RIPPING, MANURING AND CLAY SPREADING ON A DUPLEX SOIL: EARLY LEARNINGS FROM THE FIRST-YEAR RESPONSE

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TAKE HOME MESSAGES

- Applying nutrients as either duck manure or fertiliser plus deep ripping increased wheat yields in the season following application.
- Claying decreased yields, potentially due to difficulties in incorporating it on a plot scale.
- Soil amelioration techniques can increase crop yields on duplex soils in the northern Wimmera however the soil constraint and the implementation of the techniques needs to be carefully considered and supported by soil testing.

BACKGROUND

With most farmers now having a relatively settled rotation and a strong agronomic package to support high yielding crops, farmers are looking for the next area to increase yields. This has led to a growing number of farmers seeking to increase the productivity of their soils by ameliorating soil constraints.

This trial seeks to validate and further understand the effects of such soil amelioration techniques in the northern Wimmera region. 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 layer (duplex soils) also provide a benefit? Can the increasing amount of duck 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 gain a better understanding of these techniques on yield, especially given the expensive upfront costs.

AIM

To investigate the effects of deep ripping, spreading manure and claying on a constrained duplex soil.

PADDOCK DETAILS

Location:	Netherby
Crop year rainfall (Nov-Oct):	345mm
GSR (Apr-Oct):	241mm
Soil type:	Sand over clay
Paddock history:	2019 – Vetch hay

TRIAL DETAILS

Crop type/s:	Scepter wheat
Treatments:	Refer to Table 1 and 2
Target plant density:	130 plants/m^2 (achieved 94 plants/m^2)
Seeding equipment:	Knife points, press wheels, 30cm row spacing
Sowing date:	25 May 2020
Replicates:	Four
Harvest date:	10 December 2020
Trial average yield:	4.3t/ha

Trial managed as per best practice

METHOD

A replicated split-plot trial was sown with the main plot as ripping and the subplot being randomised for soil amendment treatment. The trial site was deep ripped in early April, with the clay and manure spread on 14 April and cultivated into the soil on the same day. The manure was analysed for nutrient content and matched synthetic fertiliser treatments in nitrogen and phosphorous were created (Table 2). The site was cultivated again on 5 May following a rain to further incorporate the clay. The fertiliser treatments were broadcast and incorporated by sowing on 25 May. The trial was established on a sand over clay soil with a shallow hard layer where the previous year's vetch crop was less productive than the rest of the paddock. Assessments in season included establishment counts, NDVI and biomass cuts. The plots were harvested for grain yield and the subsequent wheat analysed for protein, test weight, screenings and 100 grain weight.

Table 1. Treatment outline.

Ripping	Soil Amendment
Not Ripped	Untreated control
Ripped to ~30cm	Clay @ 100t/ha
	Clay @ 200t/ha
	Duck Manure Rate 1
	Duck Manure Rate 2
	Duck Manure Rate 3
	Fertiliser Rate 1
	Fertiliser Rate 2
	Fertiliser Rate 3

Table 2. Nutrients applied in trial.

Treatment rate	Nutrition provided	Manure applied	Fertiliser applied	Clay applied
Rate 1	13kg/ha N + 23kg/ha P	4.6t/ha duck manure with wood shaving base	49kg/ha triple super and 28kg/ha urea	-
Rate 2	28kg/ha N + 49kg/ha P	9.9t/ha duck manure with wood shaving base	106kg/ha triple super and 60kg/ha urea	-
Rate 3	55kg/ha N + 97kg/ha P	19.8t/ha duck manure with wood shaving base	211kg/ha triple super and 120kg/ha urea	-
100t/ha	3.6kg/ha N + 0kg/ha P	-	-	100t/ha clay
200t/ha	7.2kg/ha N + 0kg/ha P	-	-	200t/ha clay

RESULTS AND INTERPRETATION

Effect of deep ripping on compaction levels

The deep ripping removed a hard-compacted layer that was present at 15cm. However, the deep ripping was not as deep as expected given the tyne depth, only reducing compaction to 25-30cm (Figure 3. Differences in root growth between not ripped (L) and ripped (R) treatments in lentils 2/9/2020. 40cm ruler for scale.). There is another band of compaction at 40-50cm, which was not changed by the deep ripping as it was beyond the reach of the tyne. Despite the ripper having a tyne depth of 65cm, the working depth is approximately 30cm due to kickback and tractor power. It is important for growers to consider the working depth of their ripper when deciding if compaction can be alleviated through deep ripping.

Penetrometer resistance above 1,500 kPa indicates that root growth is beginning to be restricted, with roots becoming severely restricted at greater than 2,500kPa (Hunt and Gilkes 1992). This indicates that plant roots will struggle to grow through the soil, with roots in the not ripped treatments being restricted from ~10cm, whereas in the ripped treatment roots would be able to grow unimpeded to ~30cm. This increase in rooting depth is expected to allow plants growing in the ripped treatment greater access to moisture and nutrition than the not ripped treatment.

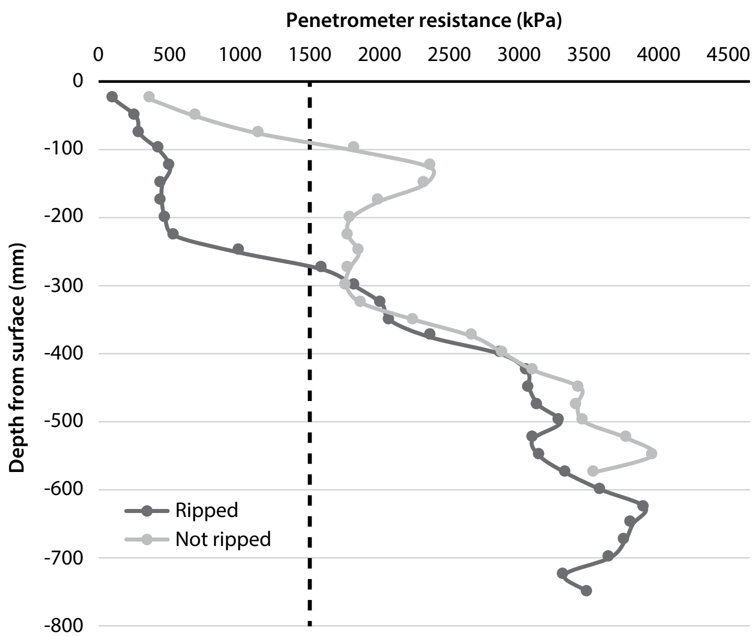


Figure 1. Average penetrometer resistance (four replicates) measured in moist soil in October across ripped and not ripped treatments.

Establishment following ripping and amendment application

Crop establishment averaged 95 plants/m^2 across the trial, lower than the targeted 130 plants/m^2. However, there were no significant differences in establishment between both ripping treatments (p=0.141, LSD=9.2 plants/m^2, CV=4.4%) and amendment treatments (p=0.5, LSD=14.8 plants/m^2, CV=15.6%). As there were no significant differences between treatments, the results seen in this trial are not caused by establishment.

Biomass response to ripping and amendment application

Biomass at early grain fill had a significant response to soil amendment (Figure 2). The higher rate nutrient treatments, rate 2 and rate 3 duck manure and rate 3 fertiliser all significantly increased biomass compared to the control, while both clay rates significantly decreased biomass. Rate 3 and rate 1 duck manure had significantly higher biomass than the matched fertiliser rate treatments. The same trends were also observed in NDVI measurements taken on 10 September (p=0.015, LSD=0.009, CV=1.1%) and 14 October (p<0.001, LSD=0.01, CV=1.2%).

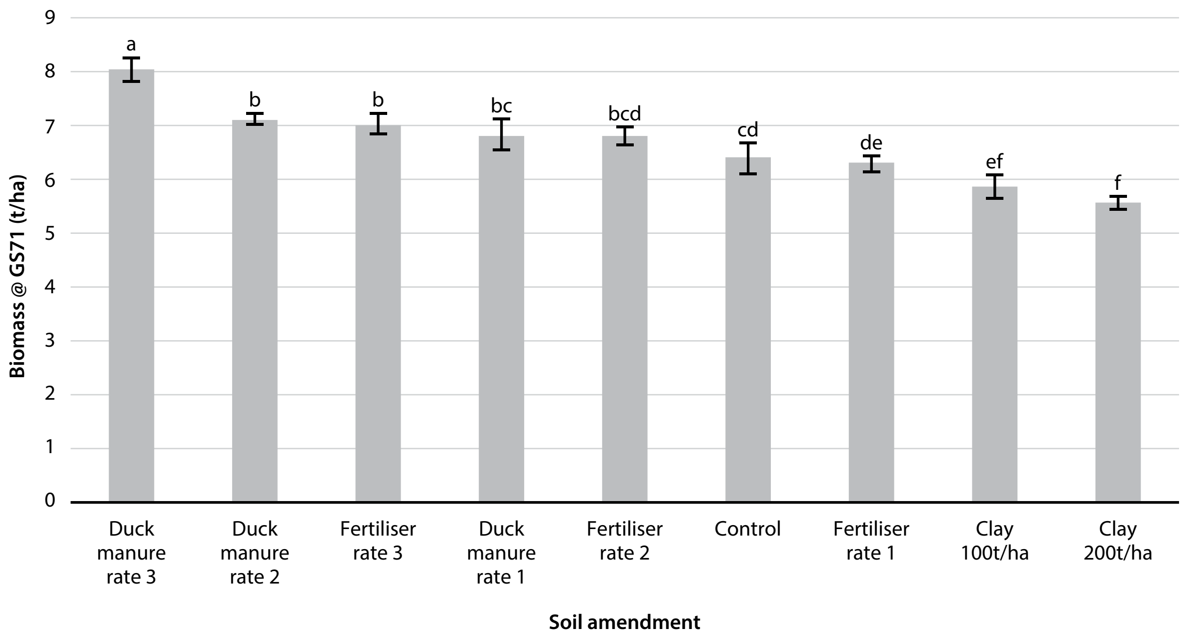


Figure 2. Biomass response to soil amendment (p<0.001, LSD=0.53t/ha, CV=7.8%).

Deep ripping did significantly increase NDVI at 10 September (p=0.015, LSD=0.008, CV=1.1%), potentially due to greater access to moisture and nutrition due to the removal of the compaction layer in the deep ripped treatments. Ripping did not have a significant effect on biomass at early grain fill (p=0.2) or on NDVI at 14 October (p=0.1). The reason as to why deep ripping did not have significant effects is unknown and further research is required to better understand this lack of response.

Yield response to ripping and amendment application

The trends observed in biomass and NDVI continued throughout the season and eventuated as differences in yield. All the duck manure and fertiliser treatments yielded significantly higher than the control, while the clay treatments yielded significantly lower than the control (Figure 3). At both the rate 3 and rate 2, duck manure yielded significantly higher than the matched fertiliser rate. Unfortunately, soil test results for the site were not available at the time of publishing, making it difficult to hypothesise the reason behind the responses to the duck manure and fertiliser treatments.

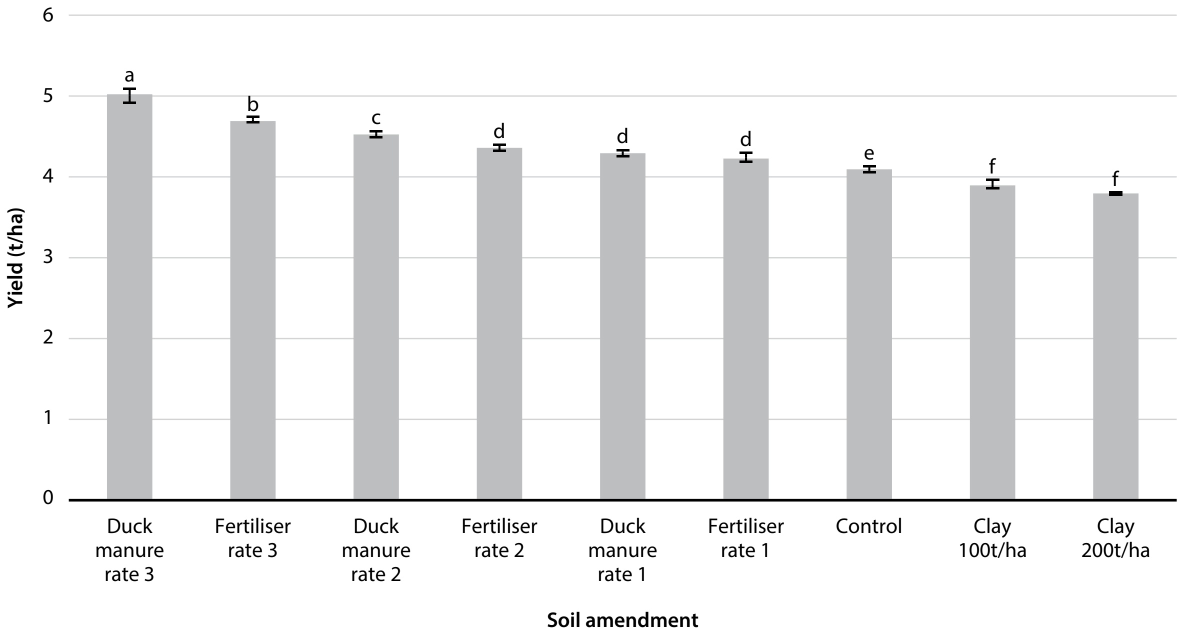


Figure 3. Yield response to soil amendment (p<0.001, LSD=0.13t/ha, CV=3.1%).

Deep ripping also significantly increased yield across the trial, by an average of 0.14t/ha (p=0.015, LSD=0.091t/ha, CV=3.1%). Ripping had a positive response across the trial, with no amendment treatments that did not yield higher when deep ripped. However, the yield response to deep ripping varied from 0.01-0.29t/ha, with deep ripping significantly increasing yields in some amendments only (Table 3). The yield increases from ripping are likely due to the removal of the compaction layer at 15cm allowing the roots greater access to moisture and nutrition in the soil than the not ripped treatments.

Table 3. Yield response to ripping and soil amendment. Ripping LSD=0.09t/ha.

	Ripped yield (t/ha)	Not ripped yield (t/ha)	Difference (t/ha)	Significant difference between ripped and not ripped?
Duck Manure Rate 3	5.15	4.86	0.29	Yes
Fertiliser Rate 3	4.75	4.65	0.11	Yes
Duck Manure Rate 2	4.62	4.43	0.19	Yes
Fertiliser Rate 2	4.39	4.31	0.08	No
Duck Manure Rate 1	4.34	4.25	0.08	No
Fertiliser Rate 1	4.32	4.14	0.18	Yes
Control	4.15	4.00	0.15	Yes
Clay 100t/ha	4.01	3.78	0.22	Yes
Clay 200t/ha	3.79	3.78	0.01	No

Grain quality response to deep ripping and amendment application

All treatments in this trial made the quality requirements of H2, with test weight, protein and screenings well above receival standards (81.27kg/hL, 12% protein and 0.6% screenings). Amendment application did have a significant effect on protein and test weight however these small differences did not matter in a commercial sense.

COMMERCIAL PRACTICE AND ON-FARM PROFITABILITY

Key learnings from the first-year response

Difficulties in crop establishment

Getting good establishment on ripped and clayed soils is difficult due to variable seeding depth. If sowing into recently ameliorated soils, seeder set up is important to ensure seeding depth is correct. A potential solution may be to roll ripped soils prior to sowing to provide a more level seed bed, with care taken to minimise compaction. Another option may be to increase seeding rates to compensate for lower establishment rates.

Yield increased from providing adequate crop nutrition

Yields increased with increasing rates of both manure and fertiliser compared to the control, indicating the control yield potential was limited by the availability of nutrients. Unfortunately, site soil test results were not available at the time of writing to determine which nutrient is limited. This highlights the importance of ensuring the crop has adequate access to nutrition to increase yields, before undertaking expensive physical soil amelioration such as deep ripping and claying.

The need to validate techniques on a small scale before investing

Trialing different techniques on a small scale to understand the crop response is a valuable tool to understand if claying, deep ripping and manuring will provide a yield increase. This allows farmers to be confident before making major investments in deep ripping or claying whole paddocks.

Key questions arising from the first-year response

Why are manuring treatments performing significantly better than the matched fertiliser treatments?

Rate 2 and rate 3 duck manure yielded significantly better than the matched N and P fertiliser treatments. A possible reason for this occurring could be that the manure contains a nutrient the soil is low in, such as sulphur or zinc, which is present in the manure but not in the N and P only treatments. Unfortunately, the site soil test results were not available at the time of writing, which would help to determine this. Another potential reason for duck manure yielding better than the fertiliser treatments could be that the organic matter in the manure is providing a benefit, or that the nutrients in the manure are more available or available faster to the crop than the nutrients in the fertiliser.

Why is clay spreading decreasing yield?

Compared to the control, yield significantly decreased with clay spreading at both 100t/ha (0.18t/ha) and 200t/ha rates (0.29t/ha). This is unexpected, as claying done by farmers in the local area has increased yields. It is likely this decrease in yield is due to difficulties in incorporating clay on a plot scale. It could also be due to the clay being slightly saltier than ideal, although wheat is generally quite salt tolerant.

What is the return on investing in these techniques?

Table 4 shows the increase in income from the yield responses compared to the unripped control. It is difficult to determine the return on investment from the first year of a multi-year investment.

Table 4. Change in income ($/ha) from different soil amelioration treatments.

	Average of Yield (t/ha)	Change in yield (t/ha)	Change in income ($/ha)
Ripped Duck Manure Rate 3	5.14	1.14	$287
Not Ripped Duck Manure Rate 3	4.86	0.85	$215
Ripped Fertiliser Rate 3	4.75	0.75	$188
Not Ripped Fertiliser Rate 3	4.64	0.64	$161
Ripped Duck Manure Rate 2	4.62	0.61	$155
Not Ripped Duck Manure Rate 2	4.43	0.42	$106
Ripped Fertiliser Rate 2	4.39	0.39	$98
Ripped Duck Manure Rate 1	4.34	0.33	$83
Ripped Fertiliser Rate 1	4.32	0.31	$79
Not Ripped Fertiliser Rate 2	4.31	0.31	$77
Not Ripped Duck Manure Rate 1	4.25	0.25	$62
Ripped Control	4.15	0.15	$37
Not Ripped Fertiliser Rate 1	4.14	0.14	$35
Ripped Clay 100t/ha	4.01	0.01	$3
Not Ripped Control	4.00	-	-
Ripped Clay 200t/ha	3.79	-0.22	-$54
Not Ripped Clay 200t/ha	3.78	-0.22	-$56
Not Ripped Clay 100t/ha	3.78	-0.22	-$56

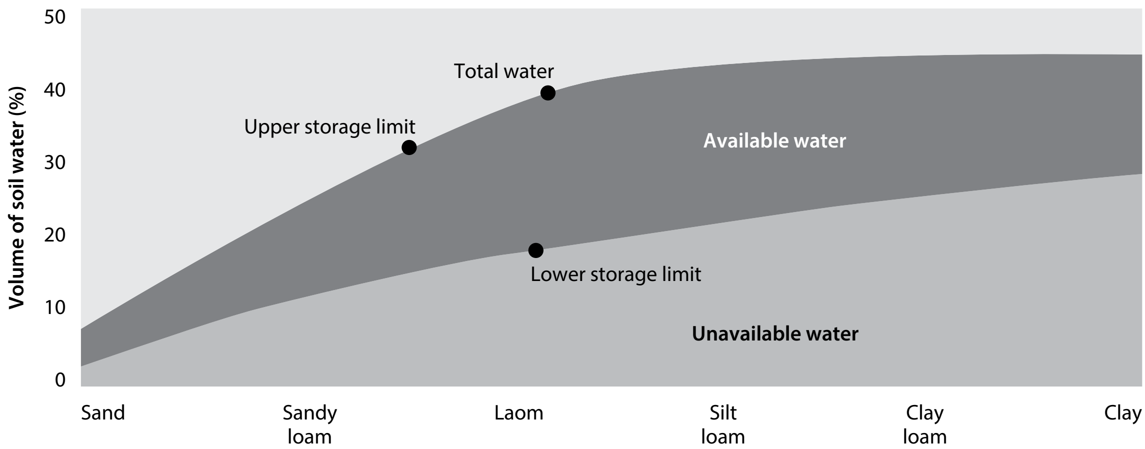
Soil amelioration considerations for your farm

Clay spreading

Non-wetting sands are usually soil types that contain less than 5% clay particles, so increasing the clay content of the soil can overcome water repellency issues. To determine the rate of clay that needs to be spread, conduct a soil test on both the soil in the paddock and the clay material that will be spread. The following formula can then be used:

$$\text{Rate of clay to apply} = \text{target clay \%} - \text{current clay \%} \times \frac{1400}{\text{clay \% of spreading material}} \times \frac{\text{incorporation depth (cm)}}{10}$$

Clay spreading can also increase the water holding capacity of the soil however care needs to be taken in lower rainfall areas. While increasing the clay content of the soil increases water holding capacity, it also increases the crop lower limit. This means the soil needs to have more stored water before the crop can begin to access the stored moisture. While this may not be an issue in some areas, in lower rainfall areas making your soil 'heavier' may lead to decreases in yields, especially in dry years.



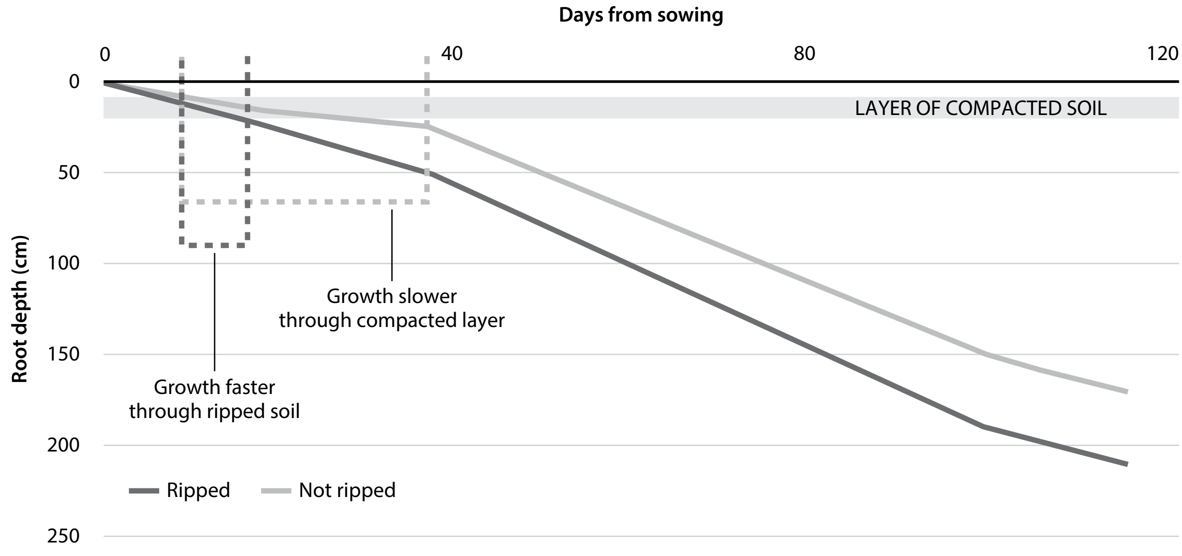
To fully gain the benefits of clay spreading, it is important to ensurethe clay is fully incorporated into the soil through discing, ploughing, spading or cultivating. Unincorporated or poorly incorporated clay can lead to surface crusting and poor water infiltration, decreasing both crop establishment and yields. Spreading clay that contains salt, boron, carbonates or the wrong pH can also decrease yields, so it is vital to get spreading material tested before you apply it to the top soil where the crop will be growing, as opposed to leaving it below the root zone of the crop.

For further information about clay spreading, Spread, delve, spade, invert – a best practice guide to the addition of clay to sandy soils is a valuable resource <www.grdc.com.au/GRDC-Booklet-SpreadDelveSpadeInvert>.

Deep ripping

Deep ripping can be used to ameliorate soils that have hard pans or compacted layers that are currently restricting crop root growth. By mechanically breaking up the hard soil, it allows the crop roots to grow deeper, potentially increasing access to moisture and nutrition. For deep ripping to have an effect, the tynes must be able to penetrate below the compacted layer.

It is important to test other soil constraints, such as sodicity, acidity or salinity to ensure these constraints are not brought up to the surface. It is also important to be aware that in drier seasons, deep ripping can increase the risk of the crop haying off as the roots grain access to soil moisture earlier, resulting in more vegetative growth, while constricted roots may use water slower. Care must be taken after deep ripping to ensure the soil is not re-compacted.



For those considering deep ripping, this factsheet <www.grdc.com.au/GRDC-FS-DeepRipping> provides useful, practical information.

Applying manure

Applying manures from intensive animal industries (chicken, duck, cattle, etc.) can provide a use for a waste product that provides nutrition to the crop. It is likely that if crop yield potential is limited by nutrition, applying manure high in nutrients will result in a yield benefit. However, it is important to get the manure analysed before spreading to determine how much of each nutrient is being applied and to ensure there is nothing in the manure that may cause a yield penalty. Applying too much nitrogen through manure applications may lead to the haying off of the crop, while manure that is acidic, high in salt or boron may reduce yields. It is also important to ensure the manure is not contaminated with weed seeds or other biosecurity hazards before spreading it across the paddock.

Areas for further research

This trial will be conducted for multiple years, to determine the longevity of the responses to soil amelioration and the responses of different crop types. Further research will focus on answering the questions outlined above and understanding the mechanisms that are causing the yield responses.

REFERENCES

Hunt N. Gilkes B. (1992) Farm Monitoring Handbook. University of Western Australia. <http://sustainableagriculture.perthregionnrm.com/sites/default/files/FMHch3_1.pdf>

ACKNOWLEDGEMENTS

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