# Agronomic strategies for water repellent soils in WA - mouldboard ploughing, deep ripping and lime incorporation

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## AIMS

1. To determine if the addition of lime and its method of incorporation (None/control, MBP or deep rip) has an effect on the soil pH profile and crop productivity.
2. Compare the impact of mouldboard ploughing and deep ripping on topsoil water repellence compared to an untreated control.

## TRIAL DETAILS

| | |
|---|---|
| **Property:** | Craig Jespersen |
| **Plot size & replication:** | 3 replications over a range of soil types |
| **Treatments:** | Control, Control + Lime, Mouldboard plough (MBP), MBP + Lime, Deep rip, Deep rip + Lime; applied 9th May 2014 |
| **Soil type:** | Sand / Loamy Sand over Gravel |
| **Crop Variety:** | Lupin, Gunyidi |
| **Sowing Date:** | 10/05/2014 |
| **Seeding Rate:** | 90 kg/ha |
| **Fertiliser (kg/ha):** | 10/05/2014 – 75 kg/ha; MAP/MOP 70:30 |
| **Paddock rotation:** | 2013 Wheat |
| **Herbicides:** | 10/05/2014 - 0.8L Glyphosate + 1.4kg Simazine + 2L Trifluralin + 0.3kg Metribuzin + 0.4kg Sulphate of Ammonia + 0.1L Alpha Cypermethrin + 0.2% Wetter 1000<br>01/06/2014 - 0.2L Diflufenican<br>23/06/2014 - 0.5L Clethodim (Select) + 0.5% Uptake + 1 kg/ha Sulphate of Ammonia |
| **Insecticides/Fungicide:** | Nil |
| **Tillage type:** | Knife point/press wheel with 254 mm spacing |

| Rep | Plot | Treatment |
|---|---|---|
| REP1 | 1 | Control |
| | 2 | Control with lime (2t/ha pre+ 2t/ha post) |
| | 3 | MBP |
| | 4 | MBP with lime (2t/ha pre+ 2t/ha post) |
| | 5 | Deep rip |
| | 6 | Deep rip with lime (2t/ha pre+ 2t/ha post) |
| REP 2 | 7 | MBP |
| | 8 | MBP with lime (2t/ha pre+ 2t/ha post) |
| | 9 | Control with lime (2t/ha pre+ 2t/ha post) |
| | 10 | Control |
| | 11 | Deep rip with lime (2t/ha pre+ 2t/ha post) |
| | 12 | Deep rip |
| REP3 | 13 | Deep rip |
| | 14 | Deep rip with lime (2t/ha pre+ 2t/ha post) |
| | 15 | MBP with lime (2t/ha pre+ 2t/ha post) |
| | 16 | MBP |
| | 17 | Control |
| | 18 | Control with lime (2t/ha pre+ 2t/ha post) |

## BACKGROUND

Soil water repellence, subsoil acidity and subsoil compaction are common constraints in WA's sandplain cropping soils. A range of options exist for managing soil water repellence in cropping systems while lime application and deep ripping are the typical approaches used to manage soil acidity and compaction. For soil water repellence 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 and the benefits are not always consistent. 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. This experiment focuses on the effects of mouldboard ploughing and deep ripping on lime incorporation and non-wetting in following years on soils within the Wickepin area, and on soil types traditionally untested.

## METHODOLOGY

Treatments – lime applications and the mouldboard plough (MBP) and deep ripping treatments were all applied on the 9$^{th}$ May and sown to lupins the following day. Lime was applied at a total 4 t/ha but this was split into 2 t/ha applied before cultivation and 2 t/ha after.
Soil profile sampling (pre-sowing) – Soil samples were taken to 50 cm in 10 cm increments. Three cores were taken per plot, with each depth bulked within that plot (composite sample) to obtain a representative sample of the area. An extra 0-10 cm non-wetting sample per plot 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 on the 28$^{th}$ May 2014 when the crop was at the 2-4 leaf stage. Three x one metre row counts at each sample point were taken, with a total of 9 counts per plot.
Surface soil water repellence – After sowing four 0-5 cm in-row samples bulked and four 0-5 cm inter-row samples bulked at each sample site were taken. 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.
Soil profile sampling (post-sowing) – Same as for pre-sowing samples. Samples analysed for pH, nutrition and particle size analysis profiles.
Soil moisture – Soil moisture readings were taken after sowing using a DAFWA theta probe.
Weed counts – 4-6 weeks after sowing nine weed counts per plot were conducted using a 30 x 30 cm quadrat on the 19$^{th}$ June.
Harvest index cuts & Grain yield – Shoot biomass, head numbers & yield assessments to be completed at crop maturity (end of grain fill) before machine harvest. Plots are then to be harvested using a yield monitor if possible.

## RESULTS & DISCUSSION

Pre-sowing soil tests were completed on the 9th of May 2014. Eighteen sites were sampled in the paddock within which the trial would be placed. Topsoil pH was below the target of 5.5 for all of the samples with ranging from 4.6 to 5.2 (see Table 1 for average paddock pH). Subsoil pH was below the target of 4.8 for all but one of the sites, although that site still had an acidic topsoil pH of 4.7. Over half (56%) of the samples had a subsoil pH in the 10-40 cm layer of 4.6 or less. This low pH was associated with an increase in extractable aluminium which was over 2 mg/kg in the subsoils of 66% of the samples (Table 1 average Al). This level of aluminium is toxic to the roots of sensitive crops and pastures. These results indicate an urgent need to lime as the topsoil needs to be above 5.5 before lime will start to lift the subsoil pH. The paddock will continue to acidify and it will take time for lime to correct it.

Post-treatment soil pH's on the trial site show that lime significantly increased the pH of the topsoil to 5.0 or more (Table 1). This is still below the topsoil target of 5.5 but at the time of sampling the lime would not have fully reacted so soil testing in 2015 should give a clearer picture of the overall pH change. There was some evidence that MBP and deep ripping in conjunction with lime had increased the soil pH of the 20-30 and 30-40cm layers (Table 1).

***Table 1**:* Soil pH ($CaCl_2$) and extractable aluminium data for pre-treatment (9th May) and soil pH for post-treatment (20th June) soil testing in 2014.

| Soil Depth (cm) | Pre-treatment soil pH and Al – 9th May | | | Post-treatment soil pH – 20th June | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average pH | Average Al | | Control (no lime) | Lime | MBP | MBP+Lime | Rip | Rip+Lime |
| **0-10** | 4.9 | 1.2 | | 4.6 | 5.0 | 5.0 | 5.7 | 4.6 | 5.0 |
| **10-20** | 4.7 | 2.5 | | 4.9 | 4.7 | 4.8 | 4.8 | 4.8 | 4.9 |
| **20-30** | 4.8 | 2.4 | | 5.0 | 5.0 | 5.2 | 5.3 | 5.1 | 5.4 |
| **30-40** | 4.9 | 1.3 | | 5.2 | 5.2 | 5.4 | 5.7 | 5.1 | 5.5 |
| **40-50** | 5.1 | 0.9 | | - | - | - | - | - | - |

Topsoil water repellence at this site prior to treatment application ranged from severe (MED = 3.0) to very severe (MED = 4.0; data not shown). Water droplet penetration tests showed that water droplets applied to dry topsoil samples took longer than 6 minutes to infiltrate the soil. Samples tested after ploughing and seeding, partway through the season, had lower water repellence ratings, which typically occur after the soil has been wet for some time. For the mouldboard plough topsoil (inverted subsoil) water repellence rating was significantly lower, only half that (MED = 0.7) of the untreated control (MED = 1.4).

Monthly rainfall data for nearby Wickepin (Table 2) shows the excellent start to the season with 101 mm in May which would have reduced the impact of topsoil water repellence on crop establishment. Overall there was 344 mm of growing season rainfall (Table 2). Good break of season rains will tend to minimise the impact of soil water repellence on crop establishment.

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

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | GSR Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Rainfall (mm)** | 2 | 1 | 11 | 22 | 101 | 34 | 62 | 44 | 42 | 39 | 39 | 1 | 344 |

Lupin establishment showed than on average there were 27-33 plants per $m^2$ (Fig. 1) with little difference between the treatments. Establishment was more patchy on the MBP plots, which is common due to seeding depth difficulties after major soil disturbance. Usually cereal cover crops are sown after MBP as they can cope better with sand blasting than lupins or canola but in a small plot trial this is less critical.

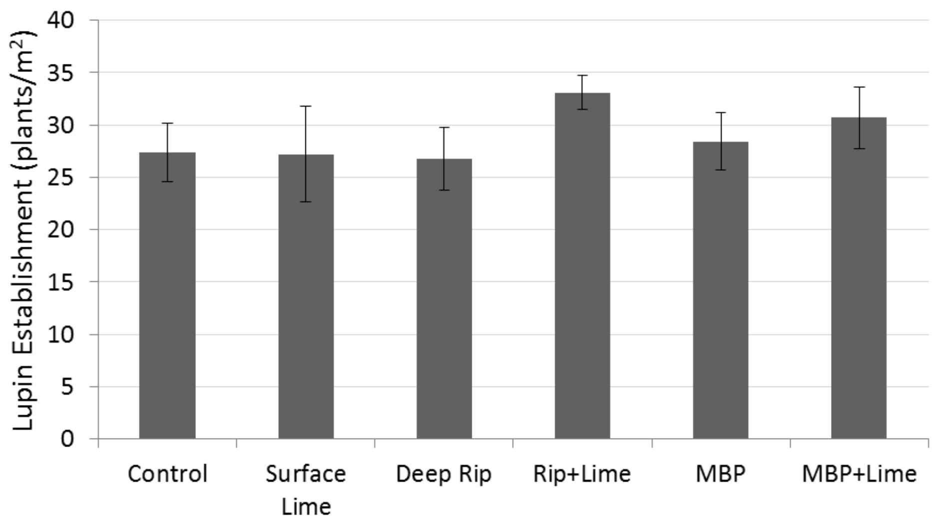


***Figure 1***: Lupin plant establishment (plants/$m^2$) on 28th May 2014. Error bars show the standard error of the mean of 3 replicates.

Weed counts showed a high degree of variability across the replicates, as indicated by the large error bars (Fig. 2). This makes it difficult to assess whether there were any real differences between the treatments. For the MBP treatment, weed numbers were low in the first 2 replicates but very high (>200 weeds) in the third (data not shown) where it appears cultivation has stimulated weed germination, similar to an 'autumn tickle' effect. High weed numbers in replicate 3 indicate that soil inversion was not complete and the weed seeds were not buried deep enough to achieve good control. The presence of gravel layers closer to the surface in replicate 3 appears to have reduced the soil inversion. Also the 3-furrow MBP used has a shallower operating depth (~25 cm) compared to the larger 5-13 furrow MBP growers use when ploughing larger areas. The addition of lime shows a trend towards lower weed numbers, possibly a result of improved herbicide efficacy at higher topsoil pH, this may become more significant over time.

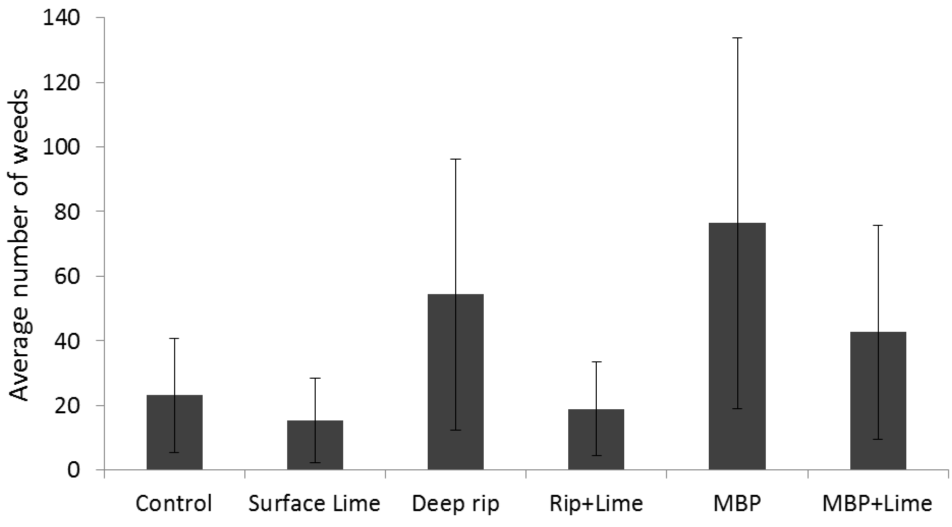


***Figure 2****:* Average number of weeds per treatment, assessed 19th June 2014. Error bars show the standard error of the mean of 3 replicates.

Lupins are highly tolerant of soil acidity and soil aluminium so they are unlikely to respond to the applied lime. Total shoot biomass for the untreated control was a little over 5 t/ha (Fig. 3) and while there was a trend toward higher biomass with cultivation and lime treatments the differences were not significant. Similarly, lupin grain yield (Fig. 4) was not significantly affected by the treatments.

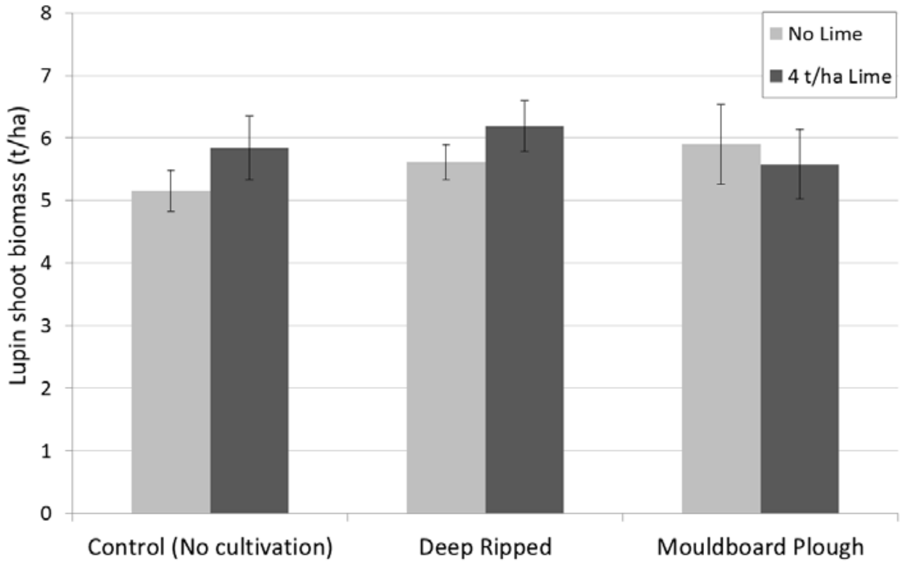


***Figure 3**:* Total lupin shoot biomass (t/ha) at crop maturity in response to cultivation and lime treatments applied 9th May 2014. Error bars show the standard error of the mean of 3 replicates.

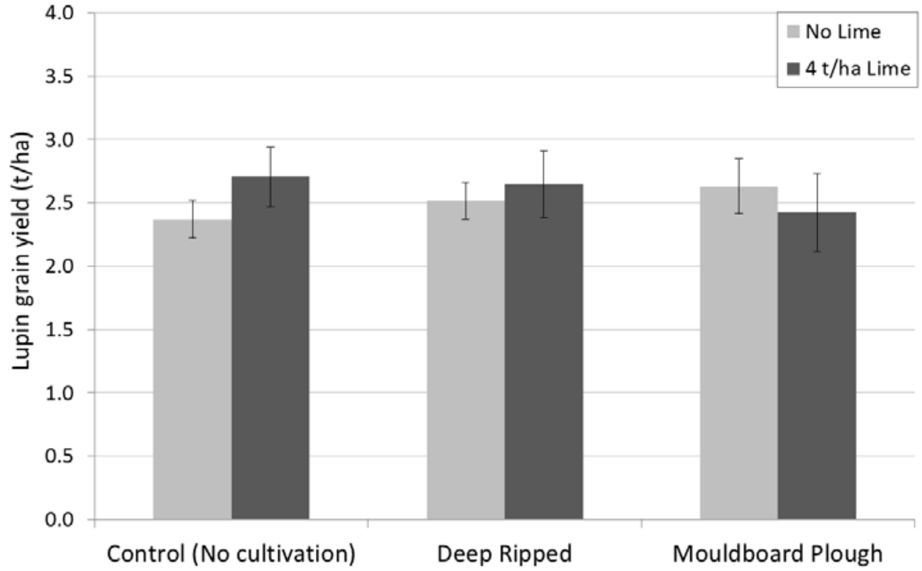


***Figure 4**:* Lupin grain yield (t/ha) in response to cultivation and lime treatments applied 9th May 2014. Error bars show the standard error of the mean of 3 replicates.

## CONCLUSION

Application of lime significantly increased the pH of the acidic topsoil from 4.6 up to 5.0 or more. Given more time under moist conditions the lime will continue to neutralise the acidity and increase the soil pH. This will be tested with further soil sampling in 2015. Cultivation with either a mouldboard plough or a deep ripper successfully incorporated some lime in the 20-30 and 30-40 cm layers. Soil pH of the untreated subsoil at the site ranges from 4.9 to 5.2, which would not restrict lupin or wheat root growth. The experiment will continue to be monitored to see if the treatments benefit the crop productivity and weed control.


## ACKNOWLEDGEMENTS

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