MANAGING SUBSOIL ACIDITY (GRDC DAN00206)

Phosphorus improves effectiveness of calcium nitrate in ameliorating soil acidity

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Phosphorus (P) potentially can improve effectiveness of calcium nitrate in ameliorating soil acidity via stimulation of root proliferation. Balanced nutrient supply at depth can improve excess anion uptake by plants, which could in turn extend rhizosphere alkalization to the bulk soil.

Introduction

Excess anion uptake in the form of nitrate has been shown to reduce soil acidification. The effectiveness of the biological manipulation of the cation/anion balance can be improved with enhanced nutrient status in the acid soil. Sufficient root growth is essential for the subsequent uptake of NO_3^- and release of OH^-. Adequate supply of P can stimulate root growth and enhance root proliferation. This study aimed to compare the effectiveness of calcium nitrate alone and in combination with P and other nutrients in ameliorating soil acidity with fertilisers placed at various depths.

Experiment design

Experiment 1. Surface (0-8 cm) and subsurface (8-15 cm) soils were collected independently from a Yellow Chromosol at Rutherglen, Victoria. Soil pH was 5.2 in $CaCl_2$ with 1.5 mg Al kg^{-1} in the surface soil and 4.7 with 2.9 mg Al kg^{-1} in the subsurface soil. The soil was reconstructed with surface soil at 0-10 cm and subsurface soil at 10-50 cm in columns with a diameter of 15 cm and a height of 60 cm. Air-dried soils (sieved <2 mm) were treated either with urea or calcium nitrate at 237 mg N per soil column (equivalent to 134 kg N ha^{-1}) in a band at either 0-10, 10-20 or 20-30 cm. The N band was either with P fertiliser (NaH_2PO_4) at 99 mg P (equivalent to 56 kg P ha^{-1}) or without P fertiliser. Twenty pre-germinated seeds of wheat (acid tolerant line ET8)

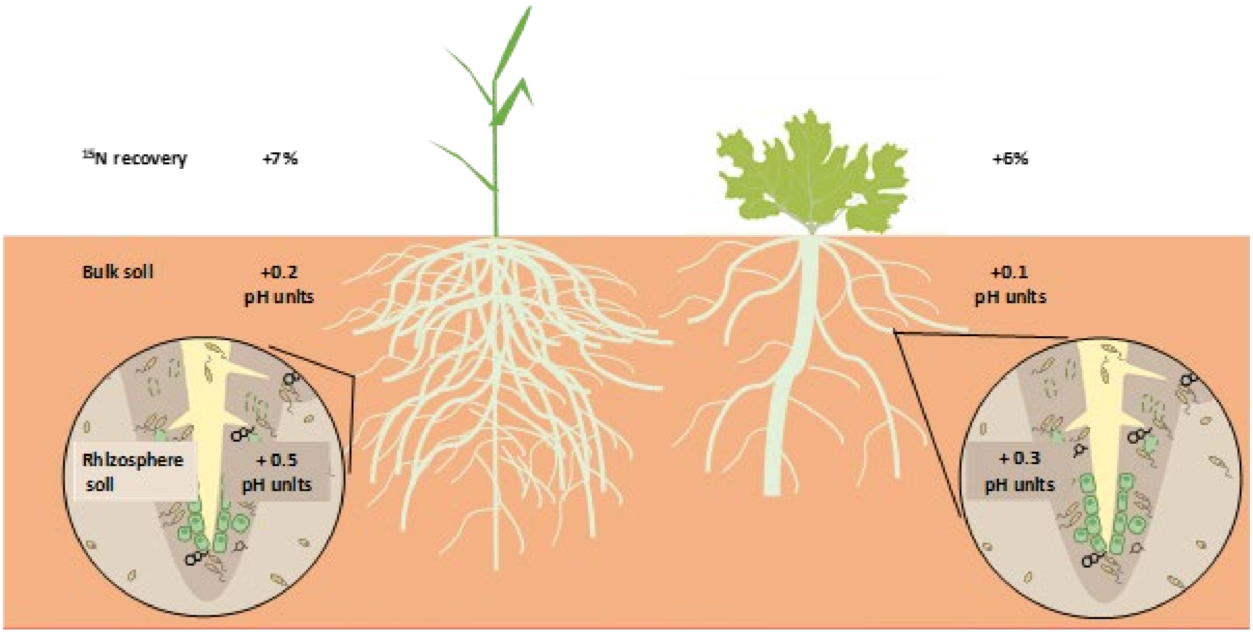

Figure 1. Calcium nitrate with P increased N use efficiency, rhizosphere pH and bulk soil pH compared with urea with P treatment after wheat (left) and canola (right) were grown for 35 days in Chromosol soil columns

or canola (44Y49) were sown evenly in each column. The seedlings were thinned to 15 plants at 7 days and 10 plants at 15 days after sowing. Plants and soils within each column were destructively harvested at day 35.

Experiment 2. To further investigate biological manipulation of soil acidity over time, another experiment was established. The subsurface soil same as in Exp 1 was used to pack up the whole soil column. Wheat (ET8) were grown over 80 days. Soils were treated with urea or $Ca(NO_3)_2$ (5% atom% ^{15}N enrichment) at 60 mg N kg^{-1}, with and without P applied as NaH_2PO_4 at 60 mg P kg^{-1}, at three depths (0-10, 10-20 or 20-30 cm) prior to sowing. Supplemental N was added four times at 30 mg N kg^{-1} every 10 days from days 40 to 70. Plants and soils within each column were destructively harvested at days 50 and 80.

Measurements. The soil columns were wet to 90% field capacity, following the addition of basal nutrients. Water was added every three days to 90% field capacity during both experiments. Shoots were cut at soil surface level, washed with 0.1 M HCl and rinsed with Milli-Q water. Plant samples were dried at 70°C. Soil from each pot was thoroughly mixed, subsampled and dried at 25°C. Soil pH was then quantified using a pH electrode after shaking end-over-end for 1 h in a 0.01 M solution of $CaCl_2$ (1:5 soil:solution).

Results

Calcium nitrate in combination with P fertiliser increased plant nitrate uptake, hence rhizosphere alkalisation. In the short term (day 35), the surface treatment at 0-10 cm was more effective compared with deeper treatments (Figure 1). Over the longer growth period, rhizosphere alkalisation was greater with deep nitrate + P treatments as these encouraged the root proliferation of deeper depths (Figure 2). The form of N and the depth of P applied had no effect on shoot biomass after 80 days of growth.

Nitrate addition significantly increased the ^{15}N recovery by up to 8% for the deep P application depths (10-30 cm) compared with the urea treatment. The P fertiliser at any depth had no impact on the shoot N concentrations of wheat. Greater root biomass and root length in the nitrate + P treatments appeared to contribute to greater nitrate uptake and consequently greater alkalization. Balanced nutrient supply at depth can improve excess anion uptake by plants, which could in turn extend rhizosphere alkalization to the bulk soil.

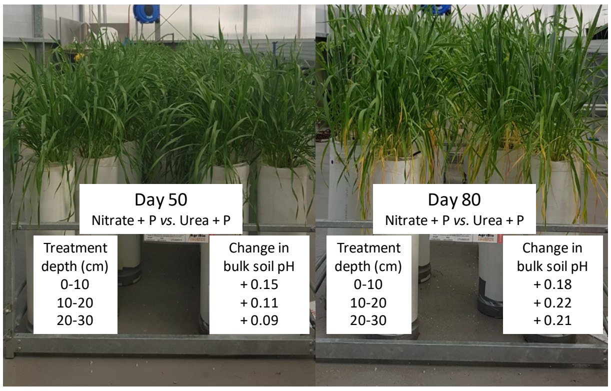

Figure 2. Changes in bulk soil pH at various depths after wheat plants were grown for 50 (left) and 80 days (right) in soil columns amended with Nitrate + P and Urea + P at either 0-10, 10-20 or 20-30 cm.

Conclusions

This study confirmed that deep placement of nitrate was effective in increasing pH at rhizosphere compared with urea. The addition of P promoted root growth in the nitrate-treated layers which increased nitrate uptake and consequently greater rhizosphere alkalization, which could in turn extend to the bulk soil.

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