Big lupin responses to amelioration of repellent soil

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Purpose: To assess water repellent soil amelioration options and to determine whether a one-way plough can be used to ameliorate non-wetting sand for much lower cost than mouldboard ploughing or rotary spading.

Location: 'Sandown' McKays Road, Badgingarra

Soil Types: Pale deep sand

Rotation: Wheat 2009; Lupin 2010, Wheat 2011; Lupin 2012

Growing Season Rainfall (May- October 2012): 325 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 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. Mouldboard ploughs and rotary spaders overcome repellence by engaging the subsoil and bringing to the surface either a layer or seams of subsoil that are non-repellent while burying at depth the repellent topsoil. These layers or seams of non-repellent subsoil brought to the surface providing pathways for water entry into the soil. In many cases these tools have proven to be very successful and yield increases have been significant in the first year, often in excess of 500 kg/ha. However both the mouldboard plough and the rotary spader are costly to purchase and to use. One-way disc ploughs can still be found and are relatively cheap to use and maintain and may offer a cheaper alternative to the more expensive deep cultivation techniques. To be effective the one-way plough would need to work in the subsoil and tip the soil on its side so that columns of subsoil are created that could act as pathways for water entry into the repellent topsoil. In this on-farm demonstration one-off one-way ploughing is compared with other soil amelioration techniques, including mouldboard ploughing, rotary spading and claying and with shallow cultivation using offset discs.

METHODOLOGY

Plot size: 9 m x 190 m

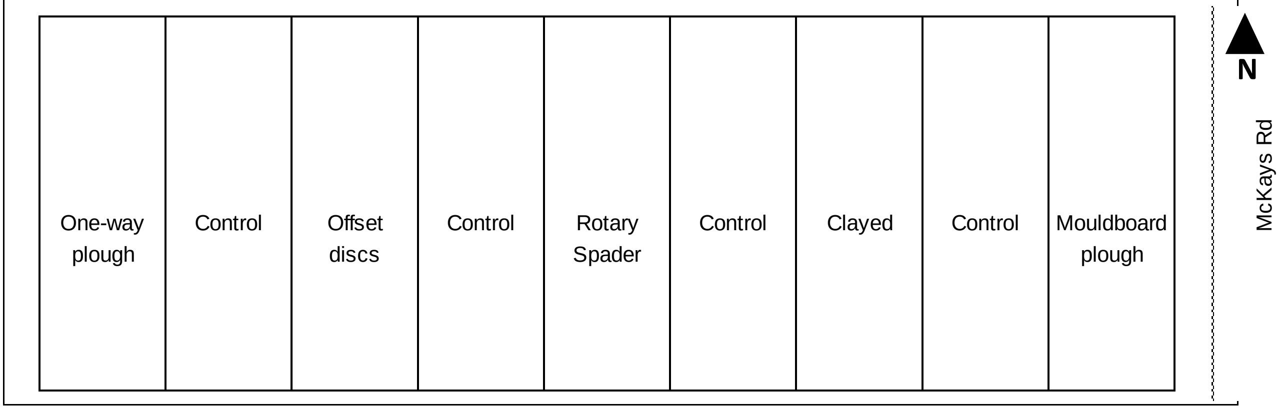
Repetitions: Repeated control (untreated) plots only (see Trial layout)

Soil amelioration treatments:

1) Control - untreated
2) Mouldboard ploughing to ~35 cm, April 2011
3) Clay-spreading, 120 t clay-rich subsoil/ha, April 2011, shallow (10 cm) incorporation
4) Rotary spaded to ~35 cm, April <u>2010</u>
5) Offset discs to ~10 cm, April 2011
6) One-way disc plough to ~15 cm, April 2011

Sowing details: Tanjil lupin, sown 28 May, 80 kg/ha

TRIAL LAYOUT



RESULTS and DISCUSSION

Harvest results are based on three transects of hand harvest cuts. For each cut, plant number, total shoot dry weight and seed dry weight were recorded. Unfortunately machine harvest grain yield could not be collected in 2012 and it should be noted that hand cuts can overestimate yield and in a more variable crop like lupin it can be difficult to get an accurate yield estimate.

Despite not being a fully replicated trial repeated control plots were included in the design which takes into account site variation so treatment differences can be compared with the nearest control.

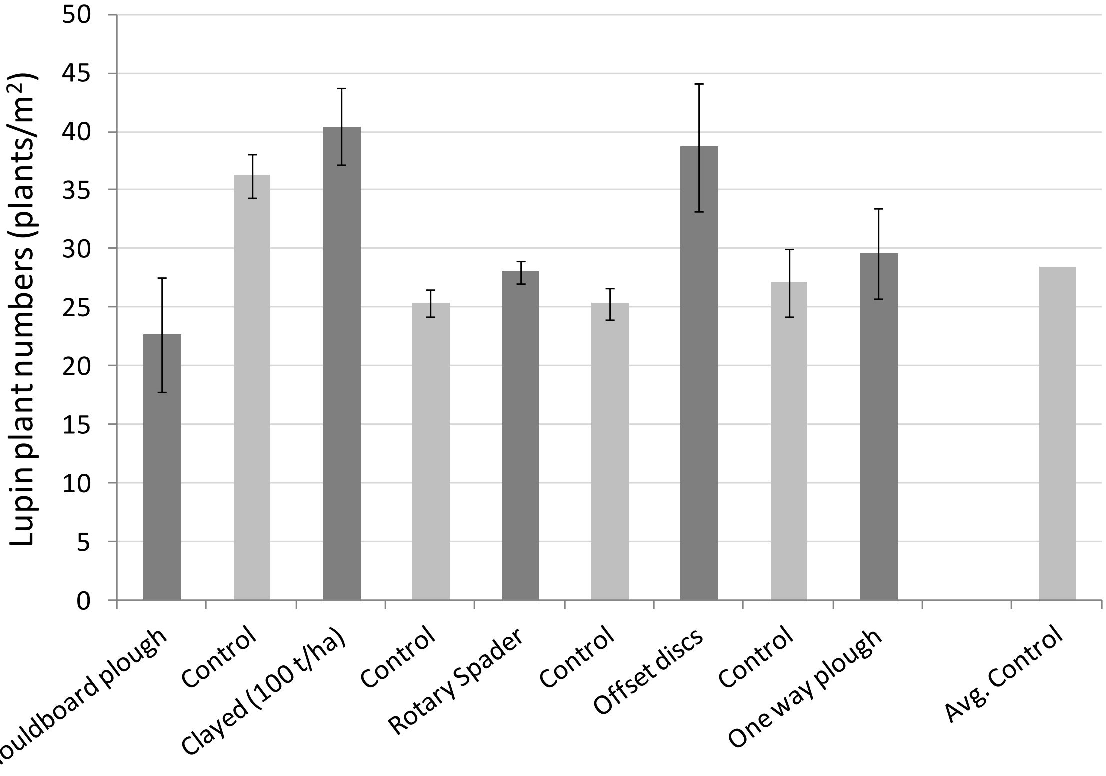


Figure 1.Lupin plant number (plants/m^2) measured from harvest cuts at crop maturity.

In general establishment was still highly staggered at the site, particularly in the control treatments. Early (21 June) establishment was best for clayed, spaded and one-way ploughed but by harvest time late emergence on the control plots in particular had reduced the difference in plant numbers (Fig. 1). Despite some recovery of plant numbers in control treatments subsequent crop growth was poor; plants were small which was reflected in low grain yield per plant (Fig. 2), low biomass (Fig. 3) and low grain yield (Fig. 4) in the untreated plots.

Mouldboard ploughing

Establishment was low (Fig. 1) possibly due to fairly poor inversion with the repellent topsoil not completely buried below the seeding depth. Despite lower plant numbers plant growth was good and plants in the mouldboard treatment had equal highest weight of seed per plant along with spading and one-way ploughing, much higher yield/plant than the untreated control (Fig. 2). Shoot biomass was increased by 2.09 t/ha over the untreated control (Fig. 3), a 91% increase, which represents significantly higher inputs of legume derived N also. Grain yield showed similar trends with mouldboard ploughing increasing the grain yield by 1.03 t/ha, a 104% increase (Fig. 4). Compared with the other treatments mouldboard ploughing had poorer establishment but compensated for this with better plant growth and yielded similarly to the best of the other treatments, namely claying and spading.

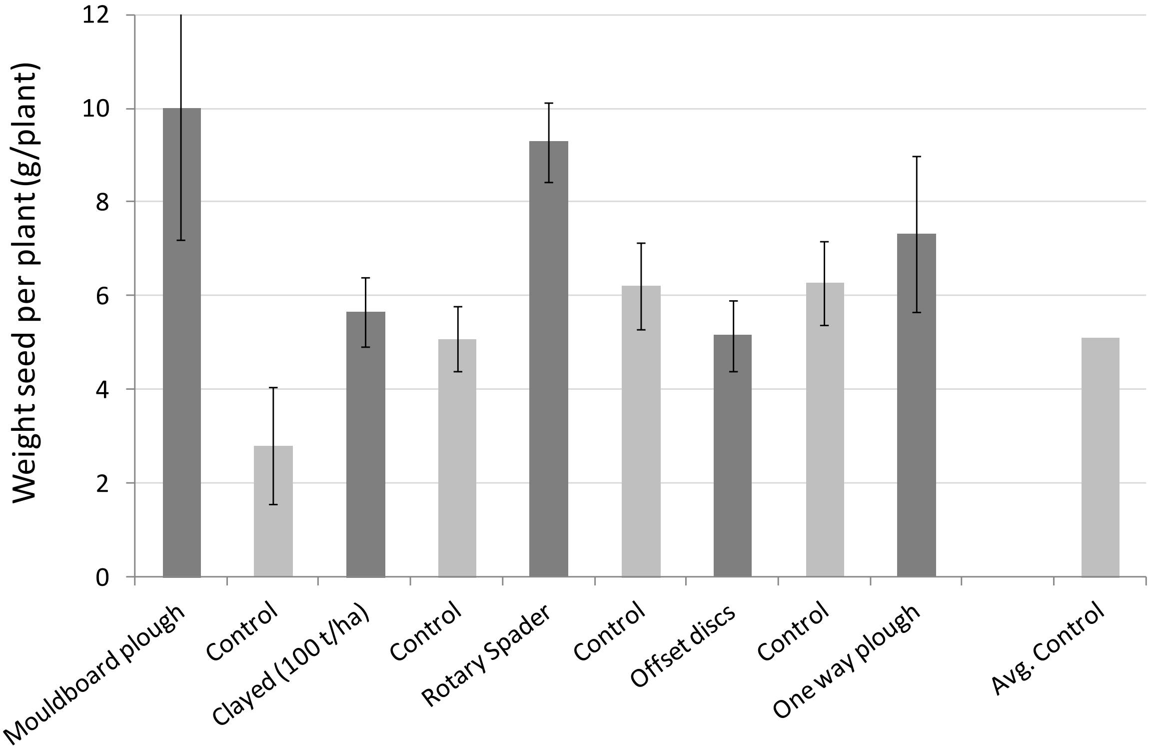


Figure 2. Total weight of seed per plant for lupin grown on pale deep sand, Badgingarra, 2012.

Claying

The clay spreading treatment had the best and most consistent establishment (Fig. 1) and establishment appeared less staggered for this treatment. Overall seed yield per plant was lower for this treatment compared with mouldboard plough and rotary spader treatments (Fig. 2) but this appeared partly due to more even establishment and consistent and moderate plant size. Due to higher plant numbers however biomass (Fig. 3) and grain yield (Fig. 4) for the claying treatment was good. Compared to the appropriate neighbouring controls claying increased biomass by 2.35 t/ha (90% increase) grain yield by 1.12 t/ha (99% increase). Claying on this pale deep (gutless) sand at a moderate clay rate is one of the highest performing treatments along with rotary spading with the added advantage of protecting the soil from wind erosion better than the other treatments.

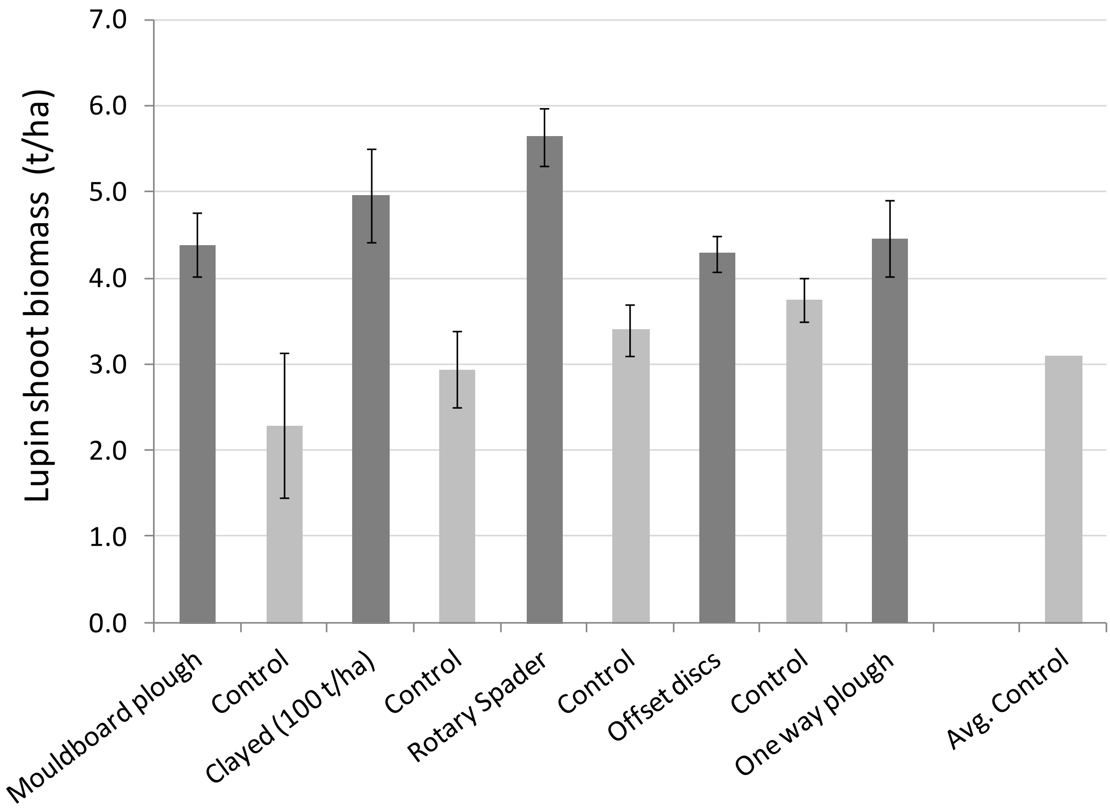


Figure 3. Total shoot biomass (t/ha) for lupin grown on repellent deep sand, Badgingarra, 2012.

Rotary Spading

The rotary spading strip was done a year before the other treatments so this is its third season since being implemented and it is encouraging to see ongoing benefits. Establishment was improved a little by spading compared to its neighbouring controls (Fig. 1), an increase of nearly 3 plants/m^2, an 11% increase. What stood out visually was the excellent and vigorous crop growth in the spaded treatment. Shoot biomass (Fig. 3) was increased by 2.47 t/ha (78% increase) and grain yield (Fig. 4) by 1.17 t/ha (82% increase). It was clearly obvious that weed numbers and weed growth were also highest on the spading with a lot more wild radish in this treatment. Overall rotary spading together with claying has been one of the best performing treatments and it is hoped that with the improved fertility coming from bigger biomass lupin crops subsequent cereal crops will continue to benefit from this treatment. Good weed control needs to be maintained after spading.

Offset discs

Shallow cultivation of water repellent soils, in this case using offset discs, will reduce water repellence to some degree. This is a consequence of a reduction in organic matter some dilution of the repellent topsoil due to the mixing process. It is anticipated that the benefits from such approaches will be relatively short-lived however in 2012 the benefits from the 2011 offset disc treatment could still be observed. Plant establishment (Fig. 1) was increased by 12 plants/m^2, a 47% increase compared to the neighbouring controls. Shoot biomass (Fig. 3) was increased by 0.71 t/ha (20% increase) and grain yield (Fig. 4) by 0.32 t/ha (20% increase). Seed weight per plant was not significantly different to the nearby control treatments.

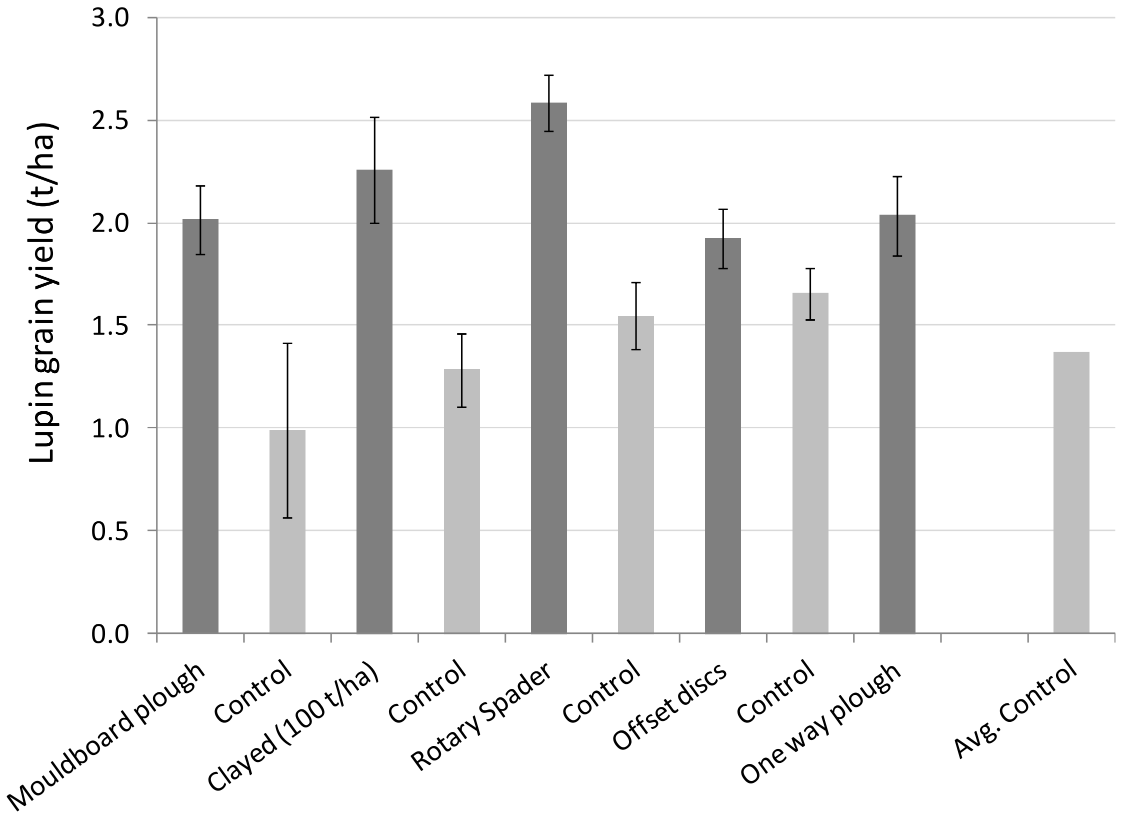


Figure 4. Grain yield (t/ha) for lupin grown on repellent pale deep sand at Badgingarra in 2012.

One-way plough

For one-way ploughing there appeared to be no significant increase in plant numbers compared to its nearest control (Fig. 1) and no significant increase in seed weight per plant. However higher trends in both of these still resulted in an increase in shoot biomass (Fig. 3) of 0.72 t/ha (19% increase) and grain yield (Fig. 4) by 0.38 t/ha (23% increase). Overall the benefit to one-way ploughing was very similar to the offset discs despite a somewhat deeper working depth for the one-way plough. Like the offset discs the interesting question for the one-way plough treatment is how long the benefits may last.

ECONOMICS

The net 2-year benefit and return on investment (ROI) has been determined for the first 2-years of the trial (Table 1). Estimated costs for the amelioration treatments are based on owner-operated and contract rates. Grain prices were based on 2011 wheat (APW2) price of $280/t and a 2012 lupin price of $300/t. Benefits associated with some of the treatments such as weed control for the mouldboard plough and reduced wind erosion for the claying treatment have not been included.

The one-way ploughing treatment was the most affected by wind erosion in 2011, resulting in a loss in grain yield and income which has substantially reduced the net benefit and the return on investment for this treatment (Table 1). Of the other treatments rotary spading and mouldboard ploughing had the highest net benefit, driven largely by large lupin yield benefit measured in 2012. Claying also had impressive yield gains and substantial increases in income (Table 1) but the high cost of this treatment reduced the 2-year net benefit and return on investment relative to the deep cultivation treatments. Given that claying can show benefits for decades the fact that the high cost has been covered in 2-years, means any long-term benefits should improve net benefit and ROI for this treatment over time. Offset discs have shown some grain yield increases and useful increases in income and given the lower cost this treatment has the highest ROI so far of $4.17 return for every $1 invested (Table 1). Ongoing measurement of yields at the site will determine how long the benefits of offset disc ploughing will last but even the 2-years of benefit has been profitable.

Table 1. Soil amelioration treatment impact on grain yield and income, net 2-year benefit and 2-year return on investment (ROI) for Mace wheat (2011; grain value $280/t) and Tanjil lupin (2012; grain value $300/t) grown on pale deep water repellent sand at Badgingarra.

Treatment	Estimated cost ($/ha)	Change in grain yield (t/ha)		Income change ($/ha)		Net 2-year Benefit ($/ha)	2-year ROI
		2011	2012	2011	2012		
Mouldboard Plough	$120	0.09	1.03	$25.48	$307.70	$213.18	2.78
Clay (100t/ha)	$400	0.37	1.12	$104.44	$337.19	$41.63	1.10
Rotary Spader	$150	0.46	1.17	$127.54	$349.89	$327.43	3.18
Offset Discs	$30	0.10	0.32	$28.28	$96.84	$95.12	4.17
One-way Plough	$30	*-0.23*	0.38	*-$63.00*	$113.93	$20.93	1.70

CONCLUSION

Pale deep sand has inherently poor yield potential and given the high cost of the water repellence amelioration treatments it can be difficult to determine whether the investment is worthwhile. At this site the productivity gains have been sufficient to offset the costs and be profitable for each of the options tested. Claying despite being expensive does have the advantage of being long-lasting and reduces wind erosion risk. Shallower cultivation with offset discs or one-way ploughing can give profitable improvements but the example of the one-way plough demonstrated that the benefits can be reduced or even negated by wind erosion damage. It should be noted that other research indicates that improving the effectiveness of the seeding operation can give yield gains of similar magnitude or even greater than those measured for the offset discs without the erosion risk. Exploring this possibility is probably a first step for growers looking to manage repellence on these soils.

PEER REVIEW: James Hagan (Economist, DAFWA Geraldton)

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