On-farm assessment of options for amelioration of water repellent sand

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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:	Badgingarra
Soil Type:	Pale deep sand
Rotation:	Wheat 2009; Lupin 2010, Wheat 2011
GSR:	485 mm (BRS weather station)

BACKGROUND

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.

TRIAL DESIGN

Plot size: 9 m x 190 m

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

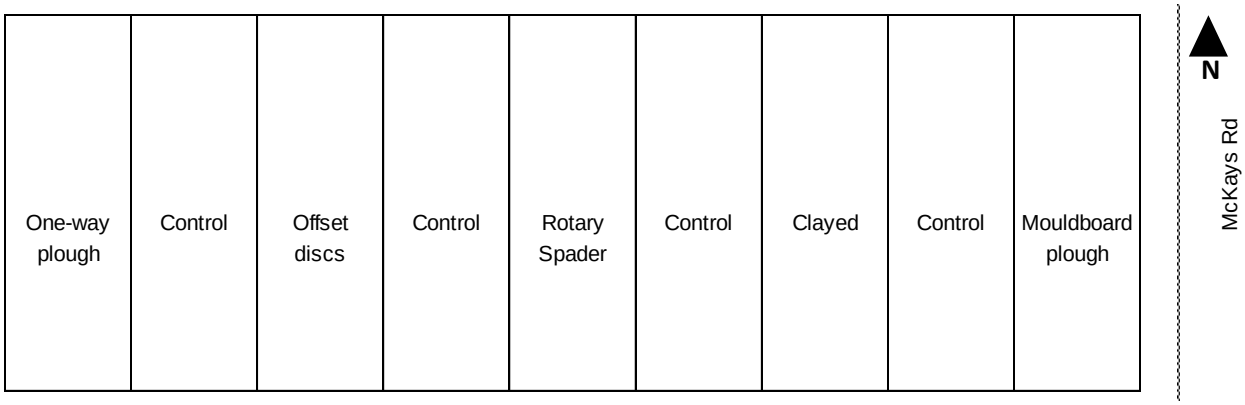
Soil amelioration treatments:

- Control - untreated
- Mouldboard ploughing to ~35 cm, April 2011
- Clay-spreading, 120 t clay-rich subsoil/ha, April 2011, shallow (10 cm) incorporation with combine

- Rotary spaded to ~35 cm, April 2010
- Offset discs to ~10 cm, April 2011
- One-way disc plough to ~15 cm, April 2011

Crop details: Mace wheat @ 90 kg/ha on 10 June 2011

Trial layout:



RESULTS

Table 1. *Strong post-seeding wind events recorded for Badgingarra Research Station, June 2011. Demonstration site was seeded on the 10 June 2011.*

2011 Date	Average wind speed (km/h)	Maximum wind speed (km/h)	Hours wind speed > 29 km/h	Daily rainfall (mm)
14 June	25	32	8	2
15 June	17	33	6	2
25 June	20	36	7	25
28 June	24	43	7	0
29 June	12	42	2	39

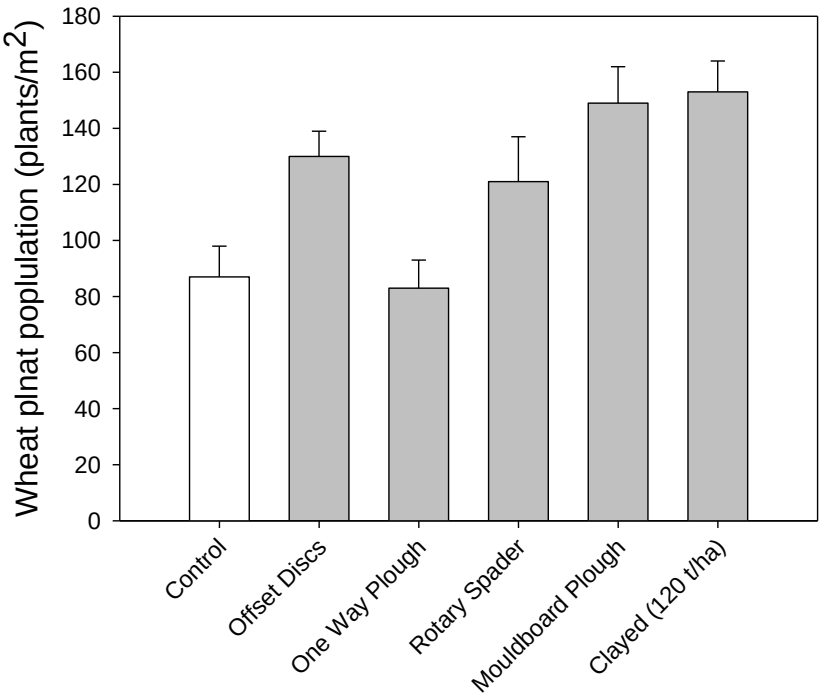


Figure 1. *Wheat establishment on water repellent pale deep sand at Badgingarra, July 2011 in response to soil amelioration treatments.*

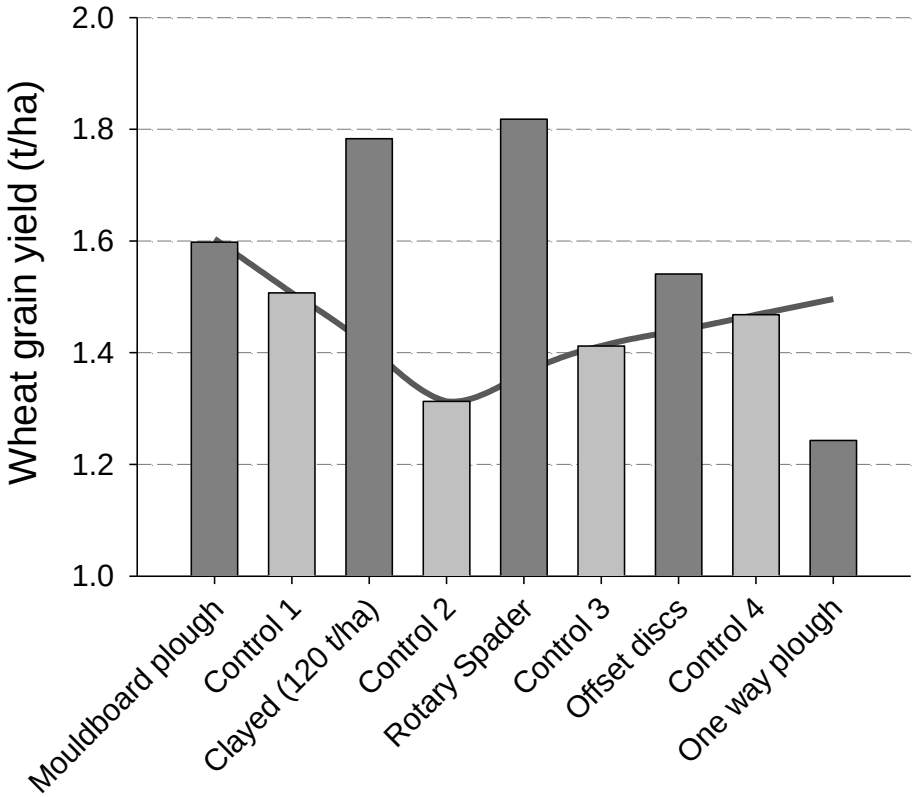


Figure 2. *Grain yield (t/ha) of Mace wheat in response to various soil amelioration treatments compared with untreated (Control) treatments on water repellent pale deep sand at Badgingarra, 2011. Line behind the bars shows the yield trend for the repeated Control (untreated) plots across the site. Treatment yield differences that are 150 kg/ha more or less than this line are likely to be significant.*

DISCUSSION

One of the greatest risks of the deep cultivation techniques is wind erosion as a result of the burial and removal of all surface cover. In 2011 strong post-seeding wind events in mid-June resulted in significant wind erosion and sand blasting of young crop seedlings (Table 1). This site was sown on the 10 June so strong, persistent and repeated wind events (Table 1) resulted in furrow infill and emerging seedlings being damaged by sand-blasting. At the end of June the furrows on all treatments were filled in and the wheat seedlings were mostly lying flat, with most of the leaf tips brown (necrotic) from wind and sand damage. Seedlings in the treatment that received clay-spreading and those in the rotary spaded plots which had been done in 2010 were least damaged as the clay stabilised the soil surface and the remnant lupin stubble in the spaded treatment provided limited protection. Despite this the furrows were still filled in on these treatments and the plants were still damaged, partly by sand from neighboring cultivated plots and the remainder of the paddock that had been one-ploughed.

The wind erosion and sand blasting of the seedlings was a significant setback for the crop and would be partly responsible for the relatively low yields at the site (Fig. 2). However, being a cereal the crop did recover and plant counts revealed that on average most of the soil amelioration treatments improved crop establishment compared to the untreated control (Fig. 1). The one-way plough treatment did not improve crop establishment but this treatment was the most severely affected by sand blasting which may have resulted in some loss of seedlings.

Grain yields at the site ranged from 1.3 to 1.8 t/ha (Fig. 2). Repeated untreated control plots at the site were used between each of the unreplicated treatment strips so yield variation across the site could be determined. Based on this it appears as though clay-spreading and rotary spading were the only treatments to increase grain yield by 360-390 kg/ha compared to the untreated control treatment (Fig. 2). It should also be noted that the spader treatment was done in 2010 and resulted in improved lupin growth that year which would have resulted in increased N inputs for this treatment and contributed to the yield result. Interestingly the offset disc treatments improved crop establishment to the same extent as the rotary spader treatment (Fig. 1) but there was no yield advantage for the offset disc treatment (Fig. 2). Presumably this is because the deeper cultivation (~35 cm) of the spader promoted root growth into the subsoil which was an advantage for water and nutrient uptake compared to the shallow (~10cm) cultivation of the offset discs. Subsoil loosening can allow roots to grow faster into the profile enabling them to keep up with leaching nutrients, particularly nitrogen.

The one-way plough treatment appears to have decreased grain yield by 180 kg/ha (Fig. 2). This treatment was most subject to damage from the sandblasting from the rest of the paddock which had also been one-way ploughed. The damage to the seedlings by sandblasting appears to have impacted on the yield outcomes in 2011 with the least affected treatments, clay-spreading and rotary spading giving in the highest yields while the one-way plough treatment most affected by sand blasting had the lowest yield (Fig. 2). The trial does highlight the added benefit of clay-spreading for amelioration given that it both overcomes water repellence and also stabilises the soil reducing wind erosion. The advantage of the moderate rate used (120 t subsoil/ha) is that it is less costly than using higher rates, is easier to incorporate and there is less risk of haying off and surface crusting that can be induced by claying.

Further monitoring of this trial and assessing yield responses in the 2012 season when there are better stubbles and improved protection from wind erosion should help clarify the benefits of these amelioration techniques. It should be noted that cultivation of the water repellent topsoil only without bringing up seams or layers of non-repellent subsoil may reduce the severity of water repellence but this is only likely to be short-term benefit with the negative impact of homogenising the soil and disrupting preferential flow pathways for water entry into the soil. It is still questionable whether one-way ploughs can work deep enough to create subsoil seams for water entry particularly on deep sands. There was evidence from

other parts of the paddock not so badly affected by sand-blasting that one-way ploughing had improved establishment and yield. It was observed that wherever the one-way plough brought up yellow sand or gravel it was much more successful and it was estimated that one-way ploughing increased grain yield by 600-800 kg/ha when used on sandy gravel and shallow sands over gravel that didn't blow. The risk with relatively shallow cultivation techniques is that they only temporarily reduce water repellence and at the same time disrupt the preferential flow paths for water that do exist in the soil. Cultivation techniques that engage the subsoil and generate subsoil seams or layers that are non-repellent are likely to give longer term benefits.

REVIEWED: Wayne Parker, DAFWA (Geraldton)

ACKNOWLEDGEMENTS

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