Organic amendments facilitate alkalinity movement down a soil profile

Issue 17: September 2020

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http://www.dpi.nsw.gov.au/agriculture/soils/acidity

Under controlled environmental conditions, the addition of lime with crop residues and animal waste composts can generate alkalinity below the amended layer and create favourable pH gradients, which facilitates the downward movement of alkalinity from organic amendments.

Introduction

Subsoil acidity is a serious constraint to crop production and is inherently difficult to correct through conventional surface application of lime. Thus, new approaches to ameliorate subsurface soil acidity are needed. Two column leaching experiments were established to determine whether crop residues and animal wastes, when combined with lime, could facilitate lime dissolution and alkalinity movement down soil columns to ameliorate subsoil acidity.

Experiment design

Experiment 1. The soil (Chromosol) was collected from Rutherglen, Victoria at 0-8 cm (surface soil) and 8-15 cm (subsurface soil). The initial pH was 5.2 in $CaCl_2$ for the surface and 4.7 for the subsurface soil. The soil was reconstructed with topsoil at 0-10 cm and subsurface soil at 10-40 cm in columns with 10.2 cm in diameter of and 40 cm in height. Five types of crop residues as canola (*Brassica napus* L.), field pea (*Pisum sativum* L.), lucerne (*Medicago sativa* L.), oat (*Avena sativa* L.) and vetch (*Vicia villosa* L.) were collected at anthesis. The crop residues were mixed with lime at 18 g dry matter kg^{-1} soil at 0-10 cm (target pH 6.6). Soil columns were leached 6 times over a 3-month incubation period and destructively sampled at 1 and 3 months for soil chemical analysis.

Experiment 2. The soil (Chromosol) was collected from Welshpool, Victoria at 0-10 cm (surface soil) and 10-20 cm (subsurface soil). The soil had an initial pH of 3.9 in $CaCl_2$ for the surface soil and 4.0 for the subsurface soil. The soils were air-dried, sieved through a 2-mm sieve and fully mixed. Five ameliorants (mature dairy compost, vegetable garden compost, poultry litter, potassium humate and gypsum) were added at a rate of 18 g dry matter kg^{-1} soil to the topsoil layer either without or with lime (target pH 5.5 in $CaCl_2$).

Results

Crop residues with greater excess cation concentrations and lower C/N ratios (vetch and lucerne) showed the greatest increases in pH over one month (Figure 1). Canola and oat residues, with higher C/N ratios, were superior in terms of soil pH increase over a longer term (3 months).

After 3 months of incubation, soil pH of the amended 0-10 cm layer changed very little when compared with the 1-month sampling time. However, the large differences between the amended soils and the non-amended control observed at 1 month had largely diminished by 3 months. This was because of the increase in pH of the nil control (0.39 pH units) and not the re-acidification of the amended 0-10 cm layers.

Among the organic amendments, poultry litter resulted in the largest increase in pH in the surface soil (0.47 units) compared to the control. However, with lime addition, only mature dairy compost and vegetable garden compost increased pH more than lime alone (Fig. 2). At 3 months, alkalinity movement from organic amendments was detected down the column. All amendments in combination with lime showed greater pH increases than lime alone in the 10-12 cm and the 12-15 cm layers (data not shown). Gypsum and vegetable garden compost with lime achieved the greatest pH increases of 0.22 and 0.14 units, respectively, in the 10-12 cm layer, and 0.09

and 0.08 units in the 12-15 cm layer, respectively, compared to the lime-alone treatment. The increase in pH below the amended layer was because of the leaching of organic compounds and the subsequent ammonification, nitrification, and release of alkalinity by microbial decarboxylation.

The results showed that even small increases in pH can reduce Al3+ bioavailability. Increase in pH and reduction in Al^{3+} toxicity by compost treatments alone remained at the end of the 3-month experimental period despite a gradual decline in magnitude over time.

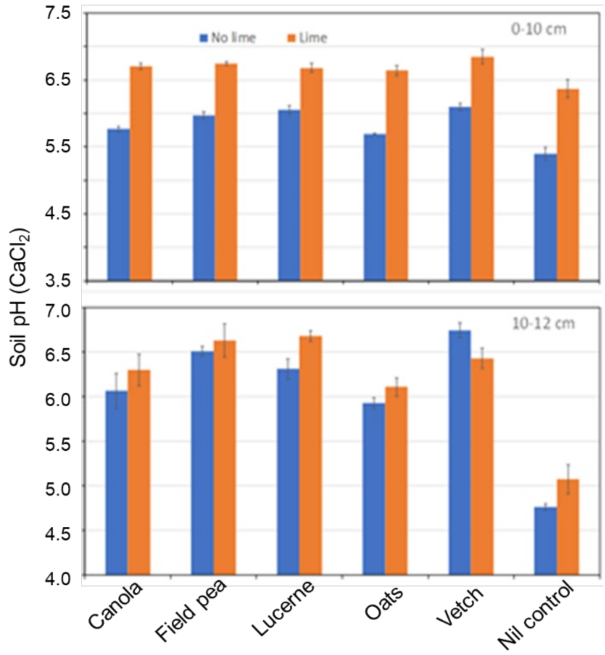

Figure 1. Soil pH (1:5 0.01 M $CaCl_2$) at 1 month from 0-10 and 10-12 cm in Experiment 1 amended with canola, field pea, lucerne, oat and vetch residues or nil control (blue bars), corresponding residues plus lime (orange bars). Vertical bars indicate ± standard errors of the mean (n=3).

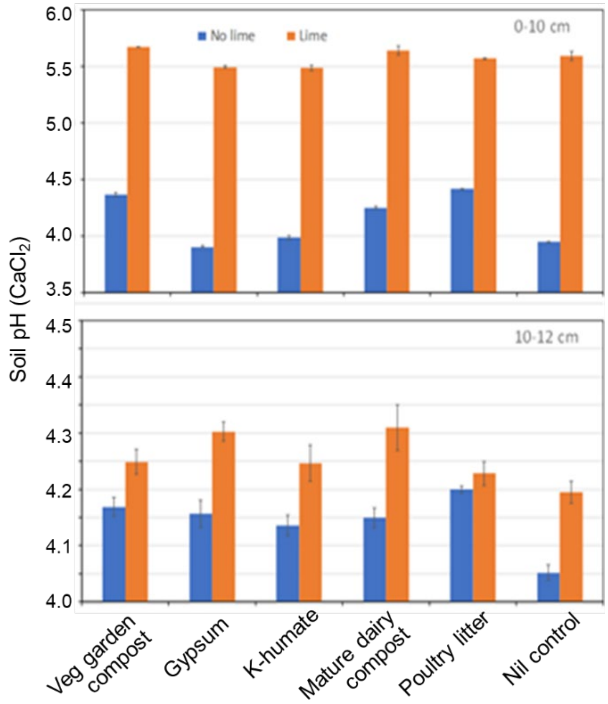

Figure 2. Soil pH (1:5 0.01 M $CaCl_2$) at 0-10 and 10-12 cm in Experiment 2 at 1 month after amendment with vegetable garden compost, gypsum, K-humate, mature dairy compost, poultry litter or nil control (blue bars), corresponding materials plus lime (orange bars). Vertical bars indicate ± standard errors of the mean (n=3).

Conclusions

Addition of crop residues can create favourable pH gradients and may be capable of facilitating downward movement of alkalinity from organic amendments when applied with lime. Crop residues may be suitable amendments in cropping soils that have low levels of acidity and low pH buffering capacity (e.g. Rutherglen site), whereas composts with lime would be suitable amendments in cropping soils with medium levels of acidity, low initial pH and high pH buffering capacity (e.g. Welshpool site).

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