Managing non-wetting and crop nutrition of forest gravels

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Key messages

- Wetting agents can be effective and economical, but timing with respect to rainfall appears to be critical.
- The use of a mouldboard plough and to a lesser extent other forms of deep cultivation while eliminating or reducing non-wetting created other not yet fully understood problems in the gravels.
- Lifting the soil pH to above 4.8 in combination with soil cultivation maximises yield.

Aims

Non-wetting soil can be a major impediment to crop germination and thus productivity. Non-wetting is caused by the presence of waxy surfaces on the sand particles and inhibits water infiltration at the soil surface leading to staggered germination of crops and weeds. In addition many of the forest gravels have high P sorption which limits the availability of P despite high soil test P levels. Non-wetting is thought to exacerbate the impact of this phenomenon because a lack of soil moisture inhibits root growth and reduces P availability. This work explores the opportunities to reduce the impact of non-wetting and its effect on P availability.

Introduction

Non-wetting soil has received a lot of attention over the years, particularly the non-wetting sandy duplex soils of the South Coast (SC), and the northern agricultural region of WA (NAR). Several management strategies dealing with these soils such as (improved) furrow and stubble row sowing, the use of wetting agents, claying, delving, and mouldboard ploughing (MBP) have been developed and implemented on a large scale. The forest gravels of the South West are also non-wetting. Due to an increase in cropping area, adoption of no-till and seeding earlier, the non-wetting problem has become more acute.

Wetting agents have been promoted widely in the forest gravel areas because the application is simple and the results have been positive at times. Other management options have not really been taken up. There has been some claying done by individuals but it is not common practice. MBP has gained momentum in certain regions (NAR and East SC) and has also shown some promise in forest gravels. MBP as well as other forms of deep cultivation have the potential to make bound soil P more available.

Methods

Several management options were tested on forest gravels. These were wetting agents, deep cultivation, mouldboard ploughing and altering crop nutrition combined with deep cultivation.

Wetting agents

The effectiveness of LureH2O as a wetting agent in 2011 was tested in a trial near Kojonup. Three different rates (5, 10 and 15 L/ha) with 100 L water/ha were applied at the end of March in 2011 in 30 m wide strips across the entire width of a selected paddock. The soil type at the surface varied from non-wetting coarse silver sand with no gravel to sandy loam with 65% gravel. The topography was undulating. Measurements consisted of a radiometric

survey, Molar Ethanol Droplet (MED) test and soil gravel survey, Plant Cell Density (PCD) imagery in late September, Greenseeker NDVI survey, and yield at harvest from the yield monitor. The radiometric survey was used to see whether some of the radiation measurements could be used to predict the presence of gravel and delineate areas where wetting agents would be more effective. The soil gravel quantity (i.e. gravel visible at the surface) survey was carried out during the first Greenseeker NDVI survey. Using this survey the area was divided into 10 classes of gravel, ranging from 0 to 100% gravel at the surface.

In 2012 multiple sites were set up across the Great Southern testing 6 different wetting agents. These were: LureH2O and Irrigator from SACOA, Spreadwet, Seedwet, and Biagra from SST, and Precision Wetter from Chem Sol. The nine locations were: Jerramungup, Nyabing, Cranbrook, Frankland (3x), South Stirling, Cordering and Tambellup. At each site the wetting agents were applied in randomised plots, split as a pre-seeding blanket spray and a post seeding banded application.

Soil management

A trial (**SM1**) was implemented in 2012 near Cordering to address the non-wetting issue using a range of treatments such as claying (1 and 3% clay), MBP +/- lime, scarifying, wetting agents (Lure and Precision Wetter), and lime were the most relevant treatments. The treatments had 3 reps and the plots were 70 m long and 13.5 m wide. Harvesting was done by the grower. Monitoring consisted of plant number counts, measurement of the Greenseeker NDVI at regular intervals in the growing season and soil sampling.

Following the results of the 2012 trial, another trial (**SM2**) was implemented in an adjacent paddock in 2013 where only LureH2O was applied pre- and post-seeding, MBP, and claying (1%). The clay spread on the surface at a rate of 9 t/ha, was Bentonite clay from Watheroo. Mineralogical analysis of the Bentonite showed it was 36% clay (Smectite) but contains also Calcite (25%) and Ankerite (29%), both Ca/(Mg)CO3 minerals with a neutralising value of the Bentonite was 71%. The rate applied was equivalent to 11.3 t/ha of lime, assuming 57% efficiency and 80% NV.

Crop nutrition

The non-wetting and soil nutrition trial had been instigated several years ago near Darkan. Over a few years two small plot trials were carried out addressing: non-wetting, cultivation, soil pH, and available P through various rates of fertiliser at seeding. In the first trial (**CN1**) that started in 2009, the treatments included lime, cultivation (one-way disc plough), wetting agents, and some combinations of those. In the second trial (**CN2**) which started in 2010, the treatments included: two lime products, cultivation (one-way disc plough (DP)), and rates of P (0, 7.5, 15 and 30 (kg/ha) at seeding. Only in one year (2011) was Lure H2O applied as a treatment. In the first year the trials were sown by a DAFWA plot seeder. In the subsequent years seeding and any additional treatments (e.g. splitting fertiliser) were applied by the farmer. All harvesting was with a DAFWA plot harvester.

Results

Wetting agents

At Kojonup in 2011, rainfall between the LureH2O application and seeding (25 May) was 68 mm. The LureH2O had probably enough rain to make a difference; it was about 28 days after application before any significant rain (21 mm) fell. Very little correlation was found between the thorium radiation levels and the amount of gravel visible at the surface. Yield differences of the strips were not significant (Mean yield: 4.06 t/ha, P = 0.92) however when the yield was separated into classes of gravel visible at the surface, it was found that in areas where gravel content was 90 or 100% the LureH2O did produce a significant difference (P=0.002), see Figure 1.

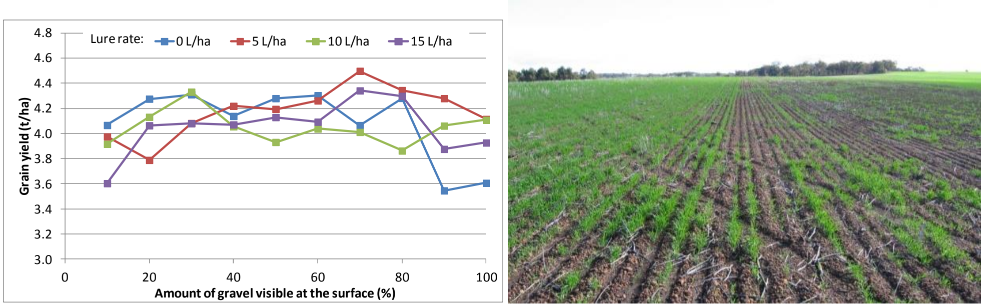

Figure 1 Mean yield for every class of visible surface gravel (left), and the soil wetter effect clearly visible in the field (right).

Based on this result when only LureH2O was applied to the heavy gravel (80 – 100%) (4.2 ha) of the *surveyed* area (20 ha) an extra return of $480 (2 t grain @ $240/tonne) could be expected by spending $100 on the LureH2O (5 l/ha @ $5/L)). This effect was not repeated in 2012, which was an extremely dry year.

The results from the multiple sites in 2012, indicated that only two sites (Cranbrook and Frankland Gravel) produced significant yield benefit (both about 0.5 t/ha) of the wetting agents over the control. There was however no difference between the wetting agents. While 2012 was an exceptionally dry year, particularly west of the Albany Highway, it was found that at the responsive sites the application (pre-or post-seeding) was quickly followed by significant rain (>25 mm). However both sites were also located on sloping ground and were very gravelly which would have added to the effectiveness of the wetting agents.

Soil management

The trial near Cordering in 2012 produced some unexpected results. Shortly after seeding it became clear that emergence was severely reduced on all the MBP plots. The LureH2O, Balance and the Bentonite had the highest establishment rates while the MBP +/- lime plots the lowest. During the season the NDVI results reflected the germination rates. Towards the end of the season however the MBP plots picked up considerably, remained green for longer and generally had bigger plants. The lower plant density would have contributed to this as did the increased rooting depth. Mid season sampling revealed an increase of more than 1 unit in the soil pH of the 1% Bentonite plots and 1.5 unit in the 3% Bentonite plots. The Bentonite functioned therefore as a good liming product as well as a claying material. Grain yields are presented in Table 1.

Table 1 Yield results from the soil management trials (SM1 and SM2) in Cordering in 2012 and 2013 and some soil properties. Selected treatments are presented.

SM1	2012	2013	2012		**SM2**	2013		
Treatment	Wheat (t/ha)	Canola (t/ha)	pH_{CaCl2} (0-10cm)	MED	Treatment	Canola (t/ha)	MED 17-May	pH_{CaCl2} 17 May
Control	4.85	2.38	4.8	3.1	Control	2.28	1.3	4.9
Bentonite 1%	5.06	2.54	6.3	3.1	Benton. 1%	2.41	1.1	5.8
MBP (no Lime)	4.55	2.02	5.2	0.8	MBP	2.36	0.0	5.1
LureH2O Pre	4.74	2.60	4.7	2.3	Lure Pre	2.42	1.5	4.9
Lime only	4.09	1.97	5.2	2.5	Lure Post	2.42	1.2	4.8
Lsd	**0.59**	**0.62**	**0.36**	**1.21**	**Lsd**	**0.13**	4.5 (7 March)	

While not statistically significant and certainly not economical ($1000/tonne) the Bentonite 1% had the highest yield in 2012 and the 2nd highest in 2013, had a large impact on the pH but did little to reduce the MED. The Lure yielded well both in 2012 and in 2013 in both **SM1** and **SM2** while doing little to the MED or the wettability. The MBP had the largest impact on the non-wetting (MED). Burying the top soil eliminated the non-wetting but created other problems that reduced the yield. It is not yet clear why the MBP treatment resulted in a poor establishment both in **SM1** and **SM2**. It was noted that the soil of the MBP was wetter and

therefore colder by as much as 5°C at the surface at seeding time and beyond. The poor establishment on freshly ploughed land particularly of canola, has also been noted in Frankland and South Stirling. At Frankland it might also have been a temperature effect while at S Stirling soil acidity might have played a role. In the forest gravels non-wetting is certainly an issue in some years, in 2012 and 2013 this was however not the case given the good yields from the control in those years. Therefore improving the wettability of the soil does not always result in higher yields.

There also appears to be a strong temporal aspect to the non-wetting properties on the forest gravels. While they are strongly repellent early in the year (MED: 4.5 on the 7 March) by 17 May this had diminished to a MED of 1.3, which is only weakly repellent. The fluctuation of the non-wetting properties plays a major role in the expression of non-wetting. As is commonly known, delayed seeding will reduce its impact. The temporal changes and the persistence of the non-wetting properties of these soils have not yet been investigated.

It is not clear why the lime treatment performed so poorly, but improving the soil pH to 6.3 (SM1) or to 5.8 in SM2 by adding the Bentonite did not improve the yield greatly because the base soil pH was already about 4.9 and increased with depth. Adding a liming product would therefore not greatly impact on the yield. This was different in the crop nutrition trial.

Crop nutrition

In the crop nutrition trials it was found that the soil pH had the greatest impact on yield and availability of P at seeding. Table 2 is a summary of both trials; several treatments and year results are not presented due to space constraints but the treatment effects are illustrated.

Table 2 Summary of the yield results of CN1 and CN2 over a four year period. Bar = Barley, Can = Canola, Wh = Wheat, WA = Wetting agent.

Lime	Cult	Fert	Bar, 2010	Can, 2011		Wh, 2012		2011	2012
				WA	No WA	With P	No P		
CN2		P (kg)	t/ha	t/ha	t/ha	t/ha	t/ha	pH	pH
No	No	0	0.24	0.58	0.18	1.8	1.0	4.3	4.5
No	No	30	0.76	1.25	1.00	1.8	1.1	4.4	4.4
No	Yes	0	1.00	0.80	0.50	1.8	1.5	4.4	4.4
Yes	No	0	0.33	1.08	0.62	2.2	1.5	5.2	5.9
Yes	No	30	1.03	1.68	1.57	2.3	1.6	5.1	5.1
Yes	Yes	0	1.21	1.21	0.93	2.7	2.0	5.0	5.2
Yes	Yes	30	1.47	1.73	1.54	2.6	1.7	4.9	5.5

	2013	2013
CN1	Barley 20 kg/P	
	t/ha	pH
Nil	1.32	4.5
DP	1.32	4.5
Lime DP	4.06	4.8
Lime	2.92	4.8

Adding lime and improving the soil pH from 4.3 to at least what appears to be a threshold of about 4.8 had a large impact on the yield, even when no additional P was applied. In all years the cultivation carried out at the beginning of the trials had a lasting effect on the yield, particularly in combination with the lime and in the absence of additional P. The type of cultivation was a one-way 3 disc plough that mixed the soil rather than inverted the soil. A modest decrease in the MED was detected in the **CN2** following the ploughing but none in the **CN1.** Wet-patch observations in both trials showed an increase in the volume of soil wetted up. While the non-wetting did not decrease greatly, the cultivation effect facilitated root growth and some improved water penetration that would have enhanced the accessibility of P.

Of interest is the impact of the wetting agent (LureH2O) on yield in 2011. Across all treatments an increase of about 0.2 to 0.3 t/ha was measured which was similar to the increase in 2013 at **SM1** and **SM2**. There were no residual effects of the LureH2O detected in 2012. The wetting agents at **CN1** were completely ineffective in 2009.

Conclusions

Wetting agents on the forest gravels are sometimes effective and economical. Timing of application in relation to rainfall (i.e. shortly before rainfall) appears to be important. Mouldboard ploughing created other not yet fully understood problems in Cordering. Lifting soil pH above a threshold of 4.8 in combination with deep cultivation maximises yield on these soils.

Key words

Non-wetting, mouldboard ploughing, wetting agents, cultivation

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