Issue 2003-2

Technical Update:

PRS™-probes measure the effect of plant uptake on nutrient bioavailability

Plant Root Simulator (PRS)™-probes assess nutrient bioavailability in soil and provide nutrient supply rates that are strongly correlated with plant uptake and growth. When your objective is to measure nutrient bioavailability over the long-term, it is imperative to account for any other competing sinks, such as plant roots. This is true especially when determining accurate estimates of N mineralization or when correlating PRS™-probe nutrient supply rates with plant uptake or growth. When buried among roots, the PRS™-probes will measure a *net nutrient supply rate*, which is the actual soil supply minus plant uptake. Although meaningful as an index of nutrient supply *vs.* demand, the resultant relationship with plant uptake and growth will not be as strong as compared with *total nutrient supply rate*, measured in the absence of root competition.

While it may be advantageous to eliminate root competition in some studies (Tech Update v.2000-2), burying PRS™-probes among plant roots is useful for measuring the influence of plant uptake on temporal changes in nutrient availability over the growing season and for predicting plant nutrient uptake (Figures 1 and 2). In the first study, PRS™-probes were buried *in situ* for successive 2-week periods during the growing season. Spring NO_3-N supply rates were significantly higher in the no tillage *vs.* the conventional tillage treatment and related well to trends in midseason and final wheat N uptake (Figure 1). Nitrate supply rates diminished rapidly until July, corresponding to the time of greatest N demand and uptake by the growing crop. Increased N supplies were observed later in the season, presumably due to root senescence and lack of N uptake as the crop matured (Jowkin and Schoenau, 1998). The researchers suggested that higher initial NO_3-N supplies were due to higher soil moisture levels in the no tillage treatment; therefore, supporting the common perception that the soil moisture level has a larger impact on plant availability of ions than total nutrient content alone.

In a second study, PRS™-probes were used to measure K supply rates in soils varying in total exchangeable-K levels, which were contained in pots growing wheat. Potassium supply rates decreased over time in all soil types as the growing wheat depleted soil K reserves (Figure 2). The Bradwell soil had a low K buffer power, resulting in a rapid decline in measured K supply rate. Alternatively, the Haverhill soil had a larger K buffer power, resulting in a sustained K supply rate for 21 days. The relative differences in PRS™-probe K supply rates among the soil types accurately reflected the K uptake by the wheat during the growth period.

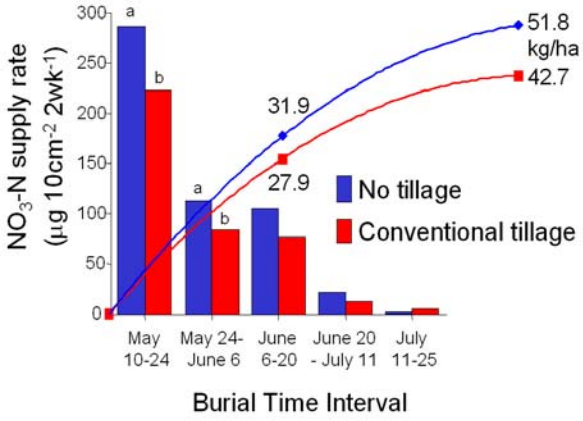

Figure 1. Mean (n=15) NO_3-N supply rates measured *in situ* during wheat growth and total wheat N uptake at midseason and maturity. Source: Jowkin and Schoenau, 1998. Can. J. Soil Sci. 78: 563-572.

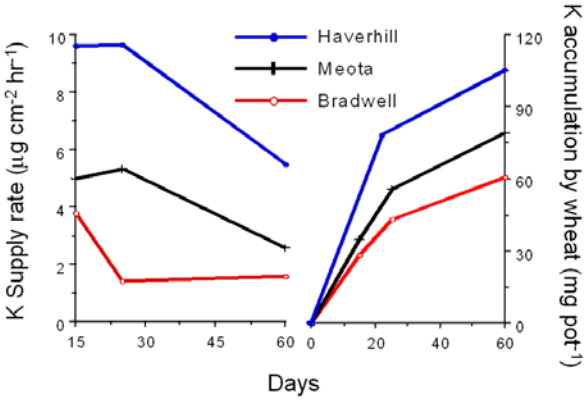

Figure 2. Comparison of PRS™-probe K supply rates with K uptake by wheat in a growth chamber (n=3). Source: Qian et al., 1998. Commun. Soil Sci. Plant Anal. 29: 635-641.

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In simulating the mechanism of nutrient uptake by plant roots, the PRS™-probes greatly improve the accuracy of measuring the biological supply of soil nutrients. These data provide valuable insight into the changing conditions of nutrient availability following plant uptake. For instance, researchers at the University of Idaho's Intermountain Forest Tree Nutrition Cooperative used PRS™-probes to measure temporal changes in nutrient availability throughout the growing season in a 50-year old coniferous forest. Comparison of N supply rate data with Douglas-fir tissue N content illustrates that as tree N uptake increased throughout the growing season, residual soil N decreased (Figure 3). These high N demand conditions coincident with limited soil N supply, suggest that N potentially was growth-limiting during the growing season.

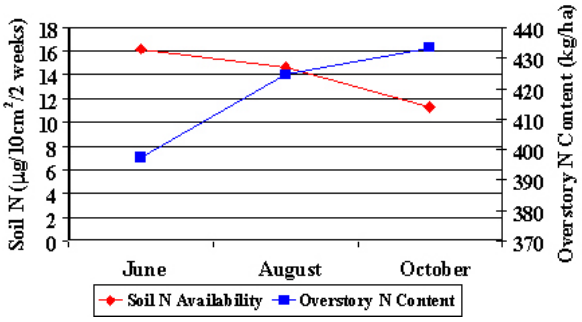

Figure 3. Mean (n=24) PRS™-probe total N supply rates compared with Douglas-fir N uptake over the growing season in a northern Idaho forest. Reprinted with permission: Garrison-Johnston, M.T. 2003. Forest nutrient cycling in a north Idaho conifer stand. PhD dissertation, University of Idaho, Moscow, ID. (marianng@uidaho.edu)

Correlation analysis of the PRS™-probe N supply rate with Douglas-fir foliar N concentration further supported the contention that N probably was growth-limiting during the growing season (Garrison-Johnston, 2003). This study demonstrates the potential use of PRS™-probes for conveniently diagnosing seasonal tree nutrient deficiencies in mature forest stands.

Nitrogen availability is an important factor influencing the community composition and direction of secondary succession and the ratio of NH_4-N to NO_3-N is a functional indicator of successional status. Recently, PRS™-probes were used to examine the relative influence of four petroleum wellsite rehabilitation strategies on disturbed Dry Mixed Grass prairie. Specifically, researchers buried PRS™-probes in the presence of plant competition and used the net N supply rate as an index of the relative competitiveness of early successional plant communities in addition to the rate of succession toward an efficient N cycling system. Nitrate supply rate was largest in the Natural Recovery treatment and smallest in the Control, with minor differences among the seeded treatments (Figure 4). Greater N uptake in the seeded

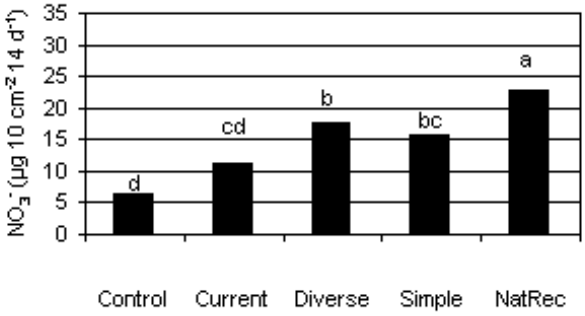

Figure 4. Mean (n=5) PRS™-probe NO_3-N supply rates following a variety of rehabilitation treatments three years after disturbance. Treatments included a non-disturbed control and four rehabilitation treatments (including three seed mixes and a non-seeded Natural Recovery treatment). Columns having the same letter are not significantly different ($P \leq 0.05$). Source: Hammermeister et al., 2003. Can. J. Soil Sci. In press.

treatments compared with Natural Recovery indicated improved biogeochemical cycling and accelerated plant community succession. The results of this study have important implications for prairie ecology and productivity and also support the use of PRS™-probes in measuring N availability as affected by succession rate.

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