Getting the edge on improving crop productivity on Southern sandy soils

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Key messages

- Edge-row sowing increases crop establishment and competition with weeds.
- Ripping and spading have had significant yield effects, even in a very low rainfall season.
- Organic inputs or fertiliser supplied with ripping and spading have shown varied responses.

Aims

The aim of this work is to increase crop water use on sandy soils in the Southern cropping region by improving constraint diagnosis and management of underperforming sands. To achieve the best possible profit-risk outcomes we are testing strategies that are relatively low cost and implemented with a seeder, through to very expensive disruptions that require specialised machinery.

Water-use and productivity on sandy soils are commonly limited by a range of co-occurring soil constraints that limit root growth. Constraints include non-wetting with poor crop establishment, soil pH issues (both acidity and alkalinity), poor nutrient supply, compaction and the presence of other subsoil constraints. Opportunities to overcome these constraints to improve crop water-use, include cost-effective seeder based strategies (seed placement, wetting agents, fertiliser placement), and higher investment profile amelioration approaches (deep ripping, spading, deep ploughing).

Method

From 2014 to 2017 we experimented with edge-row sowing (sowing as close as practical to the previous crop row) on a non-wetting sand at Karoonda, with evaluation of the effects of the strategy on surface and sub-surface soil water, crop establishment, weed competition, disease, nitrogen supply and crop yield. Findings from these experiments informed the approach taken in the GRDC Sandy Soils Program (CSP00203) that commenced in 2017. The approach investigates both seeder based and more intensive (ripping/spading) methods at seven newly established sites. The dominant soil constraints targeted were physical and nutritional constraints alone (Waikerie, Carwarp, Bute, Ouyen), or in combination with water-repellence (Murlong, Lameroo) or acidity (Yenda). A summary of the treatments at each site are provided in Table 1.

We expanded the concept of edge-row sowing by comparing this treatment to permanent fertility strips on a water repellent sand at Lameroo. A permanent fertility strip involves sowing sow crops in very close proximity to previous crop rows with the row sown on side of the first crop row in the second year and the other side of the crop row in the third year, creating a permanent and concentrated strip where all inputs are applied. Amendments (compost, clay or biochar) are being applied every year for three years (to reduce upfront risk) and including placement at 20 cm depth. At the water repellent site in Murlong, the edge-row sowing strategy has been tested with a range of wetting agent approaches (type and placement). A range of more intensive interventions have been tested at Ouyen, Murlong, Waikerie, Carwarp, Yenda and Bute to evaluate whether increasing the depth of physical treatments (ripping or spading) and/or amendments (lime, fertiliser, chicken litter, crop residue or compost) within the profile results in cost effective outcomes (Table 1).

Table 1. Summary of Sandy Soil project treatments indicating the type of physical amelioration approach, amendments used, and placement strategy.

Site (Yr Est)	Physical Treatment (depth cm)	Amendment Type	Amendment Placement
Lameroo (2017)	Seeder (20)	Compost (200 kg/ha), clay (100 kg/ha), biochar (50 kg/ha) annual	With seed and deep
Waikerie (2018)	Rip (30), Rip (60)	Chicken Litter (2.5 t/ha), fertiliser matched	Deep, surface
Carwarp (2018)	Spaded (30), Rip (30), Rip (60)	High-N biomass (6 t/ha)	Deep
Bute (2018)	Rip (30), Rip (50), TSSlot (50)	Chicken Litter (2.5-7.5 t/ha)	Deep, surface
Ouyen (2017)	Spaded (30), Rip (30)	Crop residue (6 t/ha), chicken litter, compost, fertiliser matched	Incorporated, deep
Murlong (2018)	Spaded (30), TSSlot (30), TSSlot (40)	High-N biomass (5 t/ha); fertiliser	Incorporated
Yenda (2017)	Sweep (30), Rip (30)	Chicken Litter (3-9 t/ha)	Incorporated

* amendments used at the trial sites vary depending on regional availability, where chicken litter is considered unavailable in the VIC Mallee and Eyre Peninsula. TSSlot- topsoil slotting/ inclusion plates

Results

Edge Row Sowing

Soil disease is often seen as the greatest drawback of edge row sowing. Inoculum levels for Rhizoctonia, Take All and Crown Rot are generally higher in soils from previous year's crop row (on-row) compared to inter-row which reflected in disease incidence. However, in spite of the high levels of pre-sowing inoculum in 2017, disease incidence was often low with edge-row sowing, which may be attributed to the overall increase in disease suppression potential of soil from long term stubble retention and conservation management practices (Table 2).

Table 2. Soil borne disease risk ratings for Take-all (Ggt), Rhizoctonia (RsAG8) and Fusarium crown rot in the soil edge-row and in the inter-row at the time of sowing in 2017 and a combined disease incidence rating (GS31, 2017 growing season).

Sowing Treatment	Disease risk from pathogen inoculum			Disease incidence
	Rhizoctonia	TakeAll (Ggt)	Fusarium crown rot	Root rating (0-5 scale)
Edge-row	High	Medium	High	1.4 ± 0.2
Inter-row	Low	Low	Low	0.6 ± 0.1

Edge-row sowing often improves **crop establishment**, especially on non-wetting sands. For example, in 2017 establishment was improved by nearly 40% with edge-row sowing at Karoonda, resulting in greater early biomass at first node (crop growth stage 31). However as in previous seasons, the benefit of early establishment and greater crop biomass with edge-row sowing were not transformed into significant benefits for grain yield in this highly variable water repellent soil environment.

One of the greatest advantages of edge-row sowing has been increased crop competition and subsequent suppression of weed seed set of **brome grass**. For example, in 2017 there were 10 brome plants/ m^2 more where wheat was sown inter-row vs. edge-row and no pre-emergent herbicides were used (Figure 1). Where trifluralin and metribuzin were used in conjunction with edge-row sowing, the brome grass population was reduced by a further 20 plants/m^2. In 2016, this weed suppression led to a 72% reduction in brome grass seed set in edge-row treatments.

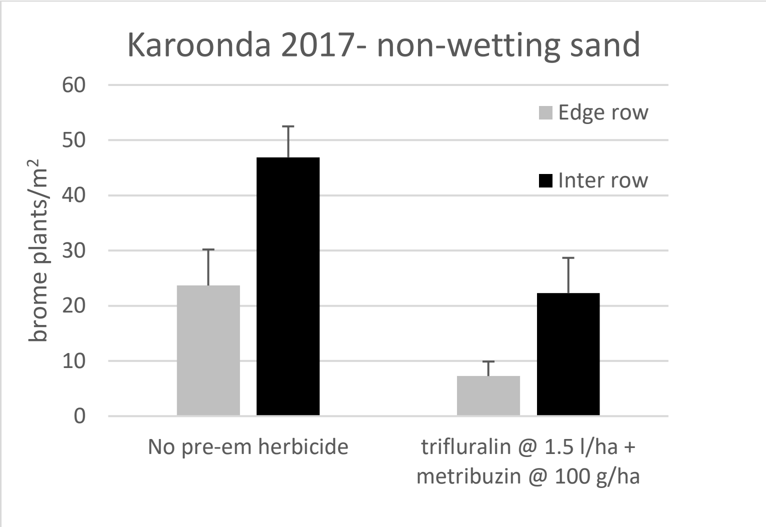

Figure 1. Brome grass population (plants/m^2) in a wheat crop sown edge-row or inter-row and with or without pre-emergent herbicide on a non-wetting sandy soil at Karoonda in 2017. Pre-emergent herbicide treatment was a mix of trifluralin at 1.5 L/ha and metribuzin at 100 g/ha was incorporated by sowing.

Edge row seeding is an effective mechanism for managing the brome grass weed seed bank. The edge row seeding position not only enhances the competitive ability of the crop through improved establishment and early vigour, but also promotes weed germination in the part of the paddock where the crops competitive ability is greatest. For example, in 2016, the density of brome that emerged in previous year's crop row was at least 7 times higher than the density of brome in the inter-row reflecting the better germination conditions in the previous year's row.

Expanding the concept of edge row seeding to the **permanent fertility strip** in 2017 revealed a 0.6 t/ha response when the amendments were placed at 20 cm depth with the seeder compared with 10 cm, while other treatments did not show a significant effect. In 2018, a poor season (decile 1) at Lameroo with crop establishment challenges there was 1.35 t/ha barley grain yield for inter-row sowing, 1.85 t/ha from sowing on the edge-row with a further 0.35 t/ha (2.2t/ha yield) for sowing on the edge-row with amendments applied at 20 cm depth. A separate test revealed that it was the physical disruption rather than the addition of amendments that had the effect.

A wide range of experiments have demonstrated that **physical interventions** (ripping, spading, deep cultivation) can improve crop productivity in compacted sandy soils. The ability to further increase yield gains with effective cost benefits by incorporating amendments (fertilisers, manure, crop biomass) is not as well understood. Depth of placement and type of amendment influence the rooting depth, the timing of nutrient supply, and access to profile moisture. These factors influence the balance of crop growth, development, and grain filling. Targeting the depth of amelioration to compaction thresholds (with/without deep placement of amendments) three new experiments (2018) demonstrated a range of site specific responses (Figure 2). The potential for yield gains at Waikerie was limited by available water (95 mm growing season rainfall, GS, low stored moisture), with small yield gains observed in 60 cm ripping treatments (+0.3 t/ha), and no response to deep placed nutrition. At Carwarp (~70 mm GS rainfall, good stored moisture) the yield response to a range of amelioration approaches (ripping, spading) were relatively consistent (+0.5 t/ha) with no significant response to depth, despite evidence of deeper crop water-use. Increasing profile nutrition through incorporation of N-rich biomass had either no benefit (deep placed) or a negative yield effect (spading) associated with high early biomass production. In contrast to the dominance of physical effects at Waikerie and Carwarp, crop yields at Bute were more responsive to **improved nutrition** (application of 7.5 t/ha surface chicken litter) demonstrating yield gains of approximately 0.9 t/ha compared to an average gain of 0.3 t/ha from physical interventions alone. The Bute site had the lowest level of soil compaction across the project sites. All trials continue for a further 2 years to evaluate the longevity of physical and nutrient carry-over effects.

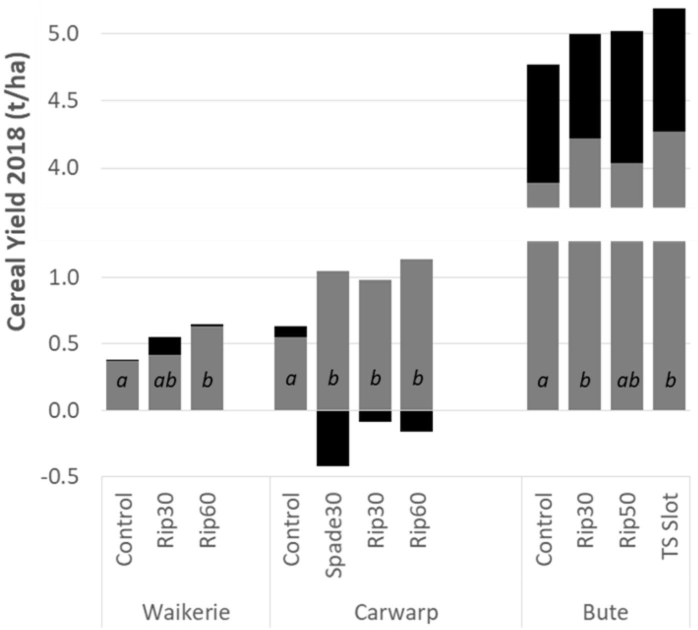

Figure 2. Cereal yields across three amelioration trial sites including non-ameliorated control, ripped (Rip30, Rip50, Rip60), spaded (Spade30), or topsoil slotted (TSSlot30) treatments, and where number indicates depth (cm) of intervention. Grey bars represent yields under best practice fertiliser inputs, while black bars indicate gains/losses under nutrient enriched treatments. Letters indicate significant amelioration impacts within sites (n=4), noting broken y-axis to account for higher yields.

Conclusion

There are a range of strategies that have been used to manage non-wetting, compaction and poor fertility in sands of the Southern cropping region. These strategies have varied in cost, reliability and longevity of effect, all key factors in profit and risk.

Key words

Ripping, spading, compaction, topsoil slotting, inclusion plates, edge/on-row sowing, organic inputs

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