FILE REPORT NOR-Y-52

Joseph Baker (1973)

NITROGEN FRACTIONATION AND DISTRIBUTION OF TWO FOREST SOILS NEAR HINTON, ALBERTA.

(Seminar given to the Department of Soil Science, University of Alberta; February 1973)

Northern Forest Research Centre
Environment Canada
Edmonton

INTRODUCTION

Since nitrogen is perhaps the most important of all nutrients essential to plant growth and survival, it is not surprising that the literature on this subject is voluminous. The greater part of this literature is concerned with the effects of nitrogen on plant growth rather than on those effects on the soil.

Generally until the late 1950's any interest in assessing soil nitrogen, its amount and distribution, was confined usually to determining the relative amounts of available and total contents. From 1955 to approximately 1965 many studies were undertaken to make a much more comprehensive survey of the various nitrogen fractions in the soil and the relationships of one fraction to another. Among the more comprehensive studies of that period were those of Stojanovic and Broadbent (1956), Tyler and Broadbent (1958), Cheng and Kurtz (1963), Stewart, Porter & Johnson (1963), and Chu and Knowles (1966). All these investigators added much to our comprehension of native nitrogen distribution in soil and the fate of applied nitrogen. All made extensive use of isotopic traces techniques.

Of the above named investigators, all, with the exception of Chu and Knowles, dealt with agronomic soils and plant remains. On the other hand Chu and Knowles studied immobilization and release in raw humus from a black spruce forest. Since the results of Chu and Knowles suggested some differences from those of the other investigators it was thought justified to initiate a study in nitrogen fractionation in several of our Alberta forest soils. It must be emphasized however, that while results from raw humus sources differed from those obtained from agronomic sources, yet in the main, the general picture was the same. Thus, it would hardly be expected that results from lodgepole pine supporting soils would differ greatly from those of a black spruce forest unless the distribution of nitrogen within the various soil nitrogen fractions is controlled largely by external factors such as soil and air temperature, available soil moisture, length of growing season, etc.

In the present study now in progress such factors as soil moisture, soil temperature, air temperature, relative humidity, light duration and intensity will be controlled in order to investigate the over all effect of these factors on the fate of applied nitrogen.

OBJECTIVE

The purpose for the present study on nitrogen fractionation is two-fold.

1) As a study by itself, its objectives are:

   a - to determine the natural nitrogen status of soil under a specific ecosystem,

   b - to determine the effects, if any, of the inherent soil properties on fate and distribution of applied nitrogen,

   c - to determine the initial impact of applied nitrogen on the relative contents in specific nitrogen fractions, d - to determine the residual effect of nitrogen fertilization on the final composition and distribution of soil nitrogen in the soil profile and,

e - to determine desirable and permanent changes in site productivity potential resulting from fertilization.

2) As an integral part of an overall fertilization program in established lodgepole pine stands, the objectives of this study are:

a - "to delineate lodgepole pine areas in the pulpwood belt of Western Alberta that would benefit from fertilization", and

b - "to provide a partial knowledge base for interpretation of growth response, refinement, and if necessary, modification in approach".

APPROACH

General

Two phases of the study are now in progress

A) Laboratory phase which involves a control of soil moisture, temperature and other environmental factors known to have an influence on the transformation, movement, and fate of applied nitrogen,

B) Field phase which involves a study of the initial and residual effects of artifically applied nitrogen on the nitrogen status of soil.

Analytical

The actual analytical approach taken in the evaluation of effects of applied nitrogen is essentially that of Cheng & Kurtz (1963). While there are shortcomings associated with this approach it is perhaps one of the better ones developed thus far as it does provide the separation of the main and important soil nitrogen fractions. In our actual use of this method certain modifications were introduced since relative rather than absolute values were thought to be more desirable.

The method of Cheng and Kurtz is as follows:

Soil Sample	Ext'd with 1N NaCl(pH1)	Sol. + Exch. Nitrogen
Soil Residue	Ext'd 16 hrs 100°C with 6 N HCl	Acid sol. Nitrogen
Soil Residue	Ext'd 24 hrs 20°C with 5 N-H_2F_2: 1N HCl: 0°6N-H_2SO_4	Fixed NH_4-N
Soil Residue	digested with conc. H_2SO_4 + catalysts	Insoluble humin Nitrogen

Each of the main fractions may, if desired, be broken down additionally.

The soluble + exchangeable - N may be differentiated into alkali labile (soluble amine and NH_4-N forms) and total available forms.

The acid soluble - N may be sub-divided into four fractions.

HCl Ext.	Alk. neutralization then aerated 16 hrs.	(hydrolyzed NH_4 - N; ~~solution~~ alk. labile - acid sol.
Solution plus residue	distilled without further alk.	(amino sugar - N; ~~solution~~ alk. lobile - acid sol.

Solution and residue separated and each digested (Kjeldhal procedure) and evaluated. The solution nitrogen is designated as acid soluble - alkali stable or non-distillable acid soluble - N. (amino acid nitrogen).

The residue nitrogen is the insoluble humin - N.

In our approach Sol. + exch. - N was evaluated as a single entity - total available - N.

Alk. labile - acid soluble - N was determined as a single entity - hydrolyzed NH_4 - N + Amino Sugar - N.

Fixed NH_4 - N + Insoluble humin - N was determined as a single entity and designated as Soil - Residue - N.

RESULTS

Nitrogen Distribution - Within soil nitrogen fractions

Native -- There were some differences of native nitrogen within the various soil nitrogen fractions, principally in the mineral soil horizon.

L-F-H horizons showed a striking similarity of nitrogen in the fractions evaluated.

Ae horizons while showing considerable difference in distribution patterns yet these horizons were considerably more similar than those patterns representative of the Bt horizon.

Bt horizons showed greatest disimilarity both on an absolute and a percentage basis.

In the litter horizons of both soil types the amino acid - N composed approximately 55.0 per cent of the total soil nitrogen. Generally the percentage proportion of this fraction decreased with profile depth; 32% in the Mercoal and 23% in the Coalspur (Bt horizons).

Residue nitrogen (fixed NH_4 - N + insoluble humin nitrogen) composed the next most abundant forms; approx. 32% in the L-F-H horizons of both soils increasing to 37% in the Mercoal Bt and to 49% in the Coalspur Bt.

Other fractions did not show consistent, absolute or percentage values, throughout the profile. However, generally, soluble + exchangeable - N showed a decrease with depth.

Amino sugar - N (includes hydrolyzed (NH_4-N) and soluble humin - N showed increases, (percentage values) with depth.

Nitrogen Distribution - Within soil profile

If the percentage of nitrogen present in a specific soil nitrogen fraction in the entire soil profile is examined by horizons, the relative proportion of each fraction in a horizon becomes much more apparent.

In the Mercoal, all fractions but the soluble humin - N form, are most abundantly supplied in the L-F-H horizon. With the exception just noted, from 70-90 per cent of the particular fraction in the soil profile appears in the L-F-H horizon.

A simialr situation was noted for the Coalspur, however, the Ae horizon of this soil was more abundantly supplied with nitrogen than its counter part in the Mercoal.

As a general rule the relative proportions of the various nitrogen fractions found in the mineral horizons of both soils are quite small compared to those in the L-F-H; the only exception being the soluble humin - N form.

Effect of Fertilization

Total overall response, both on an absolute basis as well as on percentage basis, was greater in the Coalspur; however both soil types registered a total net nitrogen gain.

Greatest gains were in the sol. + exchangeable - N and amino sugar - N, in that order. Greatest mineralization of nitrogen took place in the amino acid form.

Thus as a result of fertilization, some soil nitrogen fractions showed net gains, as contrasted to control values, while others (amino acid - N) showed losses, especially in the L-F-H horizon. As a general rule the major impact of fertilization took place in the L-F-H i.e. that's where the action is.

Initially the effects of nitrogen applications on the two soil, can be described as favorable so far as soil response is concerned. As reported by Chu and Knowles, nitrogen immobilization in the non-distillable acid soluble form, appears to be small in these samples. In fact substantial amounts of nitrogen in this form appear to have been mineralized during the first growing season and redistributed within other fractions, perhaps the immediately available forms. Fortunately very little increase in the insoluble and unavailable forms was noted after fertilization.

Results in terms of stand responses are not yet available but in view of the positive net gains of nitrogen that were observed in the soil, it would be surprising if growth responses were not observed. Presently only foliar analysis is being carried on as an indicator of uptake. The ultimate influence on growth will have to wait until stem analyses provide actual wood volume increases per acre as a result of fertilization.

CONCLUSION

The justification of such a study as this is readily seen if it is remembered that, with time, the competition for every available acre becomes more acute. With increased pressures on land use, forest operators are faced with either a fixed or a decreasing land basis (more likely decreasing) for their operations. Thus if operational productivity is to continue to increase, yield potential per acre will also have to increase. The only apparent and logical way for this to occur will be from improved management practices including the use of artificial fertilizers. However, in any such approach as this there is, for the operator, a cost-profit relationship which requires his careful attention. Many solutions to current problems which may be technologically possible, as yet are uneconomic. It would seem obvious that an operator, before he would make large dollar outlays in large scale industrial applications of artificial fertilizers, would first want to have some idea of: the amount or fraction of applied nutrient that was effective in growth and yield, how much of it is not utilized by the stand, what proportion is rendered unavailable in the soil by certain inherent soil properties; which of the soils in his holdings are likely to respond favorably to fertilizer applications, what is the long term or residual effects of fertilization, and with what frequency should fertilizer nutrients be added. All these questions, and more, bear upon the economy of such an operation as fertilization.

The answers to some of these questions we hope to supply from the results that will ~~occur~~ accrue from the present investigation.

Joseph Baker, Research Scientist
Northern Forest Research Centre
Environment Canada