Seeds coated with wetters improved cereal germination on water repellent soils

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Key messages

- Seed coating with wetters provided a higher agronomic efficiency than banded furrow placed wetters. For instance, seed coatings with wetters applied at 0.065–0.325 L/ha achieved the same increase in plant density, tiller number, biomass production and, nutrient uptake as wetters applied to the furrow at 1–5 L/ha.

Introduction

This paper examined the agronomic efficiency of wetter placement through comparisons of seed coatings and furrow applications. This research is important because water-repellent ('non-wetting') soils affect about 10 M ha of arable sandy soils which are used for agricultural production in southern Australia (Roper *et al*. 2015). Soil wetters banded on top of and in the furrow are currently used to improve crop establishment on water repellent soils in WA (Crabtree and Henderson 1999, Davies *et al*. 2016, Sherriff 2016). Coating seeds with wetters to improve crop establishment is a new field of research. Madsen *et al*. (2016) have developed the wetter seed coating technique and shown the improved establishment of grasses on water repellent soils. Erickson *et al*. (2017) have applied similar coating techniques to improve native grass establishment in the Pilbara region of Western Australia. In general, poor crop establishment in the WA cropping system on water repellent soils occurs when crops are sown dry followed by low germinating rainfall.

Method

Seed coatings

Seeds were coated using a 14–inch rotary seed coater (BraceWorks, Canada). Polyvinyl alcohol (Selvol-205) glue was the binding agent, and lime and talc powder were the drying agents and to minimise seed adhesion. We produced wetter coated seed by spraying a solution containing the wetter and Selvol-205 glue onto the seed by placing the solution on the central spinning disc of a seed coating machine (Madsen *et al*. 2016).

Field experiments

In 2017, we conducted two randomised block design field experiments replicated three times. One was on a grey sand with a molarity of ethanol droplet (MED) test of 2.0 (moderate repellence) located 11 km northeast of Badgingarra; the other was on a sandy gravel with a MED test of 5.0 (very severe repellence) located 18 km south of Darkan. The carbon content of the Badgingarra grey sand was 1.1%, and the Darkan sandy gravel was 3.6%. The gravel content of the Darkan sandy gravel was 48%. The particle size analysis of the < 2mm soil fraction for the Badgingarra sand was 96% sand with 4% clay, and for the Darkan sandy gravel was 85% sand, 9% silt and 6% clay.

We coated cereal seeds (wheat and barley) with two different wetters (named W1 and W2). The seeds were coated with wetters at rates of 0, 1.0, 2.0 and 4.0 L/t of seed which gave wetter application rates of 0.065, 0.130 and 0.260 L/ha at a seeding rate of 65 kg seed/ha. The exception was at the Badgingara experiment where we coated wetter 2 at rates of 1.3 L/t, 2.5 L/t and 5 L/t or 0.084, 0.162, 0.325 L/ha when sown at 65 kg seed/ha. These treatments were compared to banding a commercial soil wetter, SACOA's SE14™, placed on top of the furrow or in-furrow near the seeds at rates of 0, 1, 2 and 5 L/ha.

The application on top of the furrow involved banding the wetter in a continuous stream immediately behind the press wheel. The application in the furrow involved banding the wetter into the soil between the fertiliser and the seed – which were separated by approximately 2 cm. Hence, the wetter placement relative to the seed and fertiliser was considered consistent despite variations in seeding depth. In these experiments, the target sowing depth was 2–3 cm so that in-furrow wetter was applied at 4–5 cm depth.

The Badgingara experiment was sown to Scepter wheat at 65 kg seed/ha on 19 May 2017. The Darkan experiment was sown to Scope CL barley at 65 kg seed/ha on 12 May 2017. Measurements conducted at the Badgingarra site included tiller numbers (tiller/m^2) on 29 June, biomass production (t DM/ha) and nutrient uptake on 10 August, and grain yield on 10 November 2017. Unfortunately, at the Badgingarra site, only fourteen plots of replicate one block were harvested due to severe bird damage of the other plots. The average yield of these plots was 1.6 t/ha. Measurements conducted at the Darkan site included plant density (plants/m^2) on 31 May and grain yield on 2 December 2017.

Results

Badgingarra experiment

The Badgingarra experiment was sown dry on 19 May with rainfall events after seeding of 12 mm between 20 and 22 May which resulted in some wheat germination, and 31 mm between 21 and 24 of June, 2017, which resulted in more germination. Rainfall was 124 mm for July and 131 mm for August which resulted in an above average growing season rainfall (May–October) of 409 mm for Badgingarra in 2017.

Table 1. Tiller number (tiller/m^2), plant density (plant/m^2), dry biomass (t DM/ha), N and K uptake (kg/ha), grain yield (t/ha) at the Badgingarra and Darkan experimental sites in 2017.

Treatment	Badgingarra				Darkan	
	Tiller No. (tillers/m^2)	Biomass (t DM/ha)	N uptake (kg N/ha)	K uptake (kg K/ha)	Plant density (plants/m^2)	Grain yield (t/ha)
Control	44	1.5	54	46	97	3.5
W1 coated 1.0 L/t[A]	70	2.1	67	58	129	3.5
W1 coated 2.0 L/t[A]	88	2.2	66	61	137	3.0
W1 coated 4.0 L/t[A]	70	2.2	67	56	137	3.5
W2 coated 1.0 L/t	82	2.1	71	58	138	3.5
W2 coated 2.0 L/t	82	2.4	74	64	128	3.5
W2 coated 4.0 L/t	92	2.6	76	78	115	3.8
SE14 top of furrow 1 L/ha	69	2.1	66	55	145	3.5
SE14 top of furrow 2 L/ha	84	3.0	89	83	142	3.5
SE14 top of furrow 5 L/ha	101	2.9	81	70	139	3.8
SE14 in-furrow 1 L/ha	61	1.4	56	45	145	3.8
SE14 in-furrow 2 L/ha	56	2.2	77	68	139	3.7
SE14 in-furrow 5 L/ha	51	1.7	59	55	145	3.7
LSD 5%	11	0.3	10	9	14	0.6

[A] W1 coating rates at the Badgingarra experiment were 1.3, 2.5 and 5.0 L/t of seed

At the Badgingarra site, wetter SE14 applied at 5 L/ha on the top of the furrow gave the highest improvement in wheat tiller number (130%) compared to the control (Table 1). Wetter two coated to the seed at 1–4 L/t, wetter one coated to the seed at 2.5 L/t, and SE14 at 2 L/ha applied on top of the furrow had the next highest improvement of 86-109%. This higher tiller number carried through to higher biomass with SE14 placed at 2–5 L/ha on top of the furrow increasing biomass yield by 93–100%. Other treatments increased biomass by 40–73%. The exception was for in-furrow applied SE14 at rates of 1 and 5L/ha which had a very little or even negative impact on plant biomass (Table 1).

The higher biomass production diluted the N, K, P, S, Ca, Mg, Cu, Mn and Zn nutrient content (data not presented). Nevertheless, the improved biomass growth resulted in increased total nutrient uptake (kg nutrients/ha). Nitrogen uptake was increased by 50–65% when SE14 was applied at 2-5 L/ha on top of the furrow. Other treatments increased N uptake by 22–43%. The exceptions were for SE14 placed in-furrow with the seed at rates of 1 L and 5 L that had lower increases of 4–9%. Similarly, SE14 at 2–5 L/ha applied on top of the furrow, and wetter 2 coated to the seed at 4 L/t increased K uptake by 52–80%. Other treatments increased K uptake by 20–78%. The exception was for the SE14 in-furrow treatment at 1 L/ha that did not increase K uptake.

Darkan experiment

The site was sown on 12 May 2017 with germinating rainfall of 40 mm on 14–21 May. Treatments with wetter applied on top of the furrow, in-furrow and the wetters coated to the seed increased barley emergence compared to the control by 19–50% (Table 1). Nevertheless, uneven germination remained at the site over the growing season despite 108 mm of rainfall in July (Figure 1) due to persistent water repellency and the presence of the root diseases *Rhizoctonia* and *Pratylenchus neglectus*. In-furrow placement of SE14 was observed to give a 9% increase in barley grain yield (significant at $P = 0.1$). Wetter two coated at 4.0 L/t, and the SE14 on top of furrow at 5L/ha also increased barley grain yield by 9%, but this was not significant.

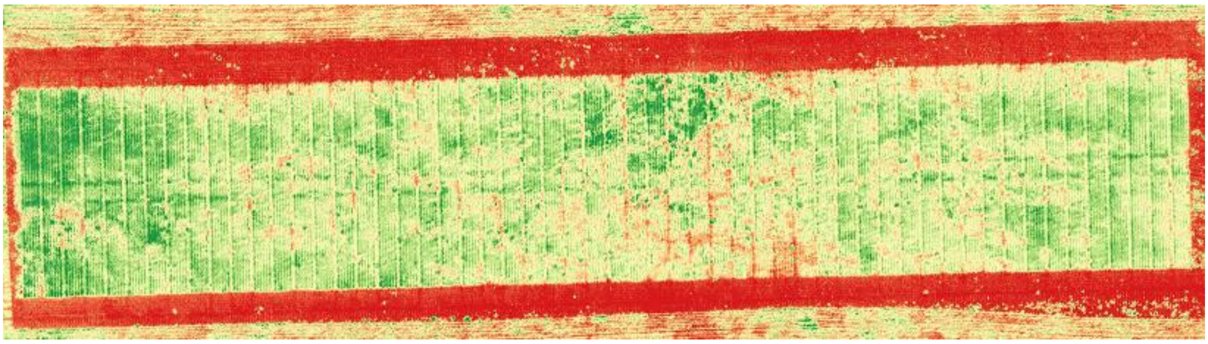

Figure 1. Drone image NDVI of the Darkan experiment site illustrating the patchy establishment and crop production.

Discussion

Seeds coated with wetters improved cereal establishment (plant density and tiller number) by up to 109%, early biomass growth by up to 73% and N uptake by up to 41% (Table 1). Wetter banded on top and in-furrow achieved slightly greater increase cereal establishment (plant density and tiller number) by up to 130%, early biomass growth by up to 100% and N uptake by up to 65%.

Improved establishment of grass species due to seed coating applications and the use of wetters has also been observed by Madsen *et al*. (2016) and Erickson *et al*. (2017). The difference between this study and other seed coating studies is that in our study the seeds are sown below the soil surface while in the other studies the seeds are topdressed on the soil surface. This difference in seed placement could result in a different mechanism acting to improve germination from wetter-coated seeds.

Wetter application to soil is used to reduce the surface tension of water at the soil surface resulting in increase water entry into the repellent soil particularly under dry conditions where wetters improve soil water infiltration uniformity (Roper *et al*. 2015). In this case, seed coating with wetters may aid in improved wetting of the seeding zone despite inconsistent soil wetting via preferential flow, or assist in seed germination at lower soil moisture contents. Further research is required to determine the exact mechanism.

The large responses in crop establishment, early growth and nutrient uptake observed in these experiments were due to the very dry May-June seasonal conditions and also because the experiments were sown dry. Improvements in plant establishment were observed to be higher than those observed by Crabtree and Henderson (1999) who showed that furrow applied wetters improving cereal crop establishment by 10–18% using rates of 2–8 L/ha with effectiveness lower on soils with higher soil carbon contents. Also, the responses were observed to be higher than those observed in more recent studies such as Davies *et al*. (2016) and Sherriff (2016) who observed wetter applied to furrows increased plant density by 10–70% and the associated increase in grain yield of 0–29%.

Conclusion

Coating wetters on to seeds increased the agronomic use efficiency of applying wetters compared to applying them on top and within the furrow or near the seed. That is, seed coating at 0.065–325 L/ha of wetter achieved similar plant density, tiller number, biomass yield and nutrient uptake as applying wetters at 1–5 L/ha on top and within the furrow. Coating wetter onto the seeds also has the potential to increase the handling efficiency. However, further work needs to be done with commercial seed coating and cleaning companies to examine ways of adapting the seed coating technique to their equipment.

Keywords

Wetters, placement, seed coating, furrow placement and water repellent soils.

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References

Davies S, McDonald G, Anderson G, Harte L, Poulish G, Devlin R, Jenkinson R 2016, New opportunities for soil wetting agents on repellent soils. In “2016 Grains Research Updates”, 29 February-1 March 2016, Perth, Western Australia. http://www.giwa.org.au/2016researchupdates.

Crabtree WL, Henderson CWL 1999, Furrows, press wheels and wetting agents improve crop emergence and yield on water repellent soils. *Plant and Soil* 214, 1–8.

Erickson TE, Rojas MM, Kildisheva OA, Stokes BA, White SA, Heyes JL, Dalziell EL, Lewandrowski W, James JJ, Madsen MD, Turner SR, Merritt DJ 2017, Benefits of adopting seed-based technologies for rehabilitation in the mining sector: a Pilbara perspective. *Australian Journal of Botany* Published online 30 November 2017.

Madsen MD, Fidanza MA, Barney NS, Kostka SJ, Badrakh T, McMillan MF 2016, Low-dose Application of non-ionic alkyl-terminated block copolymer surfactant enhances turfgrass seed germination and plant growth. *HortTechnology* 26, 379-385.

Roper MM, Davies SL, Blackwell PS, Hall DJM, Bakker DM, Jongepier R, Ward PR 2015, Management solutions for water repellent ("non-wetting) soils in Australian agriculture - a review. *Soil Research* 53, 786–806.

Sherriff M 2016, Improving crop establishment with in-furrow liquids. In “2016, Grains Research Updates”, 29 February-1 March 2016, Perth, Western Australia. http://www.giwa.org.au/2016researchupdates.