Department of Primary Industries

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MANAGING SUBSOIL ACIDITY (GRDC DAN00206)

Comparison of a range of amendments on alleviating Al and Mn toxicity in wheat

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Prepared by D. Lauricella, Dr C. Butterly and Prof C. Tang (c.tang@latrobe.edu.au)
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Poultry litter, poultry manure biochar, dairy compost, biosolids and sheep manure performed better than other organic amendments across both soils. Most of organic amendments decreased extractable Al and Mn, but did not increase soil pH.

Introduction

Soil acidity (pH<5.5 in calcium chloride) with aluminium (Al^{3+}) and manganese (Mn^{2+}) toxicities is a major constraint to global food production. In acid soils Al-toxicity inhibits root growth and function by interrupting root elongation and Mn toxicity limits shoot growth by interfering with a variety of biochemical pathways, including photosynthesis. Phosphorous (P) is often the most limiting macro nutrient in acidic soils. While lime application to increase pH is an effective practice, it is limited in treating soil acidity at depth, especially when applied at the surface.

In this study seventeen organic and inorganic amendments were evaluated in two contrasting soils to ameliorate soil acidity either due to their ability to directly bind exchangeable Al^{3+} and Mn^{2+}, increase pH directly, or via decarboxylation, supply plant nutrients and have organic compounds that could potentially move deep into soil profiles.

Experimental design

Two soils were collected from 10-20 cm soil layers: a Dermosol from Kinglake West, Victoria and a Sodosol from Holbrook, New South Wales. The Dermosol had pH of 4.1, pH buffer capacity (pHBC) of 86 $mmol_c$/kg/pH and extractable Al^{3+} of 12 µg/g. The Sodosol had pH of 3.9, pHBC of 23 $mmol_c$/kg/pH, extractable Al^{3+} of 1 µg/g and extractable Mn^{2+} of 70 µg/g.

Amendments used were: lime, dolomite, gypsum, KH_2PO_4, cow manure, sheep manure, poultry litter, dairy compost, immature hot mix compost, biosolids, brown coal, southern blue gum biochar, wheat straw biochar, poultry manure biochar, wheat straw, lucerne hay and kelp powder. All organic amendments were mixed with the soils at a rate of 1% soil weight. Lime and dolomite were applied to achieve a pH of 6, gypsum was applied equivalent to calcium added from lime and KH_2PO_4 was added at 338 mg/kg soil (3 times basal P).

Al-sensitive wheat, ES8, was grown for 7 weeks in a glasshouse experiment. ET8 (Al-tolerant wheat) was grown as a control to verify biological Al^{3+} toxicity as it is a isogenic pair of ES8 except for an Al^{3+}-activated malate transporter.

Photo by Dominic Lauricella

Figure 1. Wheat (Al-sensitive ES8) plants at harvest in a Sodosol and a Dermosol (49 days after sowing)

Results

- Poultry litter, poultry manure biochar, dairy compost, biosolids and sheep manure consistently performed better than other organic amendments across both soils.
- The different response between the soils is due to different pHBC. Sodosol had a much lower pHBC and less Al^{3+} compared to the Dermosol. Thus, Sodosol had less ability to resist soil chemical changes.
- A variety of soil chemical changes were observed with most treatments decreasing $CaCl_2$-extractable Al and Mn.
- While pH change is generally a critical factor, soil pH was not significantly increased under most of treatments.
- The best organic amendments contained the highest concentrations of P. Olsen-P had a stronger relationship with shoot biomass responses than any other measured soil property.
- This slow release of P from amendments as they breakdown enables plants to take up more P by reducing the amount of P that is fixed by the acid soils.
- Poultry litter and poultry manure biochar showed very similar effects in ameliorating soil acidity, it is possible that the effects poultry manure biochar would persist much longer due to its greater ability to resist breakdown than an easily decomposable poultry litter.

Key messages

- On-farm plant-based amendments, such as lucerne hay, significantly increased plant biomass in the less hostile Sodosol.
- In the more hostile Dermosol, only the organic amendments, such as manures with high concentrations of P, increased crop biomass.
- Future research should identify organic amendments that not only have the ability to influence pH, Al^{3+} and Mn^{2+} toxicity, but also supply key plant nutrients to overcome the strong P-fixing capacity of acid soils.

Project partners and contacts

Organisation	Key contact	Telephone
NSW Department of Primary Industries	Dr Guangdi Li Dr Ehsan Tavakkoli	02 6938 1930 02 6938 1992
La Trobe University	Prof Caixian Tang	03 9032 7416
Charles Sturt University	Dr Sergio Moroni Dr Jason Condon	02 6933 2914 02 6933 2278
CSIRO Canberra	Dr Peter Ryan	02 6246 5053
Farmlink Research	Kellie Jones	02 6980 1333
Holbrook Landcare Network	Dale Stringer	02 6036 3181
Riverine Plains	Dr Cassandra Schefe	03 5744 1713
Southern farming Systems	Lisa Miller	03 5265 1666

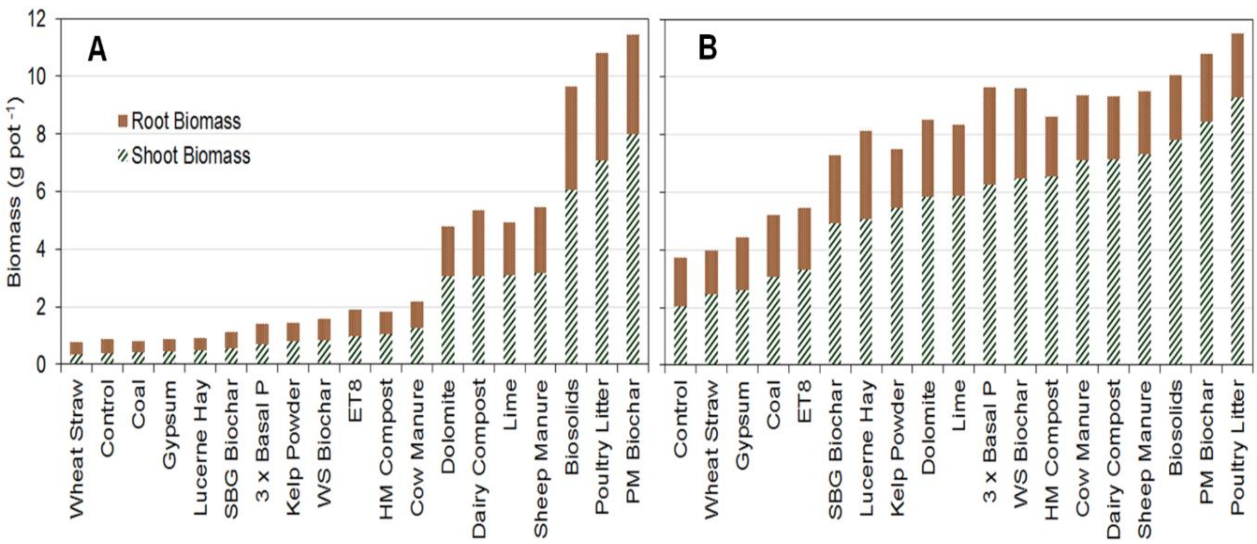

Figure 2. Effect of treatments on shoot and root biomass (g/pot) of Al-sensitive wheat ES8 grown in a Dermosol (A) and Sodosol (B) at 49 days after sowing. ET8 = Al-tolerant wheat, SBG = Southern blue gum, WS = Wheat straw, PM = Poultry manure, Basal P = 112.5 mg/kg KH_2PO_4, HM = Immature hot mix (n = 4).