Issue 2005-1

Technical Update:

PRS™-probes provide a biologically-meaningful measure of soil phosphorous

Since the early 90's, the Plant Root Simulator (PRS)™-probe has been used to study soil nutrient dynamics by nearly 200 researchers in over 20 countries. During this time, the PRS™-probe has advanced from a research tool into an alternative routine soil testing tool. Currently, PRS™-probe nutrient supply rate data provides a basis for determining fertilizer recommendations on over 1.5 million acres of farmland in western Canada for 17 cereal, oil seed, pulse, and forage crops. Recently, the PRS™-probe was awarded the prestigious Natural Sciences and Engineering Research Council ***Synergy Award for Innovation***, in acknowledgment of its significant contribution to improving crop production and fertilizer use in Canada.

Figure 1. Anion- (orange) and cation-exchange (purple) PRS™-probes used to measure temporal changes in nutrient availability throughout the growing season in different soil horizons. (Photo courtesy of Dr. Mariann Garrison-Johnson)

Measuring Phosphorous Bioavailability in Soil

The success of the PRS™-probe can be primarily attributed to its capability of providing biologically-relevant measures of soil nutrient availability, regardless of soil type. Nowhere is the exclusivity of this more recognized than when measuring plant-available phosphorous (P) in soil. The dynamics of soil P bioavailability is influenced by a complex interaction of different soil physical, mineralogical, chemical, and biological processes. Consequently, there have been more than 100 different chemical extractions developed to provide an index of soil P availability depending on the soil type. Unlike these conventional soil P indices, a PRS™-probe functions as an ion adsorbing sink and exhibits the same precision across all soil types. Such a proven tool for providing a reliable measure of soil P supply is essential for supporting the synthesis of data from across broad spatial scales.

Furthermore, a single 'point-in-time' extraction only represents a *snapshot* of the chemically-extractable P and may not adequately reflect changes in soil P supply throughout the growing season. *In situ* burials of PRS™-probes can account for the complexity of soil P transformations by continuously measuring soil solution P fluxes. This provides a basis for accurately determining situations where plant uptake and/or growth is P supply-limited, because soil solution P is the principal regulator of the mechanisms governing the soil P supply rate.

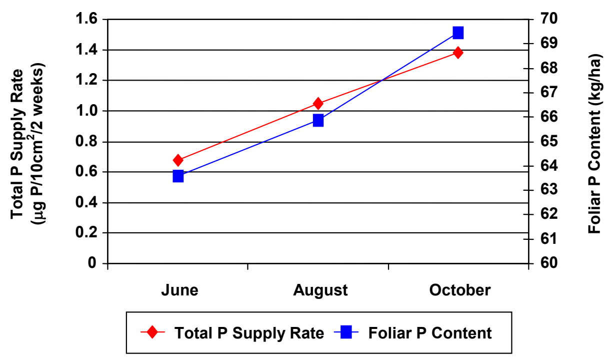

Figure 2. Mean (n=24) PRS™-probe total P supply rate (averaged from four soil horizons) and P uptake by a 50-year old Douglas-fir stand (dominant crown class) over a single growing season in a northern Idaho forest. Reprinted with permission: Garrison-Johnson, M.T. 2003. Forest Nutrient Cycling in a North Idaho Conifer Stand. PhD Dissertation, University of Idaho, Moscow, ID. (mariannq@uidaho.edu)

This predictive capacity is illustrated in the following example, where researchers at the University of Idaho's Intermountain Forest Tree Nutrition Cooperative inserted PRS™-probes into different soil horizons (Fig. 1) in order to determine the relationship between measured plant-available soil P throughout the growing season and P uptake by a 50-year old Douglas-fir stand. Comparison of the P supply rate data with Douglas-fir tissue P content of the upper crown foliage indicated that as tree P uptake increased throughout the growing season, the soils at this site had an adequate P buffer capacity and were able to maintain the soil solution P levels (Fig. 2), suggesting that P was not limiting growth in this coniferous forest during the growing season. Indeed, the PRS™-probe N supply rate data indicated that N was limiting growth in these mature forest stands (Tech Update v.2003-2). In addition, regardless of soil horizon, there was a strong relationship (R^2= 0.69-0.86; P<0.05) between the PRS™-probe P supply rate and foliar P concentration of the mature Douglas-fir trees (Garrison-Johnson, 2003).

Agro-Environmental Soil Test P Alternative

With the continued development of intensive livestock operations in North America, there is increased interest in establishing a standard soil test P (STP) method for monitoring the impact of manure application, in terms of supporting increased soil productivity in an environmentally sustainable manner. There is a need for a STP method that can be effectively applied across a variety of soil types, characteristic of watershed-scale management studies, along with providing biologically-meaningful data for predicting the risk of P movement from soil to surface water (Fig. 3).

Figure 3. PRS™-probes used to measure the effect of broadcasted liquid hog manure on soil nutrient availability. (Photo courtesy of Dr. Ken Van Rees)

Given the past success of the PRS™-probe as both a research and agronomic soil testing tool, there is growing awareness in using it for estimating potential losses of bioavailable P to surface waters following repeated applications of animal manure. Specifically, researchers at the University of Saskatchewan used PRS™-probes to measure the effects of long-term additions of animal manure on soil P supply rates and its relationship with a conventional agronomic soil test (Fig. 4). Both the PRS™-probe and Olsen test data showed increasing STP levels with higher manure rates and were consistent with higher P accumulation by the crop (data not shown). Unlike annual solid cattle manure applications that resulted in elevated STP levels, the liquid hog manure sourced from operations utilizing the phytase enzyme in the diet resulted in lower STP levels even after eight years of excessive application rates.

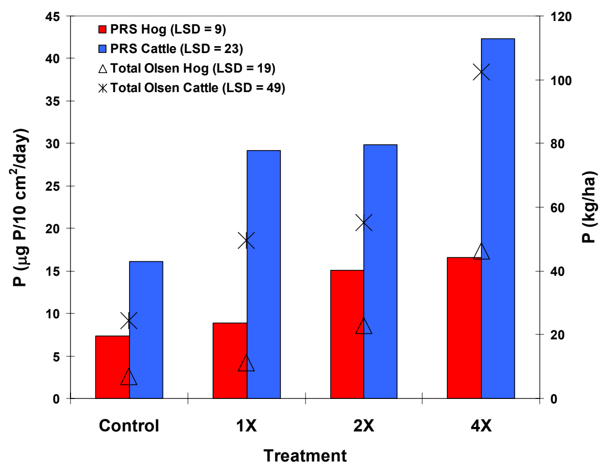

Figure 4. Mean (n=4) STP, measured using PRS™-probes (Y1-axis) and the Olsen test (Y2-axis), following eight years of animal manure application. Liquid hog and solid cattle manure were applied at 0X (control), 1X, 2X, and 4X the recommended agronomic rate (34,000 L/ha and 7.6 T/ha, respectively). Source: Chantal Stumborg, Dept. of Soil Science, Univ. of Saskatchewan (cms059@mail.usask.ca).

Although not the sole factor in determining the potential for P loading of surface waters from non-point agricultural inputs, PRS™-probes represent an inexpensive, convenient, and biologically-meaningful STP method that would be an essential component of any integrated Phosphorous Index combining source and transport factors in estimating possible P fluxes to surface waters.

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