Low-risk management strategies for crop production on water repellent sands

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Abstract

Water repellent (non-wetting) soils pose significant problems for crop production and natural resource management in southern Australia. Water infiltration is patchy, and the resulting impacts on crop and weed germination can reduce yields by more than 50%. In this research, we compared the impacts of two wetting agents and near-row sowing as low-cost strategies to improve crop emergence and yield. A randomised block trial with 4 replicates was established on a sandy soil near Wharminda on the Eyre Peninsula in SA. Wetting agents improved crop emergence in wheat (2015: 47-58%), barley (2016: 44-111%) and lupins (2017: 210-326%), and increased grain yield in 2015 (26-31%) and 2017 (26-70%) but had no impact in 2016. Near-row sowing had no significant impact on either emergence or crop yields. Neither wetting agents nor near-row sowing had any direct impact on severity of soil water repellence.

Key Words

Crop emergence, soil constraint, surfactant, on-row sowing, edge-row sowing

Introduction

Water repellent (or non-wetting) soils are common in southern and south-western Australia and occupy more than 12 Mha (Roper et al., 2015). Infiltration of rainfall into water repellent soils is spatially variable and leads to patchy and delayed crop germination. Because water repellency is common in soils of sandy texture, patchy and delayed germination can lead to increased risk of wind erosion (Harper et al., 2010), in addition to the direct effects on crop production.

Wetting agents and clay are known to assist crop production in water repellent soils. However, clay application is expensive (Cann, 2000; Hall et al., 2010) and wetting agents are not always effective (Davies et al., 2019). In recent research (Roper at al., 2013; Ward et al., 2015), near-row sowing was identified as a potential method of managing crop production. Roper et al. (2013) showed that water infiltration occurred down existing root pathways associated with the previous crop row, and this could be exploited by placing seed close to previous crop rows to encourage germination. In this research we test near-row sowing in combination with wetting agents as techniques for managing a water repellent sand on the Eyre Peninsula in South Australia.

Methods

Site details

A site was established at 33.977°S, 136.185°E near Wharminda, on the Eyre Peninsula of South Australia. The soil is a deep sand with a pH ($CaCl_2$) of 5.8 and organic carbon of 1.1% in the top 0.1 m. The Molarity of Ethanol Droplet (MED) value was about 3.0, which is classified as severely water repellent (King 1981). Wheat (*Triticum aestivum* cv Mace, sown at 80 kg/ha) was grown in 2015, barley (*Hordeum vulgare* cv Compass, sown at 72 kg/ha) was grown in 2016, and lupin (*Lupinus angustifolius* cv Mandelup, sown at 103 kg/ha) was grown in 2017. Plots were 20 m long by 6 rows (1.6 m) wide, and were sown using GPS-RTK guidance to allow accurate row placement relative to previous crop rows.

Eight treatments were compared (Table 1) in a randomised block design with four replicates. Near-row sowing aimed to place the seed for the current year within 3-5 cm of the previous crop row. This could not be implemented in the first year of the trial (2015; the trial paddock was in pasture in 2014) but was implemented in subsequent years. Wetting agents were applied in a band above the seed below the soil surface, using the recommended rate for each of the wetting agents. Kaolinite clay (Prestige NY, Granville, NSW) was applied to the soil surface at 56 t/ha and then rotary hoed to a depth of 0.1 m to mix the clay with the topsoil. An additional treatment used the rotary hoe without clay addition. The broadcast treatment was

implemented by spreading seed at half the usual seeding rate on the soil surface and then sowing the rest of the seed (also at half the rate) at the normal seeding depth.

Table 1. List of treatments applied at Wharminda site.

Treatment	Wetting agent	Row position	Other details
Control	Nil	Inter-row	
Precision Wetter	Precision Wetter 1 l/ha	Inter-row	
Near row	Nil	Near-row	
Near-row + wetter	Precision Wetter 1 l/ha	Near-row	
Clay	Nil	Inter-row	Kaolin @ 50 t/ha, rotary hoe
Rotary hoe	Nil	Inter-row	Rotary hoe
Broadcast	Nil	Inter-row	Half seed on soil surface, harrow
Rain Drover	Rain Drover 2 l/ha	Inter-row	

Measurements

Crop emergence was measured each year approximately 4 weeks after sowing by counting crop plants from adjacent rows over a length of 1.0 m in 6 random locations in each plot. Crop yield was measured with a plot harvester in each year.

Soil cores (0.0 – 0.05 m) were collected immediately after sowing each year from 5 random locations in each plot. Each sample was air dried, sieved <2 mm, and then oven dried at 105°C prior to MED measurement, using the procedure outlined by King et al. (1981).

Statistical analysis

All eight treatments were compared using analysis of variance, including year as a factor. In addition, the first four treatments (near-row vs inter-row sowing; Precision Wetter vs no wetter) were analysed by analysis of variance to determine any interaction between wetting agent and row position, also including year as a factor. Analysis was performed with Genstat 18.1.

Results

Seasonal conditions

Rainfall for the three growing seasons varied considerably (Table 2). The standout was the very dry start to the season in 2017, which resulted in severe symptoms of water repellency with poor establishment and sparse growth throughout the season.

Table 2. Monthly April-October rainfall (mm) for the Wharminda site. Average rainfall for period 1980-2018.

	April	May	Jun	Jul	Aug	Sep	Oct	Total
2015	77.0	21.6	35.6	31.4	77.0	33.0	1.2	276.8
2016	24.6	21.6	65.6	56.6	32.4	64.4	44.2	341.0
2017	15.4	6.2	2.0	46.0	75.0	33.6	27.6	206.0
Average	21.2	31.5	42.0	43.5	43.3	32.9	24.8	239.0

Crop emergence

The clay and Rain Drover wetting agent treatments provided consistently good emergence in each year (Figure 1). The Precision Wetter also resulted in significantly greater emergence than the control. Near-row sowing only increased emergence relative to the control in 2017, when the symptoms of water repellence were particularly severe. The rotary hoe treatment was effective in the first season after treatment but was not effective in subsequent years. The broadcast sowing treatment was no better than the control in any year. There was no interaction between Precision Wetter and row position (P = 0.145).

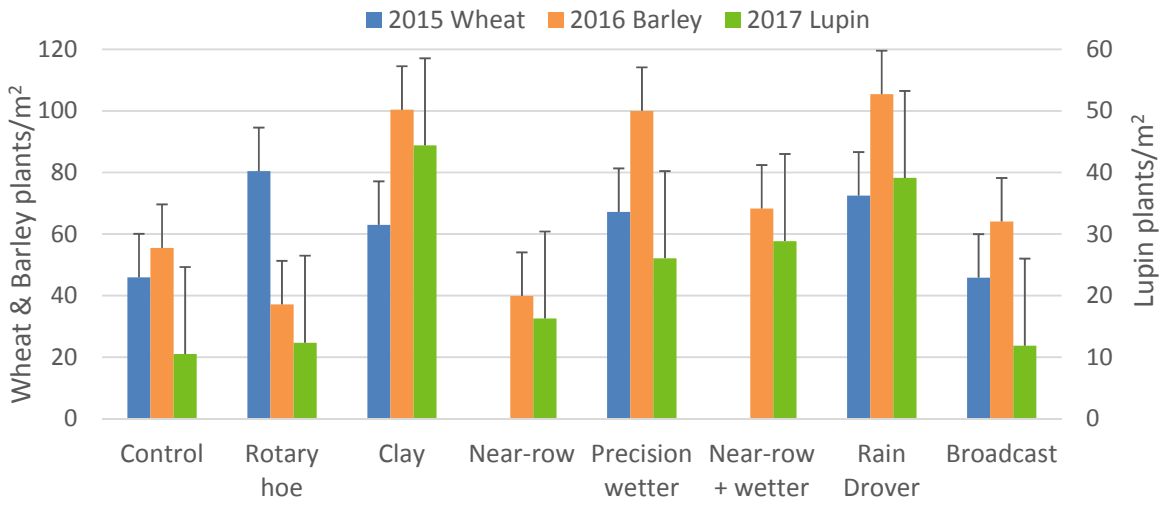

Figure 1. Emergence for various treatments over three seasons on a water repellent sand at Wharminda. Error bars represent the LSD value for comparing treatments (14.14; p=0.05).

Crop yield

Crop yield was similar to emergence, in that yields from the clay treatment were best or equal best in each year (Figure 2). The rotary hoe, broadcast and near-row sowing treatments had limited effect on yield. Wetting agents significantly increased yields relative to the control in 2015 and 2017 when symptoms were more pronounced, but not in the good growing conditions experienced in 2016. There was no interaction between the use of Precision Wetter and row position (p = 0.176).

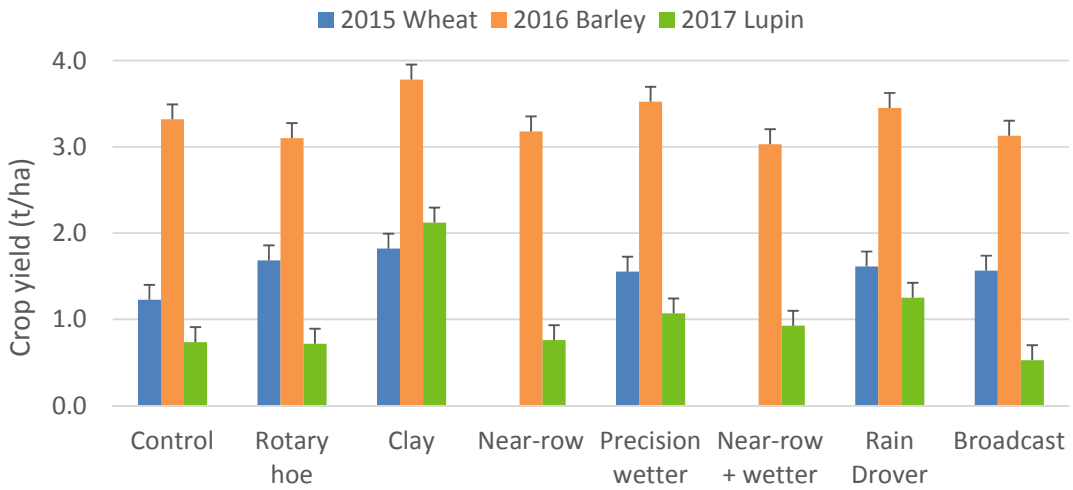

Figure 2. Crop yields for various treatments over three seasons. Error bars represent the LSD value for comparing treatments (0.174; p=0.05).

Water repellence

Water repellence varied slightly from year to year but the only treatment that affected severity of water repellence was the addition of clay (Figure 3). Interestingly, wetting agents had no impact on soil water repellence severity even after three years of addition, despite being associated with increased crop emergence.

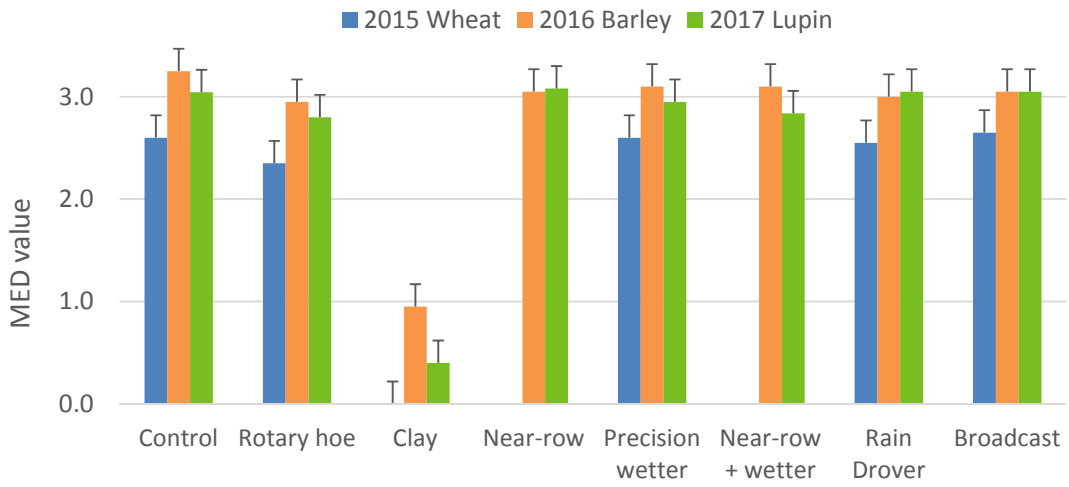

Figure 3. Soil water repellence for various treatments over three seasons. Error bars represent the LSD value for comparing treatments (0.219; p = 0.05).

Conclusion

Water repellent (non-wetting) sands pose challenges to crop production. The two wetting agents tested in this experiment were effective in increasing crop emergence and also increased crop yields when symptoms of water repellence were particularly severe. Even without effects on crop yield, increased emergence is likely to reduce the risk of wind erosion and so is a good outcome. Near-row sowing was not an effective option for either crop emergence or yield at this site. At other field sites elsewhere in Australia, near-row sowing has improved emergence and sometimes yields compared with inter-row seeding (Kerr et al., 2017). This was not seen at the Wharminda site possibly due to the difficulty in accurately seeding near-row in small plots without damaging the old crop row.

The only treatment that affected severity of water repellency was the addition of clay, which reduced MED values from around 3 to less than 1 and also resulted in increases in crop emergence and grain yield.

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