Amelioration of water repellent soils in the West Midlands – long term impacts

Stephen Davies, Research Officer, DAFWA
Colin McAlpine and Andrew Kenny, West Midlands Group

Purpose:	To assess amelioration options for water repellent sandplain soils
Location:	Badgingarra
Soil Type:	Pale deep water repellent sand
Growing Season Rainfall (April- October 2014):	407 mm (BRS)

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 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 demo was established in 2010 with initial mouldboard ploughing, in 2012 additional mouldboard ploughing and claying treatments were applied.

Mouldboard and Claying Demo Layout - Kenny

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

The amelioration demo at McAlpine's was established in 2011.

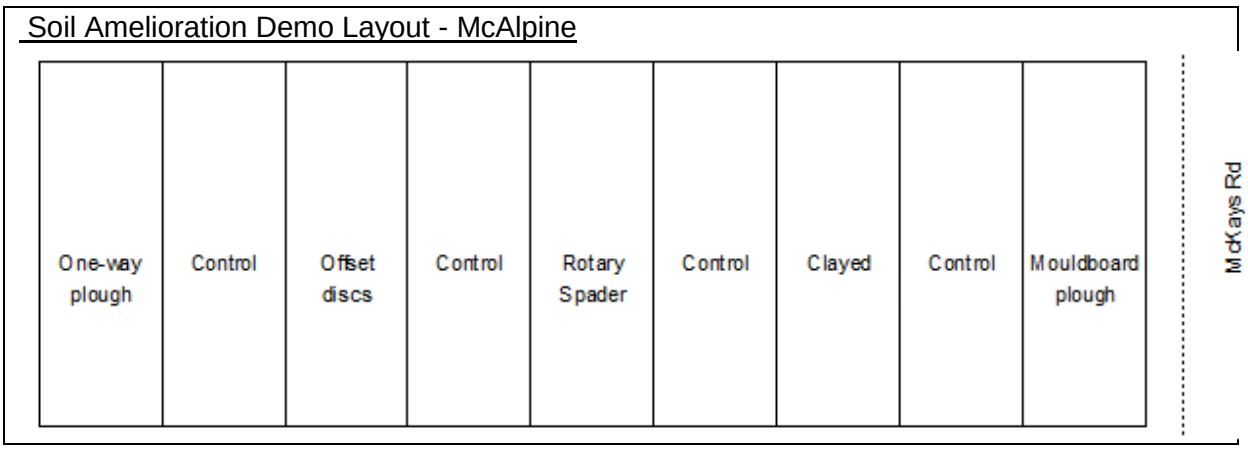

Table 1. Kenny and McAlpine Trial details

Site	Soil Water Repellence		Start year	Rotation 2011-13	2014 Crop Variety	2014 Seeding date and rate	2014 Fertiliser and rate
	MED	Rating					
Kenny "Rubicon"	4.1	Very severe	2010	Lu-Ba-Ba	Gunyidi Lupin	10 May 100 kg/ha	PMI, MAP, MOP 100 kg/ha
McAlpine "Sandown"	3.3	Severe	2011	Wh-Lu-Wh	Gunyidi Lupin	26 May 48 kg/ha	PMI, MAP, MOP 100 kg/ha

RESULTS and DISCUSSION

Mouldboard and Claying Demo - Kenny

In 2014 the site was sown to lupin following 2 years of cereal crops (Table 1). The season started well with 33 mm rain over 25 -29 April and a further 49 mm over the 5 - 10 May just before seeding (data not shown). A total of 93 mm of rain was received in May with a further 42 mm in June (Table 2). So given the good rainfall soil moisture conditions should have been good at the time of seeding but soil water repellence at this site is so severe that dry patches can always be found in the untreated control areas.

Table 2. Rainfall data for Badgingarra Research Station weather station for 2010-2014

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

Soil inversion with a mouldboard plough, either with the 2010 ploughing or the latter ploughing in 2012 resulted in very large lupin yield responses 2014. Despite a relatively good season with a good break and growing season (Apr-Oct) rainfall of 407 mm the control areas yielded only 0.6-1.1 t/ha (Figure 1).

This is partly due to poorer establishment but is also a result of poor crop vigour due to poor water use and likely reduced nutrient access because of the repellent soil limiting root growth and function. For the 2010 and 2012 mouldboard ploughing treatments the crop yielded between 2.2 and 2.5 t/ha, an increase in yield of at least 1.4 t/ha (Fig. 1). Spreading of clay at around 150 kg subsoil/ha on top of the inverted soil has tended to reduce the yield benefit. In 2012 some clay was spread and inverted using the mouldboard plough so that there is some clay in the subsoil and for the first time in 2014 there was an indication that this treatment may have yielded about 350 kg/ha more than the 2012 mouldboard ploughing without clay (Fig. 1). An area that was clay spread without mouldboard ploughing in 2012 improved the yield by about 250 kg/ha but still performed poorly compared to other treatments, yielding only 1.3 t/ha, at least 1 t/ha less than the mouldboard ploughing treatments.

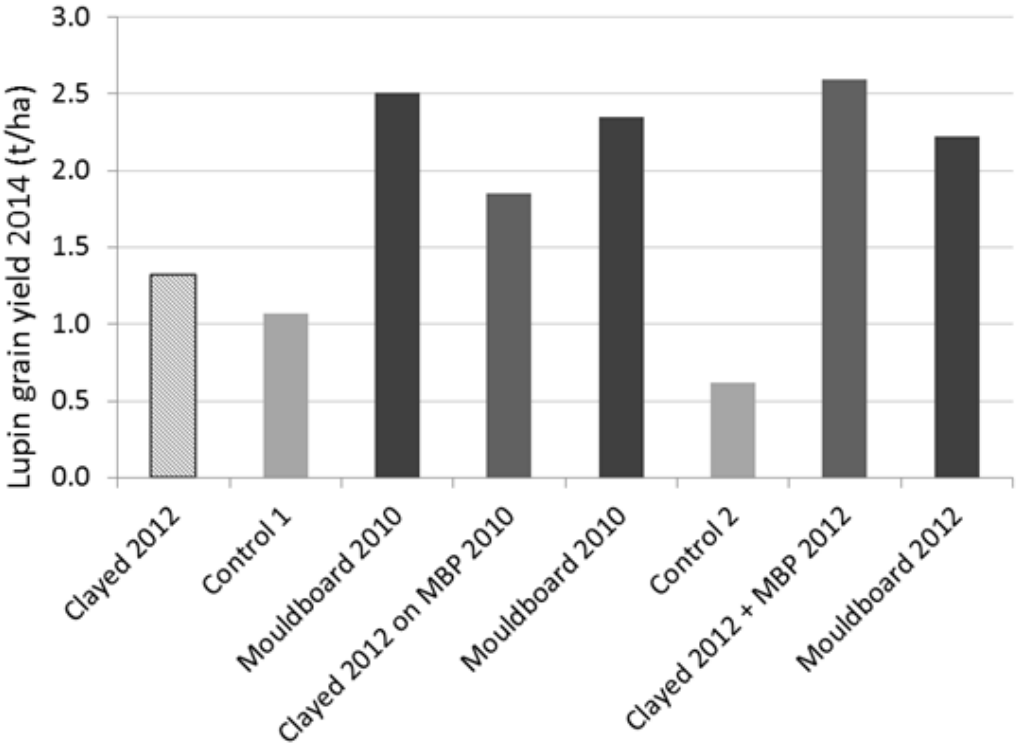

Figure 1. Lupin grain yield (t/ha) in 2014 for a range of soil amelioration treatments and untreated control strips for severely repellent pale deep sand at Badgingarra

The 2014 season was the fifth-season after the initial mouldboard ploughing treatment was applied in 2010, and grain yield increases in response to soil inversion have been in excess of 1 t/ha or more for every season (Fig. 2). This is in part due to the very severe repellence at this site which greatly restricts the yield on the untreated areas. Between 2010 - 2014 there has been an additional 3.8 t/ha of barley grain grown over 3 barley crops and 2.6 t/ha of lupin grain over two lupin crops (Fig. 2). Barley on the mouldboard ploughed soil has consistently yielded about 1.2 to 1.3 t/ha more than the control each year it has been grown.

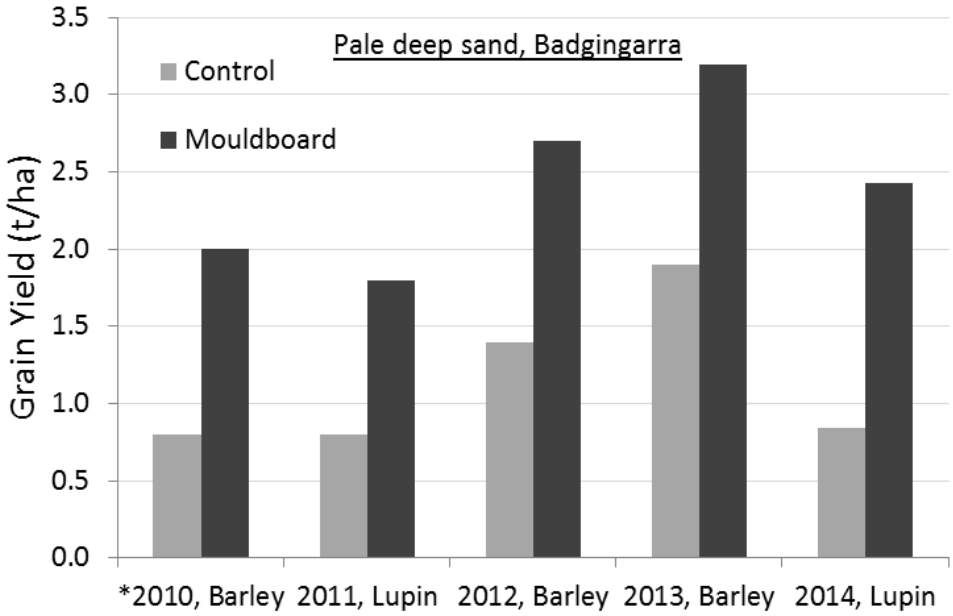

Figure 2. Grain yield (t/ha) in untreated and mouldboard ploughed treatments over 5 seasons for severely repellent pale deep sand at Badgingarra. *2010 was the year the mouldboard ploughing (soil inversion) was done and sown to a barley cover crop.

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.

Soil Amelioration Demo – McAlpine's

This site was established in 2011 when the one-off cultivation treatments were applied so 2014 was the fourth cropping season. Generally all of the treatments have resulted in yield increases but these have been smaller for the offset discs and one-way ploughing compared to the mouldboard ploughing, rotary spading or claying (Figure. 3).

In 2014 the site was sown to lupins. A shortage of seed meant that the seeding rate was low and would have reduced the potential yield of the crop, with the untreated plots yielding between 0.76 and 1.35 t/ha (data not shown).

Lupin grain yield increases in 2014 from smallest to largest were: 60 kg/ha (4%) for one-way ploughing; 150 kg/ha (13%) for spading; 210 kg/ha (17%) for offset discs, 350 kg/ha (46%) for the mouldboard ploughing and 430 kg/ha (46%) for the claying (Figure. 3). The site has repeated control strips (see site diagram) to account for the site variation and there was a trend towards increasing yield from the eastern (mouldboard) end of the trial out to the western (one-way) end. This resulted in the mouldboard plough and clayed treatments having the same % yield increase compared to their nearest control. There was no significant impact of one-way ploughing on grain yield in 2014 and the impact of the spading seems to be declining although in previous years it was one of the better performers. Similarly the impact of the disc ploughs has been variable over the years and it is expected that their impact will dissipate quicker than the deeper cultivation methods.

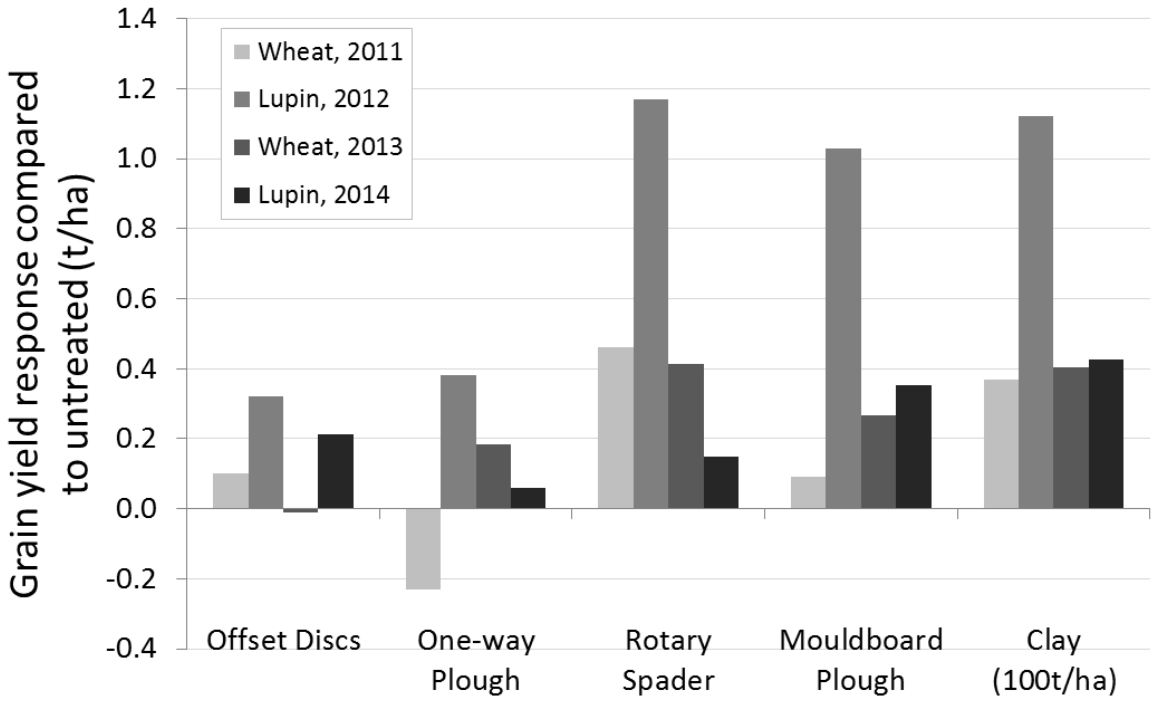

Figure 3. Change in crop grain yield over 4 seasons for a range of soil amelioration treatments applied once only in 2011 to severely water repellent pale deep sand at Badgingarra

FINANCIAL ANALYSIS

Amelioration Demo - McAlpine

The net returns and return on investment has been determined for the soil amelioration demo site annually (Table 3). Because of the lupin yield response in 2014 and the relatively low-cost the offset disc treatment has the best return on investment, while spading, mouldboard and one-way ploughing are all similar at this stage (Table 3). Overall $ returns are highest for spading, mouldboard ploughing and claying. The high cost of claying has resulted in it having the lowest return on investment so far (Table 3).

Table 3. Cost, net 4-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

Treatments, applied 2011 (Amelioration Demo)	Cost ($/ha)	Net 4-year Benefit	Return On Investment
Offset Disc	30	$162	6.4
One-way Plough	30	$96	4.2
Rotary Spader	150	$500	4.3
Mouldboard plough	120	$410	4.4
Clay (100t/ha)	400	$303	1.8

Although claying is the costliest of the amelioration options it has shown the most consistent establishment at the amelioration demo and the soil surface is firm and stable so it is at reduced risk of wind erosion. This may allow greater feed utilisation in a mixed enterprise system. Other research has shown that the benefits of claying can last many decades and at higher clay rates it has been demonstrated that, over time, soil carbon content can increase

improving soil fertility. This amelioration demo will continue to be monitored to see if ultimately the claying treatment starts to out-perform the cultivation treatments.

There is an indication that bigger responses to claying are observed when the clay-rich subsoil is high in potassium, providing an ongoing nutrition benefit to the crop. Some clay-rich subsoils can be sodic, have high levels of boron or salt and high P-fixing so it is worth getting the subsoil analysed before spreading.

CONCLUSION

These grower scale on-farm soil amelioration demonstrations have been managed by the growers according to standard practice. Both soil types were highly water repellent and the amelioration treatments have generally improved establishment but have probably had an even bigger impact on crop vigour. 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. Pale sands which overly a clayey gravel or clay base within the top 1 m often have greater potential than the very deep sands.

PEER REVIEW

Bindi Isbister (DAFWA)

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