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Technical Update:

PRS™-Probes Measure Soil Nutrient Bioavailability

Ions of agronomic and environmental interest are not available unless they can move to a root where they can be absorbed. Direct insertion of PRS™-probes into soil enables measurement of these ions and automatically accounts for the factors affecting ion flux to plant roots (soil texture, structure, temperature, moisture, location, etc.). Assessing ion dynamics *in situ* under actual field conditions represents a significant breakthrough toward understanding soil nutrient and contaminant bioavailability.

Figure 1. Cation and anion PRS™-probes buried in the field.

The PRS™-probe's ability to measure ion movement through soil was demonstrated in a recent M.Sc. research project at the University of Saskatchewan. Researchers measured nutrient availability in the seed row as affected by fertilizer placement method. The PRS™ were placed in the seed row (Figure 2) immediately after seeding and removed at successive dates following seeding until crop emergence.

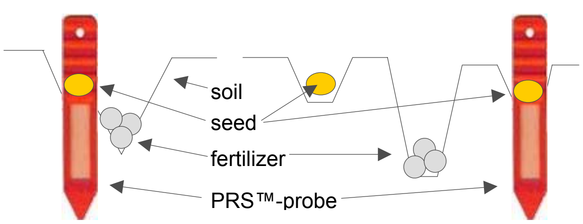

Figure 2. Placement of PRS™-probes in relation to placement of seed and fertilizer (80 kg N ha^{-1}) in two fertilizer placement treatments.

Nitrogen (N) supplies measured in the seed row were highest approximately 6 days following seeding (Table 1), corresponding to a rainfall event which probably increased N movement through the soil to the membrane surface (Tech Update 2001-2). Significantly larger supply rates were measured in the side-row banded treatment as compared to the mid-row banded treatment from the 2nd through 4th burial period. Fertilizer was closer to the PRS™-probes in the side-band treatment (1" below and 1" to the side of the seed) while mid-row bands were between every second seed row (10" row spacing).

Table 1. PRS™ NO_3-N supply rates measured in the seed row of two fertilizer placement treatments at successive dates following seeding and fertilizing.

# Days after fertilizing	Side-row banded	Mid-row banded
	NO_3-N supply rate (μg $10cm^{-2}$ $24hr^{-1}$)	
2	68.1	52.6
6	160.6	86.1
10	139.1	63.5
14	68.1	27.5

Source: D. Thavarajah, J.J. Schoenau, J.R. Bettany, G. Hultgreen, P. Qian, S.S. Mahli, and R. Lemke, 2003. J. Plant Nutr. 26: 683-690.

Soil temperature can significantly influence ion supply rates as well. It is very important to account for soil temperature when measuring supply rates as temperature affects ion diffusion and microbial activity (Table 2). Microbial activity (indicated by cumulative respiration) increases as soil temperature increases, which in turn affects nutrient turnover, resulting in larger nutrient supply rates. Alternatively, higher temperatures could cause reduced supply rates if increased microbial activity and ion demand caused ion immobilization.

Table 2. Mean (n=3) microbial activity and PRS™-probe nutrient supply rates in a loamy sand soil (O.M.= 1.8%) incubated for one week at three temperatures. (P <0.02)

Incubation Temp. (ºC)	(NO_3 + NH_4)-N	PO_4-P	Cumulative Respiration
	μg $10cm^{-2}$ $week^{-1}$		(μg CO_2-C kg^{-1} soil)
5	62	2.2	37 a
23	90	2.1	189 b
32	300	2.4	337 c

Western Ag Innovations; unpublished data.

Although long-term differences may be greater, temperature also affects ion movement to the PRS™ during short-term burials (Table 3). At reduced soil temperatures, ion diffusion decreases and thus, supply rates of diffusion limited ions (i.e. PO_4-P) will be lower. Therefore, soil temperatures should be reported with PRS™ supply rate data wherever possible. This is particularly important when comparing supply rates measured at different times of the year (i.e. early spring *vs.* midsummer) or when comparing landscape elements (i.e. knoll *vs.* foot-slope).

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Table 3. Mean (n=3) nutrient supply rates measured in soil for one hour at four soil temperatures. (P <0.05)

Soil Temp. (ºC)	Nutrient Supply Rate (μg $10cm^{-2}$ hr^{-1})			
	(NO_3 + NH_4)-N	PO_4-P	K	SO_4-S
4	63 b	2.3 b	217 c	17 c
10	74 ab	2.7 ab	248 bc	21 c
20	86 a	3.0 a	275 ab	25 a
30	90 a	3.0 a	292 a	25 a

Western Ag Innovations; unpublished data.

Another important factor affecting PRS™ supply rates is root competition for soil nutrients. It is important to be able to account for this competition as it may also affect plant growth. For example during early establishment, outplanted conifer seedlings are vulnerable to lethargic growth or mortality because of interspecific competition for soil nutrients, particularly N. Measuring soil N bioavailability, with and without the presence of competitor species and accurately relating it to outplanted seedling growth, therefore, should provide a useful index of belowground competition for supporting effective management strategies. Conventional soil tests, based on chemical extractions, historically have failed in this regard because the data provided are poorly correlated with seedling nutrient uptake and growth. Unlike conventional soil extractions, *in situ* burials of PRS™-probes integrate all of the principal edaphic factors affecting nutrient uptake by plants regardless of soil type.

Interspecific competition for soil N between outplanted white spruce and jack pine seedlings and noncrop vegetation was assessed by measuring N supply rates in different vegetation management (VM) treatment plots using PRS™-probes and correlating the N supply rates to seedling growth during the early establishment phase. Linear regressions comparing total N (i.e., NH_4-N + NO_3-N), measured using PRS™-probes, with third year growth of white spruce and jack pine seedlings are shown in Figure 3. Using pooled data from both VM treatments and all sites, PRS™-probe total N supply rate was correlated with seedling height, root collar diameter, and stem volume growth. This is not surprising considering cumulative total N supply rate is well correlated with outplanted conifer seedling tissue N concentration (Tech Update v.2002-1).

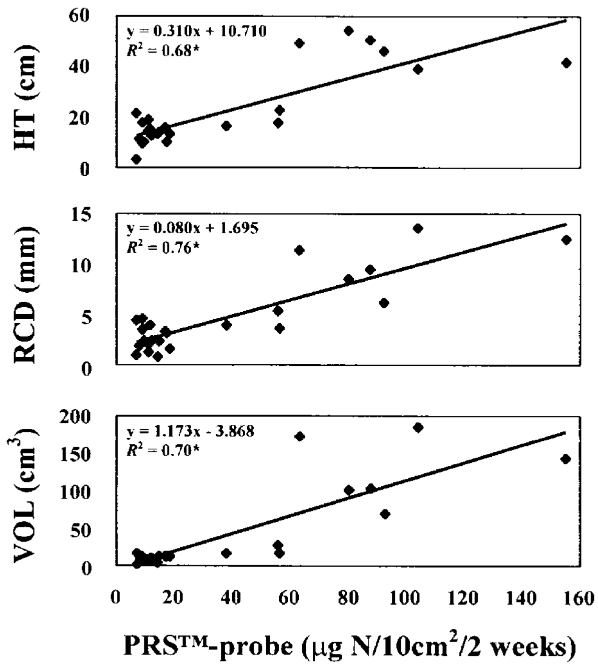

Figure 3. Correlations (n=24) of PRS™-probe total nitrogen (NH_4^+-N + NO_3^--N) supply rates measured late-season with outplanted conifer seedling height (HT), root collar diameter (RCD), and stem volume (VOL) growth at four sites in the boreal mixedwood forest of Saskatchewan. Coefficient of determination (R^2) significance of P <0.01 indicated by *. Western Ag Innovations; unpublished data.

Accurately measuring nutrient bioavailability during the early establishment phase is essential for supporting effective silvicultural decisions (i.e., VM and fertilization requirements) and ultimately boreal forest plantation productivity. In addition, collecting, handling, and analyzing a large number of soil samples is not conducive for determining spatial and temporal variability in nutrient bioavailability; therefore, *in situ* burials of PRS™-probes provide a relatively quick and inexpensive means of measuring soil nutrient bioavailability.