Amelioration of water repellent sands – long term impacts

Stephen Davies, Research Officer, DAFWA
Andrew Kenny, 'Rubicon' and Colin McAlpine, 'Sandown'

Purpose: To assess amelioration options for water repellent sandplain soils
Location: Badgingarra
Soil Type: Pale deep water repellent sand
Growing Season Rainfall (Apr-Oct): 264 mm

BACKGROUND SUMMARY

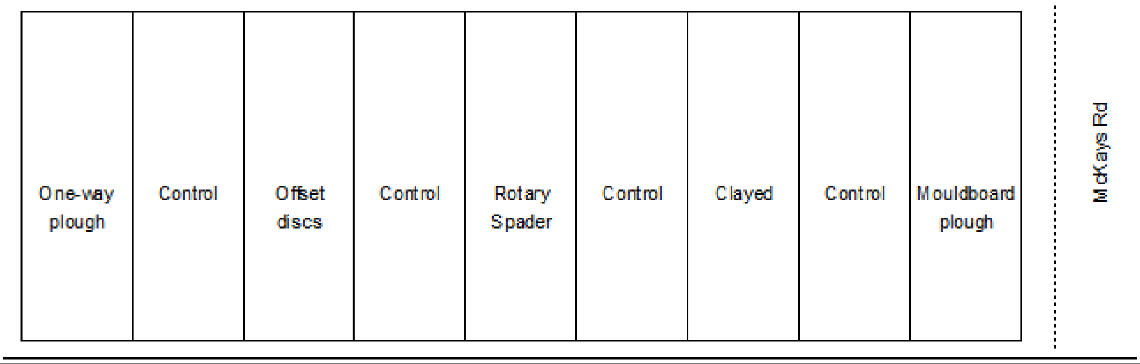
A range of options exist for managing soil water repellence in cropping systems. Mitigation options include furrow sowing and banded soil wetting agents that assist water entry into repellent soils. They are relatively cheap ($5-20/ha) to implement each season but need to be repeated every year. Soil amelioration options include one-off mouldboard ploughing, rotary spading and claying that either physically remove or overcome the topsoil water repellence. These options can give longer term and larger benefits but are slow to implement and can be expensive ($150-400/ha). To understand the financial benefit of these options is vital to know how long the productivity gains from their implementation are likely to last.

TRIAL DESIGN

Large-scale on-farm strip trials with repeated controls using grower seeders and harvesters**.** The Kenny demonstration sites was established in 2010 with initial mouldboard ploughing, in 2012 additional mouldboard ploughing and claying treatments were applied. The amelioration demonstration at McAlpine's was established in 2011.

TRIAL LAYOUT

McAlpine – Soil Amelioration Demo Layout
Plots 9m x100m



Kenny – Mouldboard and Claying Demo Layout

Clayed 2012 ~150t subsoil/ha
Untreated Control 1
Mouldboard 2010
Clayed 2012 on Mouldboard 2010
Mouldboard 2010
Untreated Control 2
Clayed 2012 + Mouldboard 2012
Mouldboard 2012

Table 1: Kenny and McAlpine trial details

Site	Soil Water Repellence		Start year	Rotation 2011-14	2015 Crop Variety	2015 Seeding date and rate	2015 Fertiliser and rate
	MED	Rating					
Kenny “Rubicon”	4.1	Very severe	2010	Lu-Ba-Ba-Lu	Mace Wheat	21 May 100 kg/ha	90 kg/ha K-Till Plus 150 kg/ha NS41
McAlpine “Sandown”	3.3	Severe	2011	Wh-Lu-Wh-Lu	Mace Wheat	10 June 90 kg/ha	100 kg/ha K-Till Extra 100 kg/ha NKS at tillering 40 L/ha Flexi-N

RESULTS and DISCUSSION

Mouldboard and Claying Demo - Kenny

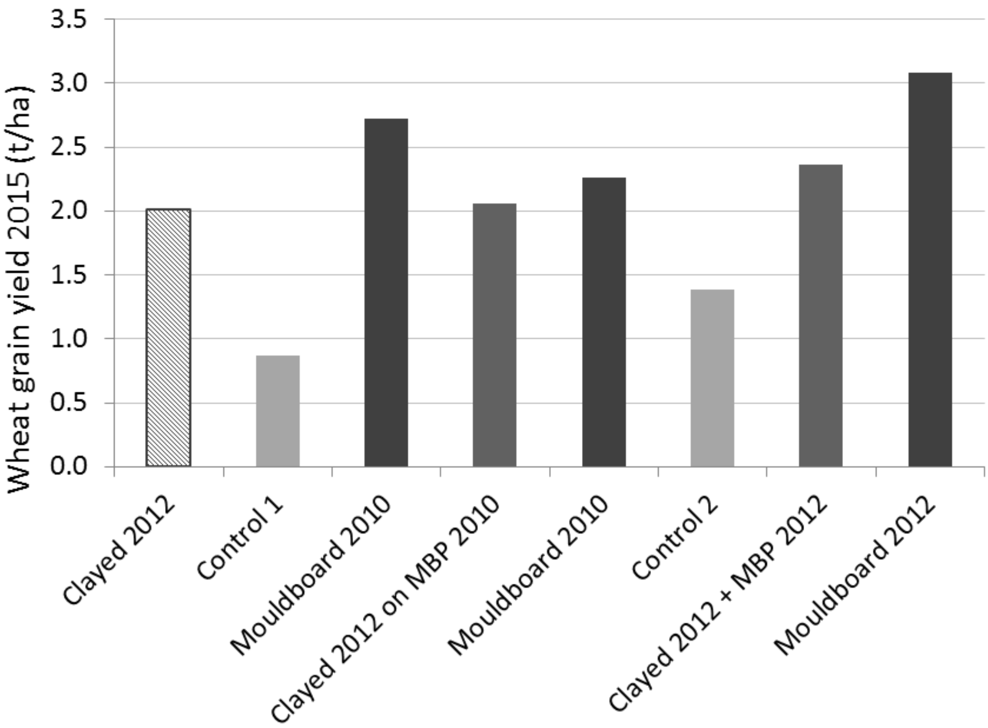
In 2015 the site was sown to wheat following a lupin crop in 2014 (Table 1). This was the sixth season of cropping since the original mouldboard ploughing was undertaken in 2010 and growing season rainfall for 2015 was the lowest recorded over that time (Table 2). Only 27 mm of rainfall was received in May (Table 2), this did follow 45 mm of rainfall in the first half of April. The crop was sown on the 21 May following about 22 mm rainfall over the previous 4 days. The season had a dry finish with only 15 mm of rainfall in September and 4 mm in October.

Table 2: Rainfall data from Badgingarra Research Station weather station, 2010-2015

Rainfall (mm)	2010	2011	2012	2013	2014	2015
May	71	76	15	116	93	27
June	26	93	113	14	42	67
Growing Season (April-October)	300	485	331	446	407	264
Annual	374	556	511	524	441	331

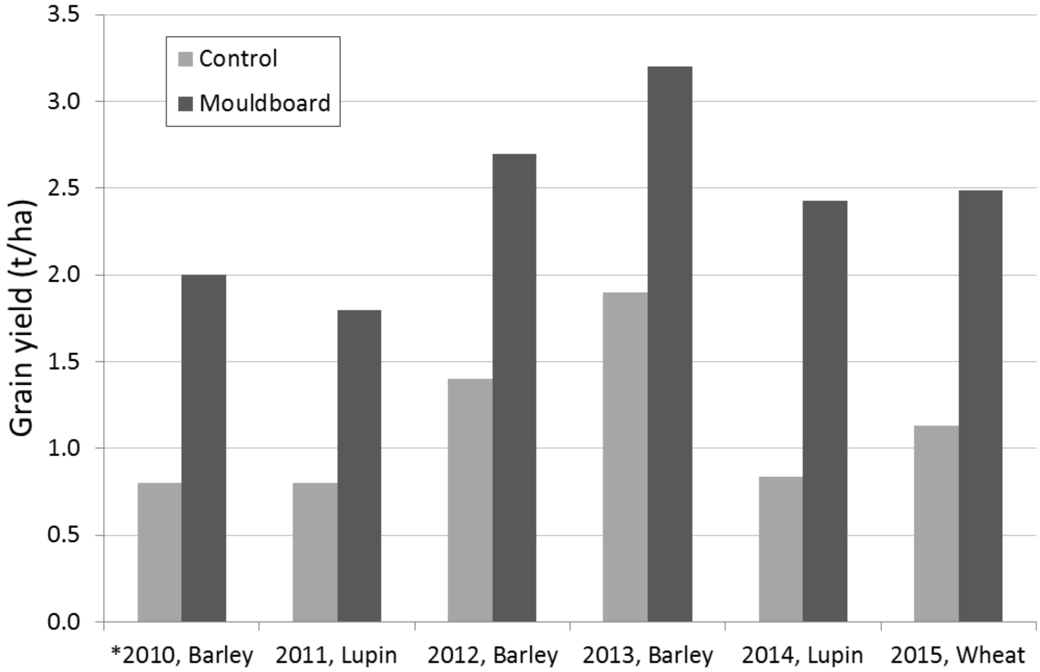
Across the site yields in the control strips ranged from just 0.9-1.4 t/ha (Fig. 1). Establishment remains poor on these areas despite continuous cropping with a paired row seeder. Soil amelioration greatly improved grain yields. In 2015 the 2010 mouldboard ploughing treatment increased the yields over the neighbouring control strips by an average of 1.4 t/ha, a 120% increase (Figs. 1 and 2). Claying on its own increased the yield by 1.1 t/ha over its neighbouring control strip in 2015 (Control 1) but addition of clay to ploughed areas has shown no additional benefit (Fig. 1). The mouldboard ploughing in 2012 had the highest yield, 3.1 t/ha, and increase of 1.7 t/ha (122%; Fig. 1).

Figure 1: Wheat grain yield (t/ha) in 2015 for a range of soil amelioration treatments and untreated control strips for severely repellent pale deep sand at Badgingarra (Kenny site)



Over the 6 seasons the site has been measured the 2010 mouldboard ploughing has increased the yield of each crop by 1.0 t/ha or more (Fig. 2). This site is severely repellent and the yield of the control crops is always low, even in wetter seasons. While the crop yield increases at this site are impressive they are not necessarily typical with yield responses in other soil amelioration experiments more commonly resulting in yield increases of 400-700 kg/ha.

Figure 2: Grain yield (t/ha) in untreated and mouldboard ploughed treatments over 6 seasons for severely repellent pale deep sand at Badgingarra (Kenny site)



*2010 was the year the mouldboard ploughing (soil inversion) was done and sown to a barley cover crop.

Amelioration Demo – Colin McAlpine

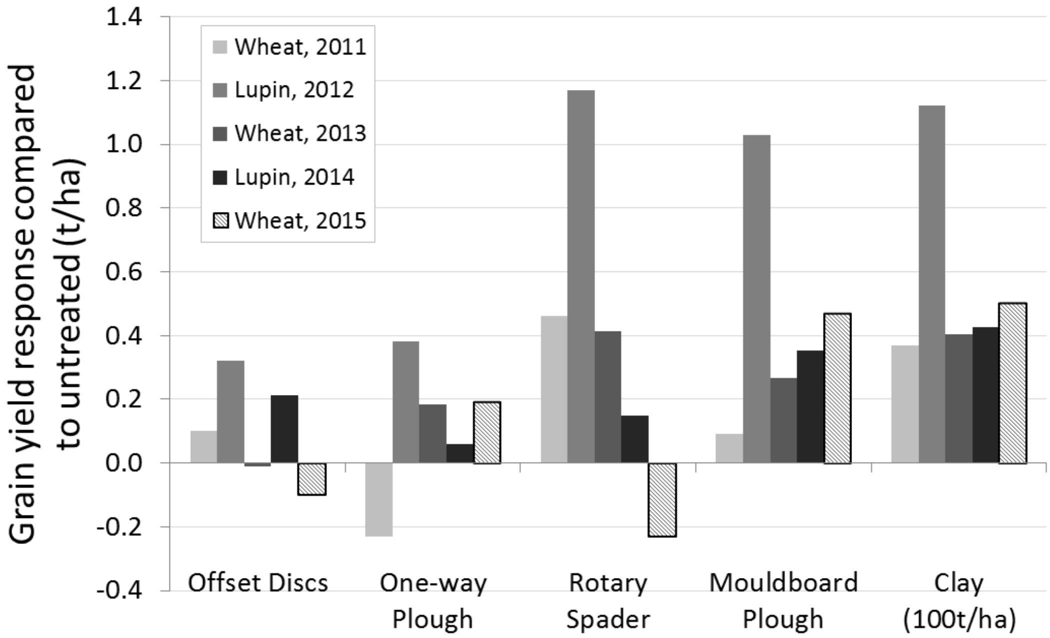
This site was established in 2011 when the one-off cultivation treatments were applied, so 2015 was the fifth cropping season. The site is largely located on poor performing area of pale deep sand, in 2015 the untreated control plots yielded between 1.2 and 1.7 t/ha (data not shown).

Wheat grain yield responses in 2015 to the soil amelioration treatments were variable with both negative and positive responses. The offset disc treatment had small yield reduction in 2015 and in general the cereal years have not responded well to this treatment (Fig. 3). Overall the relatively small yield responses in the lupin years and nil or negative responses in the cereal years indicate that this treatment is probably not significantly impacting on crop yield and the differences measured could largely be attributed to natural variation. Rotary spading gave some of the largest yield responses in the first three years after it was applied but in the last 2 years the responses have declined and in 2015 was negative (Fig. 3). Visually this treatment appeared to be performing well in both 2014 and 2015 so the poor yield results have been surprising. This treatment appears to struggle to meet its yield potential but why this is the case is something of a mystery. There is evidence that in some cases spading can disrupt deep subsoil macropores and biopores, important pathways for root growth, so this reduces the growth and proliferation of roots deeper in the subsoil below the working depth of the spader and that this may reduce the capacity of the crop to access deeper moisture during grain fill (Scanlan et. al. 2013). In that example, however, this negative impact of the spading was seen immediately whereas at this site the initial results from the spading were excellent.

Certainly this doesn't seem to be a universal problem as other trials and grower experience has not shown the same problem, although in many of those instances the sites were also deep ripped prior to spading which may have aided deeper root development in spite of the macropore disruption.

For the one-way plough, mouldboard plough and claying treatments there have still been yield increases, 5-seaons after the treatments were applied. One way ploughing increased the yield over the controls by an average of 190 kg/ha, mouldboard ploughing by 470 kg/ha and claying by 500 kg/ha (Fig. 3).

Figure 3: Change in crop grain yield over 4 seasons for a range of soil amelioration treatments applied once only in 2011 to severely water repellent pale deep sand at Badgingarra (McApline site)



Over the 5-seasons the demonstration has been running it has been possible to see trends in how crop yields are responding to different treatments (Fig. 3). Responses to the offset discs have been relatively small and highly variable, while responses to one-way ploughing have also been small but more consistently positive apart from the first season when this treatment was severely sandblasted. For the deeper tillage approaches the yield responses to spading tend to be declining over time whereas the responses to mouldboard ploughing have been tending to get better. Claying has resulted in relatively high and consistent responses over time with yield gains of 400-500 kg/ha consistently apart from the large lupin yield increase in 2012 of over 1 t/ha (Fig. 3).

FINANCIAL ANALYSIS OF RESULTS

For the Kenny demo large and consistent yield responses over 6-seasons have resulted in a high level of returns (Table 3). The initial barley yield benefit of 1.2 t/ha more than paid for the cost of the treatment. In total the discounted financial benefit over the 6-seasons is nearly $1700/ha (Table 3), representing a cumulative return on investment of 12.3.

Table 3: Grain yield increase and discounted return (interest rate 6%) in response to mouldboard ploughing (MBP) of pale deep sand at Badgingarra (Kenny site) **over 6-seasons**

Season	Crop	Yield increase from MBP (t/ha)	Grain price $/t	Discounted benefit from MBP ($/ha)
1	2010, Barley	1.2	340	258*
2	2011, Lupin	1	200	188
3	2012, Barley	1.3	310	353
4	2013, Barley	1.3	245	258
5	2014, Lupin	1.59	320	375
6	2015, Wheat	1.36	297	267
Total 6-year benefit				*1699*
Cumulative Return on Investment				*12.3*

* Initial cost of mouldboard ploughing once only in 2010 was approximately $150/ha.

For the McAlpine amelioration demo the cumulative benefit and return on investment has been determined for all 5-seasons (Table 4). Because of its relatively low cost and the yield benefits for the last 4-seasons one-way ploughing has the best return on investment with mouldboard ploughing and offset discs not far behind (Table 4). Rotary spading had been similar to mouldboard ploughing but the negative result in 2015 and poorer result in 2014 has seen it drop behind in terms of net additional income and return on investment. The high initial cost of claying still results in it having the lowest return on investment (Table 4), but it is likely that this treatment will be the longest lasting and the benefits in terms of improved soil stability and reduced wind erosion risk also needs to be considered.

Table 4: Cost, net 5-year returns (after cost) and return on investment for a range of soil amelioration treatments applied once only in 2011 to severely water repellent pale deep sand at Badgingarra (McAlpine site)

Treatments, applied 2011 (Amelioration Demo)	Cost ($/ha)	Net 5-year Benefit $/ha	Return On Investment
Offset Disc	30	$133	5.4
One-way Plough	30	$150	6.0
Rotary Spader	150	$435	3.9
Mouldboard plough	120	$544	5.5
Clay (100t/ha)	400	$446	2.1

CONCLUSION

These grower scale on-farm soil amelioration demonstrations have been managed by the growers according to standard practice. Both soil types are highly water repellent and in general the amelioration treatments have improved crop establishment, vigour and grain yield. Economic analysis indicates that the return on investment has been large as the benefits from the treatments have tended to last for at least 5-years or more at these sites. While it is possible to improve establishment, water and nutrient use efficiency and crop productivity using these techniques it is important to recognise that other constraints such as poor water and nutrient holding, soil acidity and compaction can still limit the yield potential of these soils and this needs to be considered when investing in amelioration. Liming to improve the soil pH and very deep ripping to remove compaction below 30-40 cm may well provide further yield gains beyond those achieved through amelioration of the top 10-30 cm only, and this may also help sustain the benefits of amelioration over a longer time.

REFERENCES

Scanlan C, Davies S, Best B (2013) Managing nutrition on soils that have been treated for water repellence by cultivation. 2013 Agribusiness Crop Updates, 25-26 February 2013, Perth. www.giwa.org.au/2013-crop-updates

PEER REVIEW

Liam Ryan (DAFWA)

ACKNOWLEDGEMENTS

This research is funded by DAFWA and GRDC through DAW00244 'Delivering enhanced agronomic strategies for improved crop performance on water repellent soils in WA'. Thanks to the growers, their families and staff for establishing and managing the trial sites and allowing us access to them – it is much appreciated.