Soil N mineralisation following fallow, annual crops and perennial pastures

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Abstract

Nitrogen mineralisation was measured by aerobic incubation of soil that had been fallowed or had grown annual crops (wheat, canola) or perennial pastures (cocksfoot, phalaris, lucerne, cocksfoot-phalaris mix, lucerne-cocksfoot-phalaris mix). The perennial pasture mix mineralised the most N, at the highest rate, while the annual crops and fallow treatments mineralised at the lowest rate. Treatments containing cocksfoot had the highest rate of mineralisation. Further research will determine whether pasture species mixes can be manipulated to aid N nutrition of following crops.

Key Words

nitrogen mineralisation, lucerne, canola, wheat, cocksfoot, phalaris

Introduction

Soil mineral N can vary depending on the previous crop or pasture phase. High quality annual legume pastures such as subterranean clover are capable of fixing large amounts of N (25 kg N/t DM) (1) which then become available to the following crop through mineralisation. Lucerne, a perennial legume, can also fix large amounts of N (2) but the mineralisation of lucerne residues is generally slower than annual pasture residues (3).

The N dynamics of perennial grasses in a cropping rotation have not been studied as thoroughly as those of lucerne. The C:N ratio is often considered the primary determinant of the rate of mineralisation of plant residues (4). As the C:N ratio of grasses is usually higher than that of legumes, mineralisation may be expected to be slower (3). The aim of the present study was to observe the N mineralisation dynamics of soil in which different crop and pasture species had grown in the previous year.

Methods

Soil was collected in autumn 2001 from a replicated field trial at Junee Reefs, NSW. The treatments included a fallow, canola, wheat, cocksfoot, phalaris, lucerne, cocksfoot-phalaris mix and lucerne-cocksfoot-phalaris mix. The perennials were grown undisturbed for 2 seasons, apart from mowing; the fallow was maintained for 2 years with herbicides; and the wheat (W) and canola (C) were grown as WC and CW. The cropping plots had been fallow over summer and maintained weed free with one herbicide application.

Soil from each plot was sampled to 10 cm in mid-autumn, approximately 2 months after the perennials had been removed using herbicides. The soil was passed through a 2 mm sieve to remove stones and large pieces of organic matter, wetted to field capacity (18% gravimetric water content), packed into 103 mm internal diameter PVC rings at a bulk density of 1.4 g/cm^3 and incubated in the dark at a constant 15?C temperature. Each ring was placed in a 30 µm LDPE bag to minimise evaporation whilst maintaining aerobic conditions. The soil in each ring was sampled 8 times over 30 weeks using a small 2 cm diameter corer. The core holes were filled with tightly fitting PVC tubes to maintain constant bulk density of the remaining soil. Mineral N was extracted using 2M KCl and measured using an automated colorimetric method (5). The mineral N was graphed over time and a simple linear regression conducted for each incubation ring. In all cases a simple linear model ($y = a + bx$) was a good descriptor of the relationship. One way ANOVAs were then conducted on the slope (b value), initial and final mineral N data.

Results / Discussion

Soil sampled after fallow, wheat and canola did not differ in initial N, final N or total N mineralised over 30 weeks, or in the rate of mineralisation. These annual treatments differed from the perennial treatments; they had a higher initial mineral N (though not different from those treatments containing lucerne), lower final mineral N, much lower total N mineralised over 30 weeks and 40-60% lower mineralisation rate (Table 1).

Table 1: Mineral N at the beginning and end of the incubation, total N mineralised and the mineralisation rate calculated from the fitted regression.

Treatment	Initial mineral N (mg/kg)	Final mineral N (mg/kg)	Total N mineralised in 30 weeks (mg/kg)	Average rate of mineralisation (mg/kg/week)*
Fallow	77 ^{ab}	116 ^{d}	39 ^{c}	1.56 ^{c}
Canola	87 ^{a}	139 ^{cd}	52 ^{c}	1.77 ^{c}
Wheat	71 ^{ab}	125 ^{cd}	53 ^{c}	2.08 ^{c}
Cocksfoot	48 ^{c}	147 ^{bc}	98 ^{ab}	3.59 ^{ab}
Phalaris	59 ^{bc}	140 ^{cd}	81 ^{b}	3.09 ^{b}
Phalaris /cocksfoot	57 ^{bc}	154 ^{bc}	96 ^{ab}	3.45 ^{ab}
Lucerne	77 ^{ab}	171 ^{ab}	94 ^{ab}	3.26 ^{b}
Lucerne /phalaris /cocksfoot	73 ^{ab}	183 ^{a}	110 ^{a}	3.98 ^{a}
Significance:	P = 0.010	P = 0.001	P<0.001	P<0.001
LSD at P<0.05	20	29	20	0.55

* calculated ***b*** value of the linear regression
^{a,b,c,d,} different letters denote treatments that are significantly different at P < 0.05

The fallowed soil mineralised the least N during the incubation, presumably because labile organic matter had been exhausted.

Soil containing lucerne residues had high initial and final amounts of mineral N. This is consistent with N fixation by the lucerne, the lower C:N ratio of lucerne residues compared to grasses (3) and faster subsequent mineralisation. The cocksfoot treatment is of particular interest as it contained the smallest amount of initial mineral N (48.4 mg/kg ~67 kg/ha); and mineralised a larger amount of N (98.3 mg/kg ~ 138 kg/ha). Further, the three treatments that led to the highest rate of mineralisation were those containing cocksfoot. This may be related to the number of very fine roots of cocksfoot, the total C content of the soil, or a chemical characteristic of the cocksfoot residues, such as lignin content. This may have practical implications in pasture management for N nutrition of following crops.

Conclusion

Nitrogen mineralisation was promoted by residues of lucerne and, surprisingly, of cocksfoot. It is likely that this effect is due to chemical characteristics of the residues. Further research will test this hypothesis and establish whether the provision of N from pastures to following crops may be usefully manipulated through pasture species selection.

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