Comments on "Nutrient cycling and availability in forest soils." M. K. Mahendrappa, N. W. Foster, G. F. Weetman, and H. H. Krause. Can. J. Soil Sci. 66: 547–572.

EDITOR, *Canadian Journal of Soil Science*

Referring to "Nutrient cycling and availability in forest soils" an invited review, we would like to make a short commentary.

As a basic introduction to the subject it is worth noting that nutrition is time and space related. Nutrition depends on the absorption flux F of the nutrients by the roots. F is expressed by the continuity equation introducing such parameters as soil water content, soil solution concentration and soil buffer power, and the uptake equation

$$F = \alpha \, Clo,$$

where α is the absorbing power of the roots and *Clo* is the soil solution concentration of the nutrient near the root surface, (see e.g. solute movement in the soil-root system by Nye and Tinker 1977). The statement "The quantity of available nutrient is determined by two main factors: the condition of the soils and the condition of the plants" seems not likely to be correct.

Availability of any nutrient is the ability of the soil to provide absorbable forms of the required nutrients when needed. It depends upon soil solution concentration (the intensity factor) and a related parameter, the soil buffer power in the root neighborhood. These parameters are more or less well correlated with the usual "exchangable cations", "extractable anions", and with nitrogen net mineralization. We used root absorbing power as a concept to analyze the various conditions encountered in nitrogen nutrition of forest soils (van Praag and Weissen 1973, 1976). The absorbing power is the ability of the plant to absorb nutrients under given physiological conditions.

Stress factors alter the absorbing power, and hence nutrition, but not availability. We would like to stress the usefulness of better knowing the composition of soil solution and its time- and space-dependent variability (see van Praag and Weissen 1984a, 1985). We hypothesized that for elements which move to the roots by mass flow, like calcium and magnesium, soil solution concentrations may replace the exchangeable amounts in nutrition studies.

Balance sheet estimation of nutrient cycling is of little direct use for better understanding of element absorption but rather a way to inform the forester about the ecosystem's departure from a steady state by inputs of pollutants, or output of extra amounts of leachates, and the remedy to such a situation, for example by using fertilizers cautiously (van Praag et Weissen 1984b).

It is stated "there is no rationale for analyzing a specific organic or mineral horizon alone and excluding other horizons for the determination of plant available nutrient (N), in forest soils." However, for a given system, with well-defined internal correlations, one specific soils horizon may be most discriminating. We devised a net mineralization determination technic in the field, considering the entire soil depth containing approximately 70% of absorbing root length (van Praag et al. 1974). Net mineralization, on a yearly basis depends upon temperature (and water content) variations, and cannot be estimated in a single laboratory incubation.

We would like to mention that soluble organic material of the soil solution of the upper horizons, Of2, Oh, Ah, we are studying, have rather high mean molecular weights, probably 800 or more. These molecules, with bound mineral cations as

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stated, should not be easily absorbed by tree roots, or by fungi. It was observed that small organic molecules, like (tagged) vanillic acid, with higher internal energy, may be readily absorbed by spruce seedlings (unpublished data). These small molecules, however, are very scarce or non-existent in soil solution of oligotrophic humus layers, where they are immediately absorbed, when formed, by the local microflora. It has been shown for example that when adding ammonium fertilizer to an acid moder Of2 material, $N-NH_4^+$ is not immobilized, unless sugar is added. Ammonium will reappear after a short time (see van Praag 1973).

Our findings are of a sufficiently general nature to be valid alike for Canadian mor, conditions as for European moder conditions.

NYE, P. H. and TINKER, P. B. 1977. Blackwell Scientific Publishers, Oxford, U.K.

VAN PRAGG, H. J. 1973. Cycle interne de l'azote et du soufre dans les horizons humifères forestiers des sols bruns acides, I, II, III, Plant Soil **39**: 35–69.

VAN PRAAG, H. J. and WEISSEN, F. 1973. Elements of a functional definition of oligotroph humus based on the nitrogen nutrition of forest stands. J. Appl. Ecol. **10**: 569–583.

VAN PRAAG, H. J., WEISSEN, F., BRIGODE, N. et DUFOUR, J. 1974. Evaluation de la quantité d'azote minéralisé par an, dans un sol de hêtraie ardennaise. Bull. Soc. R. Bot. Belg. **107**: 137–145.

VAN PRAAG, H. J. et WEISSEN, F. 1976. Nutrition azotée des peuplements forestiers ardennais. Bull. Soc. R. For. Belg. **83**: 175–188.

VAN PRAAG, H. J. and WEISSEN, F. 1984a. The intensity factor in acid forest soils: extraction and composition of the soil solution. Pédologie **XXXIV-2**: 203–214.

VAN PRAAG, H. J. and WEISSEN, F. 1984b. Potential nitrogen transfer and regulation through brown acid soils under beech and spruce stands. Plant Soil **82**: 179–191.

VAN PRAAG, H. J. and WEISSEN, F. 1985. Aluminium effects on spruce and beech seedlings. Plant Soil **83**: 331–356.

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Reply to Weissen and van Praag, Letter to the editor

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The respondents' main concern appears to be our view on quantifying nutrient availability in forest soils. While we repeated the common difficulties associated with this task, Dr. Weissen and Dr. van Praag seem to imply that advances have been made by applying the continuity equation (Nye 1967) for estimating nutrient flux. We see the greatest value of the continuity equation in providing a theoretical basis for the definition of nutrient availability, but are hesitant to follow along this approach in estimating nutrient flux in whole forest ecosystems at this time. Such application may be questioned especially in the case of N because of the difficulty in quantifying the relationship between intensity and capacity factor for this element. The only N fraction responding directly and in a physically controlled manner to changes of the intensity factor is exchangeable NH_4^+ which usually comprises only a small amount of N compared to that derived in one season from the mineralization of organic matter. The latter process, in turn, is largely independent of root uptake and can vary widely with environmental conditions affecting microbial activity, and with the chemical nature of the substrate. We question, therefore, whether a capacity factor, in the sense of Nye (1967), can be defined on the basis of mineralizable N.

A further complication in estimating N flux by the continuity equation is the uncertainty over nitrification in forest soils. Occasional nitrate build-up, while increasing intensity and mobility factors, could generate pulses in N uptake, which would be difficult to simulate unless conditions governing this process in forest soils are well understood.

Estimating nutrient flux by the continuity equation also requires that root absorbing power be defined. Given our present state of knowledge we question whether this can be done in a meaningful manner because of high genetic variability within stands, especially if they have originated naturally, and the varying effects of mycorrhizal symbionts within and among sites.

Considering all of the above, our statement that "the quantity of available nutrients is determined by two factors: the condition of the soil and the condition of the plant", although general, does not appear to be incorrect.

We do not disagree with the respondents' suggestion that analysis of soil solution replace determination of the exchangeable fraction for the elements which move largely by mass flow, provided that such analysis is repeated in time. As a general note, however, difficulties in tree nutrition are less often related to mass flow elements than those depending on diffusive flux.

Our statement "there is no rationale for analyzing a specific organic or mineral horizon alone and excluding other horizons for plant-available nutrients" is based on various accounts from the literature, including those of Keeney (1980) and Powers (1984 a,b). The above statement was made in the context of routine assessments of forest soils for available N. Admittedly there are cases where attention given to a single horizon has met with success, especially if such attempts involved observations in the field, repeated at various times in the growing season. In the Boreal Forest with the typically bimodal rooting pattern (forest floor and illuvial B) and high spatial variability this approach could turn out to be very costly and unsuitable for routine use.

We would like to encourage the respondents' in their work with soil solutions distinguishing between high- and low-molecular organic components, and testing the ability of these materials to bind metals and to be absorped by roots. Such information may hold the key to a number of problems in forest nutrition and lead to a better understanding of the impacts of air pollutants on soil processes.

NYE, P. H. 1967. Processes in the root environment. J. Soil Sci. **19**: 205–215.

KEENEY, D. R. 1980. Prediction of soil nitrogen availability in forest ecosystems: A literature review. For. Sci. **26(1)**: 159–171.

POWERS, R. F. 1984a. Estimating soil nitrogen availability through soil and foliar analysis. Pages 353–379 *in* E. L. Stone, ed. Forest soils and treatment impacts. Proc. 6th N. Am. Forest Soils Conference, June 1983. University of Tennessee, Knoxville, Tenn.

POWERS, R. F. 1984b. Sources of variation in mineralizable soil nitrogen. Pages 25–31 *in* Regional Forest Nutrition Research Project. Report on the Nitrogen Assessment Workshop sponsored by the Northwest Forest Soil Council, 19–20 May 1982. RFNRP Report No. 2. College of Forest Resources, University of Washington, Seattle, Wash.

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