Preliminary results from tillage and lime effects on acidic sands.

David Hall and Greg Shea, Department of Agriculture and Food, Western Australia

Key messages

- Two demonstration trials in the eastern wheatbelt were established to assess the effects of tillage (disc ploughing, deep ripping) and lime application on crop yields. After one year both trials have shown significant yield increases resulting from tillage whereas only one trial showed responses to both lime and tillage.
- Lime and disc ploughing increased soil pH mainly within the 0-10 cm layer. Small increases in soil pH at depth due to deeper incorporation were measured and are the most likely cause of the significant yield increase.
- Combining deep ripping (30, 45cm) with disc ploughing gave no additional yield benefit over the individual disc ploughed or deep ripped treatments.

Aims

The application of lime to soils remains the only long term solution to counter acidification. However both researchers and growers appreciate that raising soil pH at depth (>10 cm) from surface applied lime is a slow process, taking many years, particularly where subsoil pH is less than 4.5. Reducing the time lag between application and crop response to the lime would improve the profitability of the lime investment. Consequently mixing the lime deeper into the soil profile using tillage is seen as a way to improve the distribution of lime within the root zone and increase the rate of pH change. Spading and mouldboard ploughing lime to depth have been shown to ameliorate acidity two to three years faster than where the lime had been surface-applied (Gazey and Ryan 2015). Two way and one way disc ploughs have been shown to be effective in incorporating materials to 10 and 20 cm depth respectively (Scanlan 2015). Two demonstration trials were established in the eastern wheatbelt on acid yellow sandy earths to investigate the effects of tillage and lime on soil properties and crop yields. This paper reports on the first year's results from these trials.

Method

Trial 1. A large strip trial was established on an acid sandy duplex in the eastern wheatbelt in September 2013 in a fallowed paddock. Lime with a neutralising value (NV) of 90% was applied at three rates (0, 2 and 5 t/ha) in strips measuring 72 m by 3000 m. Each lime rate was separated by a control strip 12 m wide. Two tillage treatments (two way disc plough to 15 cm, deep ripping to 30 cm + two way disc plough) were applied as subplots within each lime treatment. Each tillage treatment was 36 m wide. Canola (cv Stingray) was sown in early May 2014 at 2.5 kg/ha and harvested in mid-October 2014. Growing season rainfall was approximately 155 mm. Grain yield was measured and recorded using the harvester's yield monitor. The harvester had a 12 m front allowing three header runs from each lime and tillage combination and one header run from the controls separating the lime and tillage treatments. Additional runs bordering the trial were also used as controls. Data from each header run was extracted from the yield map using SMS software. Six soil samples were collected from each lime treatment prior to (2013) and after (2014) the lime and tillage treatments were imposed in 2013. The 2014 soil samples were collected from the same GPS locations as those in 2013 at depths of 0–10, 10–20 and 20–30 cm. While the predominant soil type within the paddock was the acid sandy duplex with conspicuous gravel layers, a brown loam soil type was also present. This provided the opportunity to assess the effect of soil type on crop yield response to the lime and tillage treatments.

Trial 2. A small plot trial was established without a fallow at Merredin Research Facility in April 2015 on a yellow sandy earth with a topsoil pH_{Ca} of 4.4 (0–10 cm) and subsoil pH_{Ca} of 3.7 (20–30 cm). The trial has eight treatments with replicated controls (nil treatments) bordering each tillage and lime treatment. Canola hybrid (44y87) was sown in mid May at 2 kg/ha and harvested on the 26th November. Growing season rainfall was 214 mm. The treatments were:

1) Lime 4 t/ha top-dressed (approx. NV = 90%) (Lime)
2) Two way “Grizzly” disc plough to 15 cm (DP)
3) Agroplow deep ripper to 45 cm (DR)
4) Lime + DP
5) Lime + DR
6) DP + DR
7) Lime + DP + DR
8) Lime + DP + DR + Gypsum (2 t/ha)

Results

Initial results from the large scale field trial (Trial 1) indicate that both lime and disc ploughing significantly increased canola yields while disc ploughing + deep ripping had no additional effect compared to disc ploughing on the yellow duplex soils. Disc ploughing without lime significantly increased canola yields by 0.16 t/ha when compared to the control. Disc ploughing plus 2 t/ha of lime resulted in a 0.28 t/ha yield increase.

There were no significant interactions between disc ploughing and lime which suggests that the treatment effects were additive. The addition of lime at 5 t/ha gave no additional yield incease to that of lime applied at 2t/ha (Figure 1). Deep ripping with disc ploughing resulted in no further yield increase over disc ploughing at all rates of lime. The ripping was only to 30 cm and may not have been deep enough to penetrate deeper compacted layers.

Disc ploughing with lime applied at 2 and 5t/ha increased the soil pH_{Ca} by as much as 0.3, 0.1 and 0.2 units at depths of 0–10, 10–20 and 20–30 cm respectively within the first year of application when compared with the nil lime treatment. The depth to which the lime was incorporated using the two way disc plough was mainly within the 0–10 cm layer with small changes occurring at deeper depths (Figure 2). The soil pH of the disc+ nil lime treatment in 2014 was 5.3, 4.6 and 4.3 for the 0-10, 10-20 and 20-30 cm depths respectively. Hence any effect of lime on crop production would have been from increasing the pH within the 10-30 cm layer. pH trends across the treatments were highly variable as indicated by the large standard errors.

The response to lime and tillage differed between the yellow sandy duplex and brown loams. The yellow sandy earths had considerably higher yields (0.5 t/ha) than the brown loams. In this trial there was little or no response to the lime and tillage treatments in the brown loams compared to the yellow sandy earths.

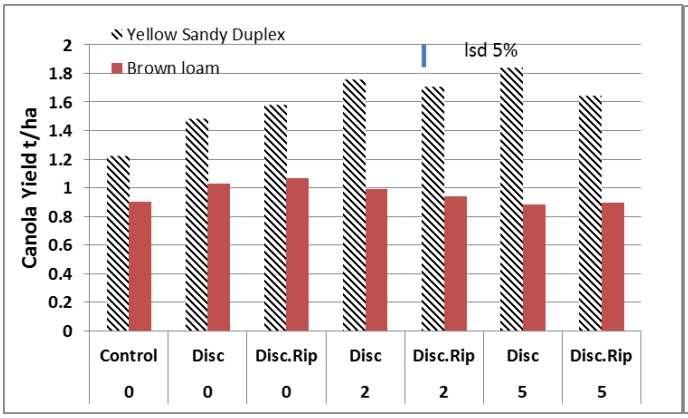

Figure 1. Canola yields (t/ha) as affected by lime rate (0, 2, 5t/ha), tillage (Disc, Disc+Rip) and soil type (Yellow sandy duplex, brown earth).

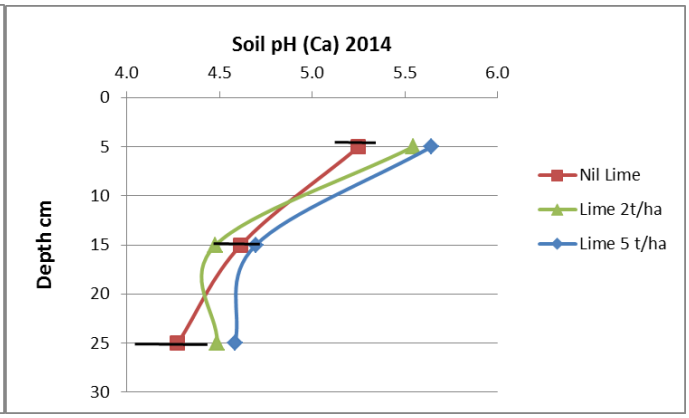

Figure 2. Soil $pH_{(Ca)}$ profiles affected by lime application on the yellow duplex soils. Samples are from the disc tillage treatments only. Standard errors for the Nil lime treatment are shown.

Yields were generally low and reflect the lack of rainfall post seeding and during spring for the trial conducted at Merredin Research Station (Trial 2). Canola yields were highly responsive to the disc ploughed and deep ripping treatments (Figures 3 and 4). Compared to the tillage treatments, the lime treatments showed only slight but not significant yield increase in the initial year of this trial. All treatments that had either been disced or deep ripped had significantly ($P<0.05$) higher yields than the control or lime alone treatment.

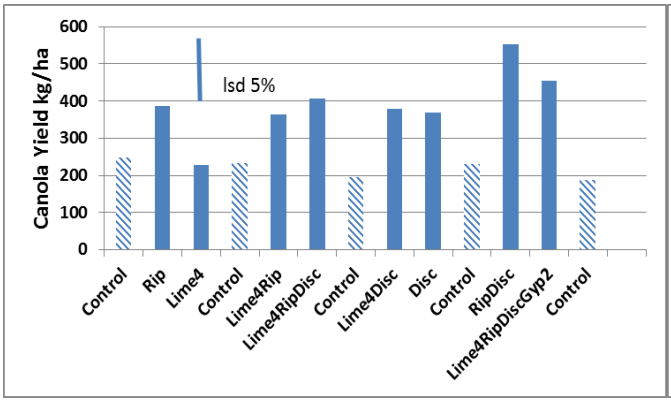

Figure 3 Canola yields as affected by tillage (disc, Ploughed, deep ripping), lime (0, 4 t/ha) and gypsum.

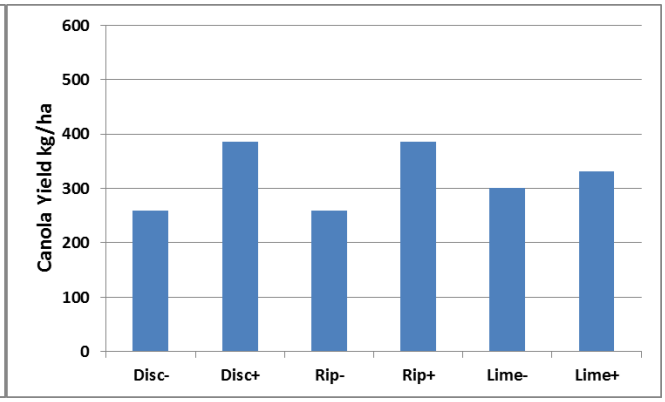

Figure 4. Main treatment effects for the disc ploughed , deep ripping and lime treatments.

The improved yields attributed to the tillage treatments were in part due to improved early vigour. There was a visual improvement in crop establishment and early crop growth within the cultivation treatments compared to the controls (Figure 5). There was also a visual increase in wild radish and ryegrass numbers in the cultivation treatments prior to being removed with the application of post emergent herbicide.

The finding that there was no observable lime effect on crop growth in the first year of this trial requires further investigation. Soil type differences within the trial potentially favoured crop growth in the treatments with the higher plot numbers, However the distribution of limed and un-limed treatments within the trial was spatially unbiased. Tillage therefore remains the dominant factor affecting crop yields. We hypothesise that lime has not had enough time to raise the pH at depths where acidity is limiting crop production. Further pH testing is required to confirm this.

Figure 5. Aerial photograph from a UAV taken on the 23rd July 2015 along with plot number and treatment.

Conclusions

- Results from the first year of two demonstration trials on acidic yellow sands and earths have shown that strategic tillage can result in increased crop yields in acidic soils with and without lime. In Trail 1 significant grain yield increases were found where tillage was combined with lime. However in Trial 2 much of the initial effect on grain yield was associated with the tillage treatments.
- In Trial 1, offset disc ploughing with lime mainly increased the soil pH within the 0-10 cm layer with minor increases in soil pH at depth. Given that the top soil was not acidic (pH >5) then the improvement in crop yield is most likely due to the minor increases in soil pH found at depth arising from the incorporation of lime.
- For both trials the combined effects of deep ripping and discing on canola yields were invariably no greater than each tillage treatment alone.
- The application of 5 t/ha of lime gave no initial improvement in crop yields compared to 2 t/ha of lime when combined with tillage (Trial 1).

Key words

Acidic yellow sand; Lime; Incorporation; soil properties

Acknowledgments

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