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Long-term dynamics of tillage impacts on repellent sandplain

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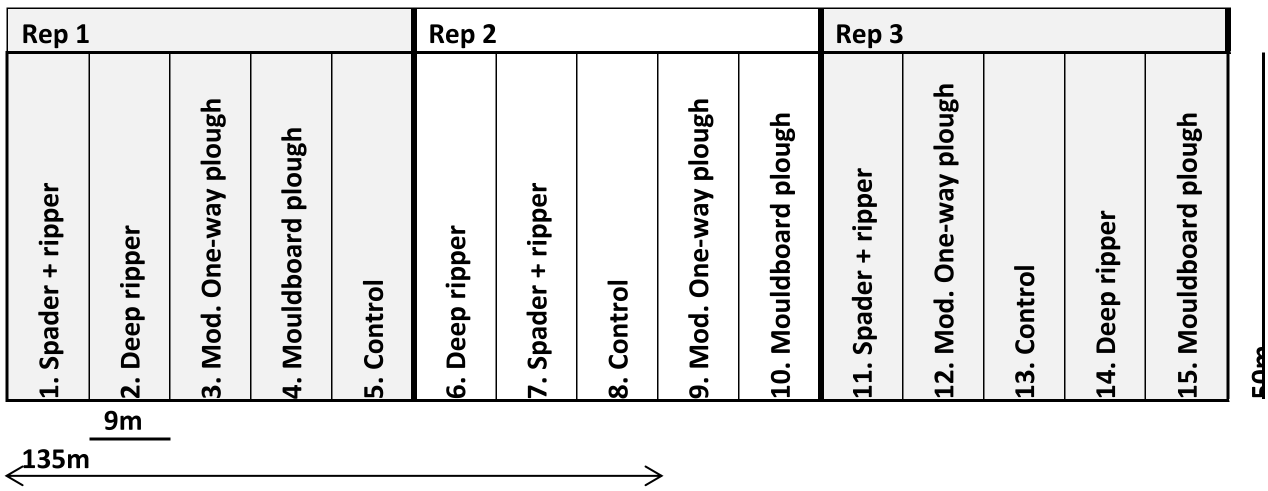
Purpose:	Detailed measurement of soil properties and plant productivity over time following amelioration with one-off deep tillage
Location:	Graeme & Helen Lethlean, Badgingarra
Soil Type:	Pale yellow deep sand-water repellent
Growing Season Rainfall (April- October 2015):	334 mm (BRS)

BACKGROUND SUMMARY

One-off soil inversion and deep soil mixing can ameliorate repellent soils, incorporate nutrients and remove some compaction. Trials to date have shown benefits in crop productivity and yield but a more detailed understanding of the changes in soil properties and crop performance over time is required to better understand the drivers of changes in productivity and implications of buried topsoil.

TRIAL DESIGN

Randomised block with three replicates of four different types of deep soil tillage: Rotary Spader; Deep ripper; Modified one-way plough (Plozza one-way) and Mouldboard plough; and one control treatment. Each strip plot measures 9x50 m. The modified one-way disc plough had every second disc removed allowing more space for soil to turn and was fitted with larger, 76 cm (30 inch) discs to increase the working depth. The trial aims to collect detailed measurement of soil water repellence, soil carbon, soil strength, water infiltration, water use, weed seed survival, crop establishment, growth and productivity over five seasons (2015-19) following amelioration with one-off deep tillage.



RESULTS and DISCUSSION

Figure 1: Average water repellence measured using the molarity of ethanol droplet (MED) test for the top 5cm of sand. Higher values of MED correspond to greater water repellence

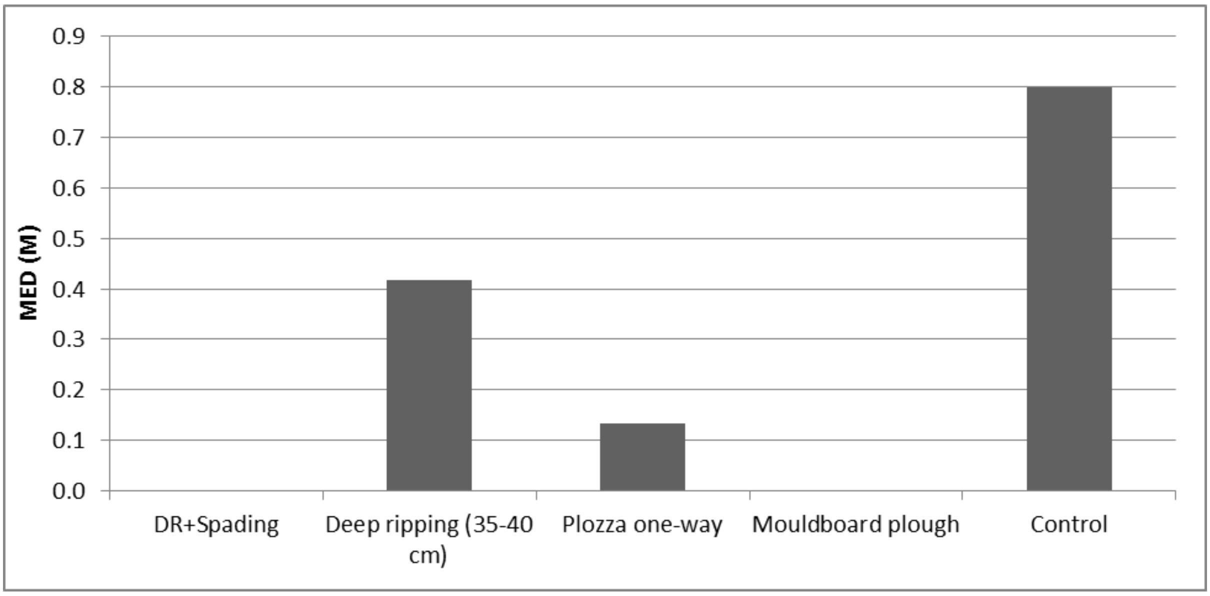


Figure 2: Distribution at depth of the organic carbon (a) and pH (b) affected by the tillage treatments (DR= deep ripping)

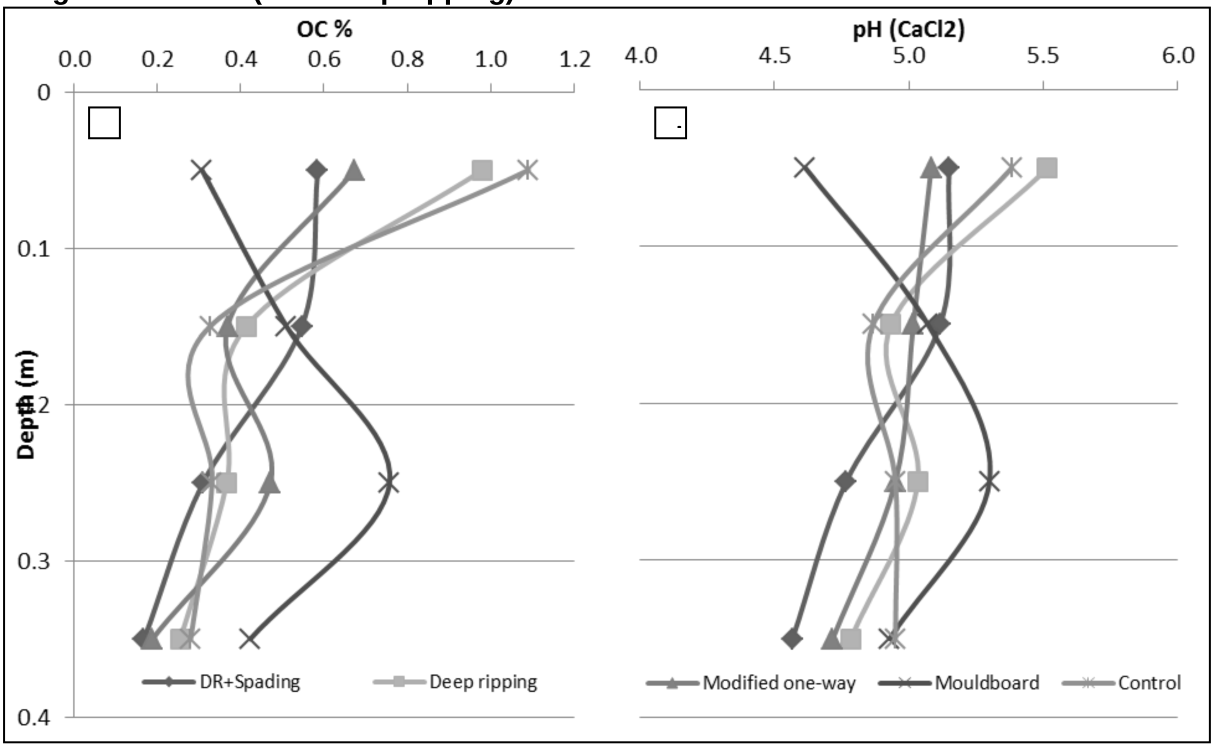


Figure 3: Average number of plants per square meter at early wheat emergence on the 18th of June (DR= deep ripping). LSD (5%) combined treatments=20.6

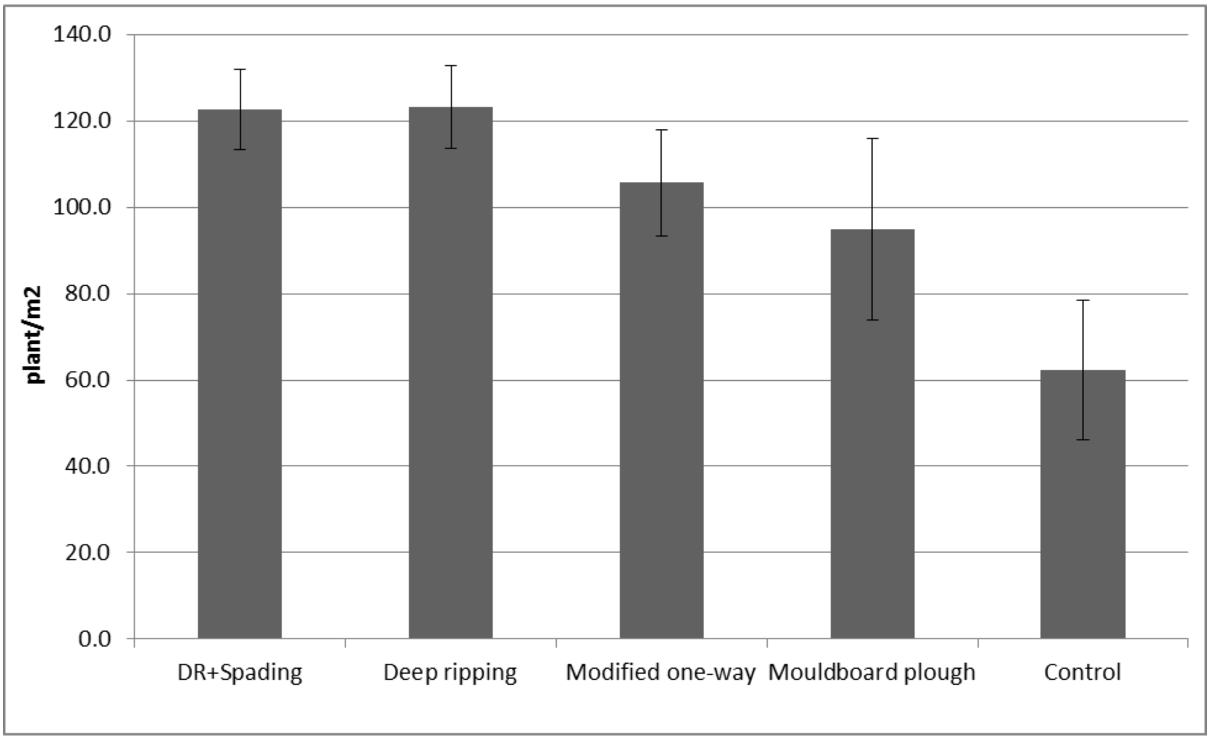
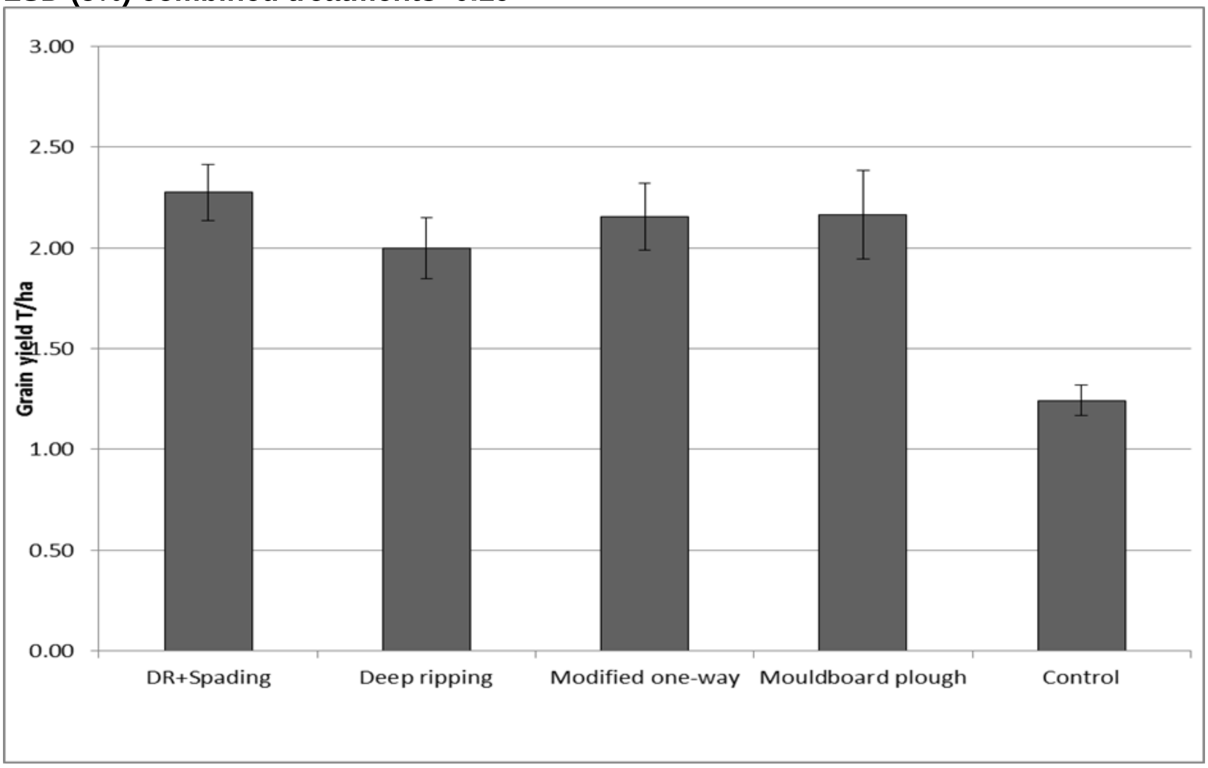


Figure 4. Grain yields (t/ha) affected by the treatments in the 2015 season (DR= deep ripping)
LSD (5%) combined treatments=0.19



FINANCIAL ANALYSIS

Table 2: Grain yield, yield response and change in income and profit as a result of the soil tillage treatments

Treatment	Grain yield (t/ha)	Yield increase compared to control (t/ha)	% Yield increase compared to control	Gross income increase compared to control ($/ha)*	Cost of the treatment ($/ha)	Profit compared to control ($/ha)
Deep Ripping + Spading	2.27	1.03	83%	**306**	160	**146**
Deep ripping	2.00	0.76	61%	**226**	40	**186**
Modified one-way (Plozza)	2.15	0.91	73%	**270**	50	**220**
Mouldboard plough	2.16	0.92	74%	**273**	120	**153**
Control (no-tillage)	1.24	0.00	0%	**0**	**0**	**0**

***Gross profit base of on average grower price for Mace wheat in Geraldton ($297/t on January 2016; source: awb.com.au)**

DISCUSSION

In Figure 1, the severity of soil water repellence (SWR) expressed as MED (Molarity of Ethanol Droplet) showed that the control treatment had low repellence (MED<1, King 1981). This was not surprising as the sampling was carried out in winter time, when the SWR is usually less expressed. Moreover, the SWR in the control plots was extremely variable and the MED values measured from several samples ranged from no-repellence to severe repellence (MED>2.2).

All the tillage treatments substantially reduced the SWR but to different magnitudes due to their different degree of soil disturbance. The extent to which each tillage treatment disturbed the soil can be appreciated by looking at Fig 2a; with the exception of the deep ripping, all the tillage treatments moved a large part of the topsoil organic carbon (OC, to which SWR is related) to a depth of 0.1 to 0.3m. As expected, the “Mouldboard plough” was particularly effective in inverting the soil and moving most of the topsoil OC to a depth of about 0.25 m. The “Deep ripping + Spading” was also an effective way to mix the OC throughout the top 0.25 m of soil. As expected, the “Deep ripping” treatment was the least effective at mixing the soil and reducing SWR.

The decrease in SWR improved the early plant establishment in all the tilled treatments with a significantly higher number of plant/m^2 in comparison of the control treatment (Fig. 3).

Plant establishment across the tilled treatments was very similar and did not reflect the differences observed with the MED values. A possible explanation of this result might be the reasonably wet April in 2015 (with about 25mm of rain) that could have mitigated the differences in SWR between the treatments. Surprisingly, the “Mouldboard plough” treatments have also the lowest number of plant/m^2 on average in comparison to the other tillage treatments. This was partly due to seeding depth issues and the uneven seed bed for this treatment. The deep ripping was done with an Agroplow deep ripper and despite limited evidence of subsoil being ripped to the surface there was still a reduction in repellence and improvement in establishment. Generally deep ripping can have variable effects on establishment, in this case the disturbed soil surface may have allowed better capture and infiltration of rain and the loosened topsoil can also act as a more effective barrier to water loss from subsoil via capillary rise compared with a more compacted soil.

Grain yield (Fig. 4) had a better correlation to the improvement on SWR and all tillage treatments significantly increased the grain yields in comparison to the control treatment. “Deep ripping+ Spading” and “Mouldboard plough” treatments produced the highest yields while the “Deep ripping” treatment produced the lowest compared to the other tillage treatments.

However, the financial analysis (Table 2) shows that the Modified one-way (Plozza) plough was most cost effective treatment in the first growing season thanks to its low running costs. On the other hand, “Deep ripping+ Spading” and “Mouldboard plough” treatments produced the lowest profit as a consequence of their much higher operating cost.

It is worth mentioning the effect that these soil modifications had on the pH through the soil profiles (Fig. 2a). In the pre-tillage conditions (represented by the control treatment), soil acidity increased through depth, with pH ($CaCl_2$) values moving from about 5.5 at the surface to less than 5 at 0.15m depth and deeper. While the “Deep ripping” had little effect on soil pH, the other tillage treatments brought more subsoil to the surface and consequently reduced the pH of the topsoil.

CONCLUSION

In the first growing season, the one-off tillage treatments showed to reduced significantly the water repellency of the soil. Significantly better plant establishment and grain yield were obtained in all the tillage treatments. In terms of grain yield, better results were achieved with the tillage treatments that mixed the soil more efficiently, such as the “Deep ripping + Spading” and the “Mouldboard plough” treatments. The “Deep ripping” treatment, which effectively targeted only subsoil compaction, provided the lowest improvements in terms SWR and the lowest grain yield.

The greatest profit in the first growing year was achieved using the “Modified one-way plough” thanks to its low capital cost which reduces its operating cost. Nonetheless, further growing season will be necessary to establish its long term profitability in comparison to the “Deep ripping + Spading” and the “Mouldboard plough” treatments.

Changes in the soil pH profile were also observed after the tillage treatments, with increased acidity in the topsoil. That was particularly the case with the “Mouldboard plough” treatment and the management of soil pH with addition of lime after the tillage needs to be considered.

We expect the next four growing seasons to give us more information to better understand the long term effects of these soil modifications on soil productivity.

PEER REVIEW

Wayne Parker (DAFWA)

ACKNOWLEDGEMENTS

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