Amelioration of Subsoil Aluminium Toxicity for Improved Productivity in the Northern Agricultural Region of WA – Latham

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Take Home Messages

- Soil sampling to depth identified that aluminium (Al) toxicity was present as a soil health and crop growth constraint.
- Ripping had a negative yield effect due to wind erosion events at the site.
- The liming ameliorant appears to have had a positive yield effect, offsetting the impact of the ripping.
- The gypsum and biochar ameliorants did not increase yield.

Aim

1. To demonstrate the benefits of using soil ameliorants with deep cultivation to address subsoil aluminium toxicity.
2. To increase awareness and support the adoption of tools and methods to identify and effectively manage aluminium toxicity.

Background

Aluminium toxicity in the subsoil is a major problem associated with acidic soils across the WA Wheatbelt. In most Wheatbelt soils, where the subsoil pH is below 4.8, Al concentrations will reach levels that are considered toxic and yield limiting to crops. Current practices to ameliorate surface soil (0-20cm) acidity have been successful and farmers are now seeking validation on practices that ameliorate subsoil (below 20cm depth) acidity and Al toxicity.

In the trial, three ameliorants (lime, gypsum & biochar) were applied to address the Al constraint. Lime application increases soil pH which subsequently converts toxic Al^{3+} to inert gibbsite (Anderson, Pathan, Sharma, Hall, & Easton, 2019). Application of gypsum increases the soil solution sulphate, which can bond with toxic Al to form inert non-toxic Al sulphate (Anderson, Pathan, Sharma, Hall, & Easton, 2019). The oxidising introduced carboxylic functional groups (- charge sites) on biochar surfaces can serve as binding sites for Al^{3+}, rendering it inert and non-toxic (Lin, et al., 2018). The Liebe Group are seeking to investigate these ameliorant options for reducing toxic Al in the soil, and which is most cost effective to implement on property.

Trial Details

Trial location	Hirsch property, Latham
Plot size & replication	12m x 300m x 2 replications
Soil type	Acidic white sand
Paddock rotation	2017 Fallow, 2018 Wheat, 2019 Barley
Sowing date	26/07/2020
Sowing rate	60 kg/ha Buff Barley
Fertiliser	26/07/2020: 40 kg/ha MAP, 50 L/ha UAN
Herbicides, Insecticides & Fungicides	26/07/2020: 3 L/ha Trifluralin, 30 g/ha Diuron 01/07/2020: 1 L/ha Jaguar, 200 ml/ha LV Ester 680

Treatments

	Treatment
1	No ameliorant, no cultivation
2	No ameliorant, cultivated*
3	Lime applied at 3t/ha, cultivated*
4	Gypsum applied at 3t/ha, cultivated*
5	Biochar applied at 2t/ha, cultivated*

*The cultivation method used was deep ripping to 400mm with inclusion plates.

Soil Composition

Depth (cm)	pH ($CaCl_2$)	Col P (mg/kg)	Col K (mg/kg)	S (mg/kg)	N (NO_3) (mg/kg)	N (NH_4) (mg/kg)	EC (ds/m)	OC (%)	Al $CaCl_2$ (mg/kg)	PBI
0-10	5.2	16	81	33	10	6	0.07	0.5	<0.2	33
10-20	4.3	6	54	26	5	3	0.04	0.3	8	44
20-30	4.2	<2	52	31	4	2	0.04	0.2	19	56
30-40	4.2	<2	43	34	4	1	0.04	0.2	20	62
40-50	4.2	<2	27	37	5	1	0.03	0.2	22	72

Results

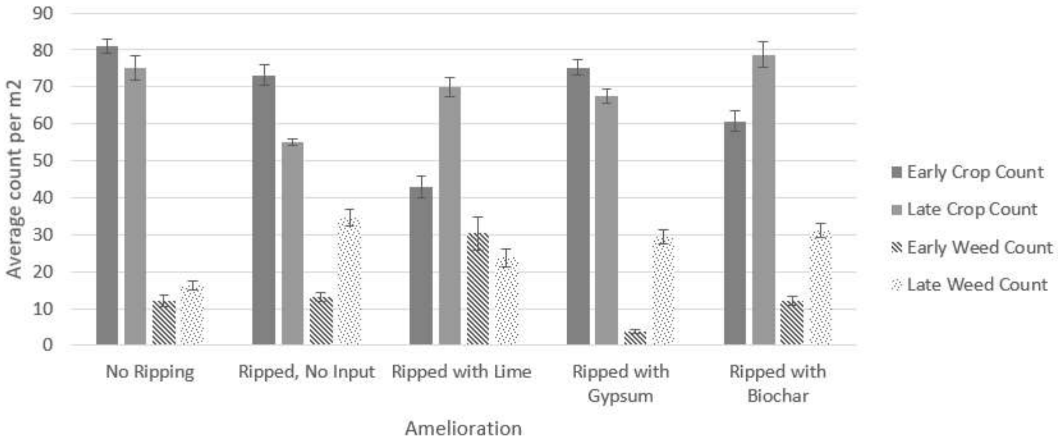

Figure 1: Average early (17/06/2020) and late (18/08/2020) crop and weed density (per m^2) in Buff barley in aluminum toxicity trial at Latham. Error bars are ± 1 S.E.

There was significant weed density across the site consisting primarily of ryegrass. The weed burden was varied across and between plots (Figure 1), however, overall the ripped treatments had a higher weed burden than the un-ripped. Crop establishment was staggered, and quite uneven within and between plots. The un-ripped (control) plots had higher crop establishment numbers, but there were no significant differences between establishment numbers in the other treatments.

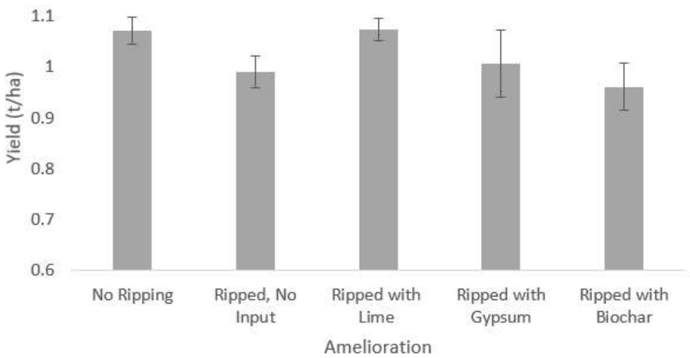

Figure 2: Yield (t/ha) of Buff barley in aluminum toxicity trial at Latham. Error bars are ± 1 S.E.

The ripping seems to have had a negative yield effect (Figure 2), while the lime appeared to have had a positive yield effect.

Comments

The host paddock received two significant wind events post sowing, which led to wind damage and row fill at the trial site.

Variation in plant and weed numbers seems to primarily be spatial due to wind damage and had little correlation to the treatments, with the exception of lower weed numbers being observed in un-ripped treatments (Figure 1).
The negative yield response to the ripping is likely due to wind damage and furrow fill moving the disturbed soil of ripped treatments more than the undisturbed soil of the un-ripped treatments.

The lime may have had a positive yield effect, mitigating some of the negative effects of the ripping treatment. The biochar and gypsum however do not appear to have had a positive effect on yield. The lack of response to gypsum was probably due to the high levels of sulphur present in the soil to render the Al non-toxic. The effectiveness of biochar is dependent on its exact makeup and what materials have been included in the product (Lin, et al., 2018). Exact understanding of when the product is most and least effective at ameliorating subsoil Al is not entirely clear.

Tissue testing was also performed on each plot, but no significant differences were found between any of the nutrient levels of the treatments. Given the impact of external factors on the performance of the treatments applied, an economic analysis was not conducted on the results.

The results from this project have provided greater understanding of soil health characteristics and crop growth responses to Al toxicity, the identification of potential management practices, and support for local growers to improve their practices to contribute to positive soil health changes in the region. Validating the quantifiable economic benefits for growers is an important step in the adoption of long-term and sustainable land management practices.

Additionally the benefits of soil sampling to depth have been introduced as an effective tool to measure positive changes in soil health due to on-farm practices, which will be highlighted further with the second set of soil tests that will be taken post-harvest 2020. This second sampling activity will assist in determining the effect each ameliorant had on Al concentrations and pH in the soil profile.

The Liebe Group would also like to quantify the long term costs and benefits of the different ameliorants used, and are looking into extending the monitoring of the project over following seasons.

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References
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Peer review
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