Ongoing yield responses to amelioration of water repellent sand 3-years after treatment

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Purpose:	To assess amelioration options for water repellent soil 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 Pale deep sand (water repellent)
Growing Season Rainfall (April- October 2013): 446 mm (Badgi. Research Station)	

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.

This large-scale on-farm soil amelioration trial was established in 2011 on highly repellent pale deep sand and included the following soil amelioration treatments:

1. Mouldboard ploughing – fully inverts the soil, burying the repellent topsoil and associated nutrients and weed seeds under a layer of wettable subsoil.
2. Rotary spading – partially buries and mixes the topsoil into the subsoil, importantly spades lift seams of subsoil to the soil surface which act as preferred pathways for water entry.
3. Offset discs – cultivates the topsoil to a depth of 10-12 cm, relatively little engagement with the subsoil, reasonably thorough mixing.
4. One-way plough – cultivates the topsoil to a depth of approximately 15 cm, some engagement with the subsurface soil.
5. Clay-spreading – clay-rich subsoil applied with a multi-spreader and incorporated into the topsoil, clay increases soil surface area and overcomes the water repellence.

TRIAL DESIGN

Plot size: 9 x 190m

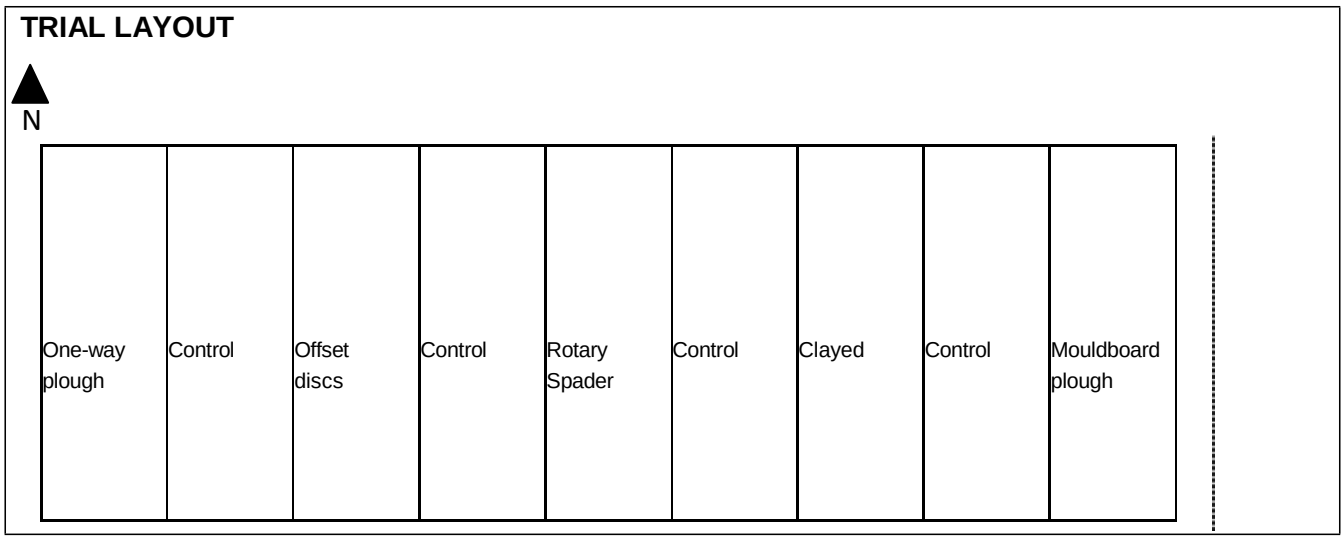
Repetitions: Repeated untreated control check strips to account for site variation

Seeding details: Mace wheat, sown at 90 kg/ha, 10 June

Fertiliser rates and dates: 120 kg/ha MacroPro Trace and 40L Flexi-N down tube at seeding; 80 kg/ha NS51 post-seeding

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 2010
5) Offset discs to ~10 cm, April 2011
6) One-way disc plough to ~15 cm, April 2011



RESULTS and DISCUSSION

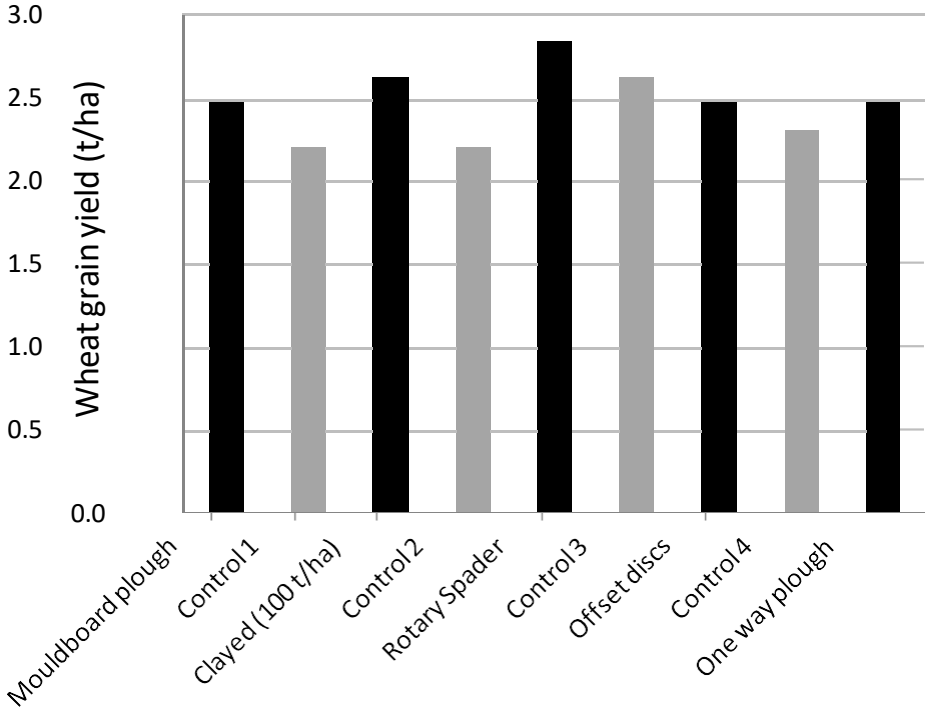


Figure 1. Machine harvest grain yields of Mace wheat in 2013 for a range of soil amelioration treatments that had been applied 3 years previously. The trial includes repeated untreated 'Control' plots to account for site variability.

Average grain yield for the untreated control plots was 2.34 t/ha. Clay spreading and rotary spading gave the largest machine harvest grain yield responses of 400 kg/ha or more, mouldboard ploughing 270 kg/ha and one-way ploughing 180 kg/ha (Figure 1) compared to their nearest comparative control plots. Offset discs gave no yield response in 2013 but did have positive yield responses in previous seasons (Table 1).

Grain protein levels averaged 11.4% for the untreated controls, clay spreading had 0.5% more protein and mouldboard ploughing 0.2% than their neighbouring controls (data not shown). Screenings for the majority of treatments averaged about 2.1%. Mouldboard ploughing was the only treatment to have significantly lower screenings of just 1.2% (data not shown).

Total above-ground shoot biomass and head number was assessed using plant cuts (Table 1). Shoot biomass on average was increased by 95% (+4.3 t/ha) by rotary spading, 57% (+2.7 t/ha) by clay spreading and 47% (+2.3 t/ha) by mouldboard ploughing compared to the untreated controls. Head numbers on average were increased by 32% (78 heads) by spading, 22% (58 heads) by mouldboard ploughing and 17% (43 heads) by claying compared to the untreated controls. Observations made earlier in the season indicated that emergence of many plants in the untreated control areas was delayed and had fewer tillers than the earlier emerging plants in the many of the treated areas.

The whole plant cut transects were taken across different soil types, rotary spading gave the best results on the poor pale deep sand at this site while mouldboard ploughing performed best on the better yellow sand (Transect 3).

Table 1. Total above-ground biomass, head number and grain yield for three whole plant hand harvest transects. Transect 1 was sampled on poor pale sand, transect 2 on pale sand and transect 3 on yellow sand.

Treatment	Biomass (t/ha)			Head no. (heads/m2)			Grain Yield (t/ha)		
	Transect			Transect			Transect		
	1	2	3	1	2	3	1	2	3
Mouldboard Plough	4.6	6.5	10.0	250	337	361	1.9	3.0	4.6
Control 1	3.4	4.8	6.1	220	273	281	1.6	2.1	2.8
Clayed	7.7	5.7	8.5	308	263	305	3.3	2.6	3.7
Control 2	3.8	4.1	5.7	227	243	248	1.7	2.1	2.8
Rotary Spader	9.0	7.7	9.7	344	293	322	4.0	3.5	4.3
Control 3	3.5	4.2	6.0	199	238	294	1.5	1.8	2.6
Offset discs	6.2	6.2	6.7	283	274	275	2.7	2.8	3.1
Control 4	5.6	8.4	5.1	263	323	228	2.5	3.8	2.3
One way Plough	6.8	6.4	5.1	289	268	274	3.1	2.8	2.3

FINANCIAL ANALYSIS OF RESULTS

The net 3-year benefit and return on investment (ROI) has been determined for the first 3-years of the trial (Table 2). Estimated costs for the amelioration treatments are based on owner-operated and contract rates. 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 although the subsequent years have been profitable (Table 2). Of the other treatments rotary spading and mouldboard ploughing had the highest net benefit, driven largely by the large lupin yield increases measured in 2012. Claying also had impressive yield gains and substantial increases in income (Table 2) but the high cost of this treatment reduced the 3-year net benefit and return on investment relative to the deep cultivation treatments. Given that claying can show benefits for decades net benefit and ROI for this treatment should continue to improve over time and it still only took 2 years to cover the cost of the treatment. Offset discs had grain yield benefits for the first 2 years but showed no response in 2013 suggesting that the benefits of the shallow cultivation may have dissipated.

Table 2. Soil amelioration treatment impact on grain yield and income, net 3-year benefit and 3-year return on investment (ROI) for Mace wheat (grain value $280/t for 2011 and $300/t for 2013) and Tanjil lupin ($300/t for 2012) grown on pale deep water repellent sand at Badgingarra. Estimated treatment costs were: $120/ha for mouldboard plough; $400/ha for claying; $150/ha for rotary spader; $30/ha for offset discs and one-way plough.

Treatment	Change in grain yield (t/ha)			Income change ($/ha)			Net 3-year Benefit ($/ha)	3 year ROI
	2011	2012	2013	2011	2012	2013		
Mouldboard	0.09	1.03	0.27	$25.48	$307.70	$80.26	$293	3.44
Clay (100t/ha)	0.37	1.12	0.40	$104.44	$337.19	$121.05	$163	1.41
Rotary Spader	0.46	1.17	0.41	$127.54	$349.89	$123.68	$451	4.00
Offset Discs	0.10	0.32	*-0.01*	$28.28	$96.84	*-$3.29*	$92	4.06
One-way	*-0.23*	0.38	0.18	*-$63.00*	$113.93	$55.26	$76	3.54

PEER REVIEW

Andrew Blake, DAFWA Geraldton

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