Title
Nitrogen mineralization of green manure legume residues in different soil types

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Introduction
Nitrogen is one of the major limiting nutrients to crop production in most soils in southern African region. Most smallholder farmers have limited resources to purchase recommended amounts of fertilizer, and hence crop yields are often low. The integration of green manure legumes as cover crops into the cropping systems, especially of smallholder farms has the potential to enhance yields of subsequent crops, an effect that can be largely attributed to increase in plant available N in the soil as a result of N release from the decomposition of the legume residues. However, understanding the nitrogen (N) mineralization patterns of green manure legume residues is crucial in the synchronization of N release from plant residue and subsequent uptake by plants.

Objective
To determine N mineralization patterns of three green manure legumes [(Mucuna (Mucuna pruriens), Lablab (Lablab purpureus cv. Rongai) and Sunhemp (Crotalaria juncea)] in three soil types (62, 20 and 12% clay), from the semi-arid smallholder farming areas of Limpopo province of South Africa.

Materials and Methods
Legume residue collection and quality determination
Aboveground legume biomass tissue of Mucuna (Mucuna pruriens), Lablab (Lablab purpureus cv. Rongai) and Sunhemp (Crotalaria juncea) was collected at the vegetative stage (approximately 110 days after emergence). The samples were oven dried at 65°C, ground to pass through the 0.5-mm sieve, and analyzed for total C (Dumas dry oxidation method), Kjeldhal N, cellulose, hemicellulose and lignin (Van Soest and Wine, 1968).

N Mineralization
The N mineralization experiment was carried out by the method described by Kuo and Sainju (1998), with slight modification. Nitrogen mineralization from the residues, expressed in per cent, was calculated from the difference in cumulative amount of mineral N between residue and control treatments at each sampling time, divided by the initial N applied as residue material. The rate constant of N mineralization (k) was estimated using a single exponential equation \( Y = \exp(-kt) \) (Wieder and Lang, 1982); where \( Y \) is the percentage N remaining in the residue mixtures at time \( t \). To calculate \( k \) value, linear regressions of \( \ln Y \) vs \( t \) were performed and the slope of the linear regression is the \( k \) value.

Statistical analysis
Data at each sampling time was analyzed as a randomized complete block using the General Linear Model (GLM) procedure of the statistical Analysis Software (SAS Institute). Linear regressions were fitted between each of the substrate variables and the mineralization rate constant (k) values in order to determine the significance of the residue quality variables in determining rates of N release.

Results and Discussion
The N release pattern of the three legume residues followed a similar pattern in all the three soils, with sunhemp treated soil having the highest amount of mineral N after 16
weeks of incubation in all the three soils, followed by lablab and then mucuna (Figures 1a, b, c).

Figure 1. N mineralized from legume residues recovered as mineral N in (a) 12% clay soil (b) 20% clay soil and (c) 62% clay soil.
The amount of mineral N ranged from 121 to 170, 96 to 134 and 92 to 108 mg kg\(^{-1}\) in the sunhemp, lablab and mucuna treated soils, respectively. The cumulative amounts of N from the legume residues mineralized, recovered as mineral N in soil after 16 weeks of incubation, ranged from 21-41% (92-121 mg kg\(^{-1}\)), 30-68% (108-170 mg kg\(^{-1}\)) and 26-60% (93-147 mg kg\(^{-1}\)) of the initial added N contained in the residues in the soils with 62, 20 and 12% clay contents, respectively. Soil with the highest clay content had the least amount of mineral N content for all the residue treatments at the end of the incubation period, with less than 50% of the initial added N being mineralized by the end of the incubation period. This could be attributed to the stabilizing effect of the clay on microorganisms and microbial metabolites, which leads to slower decomposition and N turnover (van Veen et al., 1985). Mineralization rate constant, \(k\), was significantly correlated to the residue N content, net mineralized N, C/N ratio and Lignin/N ratio (Table 1).

Table 1. Coefficients of determination (\(R^2\)) for linear regressions between substrate quality variables of legume residues and N mineralization rate constants (\(k\)) of the residues incubated for 16 weeks.

<table>
<thead>
<tr>
<th>Substrate quality variable</th>
<th>Coefficient of determination ((R^2))</th>
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<tbody>
<tr>
<td>N (%)</td>
<td>0.70*</td>
</tr>
<tr>
<td>Net N mineralized</td>
<td>0.49*</td>
</tr>
<tr>
<td>C/N</td>
<td>0.86**</td>
</tr>
<tr>
<td>Lignin/N ratio</td>
<td>0.51*</td>
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</tbody>
</table>

*Significant at 5%; **Significant at 0.1%

**Conclusions**

Results from this study indicated that all the three legumes could contribute significant amounts of N for uptake by plants, with sunhemp tending to release N at a faster rate, followed by lablab and then mucuna. Nitrogen mineralization of legume residues was slowed down in high clay content soils.

**References**


