Wheat agronomy on water repellent sands

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AIM

To systematically assess the impact of sowing time, seeding rate and wetting agents on wheat establishment and productivity across a range of environments on water repellent soil and determine whether there are interactions between the agronomic options tested.

BACKGROUND

Furrow sowing with knife points on water repellent sandplain soils is often ineffective with poor crop establishment. The problem is exacerbated in severely repellent soils, when dry sowing and in seasons with a dry start. In general, growers have increased seeding rates with the expectation of increased establishment in these situations in an effort to ensure plant numbers don't limit productivity. Another solution may be to use banded wetting agents which can help water infiltrate more consistently along the crop row.

TRIAL DETAILS

In order to assess these options in a systematic approach four trials assessing sowing time x seeding rate x soil wetter were conducted with Mace wheat in the Western Australian wheatbelt in 2014 (Table 1). Two seeding rates of 60 and 120 kg/ha and two times of sowing were tested at each site (Table 1). The intention for these experiments was to have one early time of sowing into dry soil and one later time of sowing into wet soil. Soil wetter treatments included an untreated control and seven soil wetters comprising six commercially available products and 1 new product under development (Table 2). All soil wetters were banded behind the press wheels at a product application rate of 2 L/ha and a water rate of 100 L/ha.

Soil wetters can have several modes of action, firstly they all contain penetrant compounds that help water penetrate the soil, these are typically surfactants. Secondly, some contain retention compounds that hold and retain water in the topsoil and in some cases they may be able to hold and exchange nutrients although given the small volumes applied these effects are likely very small (Table 2). Nutrient access may also be improved by better wetting of the repellent topsoil along the crop row.

Table 1: Site characteristics including location, soil type, previous crop or pasture, molarity of ethanol droplet (MED) a measure of the severity of soil water repellence, repellence rating, sowing dates and soil moisture conditions (Soil Condition) at the time of sowing in 2014.* 'Variable' conditions are when there was a mix of wet and dry soil, with dry patches or layers present.

Site Location	Soil Type	Preceding 2013 Crop or Pasture	Molarity Ethanol Droplet	Soil Water Repellence Rating	TOS 1 Sowing Date (Soil Condition)	TOS 2 Sowing Date (Soil Condition)
Binnu	Deep yellow sand	Wheat	2.7	Severe	24 April (Dry)	7 May (Wet)
Warradarge	Pale deep sand	Canola	3.0	Severe	2 May (Variable*)	19 May (Wet)
Yealering (D and V Stacey)	Loamy gravel	Subclover	2.0	Moderate	27 April (Wet)	31 May (Wet)
Cranbrook	Duplex sandy gravel	Subclover	4.0	Very Severe	25 April (Dry)	31 May (Variable*)

Table 2: Summary of the characteristics of the soil wetters used in the experiments. All of the products are commercially available apart from 'Wetter 7' which is currently being developed.

Soil wetter code name	Wetting Agent Characteristics	Penetrant (Wetter)	Retention
Wetter 1	Short-term hydrocarbon wetter	Yes	No
Wetter 2	Long-term hydrocarbon wetter	Yes	No
Wetter 3	Organic based wetter	Yes	Possibly?
Wetter 4	Carbohydrate based wetter	Yes	Possibly?
Wetter 5	Retainer with hydrocarbon wetter	Yes	Yes (dominant)
Wetter 6	Hydrocarbon wetter with retainer	Yes (dominant)	Yes
Wetter 7	Hydrocarbon wetter with retainer	Yes	Yes

RESULTS & DISCUSSION

Rainfall and Soil Conditions at Seeding

Good break-of-season rainfall occurred in late April at the Binnu, Warradarge and Yealering sites (Table 3). As a result the only dry sowing occurred at Binnu and Cranbrook, although Binnu received over 42mm of rain immediately after seeding (Table 3). At Warradarge pockets of dry soil were still common at the first time of sowing despite the significant rainfall in late April, a result of the severe soil water repellence at this site. Seeding was into wet soil for the second time of sowing at each of the sites apart from Cranbrook which still had numerous pockets of dry soil (Table 1). Following the good opening rains in April and May all of the sites had low rainfall in June, however rainfall amounts increased again in July at all sites except Binnu where little rain fell throughout June to August. The deep repellent sands at Binnu and Warradarge have poor water holding capacity so struggle to sustain crops over long dry periods.

Table 3: Rainfall data (mm) showing growing season rainfall (April to October), amount and date of opening (break-of-season) rainfall and monthly rainfall for April to November at four sites in Western Australia, 2014. Values have been rounded to the nearest millimetre.

Site	Growing Season Rainfall (Apr-Oct)	Opening Rainfall, mm (Date)	Apr rain	May rain	Jun rain	Jul rain	Aug rain	Sep rain	Oct rain	Nov rain
Binnu	263	42 (27 April)	53	85	22	32	31	53	1	1
Warradarge	416	41 (25-28 April)	42	82	52	106	59	69	6	16
Yealering	304	41 (27 April)	41	51	21	65	39	36	51	12
Cranbrook	426	8 (28-29 April)	9	112	30	100	49	44	82	22

Establishment, biomass, growth and weeds

On the water repellent sands increasing seeding rates did increase plant establishment significantly (Table 4). For the first time of sowing, a 100% increase in seeding rate (from 60 to 120kg/ha) increased plant establishment by 73%, 56% and 77% at Binnu, Warradarge and Yealering respectively (Table 4). For the Cranbrook site there were no plant counts but emergence ratings indicated that the emergence was better with the higher seeding rate (data not shown).

At Binnu and Warradarge time of sowing affected plant numbers (Table 4). At Warradarge plant numbers for the second time of sowing were lower while at Binnu there was an increase in plant numbers at the lower seed rate for the second time of sowing but a decrease in plant numbers at the higher seed rate (Table 4).

Soil wetting agents did not affect establishment at any of the sites except for the first time of sowing at Yealering where the use of soil wetters increased the plant numbers over the control by at least 18% at the 60 kg/ha seed rate and 22% at the 120 kg/ha seed rate (data not shown). At the higher seed rate all of the wetting agents increased plant numbers while at the lower seed rate 'Wetter 2' and 'Wetter 3' did not increase plant numbers while the rest of the wetting agents did (data not shown).

Table 4: Wheat establishment (plants/m^2) for two times of sowing (TOS) and two seeding rates (SR) 60 and 120 kg/ha at three sites affected by soil water repellence in Western Australia, 2014.

Site	TOS 1 60 kg/ha	TOS 1 120 kg/ha	TOS 2 60 kg/ha	TOS 2 120 kg/ha	Least Significant Difference (LSD)
Binnu	98	170	123	155	LSD TOS x SR (0.05) = 22
Warradarge	128	200	98	173	LSD TOS or SR (0.05) = 10
Yealering	115	204	n.m.	n.m.	LSD SR (0.05) = 7

Potassium deficiency on the sands at Warradarge was identified at 4 weeks after seeding in the first sowing time. Plants in the windrow strips were green and thrifty. In contrast the plants in the rest of the plots were stunted and less developed. Muriate of potash was applied following identification. This effect was less evident in the second sowing time because the fertiliser was applied earlier in the crops development. Observations of weed suppression were evident in the windrows for the first sowing time.

At Yealering growth of crops in both times of sowing and for both seed rates was good but vigour ratings undertaken on 27June indicated that plots with wetting agent were more vigorous in the early growth stages than the untreated control plots. Average vigour rating was 68 for the control treatment and ranged from 79 to 92 for soil wetting agent treatments (data not shown). This difference became less evident over time. Visual impacts for some of the wetting agents were also evident at Binnu during vegetative growth with the plants in some of the soil wetter treatments noticeably and consistently darker green than the plants in the other plots. The observation was stronger for the first time of sowing than the second but again this difference became less evident over time.

At the higher rainfall sites, Warradarge, Yealering and Cranbrook the weed burden was large and difficult to control for the first time of sowing compared to the second, which had an opportunity for an effective knockdown herbicide application prior to seeding.

Grain yield and quality

Delayed sowing was more productive on the non-wetting sands than the early sowing treatments at both Binnu and Cranbrook. The first sowing time at both sites were into dry conditions and emerged following the rains in late April (Table 1) and the second sowing time was into wet or variable soil moisture. Binnu was a low yielding site (site average = 0.6t/ha) and Cranbrook was more productive (site average = 3.2t/ha). At Warradarge, yields tended to decline at the second sowing time (Table 5).

There was no influence of seeding rate on grain production at Binnu and Warradarge at the first time of sowing which were low yielding sites (Table 5). However at Cranbrook there was a significant increase in yield from 2.48 to 2.78 t/ha with an increase in seeding rate from 60 to 120kg/ha at the first sowing time. At Binnu only there was a significant effect of wetter on grain production. Grain yields (averaged across all sowing times and seeding rates) of Wetter 1 were significantly higher than all other treatments. Wetter 2 and Wetter 7 were not significantly different to the untreated control (data not shown). It is possible that Wetter 1 enabled the crop to more effectively use the small rainfall events during the dry period by increasing water penetration. At the second sowing time only at Binnu was there a reduction in yield at higher seeding rates (Table 5).

Table 5: Wheat grain yield (t/ha) for two times of sowing (TOS) and two seeding rates (SR) 60 and 120 kg/ha at four sites affected by soil water repellence in the Western Australia, 2014.

Site	TOS 1 60kg/ha	TOS 1 120kg/ha	TOS 2 60kg/ha	TOS 2 120kg/ha	Least Significant Difference (LSD)	Site mean yield (t/ha)
Binnu	0.41	0.44	0.71	0.58	LSD TOS (0.05) = 0.10	0.6
Warradarge	1.27	1.26	0.81	0.69	LSD TOS (0.10) = 0.48	1.0
Yealering	n.a.	n.a.	3.44	3.33	Not significant	3.4 (TOS 2)
Cranbrook	2.48	2.76	3.71	3.68	LSD TOS (0.05) = 0.21	3.2

Seeding rates did not influence grain screenings at Binnu or Warradarge. However, sowing time did affect grain screenings. At Binnu, screenings and 1000 grain weights (averaged across all wetter treatments and seeding rates) were lower in the first sowing time compared to Warradarge where screenings were lower in the second sowing time (Table 6). This is reflected by the grain weights. Screenings at Warradarge were greater than 5% at both sowing times, compared to Binnu where screenings were greater than 5% at the second sowing time. Although there was an influence of wetters on grain protein at both sites, the differences were small and would not affect marketability of grain.

Table 6: Screenings (%), thousand grain weight (TGW, g), grain protein (%) of wheat for two times of sowing (TOS) and two seeding rates (SR) 60 and 120 kg/ha at four sites affected by soil water repellence in Western Australia, 2014.

Site	Quality parameter	TOS 1 60kg/ha	TOS 1 120kg/ha	TOS 2 60kg/ha	TOS 2 120kg/ha	Least Significant Difference
Binnu	Screenings (%)	4.5	4.2	5.9	5.4	LSD TOS (0.05) = 0.6
Warradarge	Screenings (%)	8.5	8.4	7.3	7.1	LSD TOS (0.05) = 0.6
Binnu	TGW (g)	34.2	32.9	32.8	32.1	LSD TOS or SR (0.05) = 0.6
Warradarge	TGW (g)	33.2	32.3	36.0	34.9	LSD TOS or SR (0.05) = 0.5
Binnu	Protein (%)	11.9	12.2	12.3	12.5	LSD TOS or SR (0.05) = 0.2
Warradarge	Protein (%)	13.0	13.2	12.8	12.9	LSD TOS (0.05) = 0.3

CONCLUSION

1. Seeding rate had a bigger impact on wheat establishment than soil wetting agents
2. High seeding rates on soils with low yield potential were sometimes a disadvantage; optimal seeding rates would need to account for yield potential as well as the degree of soil water repellence.
3. Delaying sowing providing an opportunity to get a knockdown of weeds was important on water repellent soils where staggered weed germination, and reduced herbicide activity, reduces efficacy of in-crop and pre-emergent applications.
4. In these trials soil wetting agents did not consistently impr60loamove wheat establishment and despite some evidence of benefits to vegetative growth this generally did not translate into a grain yield benefit.

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