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Potentially mineralizable n - a new role in predicting soil n supply

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Summary. The CERES-maize N sub-model was found to greatly under-estimate the mineral N supply following a legume ley in the semi-arid tropics of northern Australia. This paper reports the improvement in simulating mineral N supply when a labile pool for soil organic matter is added to the model and is initialized using values from a simple chemical extraction.

Introduction

This paper reports improvement in simulating mineral N supply when the CERES-maize N sub-model (4) is initialized for a labile soil N pool based on the concept of potentially mineralizable N (N_o) proposed by Stanford and Smith (7). The feasibility and advantages of using a chemical extraction method to quantify the labile pool for systems where residues are retained is discussed.

Methods

Experimental

Soil samples were collected from a clay loam soil at Katherine, NT, following grass *(Urochloa mozambiensis)* and legume, *Stylosanthes hamata* cv. Verano, leys of one to three seasons and a barefallow. Ley pastures were chemically killed (Roundup, L/ha) after planting rains in mid-December or early January and kept free of vegetation over the remainder of the wet seasons.

Fresh soil samples were extracted (2 M KC1) and analysed for mineral N (N1-14+NO2+NO3-N). A second sub-sample was dried at 60°C, crushed and sieved (1 mm mesh) with root removal. Aerobic incubation (30°C, 5) and chemical extraction with hot KC1-N (1) methods were used to quantify the labile organic N fraction for samples from 0-5, 15-30 and 60-90 cm depths. The exponential model, Nt = N_o * (1-e-'"), was fitted to cumulative mineralized N using non-linear least squares analysis (8). Regression analysis was used to find the relationship between hot KC1 extractable-N and N_o. Surface residues at pasture kill were sampled for dry matter and N content and root dry matter and N content in the profile were also determined.

The CERES-maize N sub-model

The N sub-model of CERES, and its precursor PAPRAN (6), simulates mineralization and immobilization of N associated with decomposition of two pools of organic matter in the soil; fresh organic N (FON) representing residues of the previous crop, and stable organic N

(NHUM) comprising all other organic nitrogen in the soil. Transformations of N from one state to another, including nitrification and denitrification, are controlled by maximal rate coefficients which are modified for environmental (moisture and temperature) and/or biological (C:N ratio, substrate levels) conditions.

We modified this model by using a more realistic C:N ratio for the humic fraction (17:1) and decomposition of and N release from this pool was restricted to the top 60 cm (6). A routine to control the rate of surface residue additions to the top soil layer was added.

Based on the laboratory analyses, a labile N pool (LABN) was initialized assuming 4% of soil total N in layers to 60 cm. Simulated N immobilization was added to this pool assuming a40% carbon content and a C:N ratio of 8:1. These values are consistent with an implicit microbial pool in the original CERES model. Decomposition of the fresh (FOM), labile (LABOM) and humic organic matter are all assumed to result in immobilization of N to the LABN pool. This was simulated assuming biological conversion efficiencies of 40, 60 and 20% for microbial decomposition of the FOM, LABOM and HUM fractions respectively.

Two configurations of the 'labile N' model were compared for simulation of the mineral N supply. Initially, a two pool model was retained by replacing the NHUM pool with the LABN pool. Immobilization was simulated for decomposition of FON only and was added to the LABN pool. The second configuration was as described above with the FON, LABN and NHUM pools all undergoing decomposition.

Results

The exponential model was successfully fitted to only 24 of the 54 soils incubated. However, for these soils there was a close relationship between $N_{.}$ and hot KC1-N which was not significantly different from the relationship for 30 Iowa soils studied by Gianello and Bremner (2).

HKCI-N in soils under the various ley treatments did not differ significantly between the start and end of the season. The amount of HKCI-N for grass and legume soils also did not differ significantly but pasture soils had higher levels of HKC1-N (7.5 ug/g soil, 0-5 cm) compared to the barefallow (5.4 ug/g, $P<0.05$).

Predicted and observed mineral N for a legume soil are shown in Figure 1. Our modified version of the CERES-N model without a labile N pool (model 1), greatly under-estimates the mineral N supply throughout the season. Where the humic pool is replaced by a labile N pool (model 2), predicted N supply agrees reasonably well with observed. Where the dynamics of the three organic N pools undergoing decomposition are simulated (model 3), mineral N is again underestimated suggesting that simulated immobilization is now too high.

However, it is the simulated changes in the labile N pool which suggest that model 3 is a more realistic representation of the soil N dynamics. Whereas model 2 showed a run-down in the labile N pool, model 3 predicted a labile N pool at the end of the season close to that which was initialized. This is in agreement with the measured labile N estimates using hot KC1 and N.

Observed and predicted levels of mineral N at the end of the season for five soil-residue systems are shown in Figure 2. The best performed model for both labile N and mineral N dynamics is model 3. The RMSD for predicted and observed mineral N supply is improved from 55 kg N/ ha for model 1, to 28 kg N/ha for model 3.

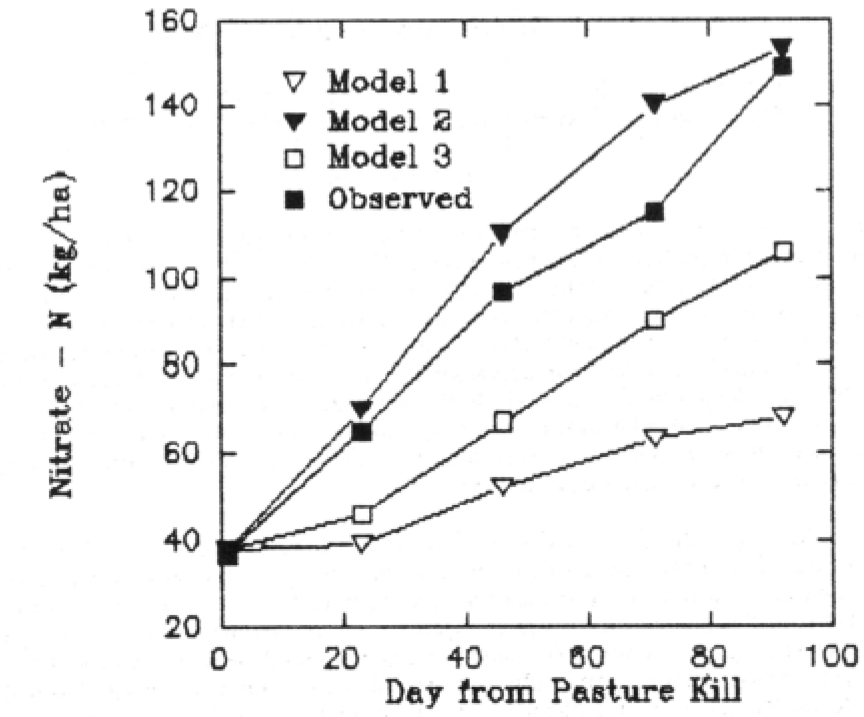

Figure 1. Predicted and observed soil mineral N supply (kg NO_3-N/ha to 1.8 m) for the legume ley sampled in 1985/86.

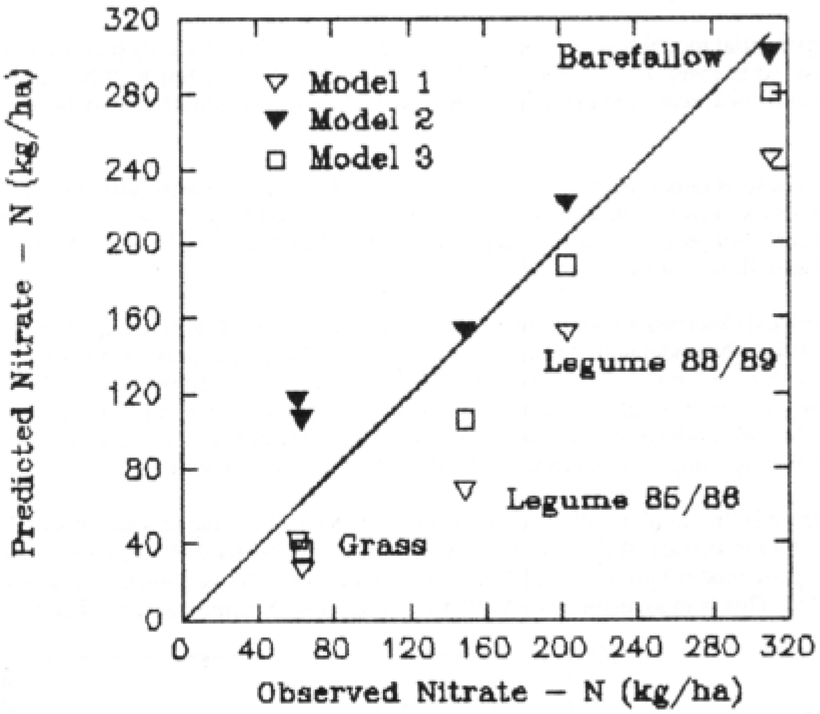

Figure 2. Predicted and observed nitrate - N (kg/ha to 1.8 m) at the end of the season for legume, grass and barefallow soils sampled in 1985/86 or 1988/89.

Discussion

The incubation and hot KCI experimentation reported in this paper was primarily an attempt to identify a labile portion of the soil organic N which could explain the high levels of mineralization which occur following legume leys and could therefore be used to improve simulation of the mineral N supply. Neither the short term incubation or the hot KCI extractions appeared to measure a portion of soil N which was directly related to the observed differences in mineralization for the various treatments measured in the field. This is because neither of the two methods adopted are able to satisfactorily deal with the dynamic and complex nature of the soil N processes involved in mineral N supply from soil organic matter, namely, the mineralization and immobilization of N associated with microbial activity, especially when fresh residues of wide C:N ratio are present (3).

Our results suggest that the hot KCI-N does provide a useful measure of a labile portion of the soil organic N. In an incubation study, the ability of such a pool to mineralize N in the presence of residues is masked by the process of immobilization. A chemical extraction procedure is insensitive to this process and, hence, irrespective of the net mineralization, there is always a labile pool of N present in soil which can be estimated by mild extraction with hot KCI. Further more, incubation techniques are unable to cope with the environmental constraints in the field. Simulation techniques, using chemical extraction methods for initialization of pool sizes, provide an attractive and efficient alternative for predicting soil N supply.

Acknowledgement

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