase across the Wimmera, there are always parts of the paddock that don't perform as well as others, sometimes due to soil constraints. This has led to a growing number of farmers seeking to increase productivity through soil amelioration techniques.

Previous research has shown the benefits of deep ripping on deep sands in the Victorian Mallee, but does deep ripping sandy soils with a clay subsoil also provide a benefit? Can the increasing amount of chicken manure being produced in the region be used to boost crop yields? Can clay spreading ameliorate non-wetting sands? This trial hopes to answer these questions and provide a better understanding about the results of these techniques, especially given the expensive upfront costs.

AIM

To investigate the long-term response to claying, deep ripping and manure spreading across different crop types on a sandy gravel.

PADDOCK DETAILS

Location:	Lubeck	
Crop year rainfall (Nov-Oct):	2019 – 429mm	2020 – 410mm
GSR (Apr-Oct):	2019 – 270mm	2020 – 283mm
Soil type:	Sandy gravel	
Paddock history:	2018 – Barley	

TRIAL DETAILS

Crop type/s:	2019 – Scepter wheat 2020 – Genesis™ 090 chickpeas
Treatments:	Refer to Table 1
Target plant density:	2019 – 140 plants/m^2; 2020 – 40 plants/m^2
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Sowing date:	2019 –7 June 2019; 2020 – 4 June 2020
Replicates:	Four
Harvest date:	2019 – 13 December 2019; 2020 – 18 December 2020
Trial average yield:	2019 – 2.4t/ha; 2020 – 0.9t/ha

TRIAL INPUTS

Soil amelioration: Refer to Table 1

Trial managed as per best practice for pests, disease and weeds.

METHOD

A site on a typical 'Wal Wal sand' – a coarse sand with ribbons of clay from 40cm – was chosen for the trial as it had consistently underperformed. Soil testing showed that the site was not chemically constrained. A replicated split-plot trial was sown with the main plot as ripping and the subplot being randomised for soil amendment treatment. The trial was ripped to a depth of 30cm on 26 March 2019. The chicken manure and clay were spread on 6 June 2019, the day before sowing. Over both years, in-season assessments included establishment counts and NDVI. The plots were harvested to assess yield and subsequently grain quality parameters were measured.

Table 1. Trial treatment outline.

Ripping	Amendment
Ripped to ~30cm	Control (no amendment)
Not ripped	Chicken Manure with rice hull base @ 20t/ha
	Clay @ 200t/ha
	Clay @ 300t/ha

RESULTS AND INTERPRETATION

OVERALL SEASON SUMMARY

2019 – Wheat

This trial was sown on June 7 but received 45mm in the week post sowing which slumped furrows. This increased the sowing depth and caused herbicide damage to the wheat. As a result, the trial established poorly and yield correlated strongly with establishment (r^2=0.5). The winter of 2019 received decile 8 rainfall before a dry finish to the growing season (decile 2 September to October). The low water holding capacity of the soil contributed towards the crop 'haying off' across the trial, with some treatments exacerbating this.

2020 – Chickpeas

The trial was sown to canola on 22 April 2020 however, establishment was incredibly low due to variable sowing depth. As a result, the trial was terminated and re-sown to chickpeas. The chickpeas were sown into moisture but were slow to establish due to the cool, dry conditions with June and July receiving only decile 2 rainfall. Establishment was patchy and significantly different between treatments, despite this, the chickpeas reached full canopy cover which allowed the plants to compensate for lower establishment. August to November received decile 7 rainfall in a soft spring with almost no frost, which suited the later finishing chickpeas perfectly.

EFFECTS OF DEEP RIPPING

2019 – Wheat

Ripping significantly decreased establishment, reducing plant density to 72 plants/m^2 compared to 109 plants/m^2 in the unripped treatments (p=0.025, LSD=28 plants/m^2, CV=23.9%). The ripping created a softer surface, leading to variable sowing depth and greater furrow slumping following the rain event. There was a trend towards deep ripping resulting in lower yields however this response was not statistically significant.

Ripping also decreased grain quality, significantly decreasing test weight and trended towards lower grain size with higher screenings. This indicates the deep ripping potentially hayed off harder than the unripped treatments, as the deep ripping allows for more early growth, running out of moisture in the profile faster.

2020 – Chickpeas

Ripping significantly decreased establishment in chickpeas (p=0.012, LSD=1.32 plants/m^2, CV=22.7%), however the decrease by 2 plants/m^2 did not affect yield as the plots reached canopy closure, allowing the lower establishment rate to compensate. There was no yield difference between ripped and unripped treatments with the chickpeas.

EFFECTS OF MANURING

2019 – Wheat

While applying 20t/ha of chicken manure did not affect wheat establishment, chicken manure did increase crop growth, as shown visually in the photos below (Figure 1). Manure treatments had significantly higher NDVI than the control treatments that received no soil amendments from drone flights on the 7 August ($p<0.001$, LSD=0.027, CV=7.6%) and 2 September ($p<0.001$, LSD=0.0589, CV=9.5%).

Figure 1. Unripped control (left) vs unripped manure treatment (right) on 9 September 2019.

Applying 20t/ha of chicken manure significantly increased yields by 1.2t/ha compared to the control, from 2.1t/ha to 3.2t/ha ($p=0.002$, LSD=0.65t/ha, CV=27.4%). However, this increased bulk led to the manure treatments haying off more severely, with protein increasing significantly by 2% ($p<0.001$, LSD=0.38%, CV=6.7%) and test weight significantly decreasing by 6kg/hL ($p<0.001$, 3.034kg/hL, CV=4.1%). Screenings increased with the application of manure from 9.9% to 11%, which while not statistically significant ($p=0.12$, LSD=NS) is significant to the grower, as this increase in screenings pushed the quality from AUH2 to FED1.

2020 – Chickpeas

The 2019 chicken manure application had a significant effect on chickpea production in 2020, increasing yields by 0.25t/ha to 1.11t/ha compared with the control that yielded an average of 0.86t/ha ($p=0.001$, LSD=0.186t/ha, CV=18%). Manuring did not significantly affect establishment compared to the control.

EFFECTS OF CLAY SPREADING

2019 – Wheat

Claying in 2019 significantly decreased establishment (Figure 2), which led to NDVI for both clay at 200t/ha and clay at 300t/ha being significantly lower than the control on 7 August ($p<0.001$, LSD=0.013, CV=7.6%) and 2 September ($p<0.001$, LSD=0.0589, CV=9.5%). Despite this lower establishment and NDVI, there was no yield impact from claying at either rate (Figure 2). Claying did not affect grain quality.

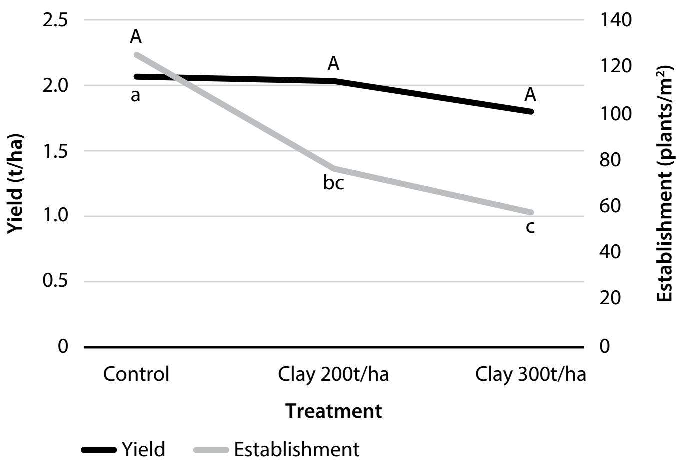

Figure 2. Establishment (right x-axis) and yield (left x-axis) across control and clay spreading in wheat in 2019. Yield p=0.002, LSD=0.6457t/ha, CV=27.4%. Establishment p<0.001 LSD=21.7plants/m², CV=23.9%. Different letters denote significant differences between treatments.

2020 – Chickpeas

Claying in 2020 did not significantly affect plant establishment between the treatments. Likewise, claying had no impact on yield with the control (0.76t/ha), clay 200t/ha (0.92t/ha) and clay 300t/ha (0.82t/ha) not statistical different (LSD 0.19t/ha).

COMMERCIAL PRACTICE AND ON-FARM PROFITABILITY

Importance of understanding soil type and constraints

Before undertaking expensive soil amelioration techniques, it is important to understand the soil constraint that is limiting production. Given the sandy gravel soil type at this trial site, it was thought the biggest limitation to producing crops was water holding capacity, which could be increased by the addition of clay. Claying has not significantly changed yields compared to the control in either 2019 or 2020, indicating this is perhaps not the underlying issue.

The addition of extra nutrition in the form of chicken manure has increased yields in both seasons. This demonstrates yields may have been limited by a nutrient deficiency that was fixed by the application of chicken manure rather than a lack of plant available water. It is recommended that all soil amelioration techniques are trialled on a small scale at least one season prior to understand their effects, before outlaying a large amount of money to conduct them on a paddock scale. It should also be considered if soil amelioration should be done across the paddock or just where required.

The importance of understanding the different constraints to production on different soil types is highlighted by the results 'Ripping, manuring and clay spreading on a duplex soil: early learnings from the first-year response' article found on page 83. On a sand-over-clay soil type, where compaction was a constraint, deep ripping increased yields, unlike in this trial. This shows that there is no 'one-size fits all' technique to increase productivity when it comes to soil amelioration.

Difficulties in establishing a crop following physical soil amelioration

Claying and deep ripping creates a looser seed bed that can lead to difficulties in establishing a crop. The loose soil can create issues with variable seeding depth, so it is important to carefully consider seeder set up to ensure seeding depth is correct and that herbicide treated soil is not being thrown back into the furrow. Timing of deep ripping and claying can also influence establishment – conducting these close to sowing results in the ameliorated soil having less time to settle and increases the risk of poor establishment. However, the earlier deep ripping and claying are done, the longer the soil surface is left bare and the greater the chance of erosion.

Deep ripping can increase haying off

Deep ripping can remove compacted layers and hard pans from the soil, making it easier for crop roots to grow and hence produce more biomass earlier in the season. In seasons like 2019, when there is a tight finish in spring, this extra biomass will have used more of the stored soil moisture earlier, which can cause the crop to hay off. This resulted in lower quality grain in 2019, due to increased screenings. While not typically a problem in higher rainfall areas such as Lubeck (420mm average annual rainfall), this haying off effect from deep ripping may be more prevalent in areas with lower rainfall. As shown by the differences in grain quality between the ripped and not ripped manure treatments, applying large amounts of nitrogen early (58kg N/ha) to deep ripped soil may make haying off worse.

Importance of testing manure and other organic amendments

Different organic amendments, such as chicken manure, can vary in nutritional content widely for a range of reasons such as different sheds, different bedding bases, different feed sources and even season to season. It is important to get any manure tested at a lab before spreading it on your paddock to ensure that it does not contain anything harmful (e.g. high salt or boron content) It is also important to understand how much N, P, K and S is being applied to help calculate the amount of additional fertiliser needed to ensure crop demands are met. Table 2 shows the nutrient analysis of the manure applied in this trial. It had a N:P:S:K ratio of 1:2:2:9 and whilst unlikely to impact on crop growth in this trial, it had higher than ideal levels of sodium, chloride and boron which should be avoided if applying to soil that already has issues with salinity or boron toxicity.

Table 2. Nutrient analysis of chicken manure applied in this trial.

Nutrient	Nutrient analysis	Nutrient applied (kg/ha @ 20t/ha)
Boron	54 mg/kg	1
Chloride	0.44%	88
Sodium	5,400 mg/kg	108
Ammonium nitrogen	2,800 mg/kg	56
Nitrate nitrogen	76 mg/kg	2
Phosphorous	6,800 mg/kg	136
Sulphur	6,800 mg/kg	136
Potassium	27,000 mg/kg	540
Zinc	63 mg/kg	4.2

Increased income from soil amelioration

While it is vital to consider how soil amelioration might fit in your farming system, if done well it can increase crop yields and hence increase income for growers. The cost of implementing techniques such as chicken manure spreading can be significantly reduced when a farmer has poultry sheds as part of their enterprise. Cost will increase if the manure needs to be carted to the paddock from a substantial distance and if a contract spreader needs to be used for application.

The economics from applying soil amendments and deep ripping in this trial is outlined in Table 3. Due to variability in the pricing and application of these amendments, only income has been calculated. Manuring significantly increased income compared to the control, while ripping did not significantly increase or decrease income (Table 3).

Table 3. Income ($/ha) across soil amelioration treatments. Income calculated using 2020 chickpea prices ($540/t) and 2019 wheat prices (AGP=$322/t, AUH2=$331/t, FED1=$250/t).

	2019 Yield (t/ha)	2019 Protein (%)	2019 Test Weight (kg/hL)	2019 Screenings (%)	2019 Wheat Grade	2019 Income ($/ha)	2020 Yield (t/ha)	2020 Income ($/ha)	2019-2020 Income ($/ha)
Not Ripped Manure @ 20t/ha	3.44	12.5	73.1	8.9	AUH2	1019	1.11	601	1620
Deep Ripped Manure @ 20t/ha	3.04	11.9	70.1	13.0	FED1	914	1.11	598	1512
Not Ripped Clay@ 200t/ha	2.01	10.8	74.5	10.8	FED1	588	1.10	595	1183
Not Ripped Control	2.19	10.2	76.4	10.6	FED1	663	0.90	484	1147
Deep Ripped Clay@ 200t/ha	2.09	10.5	75.5	10.6	FED1	566	0.97	526	1092
Deep Ripped Control	1.99	10.3	78.2	9.3	AGP	614	0.82	443	1057
Not Ripped Clay @ 300t/ha	1.96	10.7	75.6	10.5	FED1	516	0.98	528	1044
Deep Ripped Clay @ 300t/ha	1.65	11.3	73.0	11.5	FED1	447	0.86	466	913
Sig. diff									
Ripping	**0.144**	**0.137**	**0.018**	**0.077**		**0.186**	**0.179**	**0.179**	**0.177**
Amendment	**0.002**	**<0.001**	**<0.001**	**0.12**		**0.006**	**0.004**	**0.004**	**0.002**
Ripping*Amend.	**0.46**	**0.161**	**0.126**	**0.004**		**0.487**	**<0.001**	**<0.001**	**0.041**
LSD									
Ripping	**NS**	**NS**	**1.501**	**NS**		**NS**	**NS**	**NS**	**NS**
Amendment	**0.321**	**0.771**	**3.034**	**NS**		**235.9**	**0.186**	**100.6**	**276.5**
Ripping*Amend.	**NS**	**NS**	**NS**	**3.838**		**NS**	**0.510**	**257.3**	**555.9**
CV%	**27.4**	**6.7**	**4.1**	**22.2**		**33**	**18**	**18**	**22.2**

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