New opportunities for soil wetting agents on repellent soils

Stephen Davies, Glenn McDonald, Geoff Anderson, Liam Harte and Grey Poulish, DAFWA

Richard Devlin and Rebecca Jenkinson, Living Farm

Key messages

1. Banding soil wetting agents with the seed, through existing liquid banding systems and with less risk of poor placement, can improve establishment on water repellent soils and often has equivalent effect to placement on the furrow surface.

2. Some soil wetting agents are compatible with UAN, fungicides and other liquid applications and can be applied through existing liquid in-furrow banding systems improving their adoptability. This indicates soil wetting agents could be useful as a carrier for liquid nutrients.

3. Banded wetters seem particularly beneficial on water repellent loamy gravels with substantial increases in grain yield in seasons such as 2015.

Aims

1. Assess the effectiveness of wetting agents when banded with the seed compared to banded on the furrow surface.

2. Assess the effectiveness of soil wetting agents applied in formulations with UAN.

3. Assess the effectiveness of soil wetting agents on water repellent forest gravels.

Method

Table 1. Summary of seeding details, soil type, growing season rainfall (GSR Apr-Oct), soil water repellence rating and treatments applied, for five trials over three sites with water repellent soil established in 2015.

Soil Type, Location & GSR (mm)	Variety, Rate & Sowing Date	Experiment and Treatments	Soil Water Repellence (0-5 cm)	
			MED	Rating
Pale deep sand, Meckering **GSR = 184**	Mace Wheat, 75kg/ha, 9th May	SOIL WETTERS on SAND 1) Control (nil banding) 2) Water only banded on furrow or with seed 3) Wetter 1 – penetrant banded on furrow or with seed 4) Wetter 2 – penetrant & absorber banded on furrow or with seed 5) Wetter 3 – penetrant & absorber banded on furrow or with seed All wetters banded at 2 L/ha	2.4	Severe
		UAN and WETTERS on SAND 1) Control (nil banding) 2) UAN banded on furrow or with seed 3) Wetter 1 banded on furrow or with seed @ 2 or 4 L/ha 4) Wetter 1 + UAN banded on furrow or with seed @ 2 or 4 L/ha	1.5	Moderate
Loamy (forest) gravel, Kojonup **GSR = 251**	Hindmarsh Barley, 110 kg/ha, 13th & 14th May	SOIL WETTERS on LOAMY GRAVEL 1) Control (nil banding) 2) Water only banded on furrow 3) Wetter 1 – penetrant & absorber banded on furrow at 1 or 2 L/ha 4) Wetter 2 – penetrant banded on furrow at 1 or 2 L/ha 5) Wetter 3 – absorber & penetrant banded on furrow at 1 or 2 L/ha 6) Wetter 4 – penetrant & absorber banded on furrow at 1 or 2 L/ha	4.1	Very Severe
		UAN and WETTERS on LOAMY GRAVEL 1) Control – water banded on furrow or with seed 2) UAN banded on furrow or with seed 3) Wetter 1 banded on furrow or with seed 4) Wetter 1 + UAN banded on furrow or with seed 5) Wetter 2 banded on furrow or with seed 6) Wetter 2 + UAN banded on furrow or with seed	4.0	Very Severe
	Hyola 525 RT Canola, 2.5 kg/ha, 5th May	SOIL WETTERS for CANOLA on LOAMY GRAVEL 1) Water only banded on furrow or with seed 2) Wetter 1 – penetrant banded on furrow or with seed 3) Wetter 2 – penetrant & absorber banded on furrow or with seed 4) Wetter 3 – penetrant & absorber banded on furrow or with seed All wetters banded at 2 L/ha	3.2	Very Severe

Banded soil wetting agents are typically applied in a continuous stream on top of the furrow following the press wheels to improve the consistency of soil wetting in the furrow and improve crop establishment on water repellent soils. There is some evidence that banding soil wetters near the seed can also be effective at improving establishment. In these experiments the wetters were banded 5-15 mm below the seed at a water rate of 90-100 L/ha. Some recent soil wetters are compatible in formulations with UAN and may improve plant access to nutrients. In 2015 a number of trials were established to assess the impact of these developments on crop establishment and yield for crops growing on repellent soils (Table 1). The soil wetting agents used were commercially available products. All soil wetters include in their formulation a penetrant (surfactant) compound that will aid water infiltration into repellent soil but some also have water absorbing compounds (humectants) that help hold and retain soil moisture and nutrients in the topsoil (Table 1).

Results

Rainfall in March and April prior to seeding at both sites (Table 2) meant that there was some soil moisture present at the time the crop was sown but, due to the soil water repellence, the topsoils still had many dry patches. At Meckering rainfall was low throughout May and June and terminal drought was severe with only 8.6 mm in September and less than 2 mm in October (Table 2). October rainfall was also low at the Kojonup site which received only 4 mm (Table 2).

Table 2. Monthly, annual and growing season (GSR) rainfall for Meckering and Kojonup trial sites, 2015 season.

Site	Monthly Rainfall (mm)												Annual Rain (mm)	GSR May-Oct (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
Meckering	0	7.2	26.4	16.2	17.6	27.4	71	42.2	8.6	1.4	31.4	0	249	168
Kojonup	0	0	50	60.5	24.5	43	79	48	32.5	4	22.5	31	395	231

Wetting Agent Placement and Rates

At Kojonup wetting agents were banded on the surface at 2 application rates of 1 and 2 L/ha onto very severely water repellent loamy gravel. The crop was sown into variable moisture on 13th May, with subsequent rainfall of 8 mm on 19th May and 3mm on 31st May. Barley plant numbers were improved by 51-73% (63-90 plants/m^2; table 3). Grain yields were increased by 15-29% (0.53-1.02 t/ha; table 3). For most of the wetters there was no benefit from using the higher application rate.

Table 3. Impact of soil wetting agents and the rate of application on crop establishment and grain yield. (* denotes increase relative to the untreated controls at 95% confidence)

Site	Treatment	Crop Establishment (plants/m^2)		Grain Yield (t/ha)	
		Banded 1 L/ha	Banded 2 L/ha	Banded 1 L/ha	Banded 2 L/ha
Kojonup, Loamy (forest) gravel – Barley 2015					
	Control (Nil)	123		3.45	
	Water only (Control)	117		3.48	
	Wetter 1	195*	179	4.24*	4.41*
	Wetter 2	186*	187*	4.47*	4.27*
	Wetter 3	213*	206*	4.35*	4.17*
	Wetter 4	163	191*	3.98*	4.08*
	l.s.d. (95% confidence)	*63*		*0.42*	

Soil wetter placement was assessed on water repellent pale deep sand at Meckering and repellent loamy gravel at Kojonup. At the Meckering site seed banded soil wetters improved wheat establishment by 30-40% (27-36 plants/m^2) but soil wetters banded on the furrow did not significantly improve establishment (Table 4). Despite these improvements in establishment, grain yields were not improved by the soil wetting agents and in fact yields were reduced in some instances (Table 4). The site did experience severe terminal drought stress, receiving only 8.6 mm of rainfall in September and 1.4 mm in October on a soil type with low water holding capacity (Table 2). The drought

stress may well have been exacerbated by a subsoil acidity constraint with soil pH's ($CaCl_2$) of 4.3 and 4.2 in the 10-20 and 20-30 cm layers, respectively, and possibly by subsoil compaction. In addition to terminal drought the site was frosted and there was significant frost damage evident. Given this it is not surprising that the greater plant numbers in the wetter treated plots did not end up translating to a yield advantage. The biggest improvement in plant numbers occurred when wetters were banded with the seed, but in these treatments there was a yield decline. This typically occurs when the higher biomass from larger plant numbers results in the crop suffering from more severe terminal drought due to higher demand for water leaving less water for grain fill.

Table 4. Impact of soil wetting agents and their placement, banded either on the furrow surface and or near the seed, on crop establishment and grain yield. (* denotes a difference with 95% confidence)

Site	Treatment	Crop Establishment (plants/m^2)		Grain Yield (t/ha)	
		Furrow banded	Seed banded	Furrow banded	Seed banded
Meckering, Pale Deep Sand – Wheat 2015					
	Control (Nil)	90		1.06	
	Water only (Control)	86	81	1.04	1.08
	Wetter 1 - 2 L/ha	103	123*	1.00	0.92*
	Wetter 2 - 2 L/ha	98	126*	0.95	0.81*
	Wetter 3 - 2 L/ha	86	117*	0.88#	0.87*
	l.s.d.(95% confidence)	*13*		*0.11*	
Kojonup, Loamy (forest) gravel – Canola 2015					
	Control (Nil)	33		2.93	
	Water only (Control)	34	35	2.92	3.04
	Wetter 1 - 2 L/ha	45	56*	3.19*	3.37*
	Wetter 2 - 2 L/ha	51*	54*	3.26*	3.44*
	Wetter 3 - 2 L/ha	45	44	3.10	3.31*
	l.s.d.(95% confidence)	*15*		*0.22*	

At the Kojonup site the placement of soil wetters on canola establishment and yield was assessed. Banded wetters improved crop establishment by 18-21 plants/m^2 an increase of 54-70%. Use of banded soil wetters improved canola yields by 260-510 kg/ha, a grain yield increase of 9-17% (Table 4). In this experiment banding the soil wetters with the seed significantly improved the grain yield compared with banding the wetter on the furrow (Table 4).

Wetting Agents in Formulation with UAN

At the Meckering site soil wetter on its own or in formulation with UAN significantly improved wheat plant numbers by 38-90 plants/m^2 an increase of 37-88% (Table 5). There was a trend towards higher plant numbers when the soil wetter was banded with the seed compared to when it is applied to the top of the furrow (Table 5). Similar to the other soil wetter trial at Meckering the improvement in plant numbers in this experiment did not increase the grain yield due to the seasonal conditions and perhaps other soil constraints, and where soil wetter was banded with the seed grain yield tended to decline by 10-14% (Table 5).

In contrast to the crop response at the Meckering site soil wetters on their own and in formulation with UAN did not significantly increase plant numbers but did improve grain yield of barley at the Kojonup site when banded on the furrow (Table 5). The grain yield was increased by 8% (0.3 t/ha) from furrow banded wetter applied on its own and by 0.59-0.63 t/ha, an increase of 15-16% when applied in combination with UAN (Table 5).

Table 5. Impact of soil wetting agents and their placement, banded either on top of the furrow or near the seed, on crop establishment and grain yield. Soil wetting agents were applied either on their own or in formulations with UAN. (* denotes a difference with 90 or 95% confidence)

Site	Treatment	Crop Establishment (plants/m^2)		Grain Yield (t/ha)	
		Furrow banded	Seed banded	Furrow banded	Seed banded
Meckering, Pale Deep Sand – Wheat 2015					
	Control (nil)	102		1.26	
	UAN	126	133*	1.36	1.38
	Wetter - 2 L/ha	140*	183*	1.26	1.11*
	Wetter - 4 L/ha	168*	184*	1.19	1.08*
	UAN + Wetter - 2 L/ha	144*	166*	1.30	1.09*
	UAN + Wetter - 4 L/ha	174*	192*	1.25	1.14*
	l.s.d. (95% confidence)	*29*		*0.12*	
Kojonup, Loamy (forest) gravel – Barley 2015					
	Water only (Control)	161	173	3.97	3.99
	UAN	173	143	3.84	4.05
	Wetter 1	192	188	4.31*	4.11
	UAN + Wetter 1	189	165	4.56*	4.21
	Wetter 2	209	212	4.30*	4.39*
	UAN + Wetter 2	212	178	4.60*	4.05
	l.s.d.(90% confidence)	*n.s.*		*0.29*	

Discussion

Given the improvement in plant numbers as a result of using soil wetting agents on the pale deep sand at Meckering it is disappointing that this did not translate into a yield improvement and in fact for wetter treatments banded with the seed there was a yield decline. There were a number of factors that may have contributed to this:

1) The site was frosted and this reduced yield but there may be an interaction of developmental stage with frost for those treatments which had more consistent early establishment;

2) The crop experienced severe terminal drought, with only 10 mm of rain throughout September and October, and it may be that haying-off due to terminal drought stress was more severe for the treatments that had seed banded wetter due to more plants and tillers. There isn't strong evidence of this as there was no difference in screenings, which ranged from 1.5-2.5% or thousand grain weight, the only difference being higher grain protein for those treatments that were treated with banded wetter (data not shown);

3) The site had a subsoil acidity constraint and was also likely to be compacted which would restrict root growth and access to subsoil moisture, which may have further added to the severity of terminal drought and haying off. This highlights the importance of deep soil testing and understanding what other soil constraints may be present that may limit grain yield;

4) Finally soil wetters reduce the surface tension of water, this helps it penetrate repellent soil but it can also reduce the soil water retention and increase leaching. Leaching may have been enhanced by banding wetters with the seed but this is unlikely however, as the soil wetting agents tend to overcome this problem by either having a relatively short lifespan in the soil or my including water retention compounds in their formulation which negate this effect yet the negative impact on yield was seen across all soil wetter types.

It should be noted that in other studies banded soil wetters have resulted in yield improvements on deeper sands (Blackwell *et. al.* 2014), and in general yield usually is improved as a result of higher plant numbers and biomass. Yield responses of 8-36% have been measured in response to banded wetters on yellow deep sand at Binnu and pale deep sands near Badgingarra in moderate-low rainfall seasons (Blackwell *et. al.* 2014; Davies *et. al.* 2015). Soil wetting agents with water absorbing compounds, that help water and nutrient retention, have been shown to have benefits over penetrant only wetters in seasons which have leaching rains (Blackwell *et.al.* 2014).

In contrast crop yield responses on the repellent loamy gravels have been impressive and more consistent than those on deep sand. Canola yield increases have ranged from 0.3-0.5 t/ha and barley yield increases from 0.3-1.0 t/ha. In another experiment near Kojonup on this soil type in 2015 in which a broader range of treatment options was measured, banded soil wetters increased barley yield by 0.7 t/ha for furrow banded and 1.0 t/ha for seed banded (Davies *et. al.* 2016). The cost of banding wetters typically ranges from $6-12/ha, and in these studies the yield response of barley on loamy gravel to the 1.0 L/ha rate was equivalent to that achieved at double the rate, 2 L/ha, so cost of the treatment is low relative to the potential yield benefit.

Conclusion

The results of these experiments indicate some useful developments in the use of soil wetters:

- Soil wetters can give large and quite consistent yield responses on loamy forest gravels in both canola and cereals;
- Banding soil wetter with the seed can effectively increase plant numbers on repellent soils but should be used with caution on pale deep sands with greater overriding soils constraints such as aluminium toxicity and compaction;
- Some soil wetters are compatible with UAN and other liquid nutrients making their testing and adoption easier using existing liquid systems on seeders;
- Poor water holding capacity and subsoil constraints on deep sands may limit the yield benefit possible from an improvement in plant numbers resulting from the use of banded soil wetters, and amelioration of these constraints may improve the reliability of the response to soil wetting agents.

As a result of these findings ongoing research will focus on:

- Residual benefits of soil wetters, particularly on water repellent loamy gravels, and impact on a cropping rotation using longer term trials;
- Benefit of soil wetters on nutrient uptake and effectiveness when used in formulations with liquid fertilisers;
- Placement of banded soil wetter in relation to the seed row – how close does it need to be to the seed to be effective;
- Use of soil wetters in combination with lime and deep ripping on repellent soils with the aim of realising a greater yield benefit from the use of soil wetters when other soil constraints are also treated.

References

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Key words

Soil water repellence, soil wetting agents, UAN, loamy gravel, pale deep sand

Acknowledgments

Thanks to GRDC and DAFWA for funding the soil water repellence project: “Delivering enhanced agronomic strategies for improved crop performance on water repellent soils in WA’. This project is part of the GRDC’s Soil Constraints West Initiative. We acknowledge the support of SouthernDIRT grower group, Tim Boyes (AgVivo consulting), Matt Sherriff (SACOA), Wayne Foot (SST), and John Hawkesford (Chemsol). We acknowledge and thank the host growers, their families and staff: Jono Clifton, Kojonup and Darren Morrell, Meckering. Thanks to Liam Ryan and Paul Blackwell (DAFWA) for peer review.

GRDC Project Number: DAW00244