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DECOMPOSITION RATES OF LEGUME RESIDUES AND N-MINERALIZATION IN AN ULTISOL IN LAMPUNG

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ABSTRACT

Results of preliminary measurements of decomposition and N-mineralization from various sources of crop residues of leguminous cover crops and hedgerow trees are presented. Decomposition measurements in litterbags in the field were compared with those in a sheltered pot experiment and in 'decomposition tubes' installed in the field. For some residues also N mineralization under standard laboratory conditions was measured. For decomposition of pruning material of hedgerow trees the litterbag and the pot experiment gave similar results, showing a rapid decomposition of *Erythrina* prunings (50% loss of dry weight in approximately 3 weeks) and a slow decomposition of *Calliandra* and *Peltophorum* prunings (50% loss of dry weight in approximately 15 weeks). For residues of leguminous cover crops and fallen leaves of cassava intermediate rates of decomposition were established in the pot experiment (50% weight loss in about 4 and 7 weeks, respectively). The measurements in the decomposition tubes were hindered by waterlogging of the soil due to compaction when the tubes were installed. Residues of two *Calopogonium* species decomposed faster than those of *Mucuna* and *Centrosema*. Measurements of CO_2-production (respiration) confirmed this result.

N-mineralization was measured by sampling the soil under litterbags, in the pot experiment and in the decomposition tubes. The litterbag results show a 'flush' of nitrate due to decomposing tree litters and a slow but steady increase of ammonium content of the soil. The highest peak in mineral N was found after 4 weeks in *Calliandra*. Results for a *Mucuna* cover crop in between the hedgerows, showed a high mineral N-content of the soil at the moment that the cover crop was slashed. Decomposing *Mucuna* residues resulted in a moderate further increase. In the pot experiment mineral N accumulated without leaching or crop uptake. The highest N-mineralization was found for *Calliandra* prunings, followed by a *Calopogonium* crop residue. Measurements of mineral N in the decomposition tubes in the field showed

growth period of the cover crops, but showed a subsequent decline where a further accumulation was expected, as crop uptake and leaching were excluded. The possibility of denitrification under the conditions of measurement is discussed. For further studies in the field the litterbag method in combination with measurements of mineral N in the soil appears to be the most suitable. The laboratory incubation study showed that N mineralization per unit N content of the residue was well correlated with the overal C/N content of the residue. Materials with a C/N content higher than 23 showed net immobilization during a period of 160 days. Other parameters of the chemical composition did not increase the percentage of variance accounted for in this study. A further check on N mineralization from *Calliandra* seems necessary, however. Some data are presented on a chemical fractionation of soil organic matter for the topsoil of five long term experiments. The relatively high total N content of the forest soil was associated with a high C/N content of the acid soluble fraction.

INTRODUCTION

Decomposition of dead plant material can have a direct effect on crop growth, by mineralization of nitrogen, and an indirect one, by build-up of soil organic matter which may increase future efficiency of nutrient use. The two functions are partly complementary. Rapidly decomposing material of low C/N quotient contributes mainly by N-mineralization and slowly decomposing litters contribute especially to the build up of the soil organic matter pool. To predict which function can be expected from a particular type of litter and to design cropping systems with a balanced supply of organic inputs, information on the rate of decomposition and N-mineralization of various sources of litter is needed. For the N-mineralization not only the total amount during the growing season is important, but also the time pattern of N-release (and possibly immobilization), as this can be more or less synchronous with the demand for uptake by crops. The degree of 'synchronization' between N-supply and demand is important for the efficiency of nitrogen use, especially under conditions of high rainfall and leaching. Leaching problems are the more severe when crops are shallow rooted and when mineral nitrogen is present in the nitrate form (Van Noordwijk *et al.*, 1992). As environmental conditions can have a pronounced effect on decomposition rates, the measurements should be done as much as possible under field conditions.

The major determinant of the decomposition rate of crop residues is the C/N ratio, although the lignin content of the cell wall fraction and the content of polyphenolics, such as tannin, can modify the results (Alexander, 1977). Apart from the 'quality' of the litter, decomposition rates are determined by environmental conditions such as temperature and humidity (Jenkinson and Ayanaba, 1977; Ladd *et al.*, 1985) and the accessibility to soil macrofauna and soil microorganisms (Brussaard *et al.*, 1992). These factors are influenced by incorporating the litter into the soil, as compared to leaving them on the soil surface. Direct measurement of the rate of decomposition of surface applied litter is complicated by considerable spatial variability in amounts of litter present. Methods in which known amounts of litter are applied which can subsequently be quantitatively recovered, have a definite advantage. The method of isolating a certain amount of litter may, however, influence the results. In the internationally coordinated project on Tropical Soil Biology and Fertility (Anderson and Ingram, 1989) the use of 'litterbags' of standardized, coarse mesh size is recommended (Fig. 1A). The litterbag does not allow a complete direct contact of litter and soil, but the mesh size is large enough to allow the soil macrofauna to do their work. We decided to compare the results of litterbag studies with a pot experiment, in which known amounts of litter were applied to pots, kept under a shelter to avoid rainfall and too high temperatures (Fig. 1C). We further included measurements in 'decomposition tubes' inserted to the soil and covered by plastic to avoid rainfall and leaching (Fig. 1B). Table 1 summarizes some characteristics of the three methods. In all methods litter is placed on top of the soil, as happens in no-till cropping systems.

Decomposition of crop residues might be influenced by the conditions in the field during a subsequent crop (e.g. due to microclimate or the presence of other types of litter on or in the same soil). We therefore decided to include a comparison of the decomposition of a *Mucuna* cover crop in four treatments of a hedgerow intercropping trial.

A laboratory experiment with selected residues was started to evaluate the role of the tannin content as modifying factor on mineralization rates. As decomposition in the soil and in ruminants may both be determined by bacterial processes, standard methods for evaluating digestibility for cattle were applied to these residues.

MATERIALS AND METHODS

A description of the soil profile and climate can be found in Van der Heide *et al.* (1992) and Van Noordwijk *et al.* (1992), respectively. For a preliminary study of decomposition a number of contrasting litter types were chosen, relevant to a hedgerow intercropping field experiment (Sitompul *et al.*, 1992) and a cover crop/ maize/ soybean rotation experiment (Utomo *et al.*, 1992). In each case the amount of litter applied was close to that to be expected in the field. Table 2 presents sources of crop litter and amounts used in the three studies. In the presentation of the results we will concentrate on the loss of dry weight and on data on N-mineralization. For the loss of dry weight an exponential decay is to be expected and data are presented in a logarithmic form. The time required for a 50% loss of dry weight is a characteristic value.