Clay spreading reduced frost damage and increased crop yield on water repellent deep sand at Moora

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ACKNOWLEDGEMENTS: This research is funded by DAFWA and GRDC through DAW00244 soil water repellency project, part of GRDC's Soil Constraints West portfolio of projects. Thanks to Graham White and Jonathan Lampp (Lawson Grains) for clay spreading, undertaking tillage treatments and provision of trial site. Thanks also to Joanne Walker, Chad Reynolds and Larry Prosser (DAFWA) for technical support. Thanks to Ben Biddulph and the frost project for the frost damage analysis.

Purpose:	To compare different clay spreading and tillage methods for the amelioration of water repellent soils.
Location:	"Yanda" (Rowes Rd, Moora)
Soil Type:	Water repellent deep yellow sand
Rotation:	2014 Wheat, 2015 Canola, 2016 Barley

Table 1. Chemical analysis of the soil at Yanda before clay spreading (data adapted from Blackwell P)

Depth (cm)	Soil Type	Organic Carbon %	Conductivity dS/m	pH Level (CaCl2)	pH Level (H2O)	Aluminium CaCl2 mg/Kg	Ammonium Nitrogen (mg/Kg)	Nitrate Nitrogen mg/Kg	Phosphorus Colwell mg/Kg	PBI	Potassium Colwell mg/Kg
0-10	sand	0.69	0.03	5.4	6.1	1.5	5	10	15.8	11.3	44
10-20	sand	0.28	0.02	4.5	5.4	2.9	<1	3.2	8.6	11.9	36
20-40	sand	0.17	0.01	4.6	5.5	3.0	<1	2.2	7.3	14.8	35

Table 2. Chemical analysis of the sub-soil clay used for clay spreading at Yanda

	Clay %	Sand %	Organic Carbon %	Conductivity dS/m	pH Level (CaCl2) pH	pH Level (H2O) pH	Aluminium CaCl2 mg/Kg	Ammonium Nitrogen mg/Kg	Nitrate Nitrogen mg/Kg	Phosphorus Colwell mg/Kg	PBI	Potassium Colwell mg/Kg	Exc. Calcium meq/100g	Exc. Magnesium meq/100g	Exc. Potassium meq/100g	Exc. Sodium meq/100g	CEC meq/100g	Boron Hot CaCl2 mg/Kg
sub -soil clay	31	62	0.13	0.05	5.7	6.2	< 0.2	6	19	5	101	36	1.4	1.48	0.09	0.27	3.3	0.49

BACKGROUND SUMMARY

In Australia, the practice of claying (either by clay spreading or clay delving) is considered one of the most effective methods for long term remediation of soil water repellency. The addition of clay-rich subsoil significantly increases the wettability of water repellent sand, promoting a more even crop establishment and better plant growth. Other benefits of claying include increased water and nutrient holding capacity and reduced risk of wind erosion.
In WA, this approach has often proved successful in cooler and wetter climates along the south-coast but has given mixed results in central and northern parts of the Wheatbelt. High clay rates and inadequate incorporation (particularly when using carry graders) coupled with dry seasons, poor finishes or mid-season dry spells has often resulted in claying increasing haying off and reducing grain yields. Nevertheless, results from preliminary DAFWA-WMG trials in the West Midlands indicates that when the subsoil clay is spread more evenly on the topsoil using multi-spreaders and at more moderate rates (100-150 t/ha), crop yields can consistently improve over many seasons (30% or more).

Based on these promising results, in 2016 DAFWA, in collaboration with the WMG, has established 3 new claying trials in the region looking at combinations of different clay rates and incorporation methods using a range of tillage equipment. The aim of the trials is to identify the most cost-effective combination/s and produce practical guidelines for farmers seeking long term improvement for enhanced crop productivity on water repellent soils under local growing conditions. The trial at ‘Yanda’ is discussed below in more details.

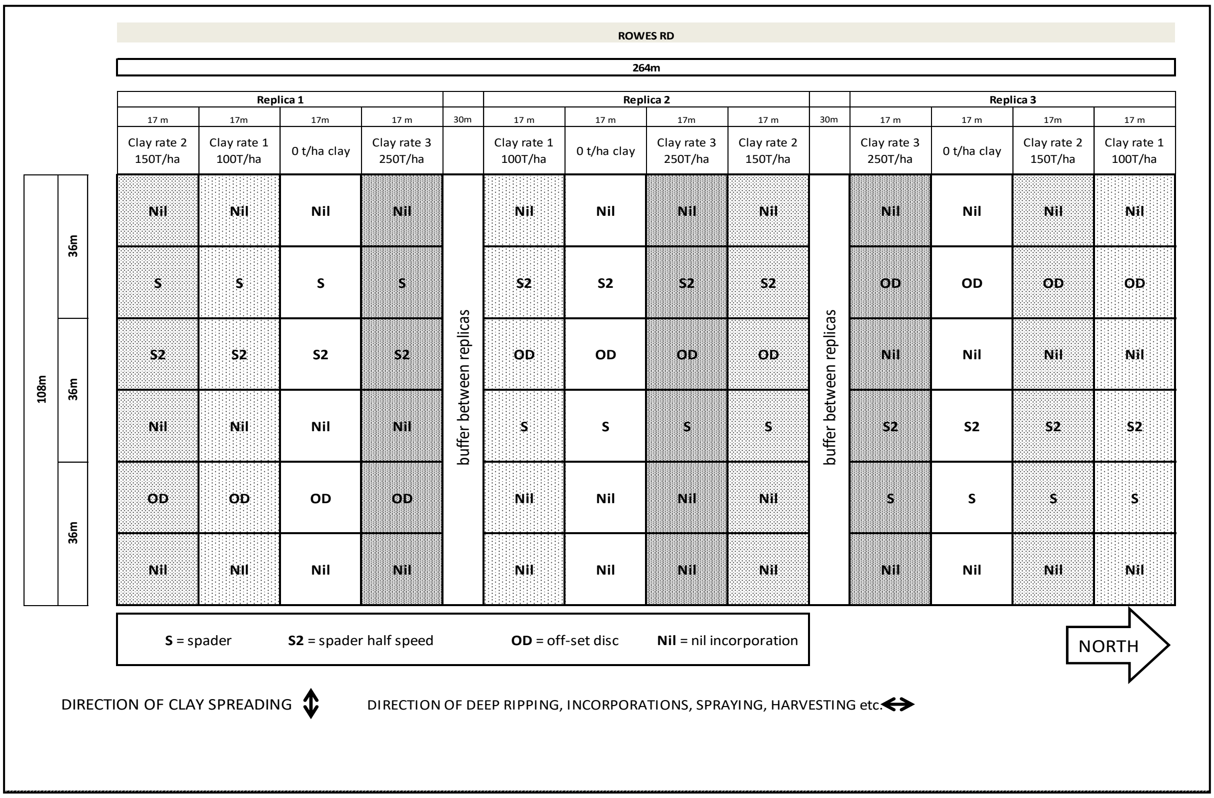
TRIAL DESIGN

The clay spreading trial at Yanda was replicate on three randomized blocks. On each block, 4 rates of subsoil clay (0, 100, 150 and 250t/ha) have been spread perpendicular to the direction of seeding using a multi-spreader. The subsoil clay (30% of clay content) was sourced from a pit located approximately 2 km from the trial.

Clay spreading was followed by either no further incorporation or incorporation using three different methods (from low to high degree of mixing): i) off-set disc, ii) rotary spader at standard working speed (approximately 5,5 Km/h) and iii) rotary spader at half standard working speed. After the clay spreading and prior to the incorporations, the entire trial site was deep ripped to about 450-500mm in order to remove subsoil compaction. Operational costs are presented in Table 3.

Plot size: 17m x 18m (trial size 264m X 108m)
Machinery use: Nufab multi-spreader, Agrowplow deep ripper, Farmax rotary spader, Offset disc, digger (clay pit excavation and clay spreader loading)
Repetitions: 3 replicates
Crop type and varieties used: La Trobe barley
Seeding date: 16 May

TRIAL LAYOUT



RESULTS

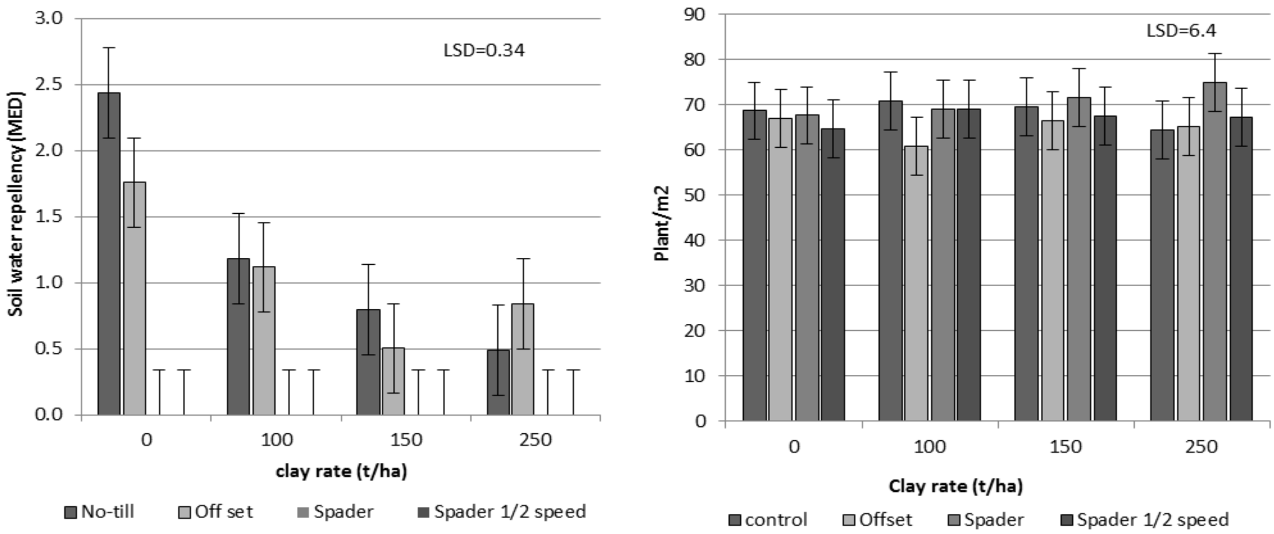


Figure 1. Left: Effect of the treatments on the severity of soil water repellency as measured by the MED test. Lower values of MED indicate less water repellency Right: effect of the treatments on early plant establishment. Error bars represent the average least significant difference (LSD)

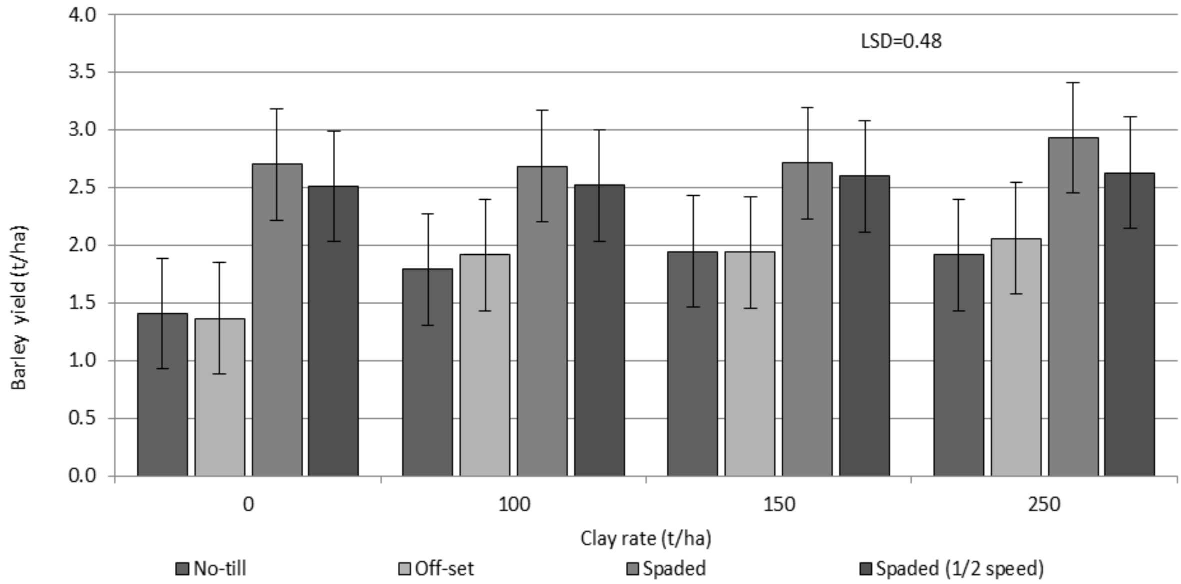


Figure 2a) Effect of the treatments on grain yields. Error bars represent the average least significant difference (LSD)

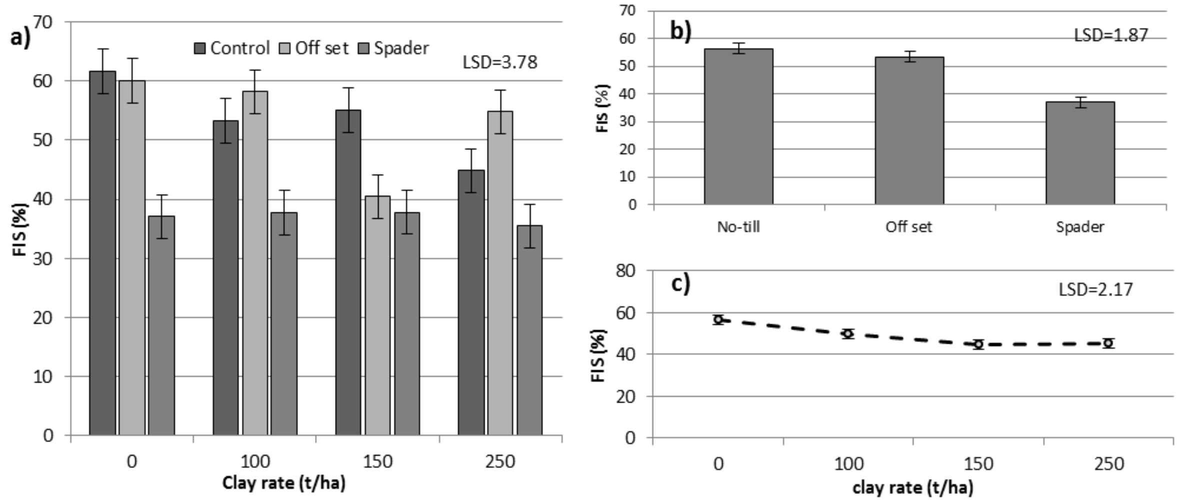


Figure 3a) Effect of the treatments on frost induced sterility percentage (FIS). b) Mean effect of the incorporation methods (tillage) FIS. c) Mean effect of the subsoil clay rates on FIS. Error bars represent the average least significant difference (LSD)

FINANCIAL ANALYSIS OF RESULTS

Table 3. Estimated costs of the clay spreading and tillage treatments

Cost of treatments			
Clay spreading		**Incorporation**	
Rate of subsoil clay (t/ha)	**Estimated cost ($/ha)**	**Tillage**	**Estimated cost ($/ha)**
100	270	**Off-set disc**	15-25
150	410	**Spading**	85-110
250	720	**Spading ½ speed**	150-200
Crop-specific direct costs & market price			
Crop		**Direct costs[1] ($/ha)**	**Market price[2] ($/t)**
La Trobe Barley		500	230

[1]Direct costs are seed, fertiliser, herbicides etc. [2]Best market price available in December 2016

DISCUSSION

The topsoil sand at Yanda was severely repellent (Figure 1, left), as measured by the molarity of ethanol droplet test (MED). Clay spreading and tillage (either combined or separated) significantly reduced the severity of water repellency. When the subsoil clay was not incorporated by tillage or was incorporated using an off-set disc, the soil water repellency generally decreased with an increasing amount of subsoil clay. However, low-repellency (MED<1) was obtained only at rates over 150 t/ha of subsoil.

In contrast, spading (either at standard speed of the tractor or at half speed) was the most effective method for the alleviation of soil water repellency. In these treatments, the MED values were completely reduced to zero (non-repellent soil) and, most importantly, this was achieved independently from the presence, or not, of clay-rich subsoil. The significant reduction of the soil water repellency however did not convert to better plant establishment measured five weeks after sowing (Figure 1, Right). This result could be explained by the wetter than usual weather recorded during April-May 2016 that reduced the impact of the soil water repellency on plant establishment. Nevertheless, tiller counts collected five weeks after plant counts showed a significant effect of tillage on the number of tillers. In particular, the spader treatments (standard and ½ speed) had the most tillers while the control had the fewest.

This trend was repeated with the barley grain yields at harvest time (Figure 2). Both tillage and rate of clay spreading, significantly improved grain yield in comparison to the control treatments (no clay and no tillage). The lowest yields were recorded in the control treatments and in the off-set tillage only (no clay) with an average of 1.41 t/ha and 1.36 t/ha respectively. The shallow tillage (or incorporation) using off-set discs did not yield significantly differently from the treatments with no incorporation at any given rate of subsoil clay. Clay spreading at 250 t/ha followed by spading at standard speed produced the highest yield on average (2.93 t/ha). Nonetheless, all treatments with spading (standard and ½ speed) were able to yield over 2.5 t/ha, even without the addition of subsoil clay (Figure 2).

Field observations showed that the trial was also affected by frost, which explained the lower than expected yields. Head samples were collected in early November 2016 from all the treatments (except spading at ½ speed) for the assessment of frost induced sterility (FIS= number of sterile florets / total number of florets) and the results are shown in Figure 3.

The results on FIS showed that frost damage might be one of the main reasons of low yields and responsible of the large yield differences between treatments. The control treatments and the off-set treatment (no clay) had over 60% frost induced sterility. Even though increasing amounts of subsoil clay significantly reduced FIS (Figure 3c), the treatments with no incorporation or with incorporation by off-set discs still recorded FIS values above 50%. Spading was the most effective treatment to significantly reduce frost damage to below 40%, regardless of the presence or not of subsoil clay (Figure 3a and b).

Spading was the most successful treatment in this first year of the trial at Yanda. Most importantly, spading was able to produce the highest yields and significantly reduce the frost damage regardless of the addition subsoil clay. This was particularly evident when estimating the simple return of investments on the first year of the trial (ROI= ($/ha gain – $/ha total direct costs) / $/ha total direct costs), based on the mean values presented in Table 3. Because of the high crop-specific costs with barley at Yanda (500 $/ha) and the yield reduction due to frost, spading alone at standard speed was the only treatment that gave a positive ROI on the first year (+0.4 $/ha) followed by negative ROI with spading at ½ speed (-0.18 $/ha) and the control (-0.35 $/ha). These estimates are indicative only, as indirect costs and interests on the initial capital investment are not included in the calculations. For more accurate estimates of ROI, yield results from multiple seasons and crops will be collected in the next 3 years.

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