Investigating Different Approaches to Manage Soil Acidification in the WA Wheatbelt

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Aims

This project aims to show the mid-long term effects of deep cultivation for management of water repellence and subsoil acidity.

Background

The short term effects of different cultivation methods are well understood however, little is known about the mid-long term. The practice is relatively new for the Liebe Group region, with these demonstrations being one of the first implemented in the area. By utilising demonstrations previously established, it is possible to see the mid-long term impact of such a major soil renovation event. The project also aims to educate farmers on the mid-long term effects of amelioration techniques to incorporate liming products in order to reduce acidity caused by unused nitrogen in the system and highlight what the different techniques used in the area have on crop productivity. Over time growers have experienced decreasing margins and increased risk which makes it imperative that they can apply knowledge from this type of research. Specifically, spading and mouldboarding to incorporate lime and the affect this has on soil acidity and gross margins.

Liebe Group members have shown a continuing interest and investment in soil health, particularly soil acidity. Adoption of liming in the Liebe Group area is 100% (Liebe Group Technical Audit, 2012) however, soil acidity remains an ongoing problem. Growers want to determine how to gain the most economical and effective response to manage subsoil acidity. Understanding of the long term effect of liming is essential to show farmers that whilst lime does not always give an immediate return there are long term benefits to the gross margins.

Project Outcome

An improved understanding of the mid-long term impacts that different amelioration techniques have on soil health.

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Evaluation of Spading with Lime Incorporation in Low pH, Non-Wetting Sand

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Key Message

Using a spader to incorporate lime and dolomite into the subsoil has improved the pH of the soil and increased yield.

Aim

To examine whether deep cultivation by spading can be used to manage water repellence and subsoil acidity on sand plain soil.

Background

This demonstration was established in 2010 to assess the impact of one-off deep soil cultivation on water repellent soils and sub-surface acidity. A rotary spader was used to mix top soil and incorporate lime. The 'spade' on a rotary spader tyne can carry topsoil down into the subsoil and also bring subsoil up to the surface, mixing to a depth between 25 and 30cm. It is estimated that the rotary spader buries at least two-thirds of the topsoil with the remaining one-third left in the topsoil.

The demonstration was implemented in May 2010 with the spader and the deep ripper, each with a working to a depth of 30cm. In 2010, the spading was successful in diluting the water repellent soil but did not increase the yield of the lupin crop. This was due to poor establishment as a result of being sown too deep, exacerbated by furrow infill.

Water repellence in soils is caused by waxes from plant residues which coat the sand particles. These waxes are hydrophobic and can cause slow and uneven infiltration of water into the soil. The mixing action of a spader reduces water repellence in sandy soils by diluting the organic matter-rich repellent topsoil through the top 30cm of the soil profile and by lifting seams of subsoil to the surface that can act as preferred pathways for water movement. As a consequence of the mixing action some of the topsoil can remain slightly water repellent after spading. The fate of the buried water repellent topsoil is not yet clear, and there is a risk that cultivation of this type may ultimately increase the depth of non-wetting. Current findings are mixed with severity of water repellence in the buried topsoil declining by half after 3 years at one site but no measureable change at another site after five years (S. Davies pers. comm.). Research to assess this further is ongoing. In poor sands with low clay content the buried topsoil and associated organic matter can hold more soil moisture than the bulk soil so it can increase the amount of water held in the root zone, albeit by a relatively small amount.

Surface applied lime in a no till system can take in excess of seven years to move down the profile. To significantly increase the subsoil pH below 10cm the lime must be incorporated. Spaders can effectively incorporate surface applied lime into acid subsoils to depths of up to 30-35cm thereby significantly speeding up the amelioration of subsoil acidity.

Demonstration Details

Property	Hunt partners, Marchagee
Plot size & replication	22.5m x 1000m x no replications
Soil type	Deep yellow sand
Soil pH ($CaCl_2$)	0-5cm: 6.0 5-10cm: 5.2 10-20cm: 5.1 20-30cm: 4.8
EC (dS/m)	0.022
Sowing date	09/04/2015
Sowing rate	2 kg/ha Hyola 401 and GT41 (50/50 blend)
Paddock rotation	2010 lupins, 2011 wheat, 2012 wheat, 2013 lupins, 2014 wheat
Soil Amelioration	2010: 1 t/ha lime and 1 t/ha dolomite 2010: Deep ripped and spaded 2011: 1 t/ha lime and 1 t/ha dolomite (topdressed)
Fertiliser	09/04/2015: 42 kg/ha AgFlow, 18 kg/ha MoP, 60 L/ha Flexi N 16/06/2015: 50 L/ha Flexi N 05/07/2015: 30 L/ha Flexi N
Herbicides & Insecticides	09/04/2015: 1.5 L/ha Propyzamide, 1.5 L/ha Spray.Seed, 500 mL/ha Lorsban 07/05/2015: 1.5 L/ha Weedmaster® DST® 04/06/2015: 1.5 L/ha Weedmaster® DST®
Growing season rainfall	298mm (May to September), 436mm total

Results

This is a large scale farmer demonstration which is not replicated. As such, the results should be viewed with caution.

Table 1: Comparison of selected soil properties as a result of incorporating lime and dolomite measured in July 2010 and November 2015.

Treatment	Depth (cm)	2015 EC (dS/m)	2010 EC (dS/m)	2015 pH ($CaCl_2$)	2010 pH ($CaCl_2$)	2015 Aluminium (mg/kg)	2010 Aluminium (mg/kg)
Spading/Lime/Dolomite	0-10	0.021	0.017	5.6	6.4	0.20	0.001
	10-20	0.018	0.024	5.2	6.4	0.81	0.001
	20-30	0.011	0.011	4.9	5.1	1.02	0.280
Spaded	0-10	0.022	0.017	5.8	5.7	0.20	0.001
	10-20	0.019	0.024	5.3	5.6	0.43	0.001
	20-30	0.017	0.031	4.9	5.5	1.04	0.120
Deep Ripped	0-10	0.030	0.026	5.9	6.3	0.21	0.001
	10-20	0.026	0.014	5.5	5.2	0.38	0.200
	20-30	0.021	0.013	5.4	4.6	0.94	0.320
Control	0-10	0.023	0.030	5.8	5.7	0.22	0.001
	10-20	0.019	0.024	5.4	4.9	0.35	0.240
	20-30	0.015	0.018	5.1	4.6	0.46	0.360

Note: Spading and deep ripping was implemented May 2010. All the treatments received a surface application of 1 t/ha lime and 1 t/ha dolomite in 2011.

The 2015 soil results show an overall decrease in pH ($CaCl_2$) for all treatments with the exception of the control (which increased) and the deep ripped treatment which decreased in the 0-10cm and increased in the 10-30cm layer, since the treatments were implemented in May 2010 (Table 1). This fall in pH could be attributed to crop production in the years following incorporation and the export of alkaline products from the paddock. The 2015 canola crop was drastically affected by hail damage, estimated at 73% by the insurance broker making it difficult to accurately compare it to previous years.

Crop yields were collected in 2010, 2011, 2012, 2014 and again in 2015 (see Table 3). In 2010, the year the spading was conducted, spading caused yields to decrease compared to the control. The lupins were sown too deep and sand-blasted due to the lack of soil cover, greatly reducing plant numbers. In 2011 and 2012 spading (no lime or dolomite) increased yield by 40% and 6% (0.2 t/ha) above the control, respectively; however, in 2014 the increase in yield was only 6% (0.1 t/ha). This is as a result of the incorporation effect wearing off. A similar trend is appearing in the deep ripped treatment which showed an increase the following year (2011) by 7.7% (0.1 t/ha) and 15% (0.2 t/ha) in 2012. However, the deep ripping showed no increase in yield when compared to the control in 2014.

Table 2: 2015 canola yield and quality at Marchagee.

Treatment	*Yield (t/ha)	Oil (%)	Screening (%)	Moisture (%)	Grade
Spade/lime/dol/2010	0.79	46.4	6.42	7.1	CAG1
Deep ripped	0.73	47.8	0.93	5.4	CAG1
Spaded	0.68	45.0	1.46	5.2	CAG1
Control	0.75	47.4	1.28	5.5	CAG1

*Note: 2015 canola crop severely affected by hail at the end of September. Yield is actual harvest recorded, insurance company quoted 73% damage.

In 2011 and 2012 an increase of 15% (0.2 t/ha) and 31% (0.4 t/ha) was observed between the control and the spaded and the spaded/lime/dolomite treatments respectively. 2014 spaded/lime/dolomite had an increase of 29% (0.5 t/ha) when compared to the spaded, as the effect from the cultivation is wearing off this can be attributed to the limesand and dolomite applications.

Table 3: Crop yields sown at Marchagee, incorporation of 1 t/ha lime and 1 t/ha dolomite using a rotary spader was carried out in 2010.

Treatment	2015 Canola Yield (t/ha)	2014 Wheat Yield (t/ha)	2012 Wheat Yield (t/ha)	2011 Wheat Yield (t/ha)	2010 Lupin Yield (t/ha)
Control (No tillage)	0.75	1.6	0.8	1.3	0.7
Deep Ripped	0.73	1.6	1.0	1.4	0.7
Spade	0.68	1.7	1.0	1.5	0.5
Spade + Lime + Dolomite	0.79	2.2	1.2	1.7	0.5

Note: All treatments were top dressed with 1 t/ha lime and 1 t/ha dolomite in 2011, bringing the total lime and dolomite on the spaded 2010 treatment to 2 t/ha lime and 2 t/ha dolomite. 2015 canola crop severely affected by hail at the end of September, insurance company quoted 73% damage. Yield not recorded in 2013.

The Hunt's have observed that the infiltration of rainfall has improved due to spading (measurements not recorded). Using the spader to incorporate lime through the soil has improved yield beyond the initial gain of spading alone. The addition of lime and dolomite increased yield by an additional 0.2 t/ha compared to spading in both 2011 and 2012 and increased yield by 0.48 t/ha in 2014, which is the greatest increase in yield to date.

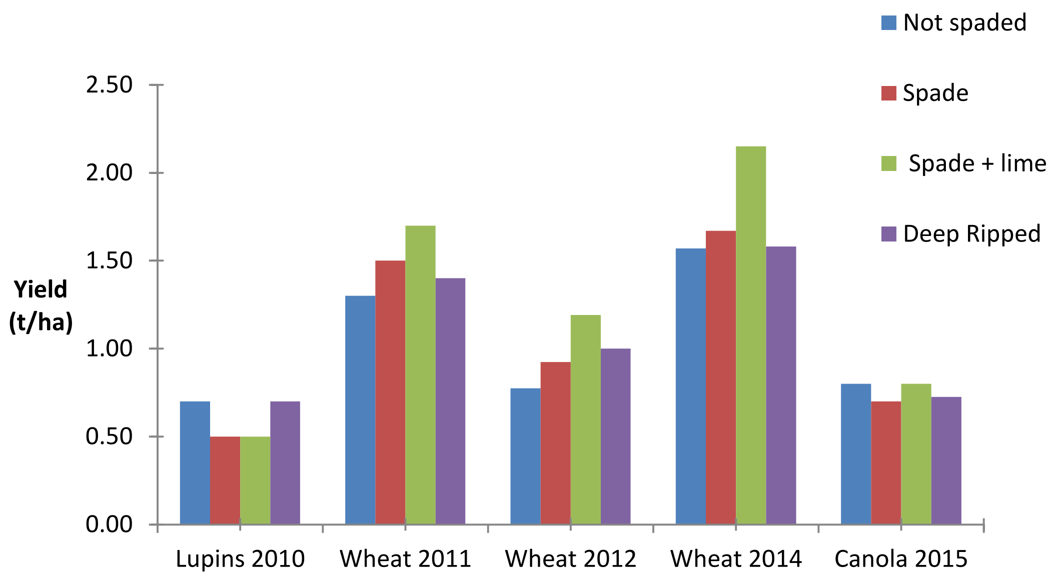

Figure 1: Comparison of yields produced since incorporation in 2010, Marchagee.
Note: 2015 yield affected by hail assessed at 73%. No yield data was recorded in 2013.

Comments

It is difficult to compare the 2015 season to the previous yields as a result of the hail damage that occurred at the end of September, Clint observed that while the damage has been assessed at 73% this percentage is not necessarily evenly represented over the treatments themselves. Canola germinated and ripened unevenly in the demonstration plots. Some plots were more mature and prone to shattering at the time of the hail and rain event (34mm).

Over the life of the demonstration the Hunt's have observed a difference over the treatments. The spading/lime/dolomite treatment attained the desired results, leading them to adopt the practice in 2011 when they implemented the treatment over the rest of the paddock. The Hunt's are still reaping the benefits of adopting this method of incorporation to deal with the two issues that the paddock was presenting.

The implementation of this practice has been proven to attain increased results in yield but it is not without its own issues as the Hunt's experienced in 2010 with wind erosion. It is a big risk with spading and led to a yield decrease in 2010, the year the spading occurred. Spading has the added benefit of reducing compaction in a similar method to deep ripping by physically breaking down any compacted layers in the top 30cm, although this benefit may only last a few years if a controlled traffic system is not implemented. In 2014 the demonstration showed no lasting impact of deep ripping or spading on crop yield, indicating that the cultivation benefit of these has disappeared, however the improved soil pH from incorporated lime and dolomite appears to be showing longer lasting benefits.

Acknowledgements

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References

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Mouldboard Plough on Wodjil Soil Demonstration

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Aim

To evaluate the effects of mouldboard ploughing on yield on poor performing wodjil soil.

Background

Mouldboard ploughing involves a one-off inversion of the topsoil. The plough in this demonstration was able to invert the top 30cm of soil. Mouldboard ploughing can help in the control of weeds, burying water repellent topsoil, incorporating lime at depth as well as having a deep ripping effect. Cost of the operation is approximately $100-120/ha (Davies *et al*., 2012).

Wodjil soils are typically deep yellow sands which are inherently highly acidic, particularly in the subsoil. The low subsoil pH results in high aluminium concentrations that creates a hostile environment for root growth and therefore reduces crop yields.

This site received 1.5 t/ha of lime in 2006 in an effort to increase pH. However, research has shown that surface applied lime usually takes four to seven years to treat subsurface acidity (Gazey, 2009). Mechanical incorporation is one of the methods used to speed up this process. Examples include rotary spading and mouldboard ploughing, which invert the top layers of the soil, allowing the lime to be buried in the subsoil thus increasing the pH at depth.

The demonstration was ploughed on the 12th June 2012, using a 3 board Kverneland plough which had a working width of 1m. The site received 63mm of rain in the 7 days prior to ploughing allowing the soil profile to wet down to at least 30cm, required for effective inversion.

In 2015, 1.5 t/ha limesand and 0.5 t/ha dolomite was incorporated across all the plots using offset discs to a depth of 10cm.

Demonstration Details

Property	Colin & Ruth Cail, east Wubin
Plot size & replication	100m x 17m x 3 replications
Soil type	Yellow wodjil sand
Soil pH ($CaCl_2$)	0-10cm: 5.7 10-20cm: 4.7 20-30cm: 4.2 30-40cm: 4.1
EC (dS/m)	0-10cm: 0.116
Sowing date	12/05/2015
Seeding rate	55 kg/ha Mace
Soil amelioration	1999: 1 t/ha lime, 2006: 1.5 t/ha lime, 2015: 1.5 t/ha lime & 0.5 t/ha dolomite
Fertiliser	05/04/2015: 60 kg/ha Potash 12/05/2015: 60 kg/ha Agflow Extra, 25.7 kg/ha MoP, (70:30% Agflow: MoP blend) 12/05/2015: 35 L/ha Flexi N 23/06/2015: 30 L/ha Flexi N 22/07/2015: 20 L/ha Flexi N
Paddock rotation	2012 wheat , 2013 wheat, 2014 pasture
Herbicides & Fungicides	05/05/2015: 1 L/ha RoundUp Ultramax 12/05/2015: 118 g/ha Sakura, 800 mL/ha Gramoxone, 0.35 kg/ha Diuron 23/06/2015: 1 L/ha Jaguar, 250 mL/ha LVE MCPA, 50 mL/ha Zinc 22/07/2015: 100 mL/ha Tebcon 26/08/2015: 300 mL/ha Tebcon
Growing season rainfall	237mm

Results

Although replicated it is important to remember that this is a farmer demonstration and not a trial and all results should be viewed with caution. The site received 1.5 t/ha of limesand and 0.5 t/ha of dolomite in 2015 which was incorporated using offset discs, this is reflected in the soil pH results in Table 1.

Table 1: Comparison of selected soil properties as a result of incorporating lime and dolomite measured in November 2012 and November 2015.

Treatment	Depth (cm)	2015 EC (dS/m)	2012 EC (dS/m)	2015 pH ($CaCl_2$)	2012 pH ($CaCl_2$)	2015 Aluminium (mg/kg)
Mouldboard	0-10	0.0593	0.064	6.2	4.7	0.24
	10-20	0.0497	0.053	6.0	5.0	0.20
	20-30	0.0603	0.045	5.8	5.1	0.20
Control	0-10	0.0793	0.137	6.4	5.1	0.20
	10-20	0.0673	0.057	6.1	4.9	0.29
	20-30	0.0797	0.050	6.0	4.8	0.22

Note: Aluminium was not recorded in 2012.

Mouldboard plough treatments returned a yield increase of 7.7% over the control (Table 2).

Table 2: Yield and quality results of Mace wheat sown at east Wubin 2015.

Treatment	Yield (t/ha)	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Grade
Mouldboard	1.4	10.8	77.5	4.3	APW1
Control	1.3	10.5	79.2	3.4	APW1

Table 3: Average gross margin for Mace wheat harvested at east Wubin, 2015.

Treatment	Yield (t/ha)	Average Gross Margin ($/ha)
Mouldboard	1.4	379
Control	1.3	345

Grain prices based on AWB prices for the Kwinana Zone on the 5th January 2016, APW1 $268/t.

Gross margins for 2015 show a $34/ha return on the mouldboard treatment over the control in 2015.

Comments

It has been four years since the demonstration was implemented and while the mouldboard treatment has yielded 0.1 t/ha more than the control, the treatment effects appear to be waning. The site pH has increased significantly with the application of 1.5 t/ha limesand and 0.5 t/ha dolomite in 2015.

Colin noticed through the season that weed control over the site was an issue and wheel tracks in the mouldboard plots affected the crop establishment significantly. When harvesting the site it was observed that the mouldboard plots were golden in colour when compared to the darker colour of the plants in the control plots.

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