APPLICATION OF ION EXCHANGE RESIN MEMBRANES TO NITRATE TESTING IN THE WEST

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INTRODUCTION

Resin membranes have been used since the 1960s to measure P supply from the soil. In the 1990's the Plant Root Simulator (PRS®) probe was invented to further refine a method to measure N mineralization from soil organic matter. The functional measurement of soil N supply during incubation has been applied to both in situ measures and in lab research studies. Extending the PRS® measurements of N 'intensity' or flux to a meaningful number that a plant can utilize was accomplished using a version of the Barber Flux equations. Our paper attempts to elucidate the N flux approach used in the PRS CropCaster® as a means to measure and then extend the Nitrate from mineralized organic material to a potential uptake by crops.

PRS® measurements of soil N release:

Soil N release is a mediated by the living soil microbial biomass (MOB). These organisms are the "soil engine" that turnover organic substrate, releasing CO_2 and N assuming the C:N ratio is narrow enough for net mineralization. Several other important factors for MOB turnover include: 1). accessible soil organic matter C (SOMC), 2). soil moisture and 3). soil temperature. Figure 1 shows the same long term rotation sites but the samples were pre-treated differently. One set of samples was run through a rotary dry sieve to collect the Wind Erodible Aggregates. Following this procedure the sieved fractions were recombined, wetted and incubated with PRS® probes for two weeks.

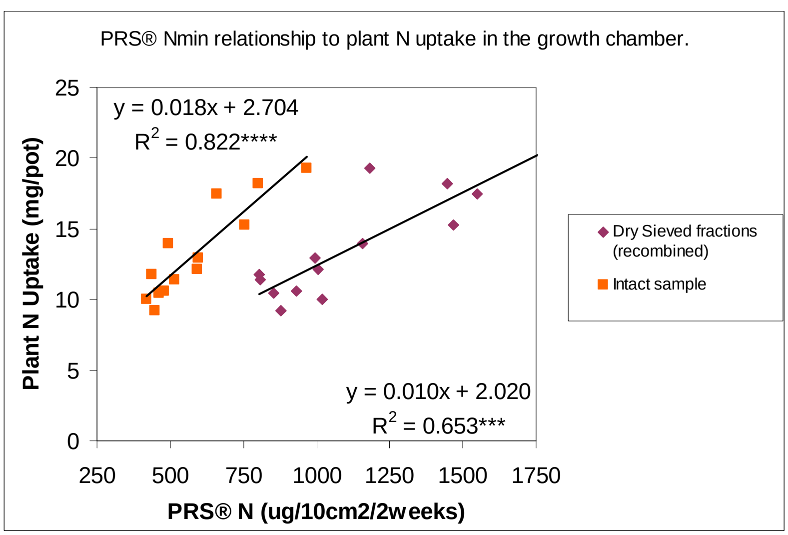

Figure 1. PRS® N supply rate in relation to plant N uptake from an 8 week growth chamber study.

A similar incubation was performed on soil samples that were kept intact. The functional supply rate of N to the PRS® was compared to the 8 week plant uptake measured in the growth chamber. Clearly the PRS® probe measured more N supply for the "soil engine" as the abrasion caused by sieving provided additional access to SOMC. This data brings into question the drying, grinding and rewetting of samples to measure the CO_2 burst as a reliable proxy for N mineralization.

The gold standard 24 week leaching incubation method (Stanford and Smith, 1972) was also performed to exhaust the mineralizable SOMC pools that release N. Figure 2 shows a similar correlation to Plant N uptake as the 2 week PRS® Nmin method. Logically the exhaustive incubation method provided more resolution separating long term plots that had little fertilizer or residue return from higher input plots.

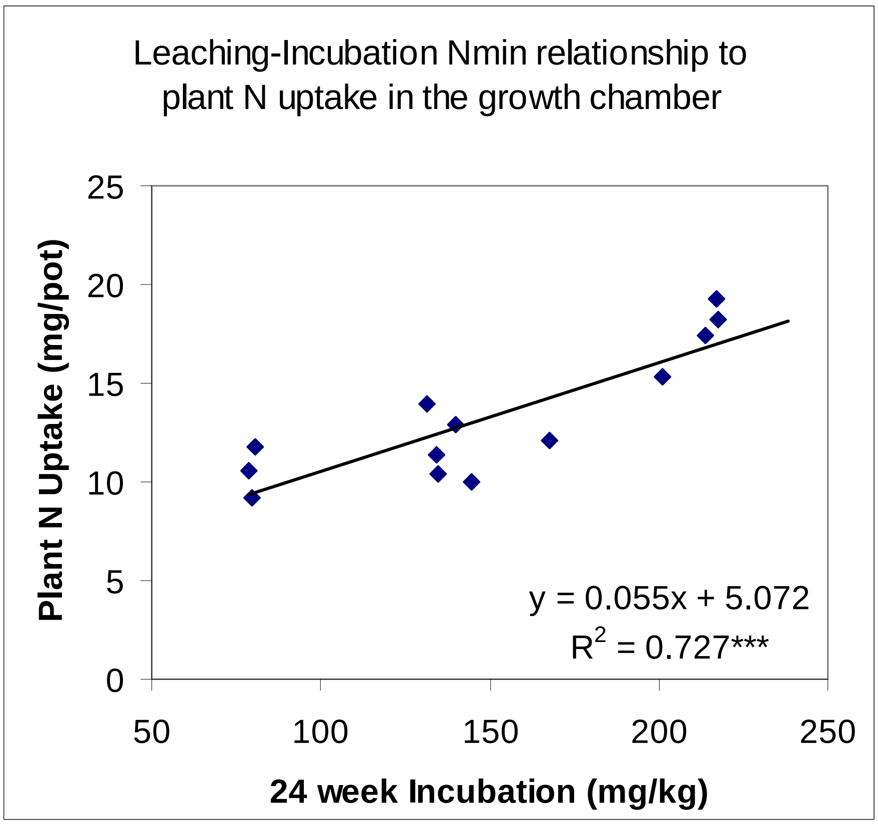

Figure 2. Cumulative N released over 24 week incubation and the relationship to plant N uptake after 8 weeks.

Substrate for turning over the MOB engine is clearly a main driver to Nmin. The following data collected on cover crop plots shows the cumulative PRS® N supply rate is increasing significantly with Hairy Vetch plow down as compared to cereal Rye. The C:N ratio of the Hairy Vetch was 13:1 while the cereal Rye was 37:1. PRS® probes provide a sensitive measure of infield mineralization not simply because of residue type, but also they are temporally tracking the MOB "engine" speeding up and slowing down with moisture (Figures 3 and 4).

The PRS® probes are a proven tool to monitor the functional output of the MOB. Release of CO_2 as the MOB decomposes residues+SOMC will obviously vary as a function of soil temperature. Table 1. shows the increasing respiration with increasing soil temperature. N min using the PRS® probes similarly increase, although the rate response to temperature is not equivalent between respiration and N supply rate.

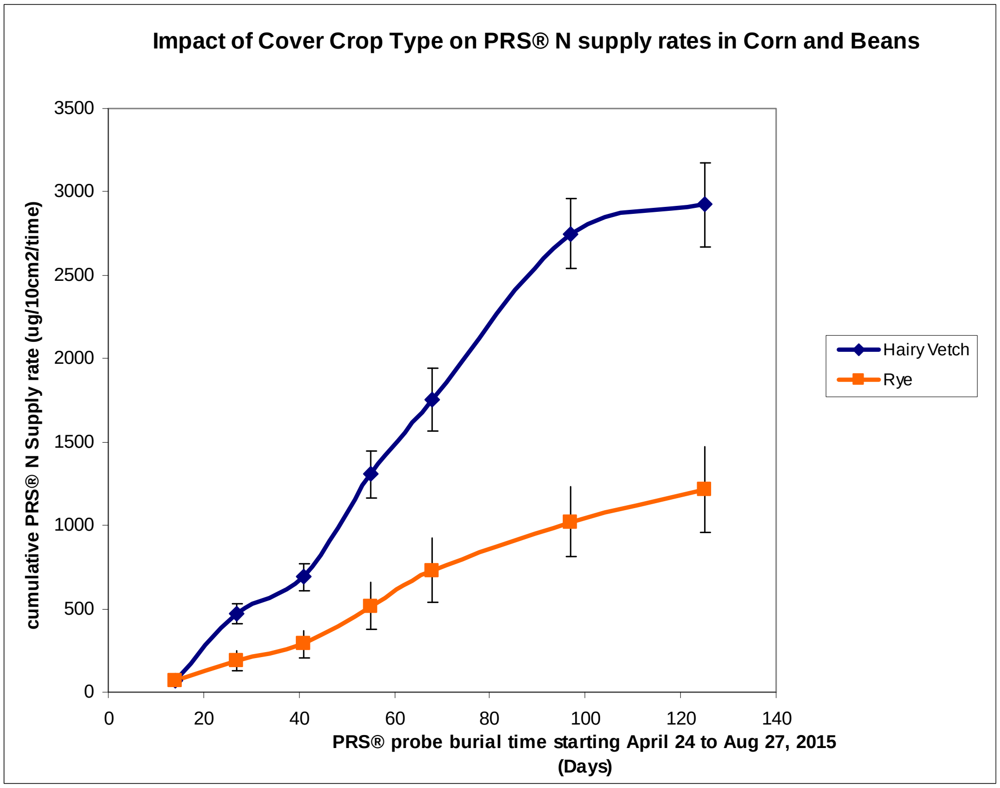

Figure 3. Cumulative PRS® N supply measured on cover crop plots in Illinois (Sievers, 2016)

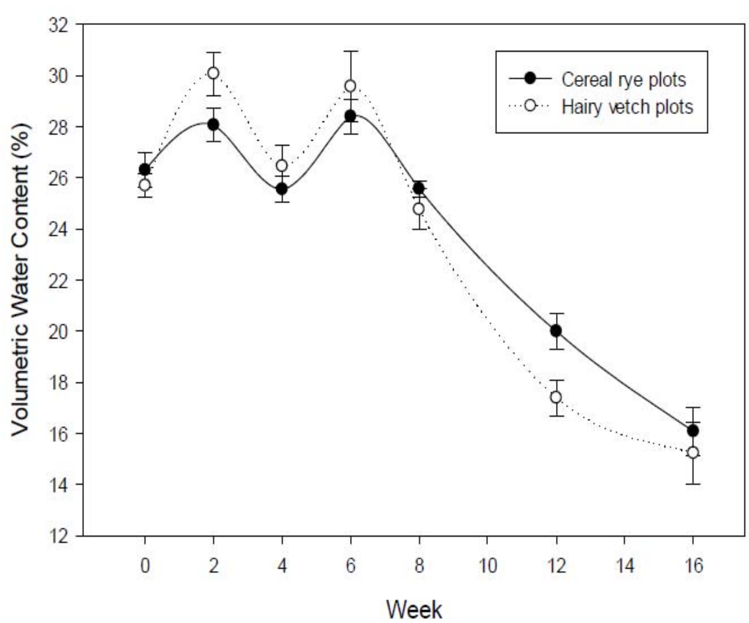

Figure 4. Soil moisture change with time across the cover crop type (Sievers, 2016)

The apparent disconnect between respiration and N mineralization is expected as the substrate to mineralize has a significant impact on the rate of N supply. Thus a simple linear metric of more CO_2 and more Nmin should not be expected in every soil and or residue input scenario.

Table 1. PRS® N and P supply rate and respiration as impacted by soil temperature.

Soil temp (°F)	N supply rate	P supply rate	Cumulative Respiration
	µg $10cm^{-2}$ $week^{-1}$		µg CO_2-C kg^{-1} O.D. soil
41	62	2.2	37 a
73	90	2.1	189 b
90	300	2.4	337 c

Soil organic C quality controls the C to N mineralization that will occur as the MOB engine turns over. The data in Figure 5 reflects the mineralization of both C and N relative to the Plant uptake of N from these same soils in a 6 week pot experiment. The soils were collected from severely wind eroded and adjacent depositional sites that were recently brought into production. Although the PRS® Nmin is strongly correlated to plant N uptake, the concomitant CO_2 respiration bears no correlation. The relative size of the labile SOMC pools is the likely reason for this. In fact, the total SOMC is more related to plant N uptake confirms that the substrate amount is more controlling than the C turnover (Figure 6).

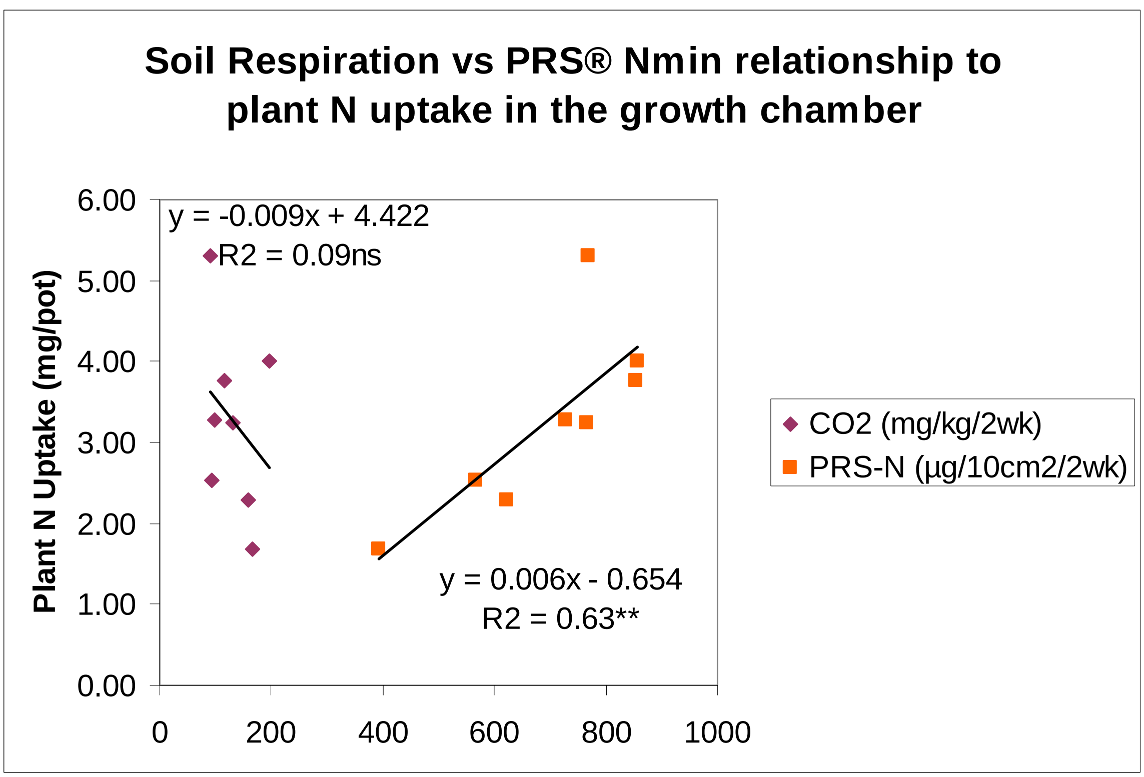

Figure 5. PRS® Nmin and Cmin form eroded, depositional and new "breaking" soils incubated for 2 weeks compared to plant N uptake measure on samples grown 6 weeks in the growth chamber.

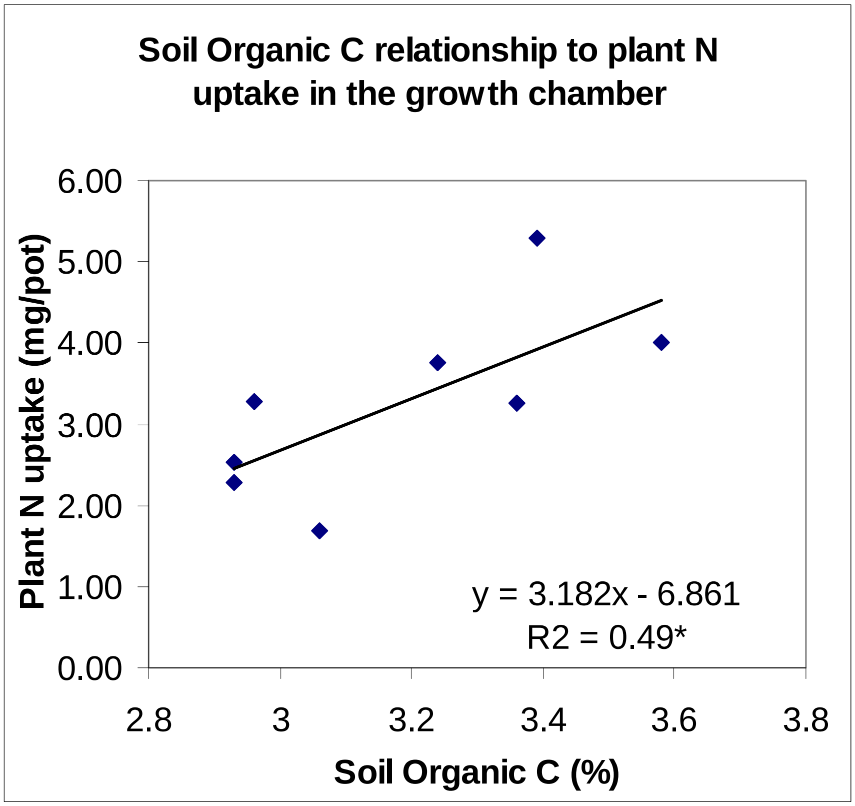

Figure 6. SOMC relationship to plant N uptake in a 6 week growth chamber experiment on eroded, depositional and "new" breaking.

CONCLUSIONS

The PRS® N supply rate is a functional measure of the MOB engine. SOMC and residue C is altering the release rate of N. However the soil moisture and temperate can equally control the MOB turnover, respiration and Nmin. Respiration on it's own can only be considered a proxy for N supply if the soil C sources have a very narrow C:N ratio and are highly labile. SOMC may have this narrow C:N ratio but may not necessarily readily mineralizable or labile. Residues from cover crops, composts and manures need to be assessed functionally to see if N mineralization will occur. Any interpretation of respiration rate alone should be considered with caution.

REFERENCES

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