Further investigation into benefits of rotary spading and liming a yellow sand-plain soil

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Purpose:	To further investigate rotary spading and other soil amelioration techniques on the yellow sand-plain soils west of Moora.
Location:	Rowes Road, Dandaragan
Soil Type:	Yellow sand-plain (Original vegetation blackbutt and sand plain pear)
Rotation:	Grassy Pasture 2009, Grassy Pasture 2010.
GSR:	334mm

BACKGROUND

Over the past few years rotary spading is one of the techniques that has been used with great success to ameliorate non wetting soils. The plan with this trial had been to compare it with mouldboard ploughing in conjunction with lime, deep ripping and copper applications. Unfortunately we had to substitute the mouldboard plough treatments with a one way plough due to being unable to source a mouldboard plough in time for sowing. A 500ha block was being spaded on the property at the time and the trial was an opportunity to accurately measure responses to these techniques on these soil types.

TRIAL DESIGN

Plot size: 11m x 30m (to fit in with conventional grower machinery)- unreplicated demonstration

Crop details: Wyalkatchem wheat @ 100kg/ha on 5 June

Fertiliser: **At seeding:** K Till Trace @ 80kg/ha

Post: NS 41 @ 60kg/ha (5 July); NS 41 @ 60 kg/ha (1 August)

Herbicide: **Pre:** Logran @ 30g/ha, trifluralin @ 1.8 L/ha, sprayseed @ 1L/ha, alpha-cypermethrin @ 100ml/ha

Post : Folicur @ 200ml/ha, Tigrex @ 750ml/ha, alpha-cypermethrin @ 125ml/ha; Folicur@ 200ml/ha and Trojan @ 12ml/ha at flag leaf.

Machinery and timing of treatments:

21 March	Topdressed with Superphosphate and Super CuZnMo treatments (immediately following 23mm of rain)
27 March	Lime treatments applied
19 April	Deep ripping (Western Ripper)conducted
30 May	Rotary Spading (Hayes machine) conducted (29mm rain the evening before).
5 June	Ploughing conducted (Chamberlain on-way plough)
	Rolling conducted (rubber tyred roller) immediately prior to sowing.

Table 1: *Soil test results 2011*

Paddock Section	West end (untreated)	West end (untreated)	West end (untreated)	East end (untreated)	East end (untreated)	East end (untreated)	2t/ha Lime, Deep-rip,spaded	2t/ha Lime, Deep-rip,spaded	2t/ha Lime, Deep-rip,spaded
Sample Depth (cm)	**0-10**	**10-20**	**20-30**	**0-10**	**10-20**	**20-30**	**0-10**	**10-20**	**20-30**
Soil texture	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand	Loamy sand
Soil colour	Light Brown	Brown Yellow	Brown Yellow	Light Brown	Brown Yellow	Brown Yellow	Brown Yellow	Brown Yellow	Light Brown
pH (1:5 CaCl2)	5.6	5.1	4.7	5.9	4.7	4.5	5.0	5.0	5.0
pH (1:5 H2O)	6.3	6.1	5.6	6.4	5.4	5.1	5.8	5.7	5.8
EC (1:5 H2O) (dS/m)	0.09	0.07	0.03	0.09	0.05	0.03	0.07	0.07	0.09
Organic carbon (Walkley Black) (%)	1.38	0.49	0.29	1.52	0.52	0.29	0.72	0.59	0.89
Nitrate nitrogen (KCl) (mg/kg)	11	4	3	13	4	2	10	17	19
Ammonium nitrogen (KCl) (mg/kg)	6	29	3	7	2	1	2	5	2
Phosphorus (Colwell) (mg/kg)	36	23	17	47	43	39	29	26	29
Phosphorus Buffer Index (PBI)	19.0	16.3	14.6	18.8	18.1	22.1	19.2	20.6	27.4
Potassium (Colwell) (mg/kg)	79	66	46	68	25	27	59	46	80
Sulfur (KCl-40) (mg/kg)	7.0	8.2	3.6	6.5	3.7	4.1	5.7	8.6	5.6
Copper (DTPA) (mg/kg)	1.1	1.1	0.7	0.7	0.9	0.7	0.7	0.9	0.7
Zinc (DTPA) (mg/kg)	1.7	0.9	0.6	2.6	0.5	0.1	0.9	1.0	1.3
Manganese (DTPA) (mg/kg)	3.4	0.1	0.5	4.1	0.2	0.2	1.3	1.4	1.4
Iron (DTPA) (mg/kg)	41.1	97.2	161.1	42.1	62.5	103.4	97.1	132.5	92.6
Boron (hot CaCl2) (mg/kg)	0.3	0.3	0.2	0.3	0.2	0.2	0.2	0.3	0.3
Aluminium (CaCl2) (mg/kg)	0.2	1.5	2.0	0.2	5.8	6.3	1.3	1.2	1.0

RESULTS & DISCUSSION

The site chosen was severely non-wetting which was evidenced on the day it was pegged by a thunderstorm in which 23mm fell in about 20 minutes. Large amounts of water ponded on the soil surface and it took over an hour for surface water to disappear (figure 1). When the surface water had finally soaked in the severe water repellence was apparent when disturbing the soil surface (picture on the right).

Figure 1: *Image taken in March after 23mm*

The only weed germination on the trial site at sowing was on the deep ripped plots in the rip lines themselves, as they had acted to harvest any rainfall over the previous 6 weeks. Depth of sowing was an issue on ripped, spaded and ploughed plots as a wind/rain event 10 days after sowing led to trench fill due to wind and water movement of the soil surface. On the 2nd July there was more wind damage apparent on plants on the spaded plots largely due to their more advanced germination. 70mm fell for the month of June but 41mm of it fell on the 29th of June. The remaining 29mm fell in 3 events ranging from 4 to 12 mm across the month. The spading treatments were able to germinate on the 3 small rainfall events whereas the un-spaded treatments largely germinated after the rainfall event on the 29th June.

Plots that had been spaded had between 46 and 61 plants per sq meter at 1 to 3 leaf growth stage compared to the control which had 4.3 plants sq meter at the 0.5 to 2 leaf stage. By spring the spaded plots had 139 plants per sq meter compared to the un-spaded which had improved to have 94. Barley grass was a major problem on the site and the plots that had been spaded had very little barley grass when compared to those which were un-spaded.

The soil test results in table 1 highlight the subsoil acidity issue on the site and also the fact that on the plots that were limed, ripped and spaded complete amelioration of the pH in the top 30cm in the year of lime application was able to be achieved. They also highlight the dilution effect spading has had on the organic carbon and soil phosphorus, potassium and sulphur levels. Increased nitrogen availability on spaded plots is apparent in both the last 3 soil tests in table 1 as well as the significant increase in nitrogen recovery achieved in the protein yield results in table 2. The soil nitrogen increase would largely be due to mineralisation as a result of the spading process as well as some recovery of residual nitrogen from down the profile and would most likely only have a one year benefit.

Table 2: *Yields and Gross margin results.*

Treatments (in plot order)	**Grain Yield** (t/ha)	**Protein** (%)	**Protein Yield** (kg/ha)	**Gross Return*** ($/ha)	**Treatment Cost**** ($/ha)	**Gross Margin** (GM) ($ ha)***	**GM with treatment cost amortized over 5 years** ($ ha)***
2 t/ha Lime, Deep-ripped, One way plough	1.63	15.1	246	376	148	-74	44
Nil	1.24	14.7	181	284	-	-18	-18
2 t/ha Lime	1.42	14.9	212	326	68	-44	10
Deep-ripped	1.83	13.5	250	421	50	69	109
2 t/ha Lime, Deep-ripped	1.88	14.2	266	432	118	12	106
Deep-ripped, Spaded	2.30	13.6	311	530	150	78	198
2 t/ha Lime, Deep-ripped, Spaded	2.33	14.2	329	535	218	15	189
2 t/ha Lime, Spaded	2.39	13.5	322	550	168	80	214
2 t/ha Lime, 167 kg/ha Super, Deep-ripped, Spaded	2.04	14.3	292	470	275	-107	113
2 t/ha Lime, 167 kg/ha Super CuZnMo, Deep-ripped, Spaded	2.01	13.2	265	462	300	-140	100
4 t/ha Lime, Deep-ripped, Spaded	1.74	14.5	252	401	286	-187	42

2 t/ha Lime, One way plough	1.23	14.8	181	282	98	-118	-40
Spaded	1.83	14.3	261	422	100	20	100
One way plough	1.32	14.7	194	303	30	-29	-5

Based on APW @ $230/t, ** Based on actual, * All other costs assume $302/ha all plots*

Good yield responses were achieved in all the treatments that involved either ripping or spading or a combination of both with deep ripping alone producing a 0.59 t/ha response and 2t/ha lime, deep ripping and spading a 1.09t/ha increase over the control. The one way plough treatments did slightly improve plant establishment but this didn't translate to a significant yield gain. The yield gain is primarily driven by increased plant numbers being established which in turn has led to greater numbers of heads being produced per square metre (Table 3).

Table 3. *Head numbers and whole shoot biomass at maturity determined from hand harvest cuts for selected treatments (courtesy of Stephen Davies and Breanne Best DAFWA). *Control (East) is from samples collected from an untreated area just immediately alongside the trial area. It gives an indication of any trend in site yield across the unreplicated trial.*

Treatment	**Head numbers/m²**	**Head number Diff. to Control (West)**		**Whole shoot biomass** (t/ha)	**Biomass Diff. to Control (West)**	
		Heads/m²	%		t/ha	%
Control (West)	149	-	-	3.27	-	-
Control (East)*	139	-10	-7%	2.45	-0.82	-25%
Lime 2t	172	23	15%	3.56	0.29	8%
One-way Plough	169	20	13%	3.90	0.63	19%
Ripped	187	38	26%	4.91	1.64	50%
Spaded	248	99	66%	6.10	2.83	87%
Lime+Rip+Spade	239	90	60%	6.11	2.84	87%
Rip+Spade	258	109	73%	6.12	2.85	87%
Spaded treatments average	*248*	*99*	*66%*	*6.11*	*2.84*	*87%*

The site had very good soil phosphorus levels (Table 1) and as a result there was no benefit from the extra phosphorus provided by the super application, although during the early part of the season the super and super CuZnMo treatments did recover from the wind damage noticeably faster. There was no benefit from the trace element application in the super CuZnMo treatment but again the site has had a reasonable trace element history. Despite these results trace element application prior to spading is an important step in the spading process as many of the soil types that are suitable for spading can be prone to poor trace element levels particularly copper. Ideally plant analysis data should be used to identify paddocks where a benefit will be gained.

One year gross margin data (Table 2) shows that a number of treatments had a negative gross margin in the first year but the spading and ripping treatments were able to more than pay for themselves in the first year which is encouraging when implementing new technology. When we undertake these types of soil amelioration operations there is a longer term view in regards to cost recovery. The gross margin with the treatment cost amortized over 5 years, perhaps more accurately highlights the benefits of the spading treatments. The 2t/ha lime, deep ripping and spading treatment is $207/ha better off than the untreated control (Table 2). Although the 2 t/ha lime and spading treatment without ripping produced the highest yield and gross margin, deep ripping is still an important step from a practical point of view with regard to the speed of the spading operation as well as wear and tear on the spader and improved amelioration of soil compaction.

Soil penetration resistance was measured during the growing season which showed that this soil is extremely compacted (Fig. 2). Levels above 2 MPa are regarded as starting to inhibit root development and plant growth and these were reached at a depth of 10cm in the control plots (Fig. 2) whereas in the deep ripping and spaded treatment this didn't occur until 30cm.The ripping and spading treatments significantly improved the penetrometer readings overall but long term, careful management will be required to minimize soil compaction issues. Of note is the fact that soil strengths below 40 cm ranged from 4-5 MPa depending on location across the site and these strengths will certainly significantly slow root growth and are beyond the usual ripping depth.

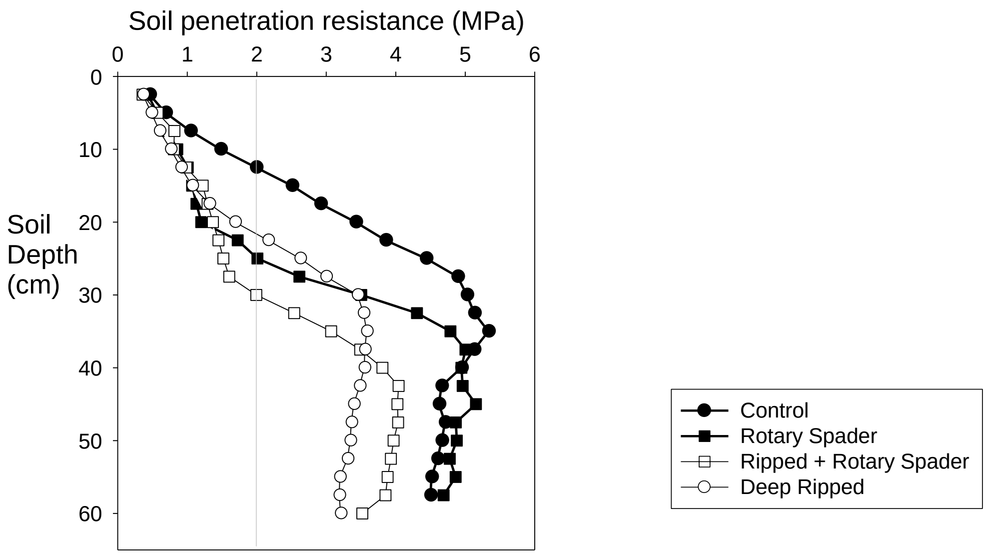

***Figure 2**. Soil penetration resistance data (courtesy of Stephen Davies DAFWA)*

CONCLUSION

- One way ploughing slightly improved establishment, head numbers, biomass production and yield but is not a viable long term solution for the severe non wetting on this soil type.
- Deep ripping and spading improved head numbers by over 60% and biomass production by 87% compared to the control.
- Grain yields were improved by over a 1 t/ha and gross margin by about $200/ha when treatment costs were amortized over 5 years in the combined ripping and spading treatments.

REVIEWED: Stephen Davies (DAFWA Geraldton)

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