Large barley yield responses four years after soil inversion on highly repellent pale deep sand

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Purpose:	To assess the impact of mouldboard ploughing and clay spreading on soil water repellence and grain yield
Location:	'Rubicon' Goonderoo Rd, Badgingarra
Soil Type:	Pale deep sand (severely water repellent)
Rotation:	2010 Barley; 2011 Lupin; 2012 Barley; 2013 Barley
Growing Season Rainfall (April- October 2013):	446 mm (Badgingarra Research Station)

BACKGROUND SUMMARY

A number of options exist for managing water repellent sandplain soils. The range of options includes better sowing methods that are relatively cheap to implement and can be used over the whole cropping program and long-term more costly amelioration methods such as clay spreading, mouldboard ploughing and rotary spading. Given the relatively high cost of soil amelioration treatments it is important that they result in substantial yield gains and are long lasting. Large-scale on-farm demonstrations provide an opportunity to test the soil amelioration treatments within the farming system. This demonstration site is on severely repellent pale deep sand that had a history of blue lupins. A trial area of mouldboard ploughing was initially established in 2010. In 2012 more mouldboard ploughing and clay-spreading treatments were implemented at the site. Clay-rich subsoil (~30% clay) was spread at a rate of ~150 t/ha using a multi-spreader.

TRIAL DESIGN

Repetitions: Large scale demonstration – 2 replicated control strips

Crop type and varieties used: Hindmarsh barley

Seeding rates and dates: 70 kg/ha on 7 May 2013

Fertilizer rates and dates: 100 kg/ha MacroPro and 40 L/ha Flexi-N with Intake at seeding

80 kg/ha NS51 on 10 July

40 L/ha Flexi-N on 15 August

Treatment rates and dates:

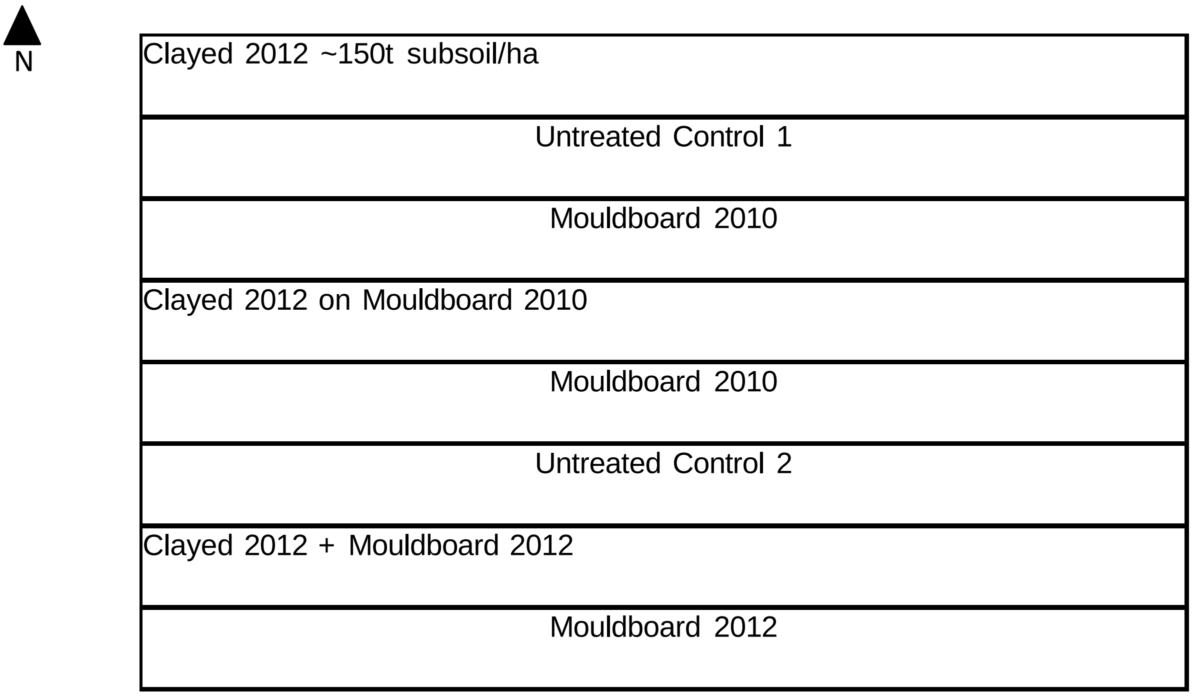
2010 – mouldboard ploughed 5 ha

2012 – mouldboard ploughed a further 30 ha in the trial paddock 2012

– clay strips 150 t clay-rich subsoil/ha

2012 – combined treatments included a strip of clay spread on top of part of the 2010 mouldboard ploughing (Mouldboard 2010 + Clay) or an area of spread clay that was then inverted into the subsoil using a mouldboard plough (Clay + Mouldboard 2012).

TRIAL LAYOUT



RESULTS and DISCUSSION

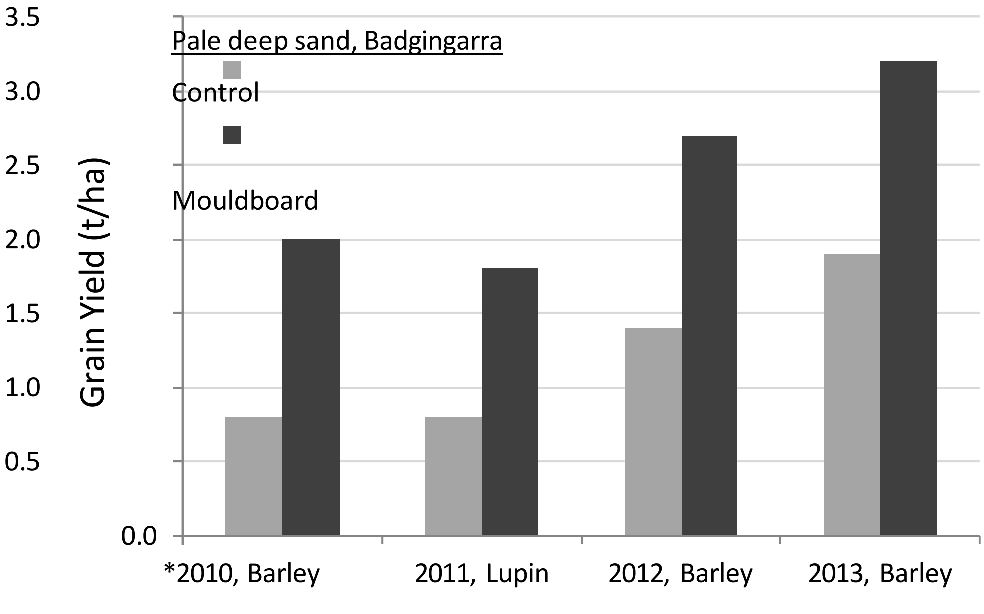


Figure 1. Grain yield (t/ha) in untreated and mouldboard ploughed treatments over 4 seasons for severely repellent pale deep sand at Badgingarra. *2010 was the year the mouldboard ploughing (soil inversion) was done and sown to a barley cover crop.

The one-off 2010 mouldboard ploughing treatment has resulted in yield increases of 1.0 t/ha or more for the past 4 seasons (Figure 1). The measured yield increases were partly a result of overcoming the water repellence by soil inversion and improving crop establishment. Barley establishment was improved by ~50% (40 more plants/m^2) in 2010, lupin establishment increased by 300% (33 more plants/m^2) in 2011 and barley establishment by 75% (75 more plants/m^2) in 2012. Improved nutrient access and enhanced crop root growth in the 10-40 cm layer and, in the first few seasons at least, a soil loosening (deep ripping effect), could all contribute to the measured yield improvements. Soil moisture measurements at this site have shown that the buried topsoil can hold more moisture in the 10-40 cm layer than the pale, low clay content (<5% clay) sand.

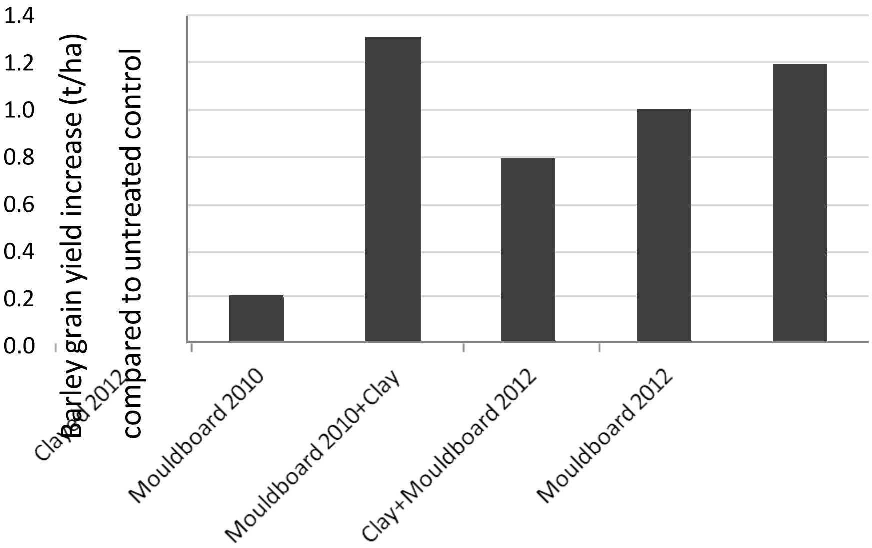


Figure 2. Barley grain yield (t/ha) response across a range of amelioration treatments compared with untreated control strips at Badgingarra in 2013. Note all clay spreading treatments were applied in 2012.

There is no evidence that productivity benefits from mouldboard ploughing in 2010 is starting to decline as the yield increase in 2013 was still greater for the 2010 mouldboard ploughing than the more recent 2012 mouldboard ploughing (Fig. 2). Clay spreading increased yield by 200 kg/ha and addition of clay-rich subsoil either on top of 2010 ploughed soil or prior to the 2012 ploughing has tended to reduce the yield benefit (Fig. 2). Where clay has been applied to the surface better incorporation is likely to increase the benefits.

Whole plant hand cuts were also taken to get an estimate of the change in whole shoot biomass. Claying increased shoot biomass by 1.5 t/ha; 2010 mouldboard ploughing by 2.2 t/ha and 2012 mouldboard ploughing by 1.9 t/ha (data not shown). This additional above ground biomass would be matched by increases in root biomass and represents increased return of carbon and nutrients back into the soil as the stubble breaks down over time and also improved soil cover over summer.

LONGEVITY OF ONE-OFF SOIL INVERSION BENEFITS

The large grain yield responses from one-off soil inversion at this site over the past four seasons have well and truly paid for the cost of one-off mouldboard ploughing but questions remain regarding how long the benefits are going to last. The longest running, replicated experimental trial with mouldboard ploughing was established by DAFWA in 2007 at Casuarinas (north of Mingenew) to look primarily at weed control and lime incorporation into acidic subsoil. The site is yellow sandplain with mild water repellence and an acid layer in the subsurface (10-30 cm) with pH ($CaCl_2$) typically ranging from 4.2-4.6. Treatments applied in 2007 were:

- untreated control
- 2 t/ha surface applied limesand (no incorporation)
- mouldboard ploughing, no lime
- 2 t/ha lime then mouldboard ploughed
- mouldboard ploughed then 2 t/ha lime on top
- 1 t/ha lime then mouldboard ploughed then 1 t/ha lime on top

In 2013, the seventh season after treatments were applied, all the plots were harvested with a plot header to look at lime impacts (Figure 3). Prior to this and post-2007 only yields of mouldboard ploughed versus control (not ploughed) were compared (Table 1).

Overall one-off soil inversion at this site has tended to improve wheat yields by 400-500 kg/ha and encouragingly this was also seen in 2013, seven seasons after the soil inversion (Table 1). These wheat yield increases have occurred despite the fact that there has been no increase in lupin grain yields as a result of soil inversion. Improved lupin growth and the additional soil nitrogen that is supplied as a result are often seen as an important driver for yield benefits in the subsequent cereal crop. Despite some cross-contamination from neighbouring plots it was clear from visual observation at harvest that the grass weed burden on the mouldboard ploughed plots was lower than on those that had not been ploughed.

Table 1. Crop types and grain yield over 7 seasons in response to one-off soil inversion with a mouldboard plough in 2007. GSR = growing season (Apr-Oct) rainfall. Note: barley sown late in 2007 after ploughing; canola sown too deep on ploughed plots using DAFWA cone seeder in 2008; 2013 wheat yield is an average of limed and unlimed treatments.

Year	Years after Treatment	Crop	GSR (mm)	Untreated Control	Mouldboard Ploughing	Difference (t/ha)
2007	1	Barley	233	0.7	0.8	+0.1
2008	2	Canola	313	1.5	1.4	-0.1
2009	3	Wheat	384	3.6	4.0	+0.4
2010	4	Lupins	257	1.6	1.6	0
2011	5	Wheat	361	5.1	5.5	+0.4
2012	6	Lupins	313	1.6	1.5	-0.1
2013	7	Wheat	350	2.8	3.3	+0.5

A look at the detailed breakdown of the 2013 yields (Figure 3) showed that application of 2 t/ha surface lime in 2007 without incorporation gave no yield benefit. Soil inversion with the mouldboard and no lime gave a 300 kg/ha yield benefit with application of lime at some point in the inversion process giving an additional 200 kg/ha yield benefit (Figure 3). Interestingly the data indicates that it may be more important to put at least some lime on the soil after inversion rather than all before although the difference between any of the liming strategies is not significant.

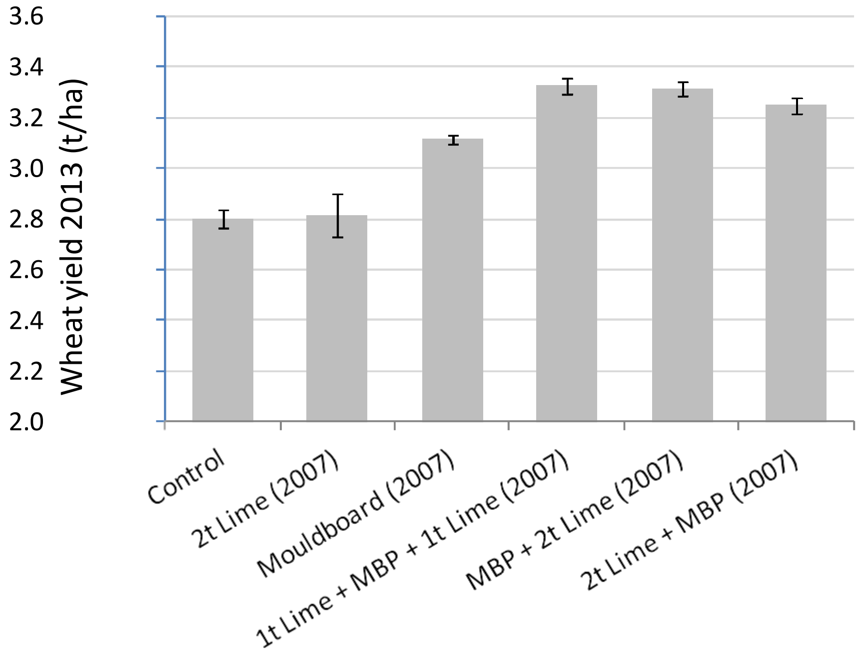


Figure 3. Wheat grain yields in 2013 for soil amelioration treatments applied once-only in 2007 on yellow deep sandy earth at Casuarina. (MBP = mouldboard plough). Error bars show the standard error of the mean of 4 replicates.

From these and other soil inversion trials it appears that longer-lasting benefits are generally obtained when:

- lower weed populations are sustained following soil inversion
- the topsoil buried by inversion is relatively high in organic matter
- improved lupin establishment and growth results in higher inputs of biological nitrogen
- capacity of the soil to hold and supply nutrients and water from the buried topsoil in the root zone is improved
- overall organic matter inputs are improved with higher productivity and crop biomass production which benefits overall soil fertility and may benefit biological activity.

PEER REVIEW

Megan Abrahams, DAFWA Geraldton

ACKNOWLEDGEMENTS

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