Understanding the impact of strategic tillage practices on crop performance and soil properties for a shallow sandy duplex at York

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Key messages

1. Inversion ploughing of water repellent sands can significantly reduce repellence and increase critical components of grain yield.
2. Deep ripping in the presence of problem background ryegrass can stimulate ryegrass emergence and worsen weed competition with the crop.
3. The strength of the subsoil resource (i.e. clay component) appears important in sustaining the crop production potential and realisation of grain yield improvement.

Aims

To compare and showcase a range of strategic tillage options for amelioration of shallow sandy duplex soils (Sand over clay/gravel) and to assess their effectiveness at overcoming a range of soil constraints including topsoil water repellence and Compaction and increasing crop productivity over a period of 4-5 years.

Method

The York experiment is a randomised complete block design with 4 replications and was established in 2018 on a shallow sandy duplex (Sand over clay/gravel) at Warding Road, Caljie (North East of York, WA). The plots were established using the growers existing 12m seeding system. Plots are 4m wide and 20m long and are located in the wings, either side of the wheel tracks. The area between the wheel tracks has been left as an untreated buffer. The entire site is seeded and managed by the grower throughout the season but harvesting is undertaken with a small plot harvester so yield can be assessed on individual plots.

Table 1. Experimental site location, soil type, annual and 2018 growing season rainfall and soil properties.

Site	Rainfall (mm)		Repellency rating	Soil pH(Cacl2)					Compaction (Severe)	Soil Fertility (0-10cm)		
	Average annual	Growing Season	MED Test	0-10cm	10-20cm	20-30cm	30-40cm	40-50cm	20-40cm	OC	P	K
York (Shallow Sandy Duplex - Sand over clay/gravel)	365	266 (2018)	1.0-2.7 (Average 1.6)	5.3	4.5	4.8	4.7	4.9	2.6->4.0mPa	0.98	15	65

Machines used for the tillage treatments included a Bednar Terraland deep ripper, Farmax rotary spader, Kverneland reversible mouldboard plough, a modified Shearer 5GP Plozza system one-way plough and a Grizzly Tiny off-set disc. All of the tillage treatments were applied prior to seeding.

The York site was sown to Spartacus barley at 70kg/ha with 90kgs/ha K-Till Max and 70kgs NK21 fertiliser at sowing. Nutrition top ups in season comprised of 100L/ha UAN on the 21st July and 23L/ha UAN on the 27th August.

1.0L Trifluralin 480 was applied as pre-emergent ryegrass control with a knockdown of 1.5L/Ha of Glyphosate 450gai.

Post emergent annual ryegrass suppression was achieved with 2.5L/ha Boxer Gold applied at the 2 leaf crop stage on the 12th June. Post emergent broadleaf and barley grass weed control was achieved with 1L/ha Soar plus 500ml/ha Intervix.

Table 2. Experimental treatment details

fenceline

	Rep 1	20m	20m Buffer	Rep 2	20m Buffer	Rep 3	20m Buffer	Rep 4
4m	Traffic line							
	1.1	one-way Plozza plough		2.1 control		3.1 deep rip + spade		4.1 one-way Plozza plough + deep rip
	1.2	one-way Plozza plough + deep rip		2.2 deep rip 350mm (Bednar)		3.2 control		4.2 deep rip + offset disc
4m	Traffic line							
	1.3	control		2.3 deep rip + spade		3.3 one-way Plozza plough + deep rip		4.3 mouldboard plough + deep rip
	1.4	mouldboard plough + deep rip		2.4 one-way Plozza plough		3.4 deep rip + offset disc		4.4 mouldboard plough
4m	Traffic line							
	1.5	deep rip 350mm (Bednar)		2.5 mouldboard plough		3.5 mouldboard plough + deep rip		4.5 deep rip + spade
	1.6	deep rip + offset disc		2.6 one-way Plozza plough + deep rip		3.6 one-way Plozza plough		4.6 deep rip 350mm (Bednar)
4m	Traffic line							
	1.7	mouldboard plough		2.7 mouldboard plough + deep rip		3.7 deep rip 350mm (Bednar)		4.7 control
	1.8	deep rip + spade		2.8 deep rip + offset disc		3.8 mouldboard plough		4.8 one-way Plozza plough
4m	Traffic line							

Measurements at the site in 2018 included:

- Soil Penetrometer Data logging measurements for effective working depth of tillage
- Molarity of ethanol droplet (MED) soil water repellence tests post-treatment
- Plant establishment counts
- NDVI analysis
- Leaf analysis (whole plant) for tissue nutrient concentrations
- Tiller counts
- Soil pit face root assessment
- Grain yield and quality

Results and Discussion

Rainfall

The barley crop was wet sown on the 26th May 2018, one day after the opening season rainfall of 28mm. Incomplete soil wetting was observed at the site with pockets of dry soil observed during the seeding process. A total of 266mm of growing season rainfall was recorded at Caljie throughout the season (Table 1) with additional benefit likely from an additional 106.7mm of summer rainfall accumulated in January and February 2018.

A prolonged dry period during spring occurred during the critical periods of flowering and grain fill, with less than 10mm of rainfall occurring in September 2018. Late season grain fill was benefited by 23mm of October rainfall.

Soil Constraints

Soil strength measurements were difficult to assess accurately with a penetrometer due to the gravel and clay component of the subsoil duplex interfering with penetrometer insertion. Penetrometer readings are a good indicator of the effective working depth of tillage implements more than they are an accurate measurement of finite soil strength at this site due to dry soil conditions at the time of measurement and presence of clay and gravel subsoils.

The effective working depth of the tillage treatments varied from 225mm to more than 350mm, with the cumulative benefit of combinations of deep ripping followed by inversion ploughing achieving the greatest depth. All of the treatments reduced the soil strength of the top 22cm of soil to a penetration resistance less than 2.6MPa (Figure 1).

Water repellence in the control plots was moderate (1) to severe (3.0) based on the laboratory MED test result.

Deep ripping slightly (statistically significant) reduced the expression of water repellence in the test results whereas spading, one way ploughing and mouldboard ploughing significantly decreased or totally removed the repellence of the topsoils (Figure 2).

Subsoil acidity is potentially an issue for the York site with an average pH_{Ca} of 4.5 in the 10-20cm depth increments (Table 1), however lime amendments have not been undertaken at this site at the time of trial establishment. Ongoing acidification will, in time, reduce crop performance.

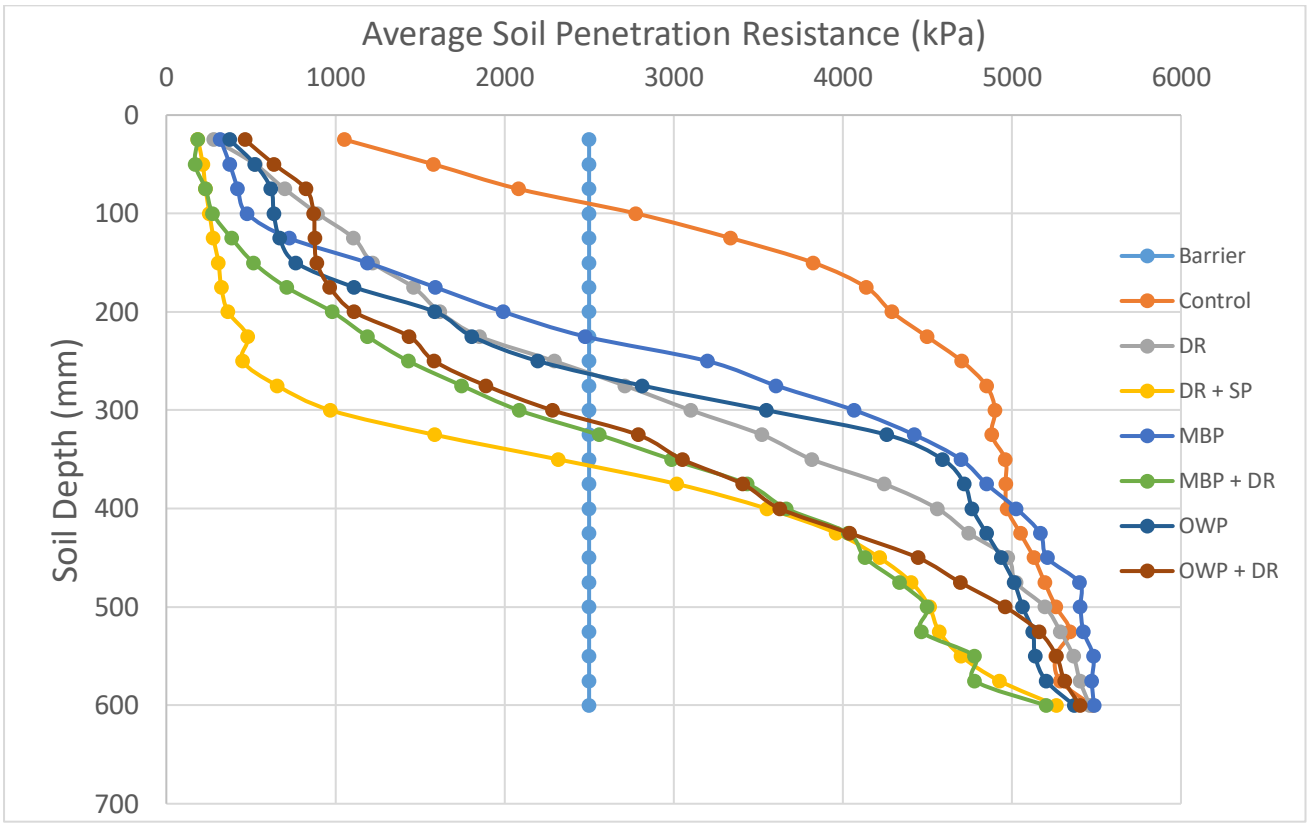

Figure 1. Effective working depth of tillage implements assessed by a RIMIK data logging soil Penetrometer measuring penetration resistance (kPa) in April of 2018. (Note gravel/clay subsoil duplex measured in dry conditions so measurements are an indicator of tillage implement effective working depth and not finite physical soil strength).

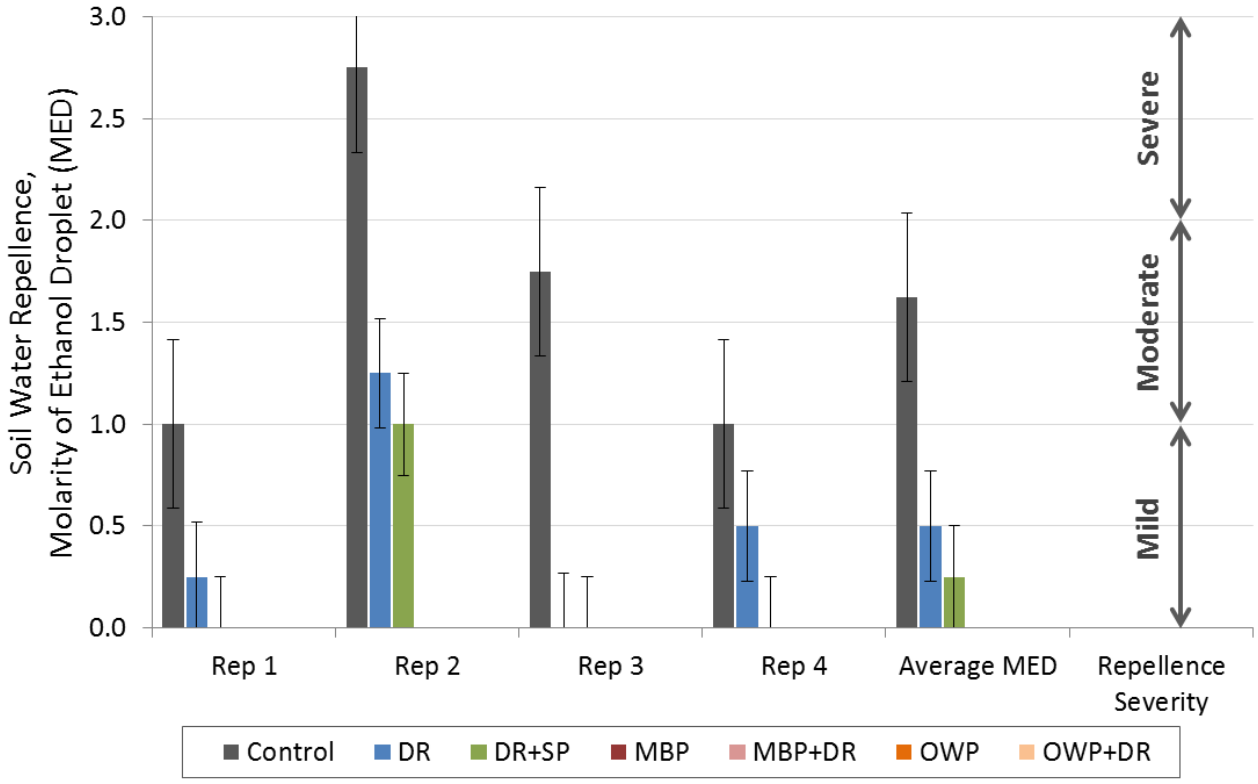

Figure 2. Molarity of ethanol droplet (MED) for topsoil water repellence rating. (York - Measured 2018). Note inversion treatments have reduced topsoil repellence to nil, hence bars do not show.

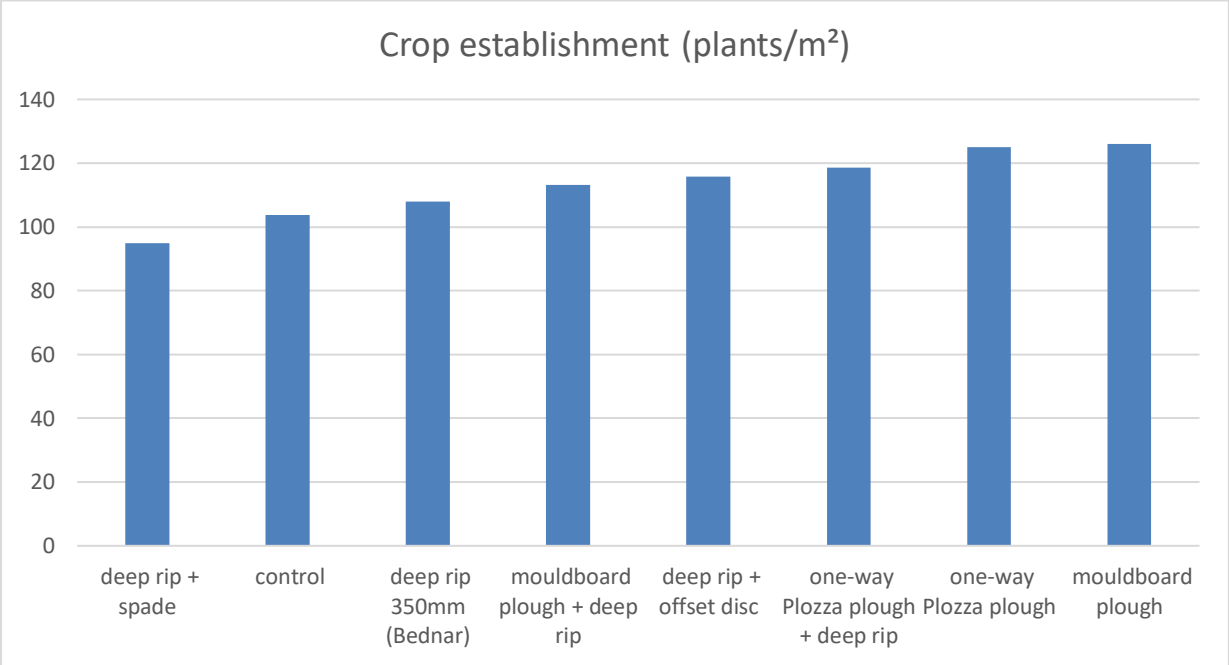

Figure 3. Barley plant establishment counts in 2018 from selected treatments.

Crop establishment was assessed 4 weeks post seeding, on 29th June 2018, using plant counts.

The reduction of water repellent topsoils through inversion ploughing techniques appeared to have the most significant impact on plant establishment (Figure 3).

Establishment outcomes ranged from 95 plants/m^2 to 126 plants/m^2. The untreated control measured 103 plants/m^2 with Deep ripping and spading reducing establishment to 95 plants/m^2. The stand-alone One-way (Plozza) and Mouldboard ploughing treatments provided the best establishment outcomes of 124 to 126 plants/m^2 respectively, a 20%-22% improvement in plant number. The stand-alone deep ripping treatment delivered an establishment count of 107 plants/m^2, not statistically different from the untreated control.

Tiller counts were completed in September 2018. The control plots averaged 436 tillers/m^2 with the greatest crop production potential improvement measured in the ploughing treatments. Mouldboard ploughing, One Way ploughing, Mouldboard ploughing plus Deep ripping and One Way ploughing plus Deep ripping delivered tiller increases of 35%, 50% 42% and 38% respectively whilst standard deep ripping did not change tiller density (Figure 4).

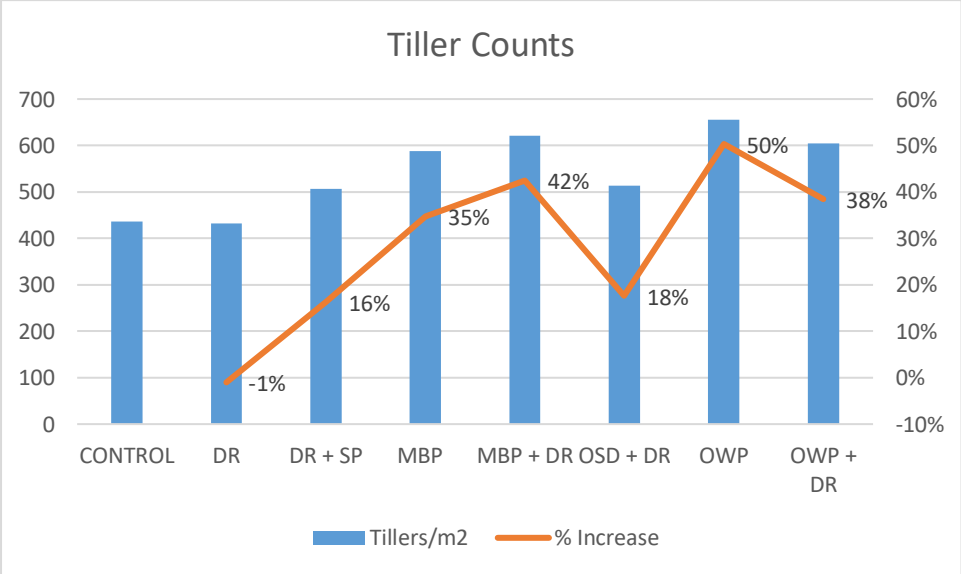

Figure 4. Tiller counts in September 2018.

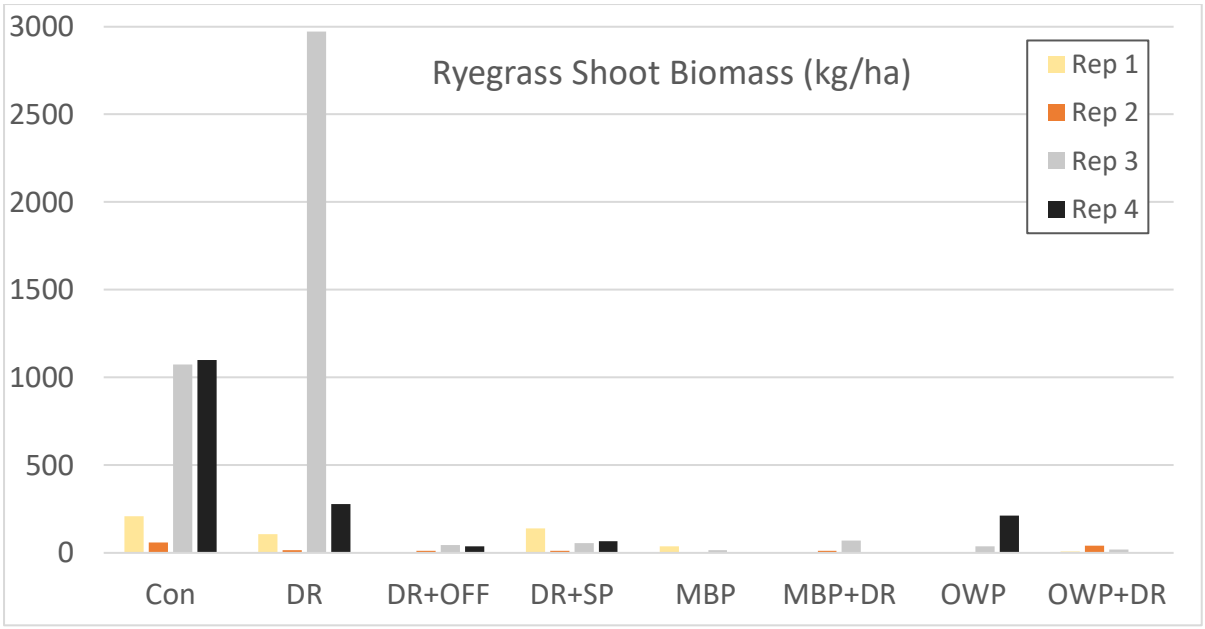

Figure 5. Ryegrass shoot biomass (kg/ha) for each treatment and replicate, measured from hand harvest cuts collected November 2018.

Ryegrass shoot biomass (Fig.5) and potential seed production (Fig.6) was assessed from hand harvest cuts. Ryegrass density varied considerably with highest levels in replicates 3 and 4. Despite this the control and deep ripping only treatments had the highest ryegrass density (Fig.5) and potential seed production (Fig.6) for each replicate. Those treatments which modified or inverted the topsoil had significantly less ryegrass.

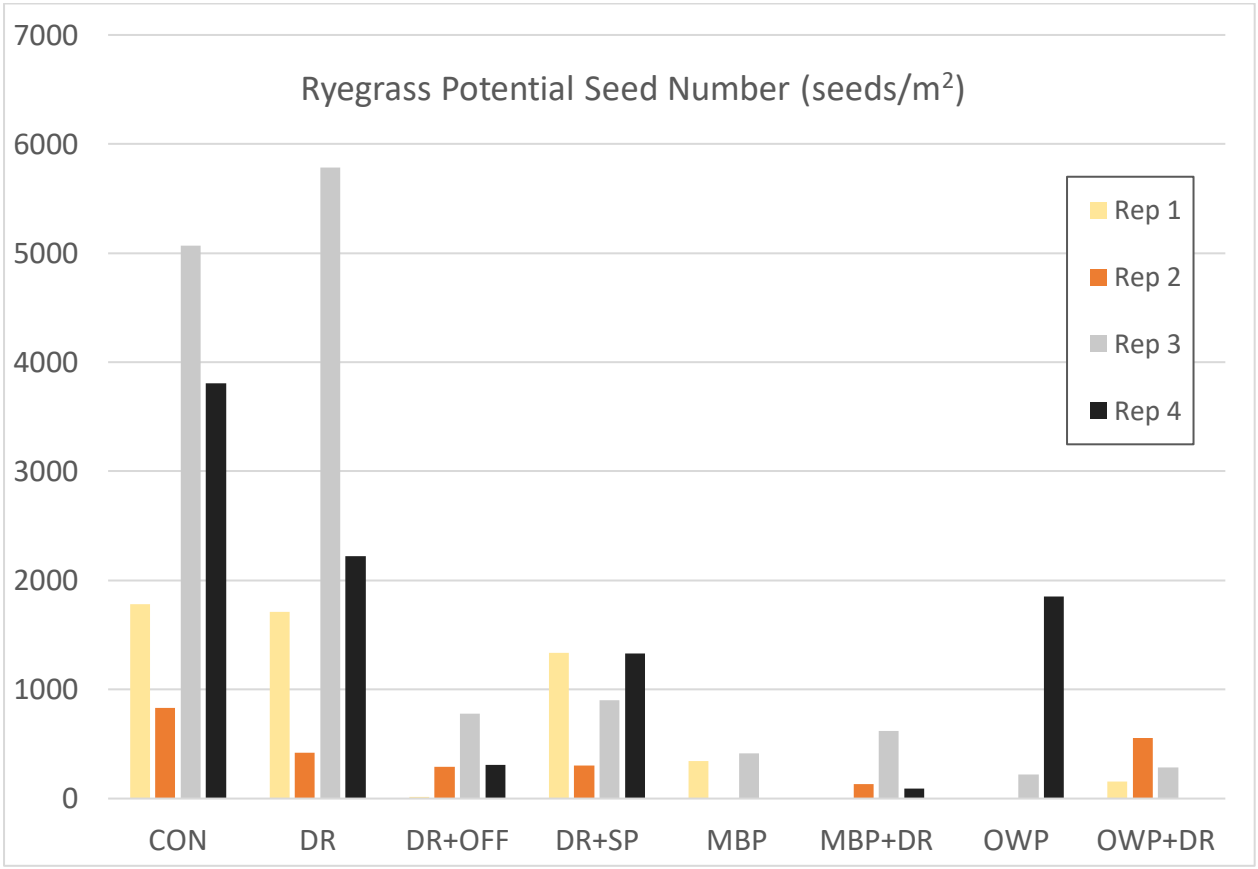

Figure 6. Potential ryegrass seed number (kg/ha) assessed from counts of ryegrass spikes from hand harvest cuts collected November 2018, for each treatment and replicate.

All treatments delivered statistically significant yield increases with an LSD at a 95% confidence level of 0.52 t/ha. The lowest yield improvement was from deep ripping, a 0.68 t/ha (19%) increase. Larger yield improvements were generated by Mouldboard ploughing (25%), Deep ripping plus off-set disc (29%), One-way ploughing (Plozza) plus

deep ripping (33%), Deep ripping plus spading (34%), Mouldboard ploughing plus Deep ripping (37%) and One-way Plozza ploughing (38%) (Figure 7).

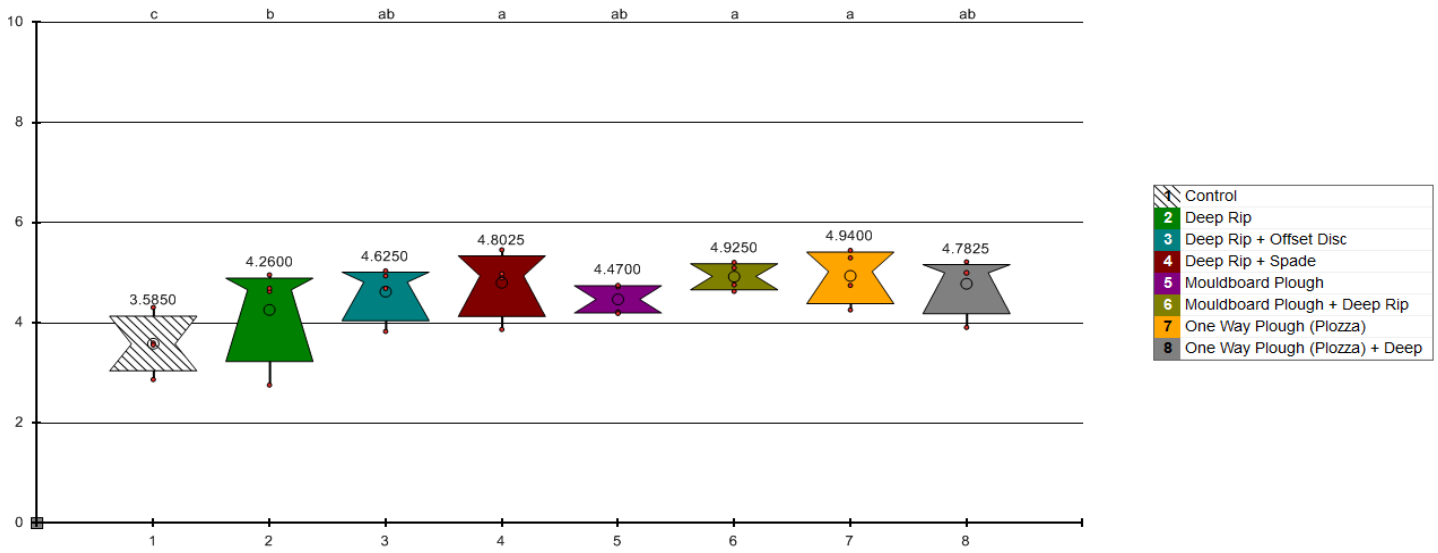

Figure 7. Barley grain yields in response to one-off deep tillage soil amelioration treatments on Shallow sandy duplex (Sand over gravel/clay), York, Western Australia. Bars represent LSD (0.05) of 0.52 t/ha 2018.

Table 3. Grain yield of Spartacus barley in 2018 in response to a range of strategic deep tillage soil amelioration treatments applied in 2018 before seeding.

Treatment	Grain Yield (t/ha)	Harvest Index
Control	3.59	0.45
Deep Ripping (DR)	4.26	0.44
DR + Offsets	4.63	0.51
DR + Spading	4.80	0.50
Mouldboard (MBP)	4.47	0.52
MBP +DR	4.93	0.49
One-way Plough (OWP)	4.94	0.46
OWP + DR	4.78	0.51

Conclusion

On shallow sandy duplex soils (Sand over gravel/clay) at York topsoil repellence removal was important to achieve better crop establishment and subsequent tiller number. Deep ripping plus spading, One-way ploughing and Mouldboard ploughing appeared to totally remove topsoil water repellence impacts at the site.

Ryegrass competition had a significant influence on final crop yield outcomes (harvest indexes not provided in this report).One-way ploughing and Mouldboard ploughing appeared to reduce subsequent ryegrass germination post crop establishment whereas deep ripping significantly increased the germination and competition experienced from ryegrass.

The improved plant establishment counts, tiller counts and subsequent components of grain yield appeared to be the drivers of increased yield responses at this site.

The strength of the subsoil, its water and nutrient holding capacity and delivery to crop appeared very important in achieving the excellent crop yield responses at this site.

Key words

Soil amelioration; soil water repellence; soil compaction; soil acidity; strategic deep tillage

Acknowledgments

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