Agronomic strategies for water repellent soils in WA - Mouldboard ploughing

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AIM

Compare changes in soil characteristics, including non-wetting and crop growth and performance in a mouldboard ploughed area versus untreated (control) area using an on-farm large scale demonstration site.

TRIAL DETAILS

Property:	Graeme Manton
Plot size & replication:	1000 x 50 m adjacent strips of Mouldboard and Undisturbed (control), split into 10 x 100m Zones
Soil type:	Sand to Loamy Sand over Gravel
Crop Variety:	Wheat, Mace
Treatment Date:	06/06/2014 using 3-furrow Kvernerland Mouldboard Plough
Sowing Date:	11/06/2014
Seeding Rate:	80kg/ha
Fertiliser (kg/ha):	11/06/2014 - 120 kg K Till Extra Plus
Paddock rotation:	2013 - Fallow
Herbicides:	15/05/2014 - 1L glyphosate + 120ml Ecopar + 2% wetta 11/06/2014 - 2L trifluralin + 800ml Paraquat (Non-MBP Only) 10/07/2014 - 800ml Jaguar (Non-MBP Only)
Insecticides:	Nil
Fungicides:	Nil

BACKGROUND

A range of options exist for managing soil water repellence in cropping systems. Mitigation options include furrow sowing and banded soil wetting agents that assist water entry into repellent soils. They are relatively cheap to implement each season but need to be repeated every year. Soil amelioration options include one-off mouldboard ploughing, rotary spading and claying that either physically remove or overcome the topsoil water repellence and can also be an opportunity to incorporate lime, control weeds and remove some subsoil compaction. These options can give longer term benefits but are slow to implement and can be expensive so local testing across a range of soil types, over a number of seasons is needed to ensure that the practices are profitable.

METHODOLOGY

The trial set up as a farm scale paired comparison between a mouldboard plough strip and adjacent control (no cultivation), with similar soil characteristics. A series of 10 monitoring zones were established as areas for paired comparison between the treated and untreated soil.

<u>Soil profile sampling (pre-sowing)</u> - Soil samples were taken to 50 cm in 10 cm increments. Three cores were taken per general soil type zone over whole paddock, with each depth bulked within that zone (composite sample) to obtain a representative sample of the area. An extra 0-10cm non-wetting sample was also taken. Samples underwent standard soil analysis for each sample plus particle size analysis on selected samples.

Crop establishment counts - Plant stand counts occurred 10 days after sowing. Three x one meter row counts in each zone within each treatment were taken, these numbers were then converted to plants/m2 depending on row spacing.
Soil profile sampling (post-sowing) - Soil samples were taken to 40 cm in 10 cm increments. Three cores were taken per in every second zone in both treatments, with each depth bulked within that zone (composite sample). Samples underwent standard soil analysis.
Surface soil water repellence - An extra 0-10cm non-wetting sample per zone was taken at time of post-sowing soil sampling, and used for repellence testing. Testing was undertaken on air-dried soil samples using a standardised laboratory test called the molarity of ethanol droplet (MED) test. The test looks at the infiltration of solutions of varying concentration of ethanol, which acts as surfactant reducing the surface tension of the water allowing it to infiltrate repellent soils more easily. The higher the ethanol concentration required to get droplets of the solution to infiltrate the soil within 10 seconds the more severe the water repellence.
Weed counts - Three weed counts per zone in both MBP and adjacent Control using a 30 x 30 cm quadrat were conducted 4-6 weeks after sowing.
Harvest index cuts & Grain yield – Shoot biomass, head numbers & yield assessments were made at crop maturity (end of grain fill) using hand harvest samples and growers harvester.

RESULTS & DISCUSSION

Pre seeding soil tests were taken on 30th April 2014 (Table 1). Average topsoil pH is below the target topsoil pH of 5.5 (Table 1). Subsoil pH in the 10-20 cm layer is below the subsoil target pH of 4.8, while the 20-40 cm layer is just at the target, and likely to fall below with ongoing acidification, unless lime is applied (Table 1). Furthermore, because the values shown are averages this indicates that some of the sampling sites would have had lower pH's already and have a subsoil acidity problem. Topsoil P and K levels are on the low side, but K increases with depth so with a good break to the season and early growth K is unlikely to be deficient but the site is likely to be P responsive (Table 1).

Table 1: Pre-seeding soil test results for the general area and soil type sampled 30th April 2014.

Soil Test	**Soil Depth (cm)**				
	0-10	**10-20**	**20-30**	**30-40**	**40-50**
pH ($CaCl_2$)	5.2	4.6	4.8	4.8	5.1
Organic Carbon (%)	0.8	0.3	0.2	0.1	0.1
Nitrate Nitrogen (mg/kg)	9	5	5	5	6
Phosphorous (mg/kg)	14	16	18	12	9
Potassium (mg/kg)	29	22	19	36	81
Sulphur (mg/kg)	12.3	2.8	2.2	13.6	18.5

Topsoil (0-10 cm) water repellence at the site was rated as moderate (MED = 2.0) to severe (MED = 3.0; data not shown). Variability in water repellence is related to variation in soil type, particularly the clay content, within the paddock. Severe water repellence will tend to be expressed in most seasons, even with a good break, although the impact is reduced. Even if plant establishment is reasonable it is likely that severely water repellent soil will still restrict nutrient uptake from topsoil at times during the season.

The site was ploughed when the soil was wet on the 6th June following 103 mm of rainfall over the preceding two months (Table 2). While June only received 21 mm a further 126 mm was received through July and August. Over the growing season (Apr-Oct) the site received 344 mm of rain (Table 2).

Table 2: Total rainfall (mm) per month in 2014 and total April-October Growing Season Rainfall (GSR; BOM Colorado Weather Station).

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	GSR Total
Rainfall (mm)	4	0	6	41	62	21	67	59	29	65	6	344

Wheat establishment counts were completed on 14th June 2014 (Fig. 1), with no consistent trends observed. On average just over 150 wheat plants/m^2 were established, regardless of treatment, which is adequate for a yield potential of 3.0 t/ha.

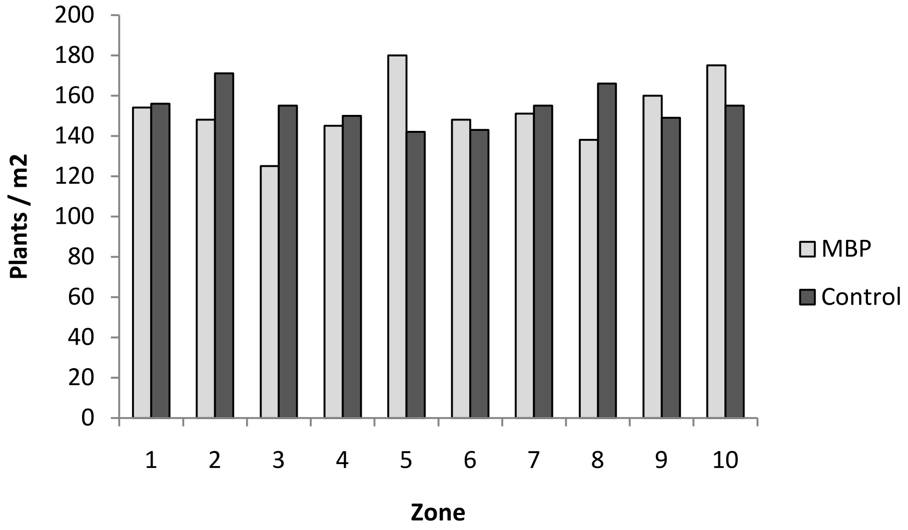

Figure 1: Wheat establishment counts from zones 1-10 in Mouldboard (MBP) and Untreated (Control) adjacent plots.

Post seeding soil tests (4th August 2014; Table 3) demonstrate how soil inversion with a mouldboard plough can tend to decrease the pH, organic carbon, and major nutrients in the top 10 cm but these can end up higher at depth, where the topsoil is turned in. Cultivation does cause an overall reduction in soil organic carbon.

Table 3: Post-treatment soil analyses, samples collected 4th August 2014.

Soil depth (cm)	Soil pH ($CaCl_2$)		Organic Carbon (%)		P (mg/kg)		K (mg/kg)		S (mg/kg)	
	Con	**MBP**	**Con**	**MBP**	**Con**	**MBP**	**Con**	**MBP**	**Con**	**MBP**
0-10	5.76	5.66	0.73	0.52	14	13	29	22	6.1	2.5
10-20	5.04	6.04	0.32	0.55	15	13	22	23	5.5	5.2
20-30	5.16	5.34	0.19	0.18	14	15	29	22	6.2	6.8
30-40	5.26	5.36	0.17	0.18	10	11	41	47	11.8	14.5

Hand harvest cuts were taken at crop maturity before the machine harvest so that total biomass and yield components could be assessed. Cuts were taken from five paired comparison sites. For all of the sites the total shoot biomass of the crop on the MBP treatment was significantly higher, on average 1 t/ha more (Table 4). There were also, on average, 47 more heads/m^2 in the MBP treatment compared to the untreated control (Table 4). Grain yield response however was complicated by the fact that two of the five comparisons were affected by frost. This appeared to impact the MBP treatment more than the untreated control treatment. On average, for all of the paired comparisons, there was a 300 kg/ha yield increase as a result of MBP, but if the frost affected comparisons are removed then the yield advantage from MBP increases to 700 kg/ha (Table 4). The fact that the total shoot biomass of the frosted sites is similar to those less affected sites indicates that the yield potential of these areas is likely to have been similar had they not been affected by frost.

Table 4: Biomass, head number and grain yield for Mace wheat determined using hand harvest cuts.

Treatment	Shoot Biomass (t/ha)	Grain Yield (t/ha)	Head Biomass (t/ha)	Head number/m^2	Harvest Index
Control – all samples	6.4	2.6	3.5	244	0.41
MBP – all samples	7.4	2.9	3.9	291	0.39
Control – excluding frosted	6.4	2.6	3.5	249	0.41
MBP – excluding frosted	7.3	3.3	4.2	254	0.45

Grain yield from the harvester, which is a better indicator of actual yield, was less encouraging with no real difference between the treatments with the MBP plot yielding 2.9 t/ha and the untreated 3.0 t/ha (data not shown).

Together the harvest cut and yield monitor results indicate that there was probably was a higher yield potential in the mouldboard plough area but this was not realised due to increased frost damage and possibly variation within the mouldboard ploughed area.

A weed assessment was also done on the 4th August, with only a small number and variety of weeds recorded in both treatments, and no significant variation observed between them (data not shown).

CONCLUSION

This large scale on-farm demonstration has shown how soil inversion with a mouldboard plough can provide wheat yield benefits on sandplain soil. The mouldboard ploughing reduced the soil water repellence by about a third, but moderate repellence was still present. In this trial frost affected the mouldboard plough treated area more than the untreated area which is opposite to what some growers have reported who felt that crops on mouldboard ploughed soil were less affected by frost. Soil type, soil moisture, crop biomass and timing of the frost event may have had an impact in 2014.

Short-term grain yield responses to cultivation on sandplain soils are typical and the potential benefits need to be studied for several more seasons before the value of the practice can be properly assessed. Other deep soil cultivation practices, such as deep ripping, can also give wheat yield responses in the first year.

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