Impact of water repellence management on the availability of soil nutrients

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11WMG21

Purpose:	The aim of the study was to determine how mouldboard ploughing (soil inversion), rotary spading and banded wetting agent affect the availability of soil nutrients.
Location:	Badgingarra
Soil Type:	Deep yellow sand
Rotation:	2010 : Pasture, 2009 : Wheat, 2008 : Canola
GSR:	433 mm

BACKGROUND

Methods for managing non-wetting soils can change the distribution of soil nutrients which may require a change in Fertiliser management. In most soils, the nutrient reserves are greatest in the surface layer and this provides the majority of the nutrients required to crops. Soil inversion by mouldboard ploughing or spading changes the distribution of these soil nutrients within the soil profile, which is likely to change the timing of when crops have access to the soil nutrient supply. Banded surfactants may also change the timing of the availability of soil nutrients near the row by allowing this area to wet up more evenly following seeding.

TRIAL DESIGN

The trial was a split-plot design of 4 main treatments being; mouldboard ploughing to 35 cm, spading to 30 cm, banded wetting agent in the base of the furrow and a control with sub-treatments where rates of nutrients (N, P, and K) were applied. A three point linkage three-furrow Kvernerland plough was used for the mouldboard ploughing, a 4-metre ProFarmer 4000 rotary spader was used for the spading treatment and Irrigator was applied at 2 L ha^{-1} in the furrow behind the press wheels for the banded wetter treatment. For the nutrition treatments, a complete factorial of nitrogen (nil, 20 kg N/ha as Urea drilled + 40 kg N /ha as Urea topdressed 6 weeks after sowing), phosphorus (nil, 20 kg P/ha as superphosphate drilled) and potassium (nil, 60 kg K/ha topdressed at seeding) was applied for each main treatment. A basal of manganese sulphate (10 kg/ha), copper sulphate (5 kg/ha) and zinc sulphate (5 kg/ha) were drilled with the seed.

Plot size: 1.54m x 30 m

Repetitions: 3

Crop details: Calingiri wheat @ 80 kg/ha on 8 June 2011

Pit face measurements were made on 4th of October (flowering). Four pit faces were dug with a mini-excavator at the end of each 60N 20P 60K plot in each of the main treatments in replicate 2. Soil moisture and pH were measured on a 5 x 5 cm grid and root maps were taken by marking each root intersection with the pit face on a transparent film.

Plant density was measured 2 weeks after seeding by counting 6 metre rows in each plot, follow up counts were made several weeks later to check for later emergence. Whole tops samples were taken from each plot (6 m rows) at 8 and 17 weeks after seeding for dry weight and nutrient measurements.

RESULTS

Post-tillage nutrient profiles

The soil chemical analysis results from the soil profiles after mouldboard ploughing and spading are shown in Figure 1. Overall, the mouldboard ploughing created nutrient profiles with a bulge at 10 to 30 cm for K, while the spading created gradational profiles. Both tillage treatments caused major changes to distribution of potassium, organic carbon and pH in the top 40 cm, however, changes were less for phosphorus distribution. The similarity between the soil phosphorus profiles in the control, mouldboard plough and spading treatments is due to the relatively high and even phosphorus concentrations to 20 cm depth, meaning that the soil being bought to the surface was a similar P concentration as the surface soil being buried. The results indicate how soil testing to 40 cm after mouldboard ploughing and spading is essential to determine how nutrients have been redistributed in the soil.

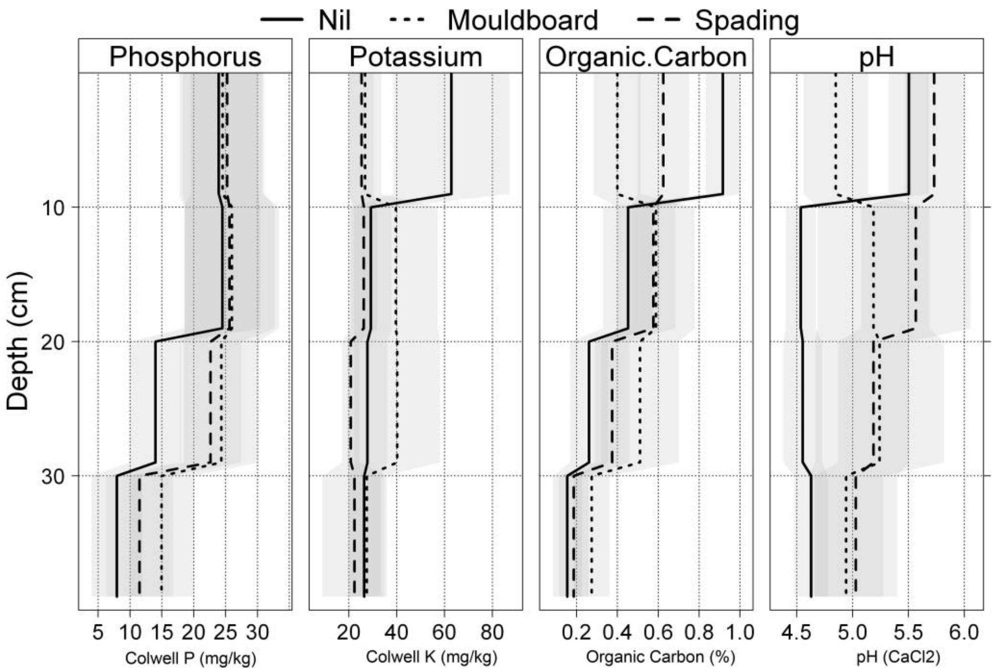

Figure 1: *Soil nutrient distribution after mouldboard ploughing and spading in comparison to the control (nil). Lines are means of 24 samples and shaded area shows the bounds of the 25th and 75th percentiles.*

Root distribution

Measurements of root distribution at flowering revealed that the water repellence treatments had a greater impact on the distribution of roots than on the total amount of roots (Figure 2). The percentage of roots in the surface 10 cm was 54%, 56%, 16% and 6% for the control, banded wetter, spading and mouldboard plots respectively. However, the total amount of root intersections at the pit face (120 x 70 cm) were not different: and where 3147, 3522, 3363 and 3867 intersections were marked for the control, banded wetter, spading and mouldboard plots respectively.

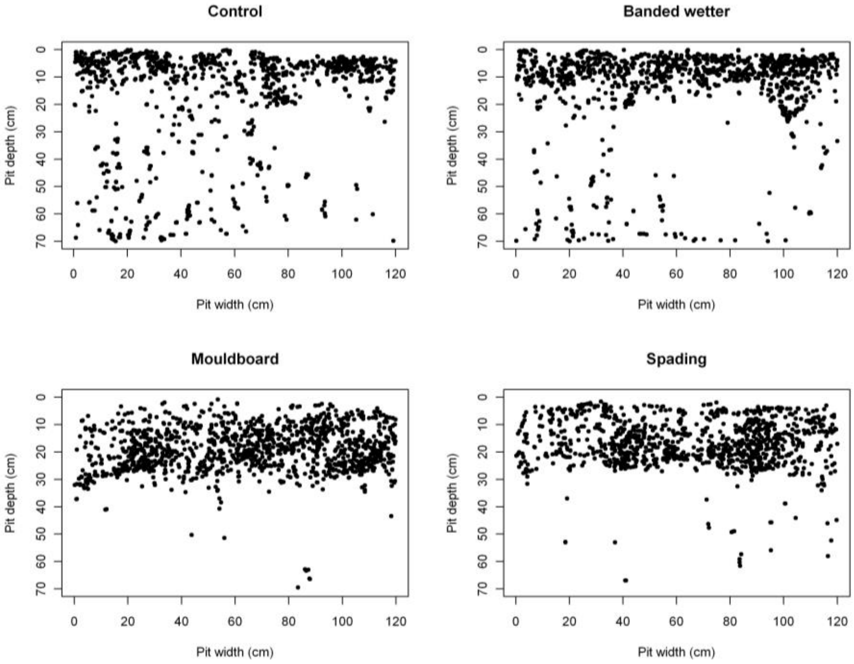

Figure 2: *Maps of root-intersections at pit face. Each dot represents an individual root.*

Soil moisture

Soil moisture measurements taken on the 8th of August (~ 8 weeks after seeding) showed differences between water repellence treatments (Figure 3). The two tillage treatments; mouldboard ploughing and spading were significantly different to the control and banded wetter, however, the change depended on depth. The tillage treatments had significantly lower soil water content at the 0-10 cm layer than the nil and banded wetter, however, they had a higher soil water content in the 10 to 20 cm layer.

The different pattern of soil moisture storage is most likely due to the change in organic carbon distribution in the tillage treatments. In sandy soils, such as this site, organic carbon has an important role in water storage. Comparison of soil water content in and between furrows showed little difference. In the 0 to 10 cm layer, soil water content was significantly higher between the row in the control though the difference was small (17.49% in the furrow, 18.38% between the furrows). Both mouldboard ploughing and spading had significantly higher water content in the 10 to 20 cm layer directly beneath the furrow compared to between the furrows, though the differences were also small (~ 1%).

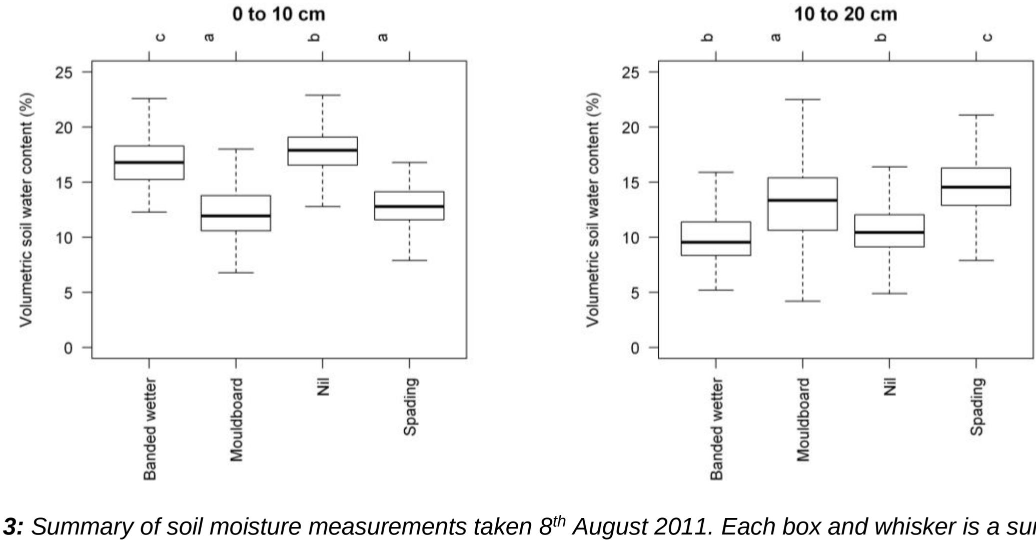

Figure 3: *Summary of soil moisture measurements taken 8th August 2011. Each box and whisker is a summary of 240 measurements where half were taken in the crop rows and half between the crop rows.*

Crop establishment

Crop establishment was poor in the mouldboard and spading plots (Table 1). At 2 weeks after seeding plant density in the mouldboard and spading plots was approximately 50% of the density in the nil and banded wetter plots. This decrease was due to wind erosion after seeding causing furrows to fill in and possibly some damage to coleoptiles.

Dry matter and grain yield

The poor seedling establishment in the tilled plots was reflected in the dry matter yield at 8 weeks after seeding. The mouldboard and spading plots were significantly lower than the nil and control plots. However, differences emerged between the spading and mouldboard treatments at the end of the growing season.

Flowering and harvest measurements indicate a different dynamic in soil water supply in spading and mouldboard plots. At flowering the mean dry matter yield in spading was significantly lower than mouldboard and nil treatments, and this also occurred for harvest index. These differences are not well explained by crop establishment: plant density measured 2 weeks after seeding was also lower in the mouldboard. It is likely that the difference in yield and harvest index between mouldboard ploughing and spading has occurred due to less soil water being available in the spading treatments at the end of the season. These results differ with the majority of our trial work where mouldboard ploughing and spading consistently yield higher than the control in the first year. We will continue this trial to assess future productivity responses and to better understand these differences.

Figure 4 shows the mean grain yield for the different main treatments and nutrition treatments. The application of potassium had no significant effect and the results shown in Figure 4 are the mean of 0K and 60K treatments. Significant responses to applying P (20P yield – 0P yield) only occurred in the nil and banded wetter treatment, however, significant responses to applying N (60N yield – 0N yield) occurred for every treatment and P treatment.

Table 1: *Summary of mean grain yields for each water repellence main treatment. Different letters indicate significant difference (p<0.05). WAS = weeks after seeding.*

Main treatment	**Plant density 2 WAS** (plants m^{-2})	**Mean biomass 8 WAS** (kg/ha)	**Mean biomass at flowering** (kg/ha)	**Mean grain yield** (kg/ha)	**Grain yield : flowering biomass ratio** (kg/kg)
Spading	50 ^{a}	183 ^{a}	2746 ^{a}	991 ^{a}	0.36 ^{a}
Banded wetter	95 ^{b}	278 ^{b}	3099 ^{ab}	1408 ^{b}	0.46 ^{b}
Mouldboard	60 ^{a}	192 ^{a}	3303 ^{bc}	1611 ^{c}	0.49 ^{b}
Nil	103 ^{b}	285 ^{b}	3564 ^{c}	1647 ^{c}	0.46 ^{b}

The difference in response to applying P in the tilled plots compared to the untilled plots may be due to two possible causes. Firstly, the removal of water repellence by the tillage treatments may have resulted in more even wetting of the topsoil and therefore the P in the topsoil is more readily available to the crop. Secondly, mineralisation of P following the tillage treatments may have resulted in a greater proportion of the P measured actually being available to the crop. Further measurements in following years will allow us to investigate this further.

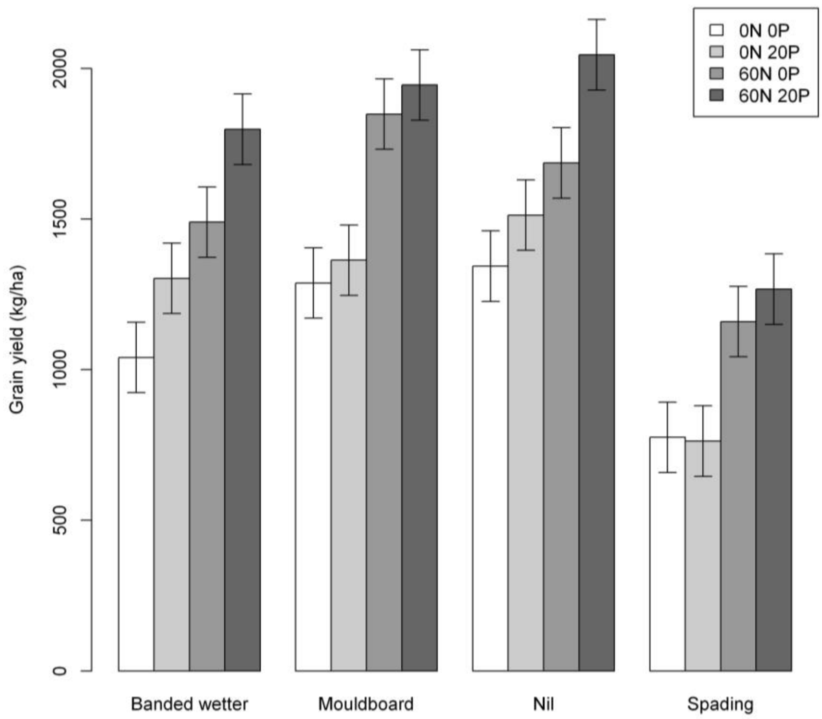

Figure 4: *Grain yield response to water repellence treatment and applied nutrients. Data are means of potassium treatments (0K, 60K) and 3 replicates. Error bars are S.E.D: significant differences (p<0.05) occur where error bars do not overlap.*

Weed and disease control

Wild radish density at the site was reduced by 88% due to rotary spading and by 99% due to mouldboard ploughing (Table 2). In contrast the density of barley grass and ryegrass was increased by rotary spading presumably by stimulating germination and reducing dry soil patches due to water repellence (Table 2). This agrees with grower observations of increased grass weed germination after rotary spading. Mouldboard ploughing reduced barley grass numbers by 50% and ryegrass by 88% (Table 2). Mouldboard ploughing significantly reduced the incidence of stubble-borne septoria nodorum blotch and yellow spot leaf diseases (Table 2) measured during stem elongation (Z37; August) and ear emergence (Z55; October).

Table 2: *Density of wild radish, barley grass and ryegrass and incidence of stubble-borne leaf diseases, septoria nodorum blotch and yellow spot in untreated (Nil), rotary spaded or mouldboard ploughed treatments applied in 2011 to deep yellow sand at Badgingarra, 2011.*

Treatment	**Weed density** (plants/m^2)			**Stubble-borne leaf disease** Average % leaf area diseased	
	Radish	**Barley Grass**	**Ryegrass**	**19 August** (Z37)	**4 October** (Z55)
Nil (Untreated)	25.9	0.3	1.0	17	49
Rotary Spader	3.1	4.2	2.6	15	39
Mouldboard Plough	0.2	0.2	0.1	9	35
l.s.d. (p<0.05)	*6.0*	*0.7*	*0.8*	*4*	*10*

CONCLUSION

Our results from the first year of the study show that the method used to manage soil water repellence had little impact on soil nutrient supply with the exception of phosphorus. The lack of grain yield response to applied P in the mouldboard and spading treatments suggest that soil phosphorus is more available in these soils, though is not clear whether this is due to the removal of the non-wetting constraint or mineralisation following tillage.

The lower grain yield and harvest index in the spading treatment suggests that there was less soil water available late in the growing season. Further research is required to determine how these management practices, in particular inversion and rotary spading, changes fertiliser advice. The results of this work will be used to develop guidelines on if or how nutrition should be managed for crops sown on soils treated for water repellence.

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