Seeder-based approaches to reduce the impact of water repellence on crop productivity: Seeder-based strategies

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Location
Murlong
-33.691295S, 135.944050E
Mark and Amy Siviour

Rainfall
Av. Annual: 385 mm
Av. GSR: 270 mm
2019 Total: 223 mm
2019 GSR: 209 mm

Yield
Potential: 2.7 t/ha for decile 1(W)
Actual: 2.4 t/ha (B)

Paddock history
2018: CL Razor wheat
2017: CL Scope barley
2016: Pasture
2015: Mace wheat

Soil type
Grey, non-wetting deep sand

Soil test
$pH_{(Water)}$: 7.7

Plot size
25 m x 1.68 m (6 rows) x 4 reps

Yield limiting factors
Water repellence

Key messages

- **Low-cost, low risk seeder-based strategies achieved valuable wheat/barley crop establishment and grain yield benefits in a severely water repellent sand in two below-average rainfall seasons.**
- **Edge-row/on-row sowing and 230 mm deep furrow till achieved the greatest crop benefits by exploiting existing in-furrow moisture (via guided sowing) and deeper moisture (via lifting by furrow opener), respectively.**
- **While adoption of these strategies involve Real Time Kinematic (RTK) guidance, liquid dispensing and compatible seeding system technologies, scope for simplified solutions to reduce practical challenges exist and their performance should be tested in farm scale demonstrations.**

Why do the trial?

Non-wetting sands have low fertility and suffer from delayed and uneven wetting, which leads to erratic crop establishment, staggered weed germination and generally poor crop productivity due to low plant densities, low nutrient access, poor weed control and crop damage in areas prone to wind erosion. A range of trials in the GRDC funded Sandy Soils Project (CSP00203) are investigating effective solutions available at seeding time to mitigate the impacts of water repellence. A range of seeder strategy experiments in the SA Mallee and in WA have demonstrated the potential for edge-row, on-row, paired-row and deep furrow till sowing to deliver establishment and yield benefits in water repellent sands. Another project trial conducted in a non-wetting deep sand at Lameroo during 2017-2019, quantified significant benefits of edge-row and on-row sowing on wheat and barley crop establishment and grain yield, while significant biomass and grain yield responses to 230 mm deep furrow till were also measured (Desbiolles *et al*. 2019). In addition, experiments at Murlong have demonstrated some consistency in crop responses to wetters on water repellent sand (see Soil Wetter Evaluation article).

The aim of this work was to test the impact of single and combined strategies that could be available to farmers around seed row location relative to stubble row (using RTK guidance), soil wetter (using liquid application), depth of furrow till (adjusting furrow opener to suit), opener type (knife point vs inverted T) and paired row sowing (vs single row baseline), with the aim to recommend a seeding strategy that maximises crop establishment and yield in a water repellent sand.

How was it done?

A trial was set up at Murlong on EP in 2019. This trial was sown with barley on 20-22 May 2019 into 6 row wheat stubble plots established in 2018 on an RTK AB-line to ensure high accuracy when implementing row guided sowing treatments. The soil wetter (SACOA SE14 at 3 L/ha) was applied to the seed zone into 100 L/ha water volume. The seeding agronomy is summarised in the Soil Wetter Evaluation article. Two separate double shoot tine seeding systems were used, namely knife point side banding to achieve edge-row sowing and a baseline knife point centre row banding to achieve inter-row and on-row sowing, both followed by a 100 mm wide banked press wheel.

The 230 mm depth of furrow-till contrast was achieved by using a 120 mm longer knife point (side banding) or by operating 120 mm deeper and setting the seed boot 120 mm higher (centre-row banding).

Eleven experimental treatments with 4 replicates were organised in a randomised complete block design and consisted of: a) six treatments assessing the impact of a selected seed-zone soil wetter under inter-row, edge row and on-row sowing configurations at a reference 110 mm depth of furrow till, b) two soil wetter treatments assessing the additional impact of a 230 mm deep furrow till under inter-row and edge row sowing, c) two soil wetter treatments contrasting the impact of an inverted T opener (95 mm wide) and of paired row sowing (75 mm spread) at the reference 110 mm depth of furrow till under on-row sowing and, d) an additional contrast to the no-wetter control under inter-row sowing, assessing the impact of a proportion of in-furrow fertiliser (6N+12P) applied with the seeds. The treatment factors are listed in Table 1 and illustrated in Figure 1.

Table 1. Key treatment factors and the combinations tested in the seeder strategy evaluation trial at Murlong in 2019.

Treatment label	Seed row placement	Wetter (W)	Furrow Tillage (mm)	Fertiliser (28N, 12P+6S+1.5Zn)
IR+Fert	Inter-row	nil	110	6N+12P with seed
Inter-Row (IR)	Inter-row	nil	110	Deep banded
IR+W	Inter-row	SE14	110	Deep banded
IR+W+Deep-Till	Inter-row	SE14	230	Deep banded
Edge row (ER)	Edge-row	nil	110	Deep banded
ER+W	Edge-row	SE14	110	Deep banded
ER+W+ Deep-Till	Edge-row	SE14	230	Deep banded
On-Row (OR)	On-row	nil	110	Deep banded
OR+W	On-row	SE14	110	Deep banded
OR+W+Paired row	On-row, Paired-row	SE14	110	Deep banded
OR+W+Inv.T	On-row, Inverted T	SE14	110	Deep banded

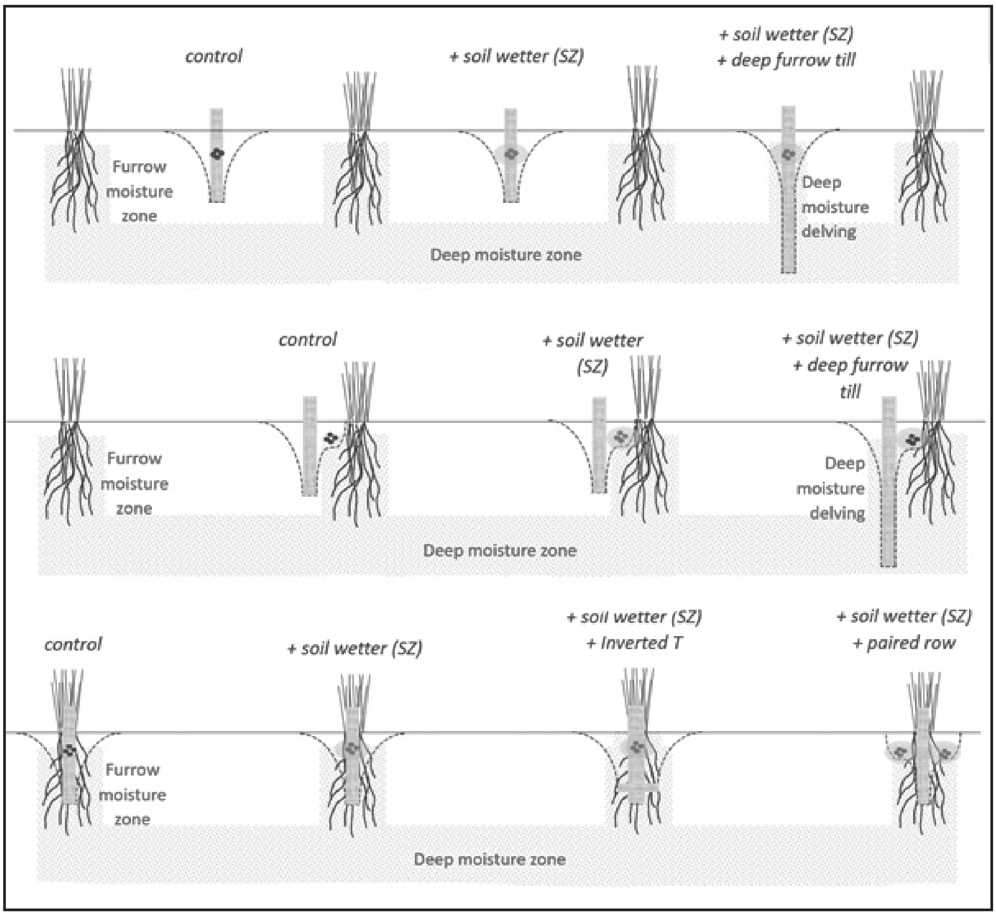

Figure 1. Visual representation of seeder-based strategies for non-wetting sands evaluated at Murlong: Top: inter-row sowing; Centre: edge-row sowing; Bottom: on-row sowing. The schematic highlights the previous year stubble rows; the seeding opener and co-placement of seeds and wetting agent; the moisture zones in furrow and at depth.

Soils

What happened?

A dry 11-12 cm thick repellent top layer was present in the inter-row zone at seeding but with consistent moisture below 16-17 cm, which was separated by a patchy transition zone. In contrast, the existing stubble row zone had good moisture below 4-5 cm dry top layer. Measurements quantified 9 mm more water stored in the 0-40 cm layer in the stubble row zone compared to the inter-row zone, with the majority occurring in the top 25 cm layer. This moisture benefit in the stubble row was consistent with observations made in water repellent sands at Lameroo during 2018/19, which ranged between 7-9 mm of extra water stored on the 0-40 cm layer in both seasons.

On-row sowing alone increased plant density by 39 plants/m^2 over edge-row sowing and by 95 plants/m^2 over inter-row sowing (Figure 2). Edge-row sowing results were much more variable indicating the sensitivity of this strategy to an optimum position relative to the stubble row and representing a greater difficulty for farm adoption. Inter-row sowing crop establishment was 21 plants/m^2 worse than the equivalent control under the soil wetter evaluation trial (see Soil Wetter Evaluation article), which had used a more accurate seeding system. The placement of 6N+12P fertiliser with the seed created a small additional loss to an already very poor control crop establishment (at 0.28 m row spacing, approximately 10% seedbed utilisation).

The addition of soil wetter increased plant density by 22 and 29 plants/m^2 in inter-row and edge-row sowing, respectively (Figure 2). In contrast, no soil wetter benefits were measured under on-row sowing, where the stubble row soil was already sufficiently moist to achieve good germination on its own. The benefit of the soil wetter (SACOA SE14 at 3 L/ha) under inter-row sowing was slightly less (i.e. 22 plants/m^2 vs 36 plants/m^2) than that measured in the Soil Wetter Evaluation trial, which may be due to the better seed and wetter co-placement and water harvesting furrow quality obtained by the tine-disc-wide press wheel seeding system of that trial. This perhaps emphasises the importance of considering seeder set-up issues in combination with wetter application to extract the best possible response from the wetter.

Deep furrow till to 230 mm depth had a major positive impact (extra 74 plants/m^2) under inter-row sowing with soil wetter, where deeper moisture delving most benefited an otherwise dry seed zone (Figure 2). Deep furrow till did not improve establishment under edge-row sowing where a 26 plants/m^2 decrease was recorded. This may be due to the long steep knife point to reach 230 mm depth likely less effective at delving moisture up and the extra disturbance also affecting seed placement uniformity with this compact side banding unit. Deep furrow till was not evaluated under on-row sowing. However, a positive response to inverted T opener (+20 plants/m^2) was measured, indicating that the extra quantity of moist furrow soil lifting and mixing benefited seed germination.

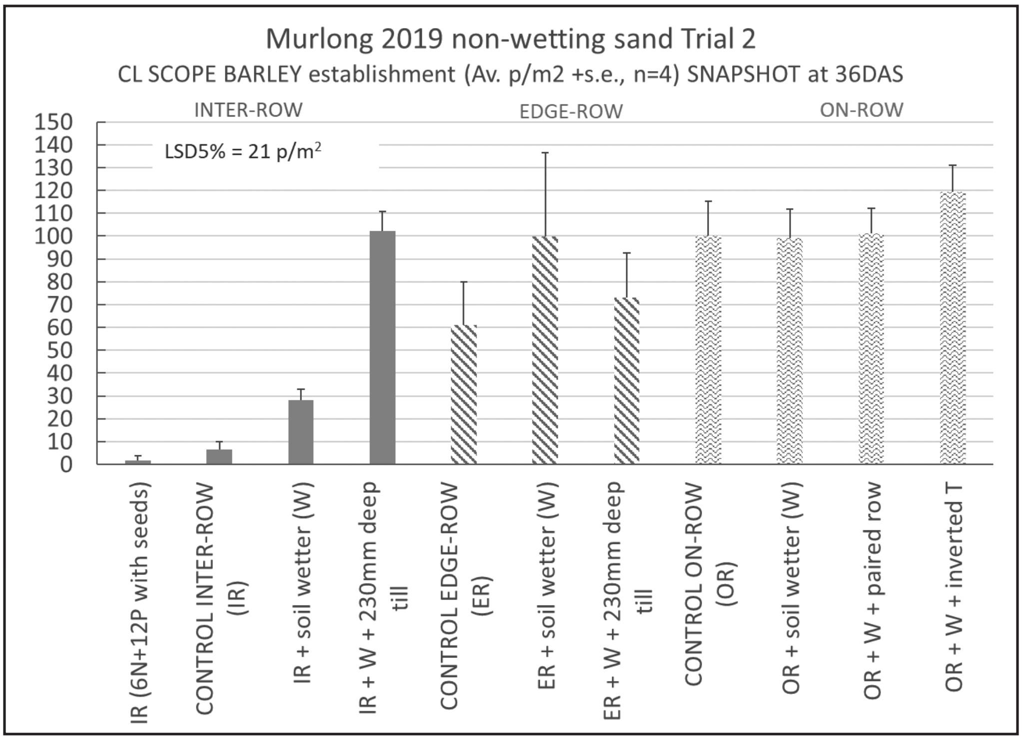

Figure 2. Impacts of various inter-row, edge-row and on-row sowing strategies on crop establishment at 5 weeks after sowing in barley at Murlong in 2019. The error bars represent the standard errors of the treatment means.

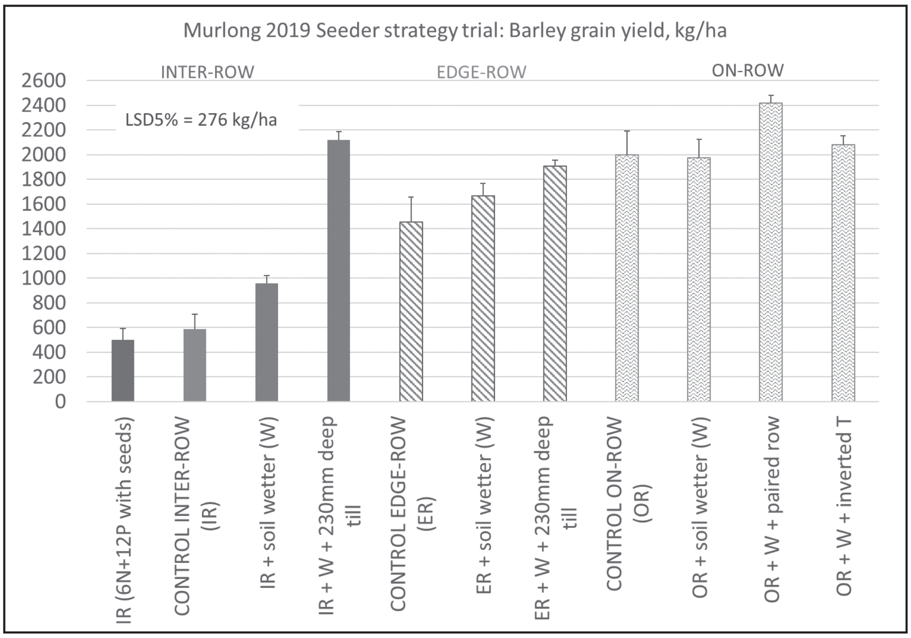

Figure 3. Impacts of various inter-row, edge-row and on-row sowing strategies on barley grain yield in 2019 at Murlong. The error bars represent the standard errors of the treatment means.

Under on-row sowing with soil wetter, the paired row system did not improve crop establishment over the single row equivalent, both using a knife point opener.

Figure 3 shows grain yields ranged from 0.5-2.42 t/ha. Inter-row, edge-row and on-row sowing controls yielded 0.59, 1.45 and 2.0 t/ha, respectively. All on-row treatments yielded at or above 2 t/ha, with paired row sowing yielding the highest (2.42 t/ha). Inter-row sowing benefited from the soil wetter (0.37 t/ha gain), and even more drastically from the 230 mm deep furrow till (1.16 t/ha additional gain). The soil wetter had no effect on grain yield when applied on-row where furrow moisture was sufficient to achieve good germination. Overall, grain yield responses to treatments were highly correlated with their established plant densities, indicating higher plant numbers was a key factor driving barley grain yield under the trial conditions. The inter-row control in the soil wetter evaluation trial (see Soil Wetter Evaluation article) yielded more (0.5 t/ha) than in this trial, which may be explained by the combined benefits of 5 days earlier sowing, greater water harvesting and more stable furrows, more precise seed placement and soil wetter co-location achieved by the tine-disc-wide press wheel seeding system.

What does this mean?

Seeder-based strategies for reducing the impact of water repellence can deliver large benefits on crop establishment and productivity in terms of grain yield. The strategies evaluated focussed on accessing the stored moisture within existing stubble rows, the deeper moisture found below a dry non-wetting top layer and maximising in-season rainfall infiltration and use.

Specific technologies were required to implement these strategies, such as: precision guidance (on-row, edge-row sowing), liquid dispensing (soil wetters), seeding system attributes (adjustable depth of furrow till, stable water-harvesting furrows, precision placement of seed and liquids in furrow, paired row seeding, seed-fertiliser separation).

Combining technologies can deliver additive crop establishment and productivity benefits, thus have the potential to form the basis of best-practice on-farm. Adoption of some strategies, however, is likely to be limited if major investments are required by the grain grower. Other complications include issues such as water repellent sands only occupying part of larger paddocks and larger scale machinery with variable tracking accuracy.

Some of the benefits summarised above could be achieved with low-technology options such as upgrading seeders for deeper moisture delving capability and seeding (without RTK guidance) at a small angle to existing stubble rows, in order to maximise the benefits of furrow moisture access. Project validation activities in 2020 will work with growers to evaluate which seeder-based strategies can be effectively implemented at farmer scale in different sand environments.

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