Long-term assessment of management options for water repellent sandy gravel soils

Stephen Davies, Giacomo Betti and Liam Harte (DAFWA)

Purpose:	Identify suitable options for managing soil water repellence on sandy gravels
Location:	Graeme & Helen Lethlean, Badgingarra
Soil Type:	Sandy gravel – water repellent
Soil Test Results:	pH ($CaCl_2$): 5.4 0-10cm; 4.9 10-20cm; 5.0 20-30cm; 5.0 30-40cm Colwell P (0-10cm) = 33; Colwell K (0-10 cm) = 13; OC% (0-10 cm) = 1.1
Rotation:	Cereal-break crop (lupin, canola)
Growing Season Rainfall (April- October 2015):	334 mm (BRS)

BACKGROUND SUMMARY

Water repellence is an increasing problem on sandy gravel soils as reported by many growers in the West Midlands. Over the past 5 years considerable research has been undertaken assessing options for water repellent sands but less has been done for the gravel soils. The aim of this research is to look at soil water repellence management options for sandy gravel soils over a 4-year period (until December 2018).

TRIAL DESIGN

On-farm strip trials consisting of five different treatments for water repellence (Control, Paired row, minimal disturbance and two types of wetting agents) in combination with two cultivation treatments (modified one-way plough or no plough). The soil wetting agents are both recommended for banding on water repellent sands. 'Wetter 1' is a penetrant-only formulation that aids water infiltration while 'Wetter 2' has both penetrant and retention compounds in its formulation so it aids both water infiltration and retention of water in the topsoil.

As the "Minimal disturbance" treatment (knife points at slow speed) turned out to be very similar to the "Control" treatment (Table 1), the data from these two treatments have been merged for the discussion of the results.

Plot size: 2 x 10 m

Machinery use: Cone seeder**,** Modified one-way plough

Repetitions: 4 replicates for the water repellence treatments and 2 replicates for the tillage treatment

Crop type and varieties used: Mace wheat

Seeding rates and dates: 75 kg/ha (28/05/15)

Fertilizer rates and dates: 80 kg/ha of Agstar extra (28/05/15) and 50 L/ha of UAN (23/06/15).

Herbicide rates and dates: 150 g/ha of Sakura (28/05/15), 0.4 L/ha of MCPA 600 LVE (08/07/15) and 800 ml/ha of Velocity (08/07/15).

Insecticide rates and dates: 200 ml/ha of Lorsban (28/05/15) and 200 ml/ha of Dominex (28/05/15)

Table 1. TRIAL LAYOUT

	Rep 1					Rep 2					Rep 3					Rep 4					
Modified one-way plough (Rep 1)	6. Paired Row	3. Wetter 2	3. Wetter 1	1. Control 1	8. Minimal	3. Wetter 2	3. Wetter 1	6. Paired Row	1. Control	8. Minimal	3. Wetter 1	6. Paired Row	1. Control	3. Wetter 2	8. Minimal	1. Control 1	3. Wetter 2	8. Minimal	6. Paired Row	3. Wetter 1	10m
No plough (Rep 1)	6. Paired	3. Wetter 2	3. Wetter 1	1. Control 1	8. Minimal	3. Wetter 2	3. Wetter 1	6. Paired	1. Control	8. Minimal	3. Wetter 1	6. Paired	1. Control	3. Wetter 2	8. Minimal	1. Control 1	3. Wetter 2	8. Minimal	6. Paired	3. Wetter 1	10m
Modified one-way plough (Rep 2)	6. Paired Row	3. Wetter 2	3. Wetter 1	1. Control 1	8. Minimal	3. Wetter 2	3. Wetter 1	6. Paired Row	1. Control	8. Minimal	3. Wetter 1	6. Paired Row	1. Control	3. Wetter 2	8. Minimal	1. Control 1	3. Wetter 2	8. Minimal	6. Paired Row	3. Wetter 1	10m
No plough (Rep 2)	6. Paired	3. Wetter 2	3. Wetter 1	1. Control 1	8. Minimal	3. Wetter 2	3. Wetter 1	6. Paired	1. Control	8. Minimal	3. Wetter 1	6. Paired	1. Control	3. Wetter 2	8. Minimal	1. Control 1	3. Wetter 2	8. Minimal	6. Paired	3. Wetter 1	10m

2 m

44m

RESULTS

Figure 1: Water repellence measured from the top 5cm of sand of the treatments. Higher values of MED (Molarity of Ethanol Droplet) correspond to greater water repellence. LSD (5%)combined treatments=0.86

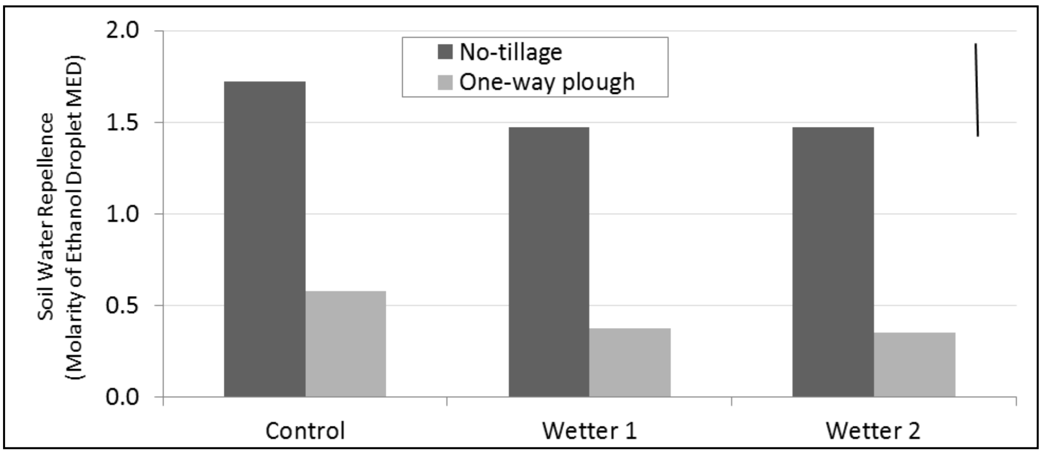

Figure 2: Average number of plants per square meter at early wheat emergence on 18th June. LSD (5%)combined treatments=15.8

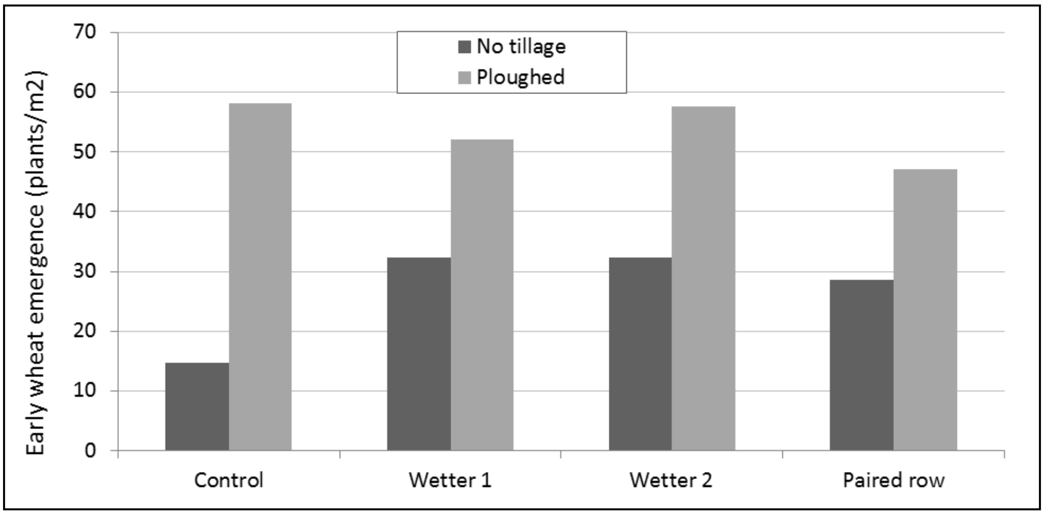

Figure 3: Grain yields (t/ha) affected by the treatments in the 2015 season. LSD (5%) combined treatments=0.26

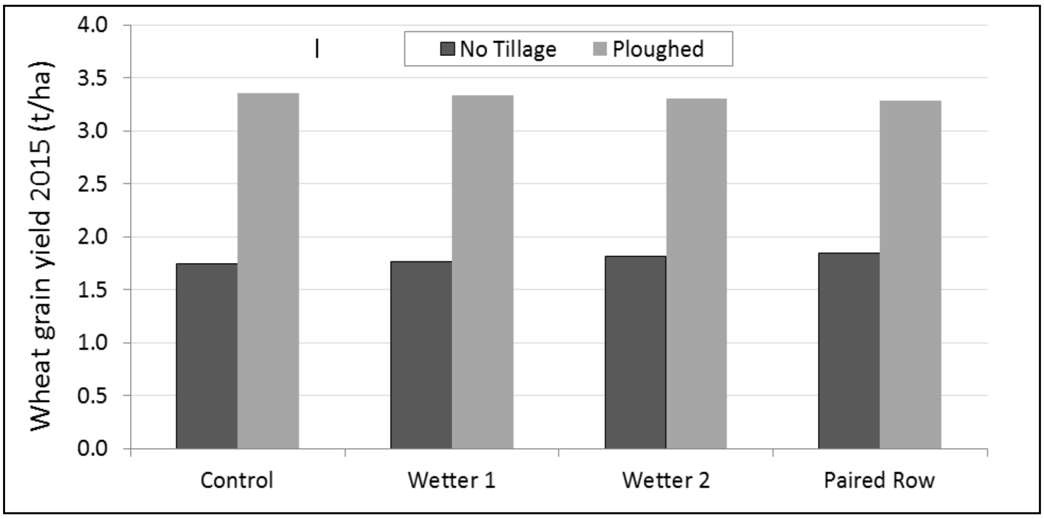

Table 1: Comparison of plant nutrient uptake (kg/ha) in ploughed and no-tilled plots

Nutrient uptake kg/ha												
	Boron	**Calcium**	**Copper**	**Iron**	**Magnesium**	**Manganese**	**Phosphorus**	**Potassium**	**Sodium**	**Sulphur**	**Total Nitrogen**	**Zinc**
No tillage	0.004	4.31	0.007	0.085	2.13	0.125	3.82	41.58	0.436	3.54	37.40	0.028
Ploughed	0.012	10.32	0.024	0.198	5.73	0.165	9.53	118.0	1.026	9.37	95.45	0.076
% increase	**187%**	**139%**	**227%**	**132%**	**169%**	**32%**	**149%**	**184%**	**135%**	**165%**	**155%**	**170%**

FINANCIAL ANALYSIS OF RESULTS

Table 2: Grain yield, yield change and change in income and profit in response to the treatments

Treatment		Grain yield (t/ha)	Yield increase compared to control (t/ha)	% Yield increase compared to control	Gross income increase compared to control ($/ha)*	Cost of the treatment ($/ha)	Profit compared to control ($/ha)
NO TILLAGE	**Control**	**1.74**	**0**	**0%**	0	**0**	0
	Wetter 1	1.76	0.02	1%	6	11	-5
	Wetter 2	1.81	0.07	4%	21	12	9
	Paired Row	1.85	0.10	6%	31	5	26
PLOUGHED	Control	3.35	1.61	92%	478	50	428
	Wetter 1	3.33	1.59	91%	471	61	410
	Wetter 2	3.31	1.56	90%	465	62	403
	Paired Row	3.28	1.54	88%	458	55	403

*Gross income based on an average grower price for Mace wheat in Geraldton of $297/t in January 2016. (source: awb.com.au)

DISCUSSION

The modified one-way plough disturbed the gravelly soil to a depth of about 20-25 cm. As a result, the top water repellent sand was mixed with the subsoil (wettable) pale sand that effectively diluted the soil water repellence (SWR) at the soil surface. The effectiveness of the plough on reducing the SWR is clear when looking at Table 1 where the MED values of the topsoil are significantly reduced after the tillage, moving from average values above 1.5 molarity (moderate repellence) to values below 0.5 molarity (low repellence). Note that these results were achieved regardless of the application or not of the wetters. The wetters did not show a significant reduction of SWR in terms of MED (Fig. 1), either in the ploughed or no-tillage treatments. It is possible however that these results were affected by sampling accuracy, given that the wetters were only applied as a narrow band on the furrow surface.

Field observation also showed that the tillage increased the amount of gravel at surface (brought up from the subsoil). Nevertheless, the implications of increased gravel content on the soil chemical/physical properties and plant growth are still unclear and need to be investigated.

Crop establishment (Fig. 2) reflected the results on SWR with the tilled plots having a significant increase in the number of emerged plants. On the other hand, even though the paired rows and the wetters tended to improve plant emergence the difference with the control plots was not significant.

The results on grain yields confirmed the previous observations (Fig. 3). All the ploughed treatments outperformed the no tillage treatments (with no significant difference within the ploughed treatments), increasing the yield by 90% on average when compared to the no-tilled control plots (more than 1.5 t/ha, Table 2). Surprisingly, very modest improvements on grain yield were found in the no-tillage treatments, either in combination with the wetters or paired-row sowing. This outcome was particularly negative in the case of Wetter 1, where the increased yield did not cover the cost of the treatment (Table 2).

Plant tissue analysis also showed that the ploughed plots produced a significant increase in plant nutrient uptake (Table 1). The increase in nutrient uptake may be due to the increased availability of nutrients after the soil disturbance and/or to the improved root exploration after the reduction in SWR.

CONCLUSION

This first year study has shown that the adoption of a strategic tillage practice (one-way plough) provided a significant improvement in terms of crop establishment and grain yields on a moderately repellent sandy gravel. The adoption of other agronomic options, such as paired-row sowing or wetters, in this instance did not provide any noticeable improvement in comparison to the control treatments. In fact, in one case (wetter 1), the cost of the treatment was not covered by the yield increase.

Without doubt, the tillage proved to be the most effective treatment for reducing SWR but at this stage it is not possible to evaluate the extent to which this improvement alone contributed to the significant increase in yields.

With this long term experiment, we expect the following seasons to give us more information to better understand what changes drive the yield increase and possibly the potential longevity of these improvements.

PEER REVIEW

Megan Abrahams (DAFWA)

ACKNOWLEDGEMENTS

This work was supported by DAFWA and GRDC (DAW00244: Delivering enhanced agronomic strategies for improved crop performance on water repellent soils in Western Australia). Thanks and appreciation to Graham and Helen Lethlean for hosting the trial site. Thanks to Ben and Sean Plozza for one-way ploughing and Trevor Bell and Greg Brown (DAFWA) for technical support.