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Evaluating the Spatial Variation in Soil Nitrogen Supply of Potato Fields in Prince Edward Island

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Introduction

The PEI Potato Board would like to advise their members on the potential for "right rate" soil N testing-based site-specific N fertilizer rates, to improve the profitability and reduce the environmental impact of potato production in PEI. PEI potato producers do not currently have an effective means of quantifying soil N supply on their farm to optimize N fertilizer application rates. Currently there is no data quantifying the magnitude and variability of soil N supply as a function of climate, soil type or agricultural management. This study surveyed 26 fields in fall and spring prior to potato production to assess the extent of within- and between-field variation of various measures of soil N supply.

Objective

To determine the extent of variation in soil N supply in fields in a potato rotation as influenced by soil type, climatic conditions and management practices.

Methodology

The 26 fields were selected from sites across all potato growing regions in PEI (Fig. 1) and were grouped in to Western (7), central west (7), central east (6) and eastern (6) regions. On each farm fields were selected that would be cropped to potato in 2015. The crops grown in 2014 were: hay (9); clover/timothy mixtures (6); forage (3); cereals (4); mustard (3); and soybeans (1). Ten of the fields had received manure in the past with four receiving manure in the fall of 2014. Glyphosate was applied to six of the fields prior to sample collection. Ten of the fields had been ploughed prior to sampling.

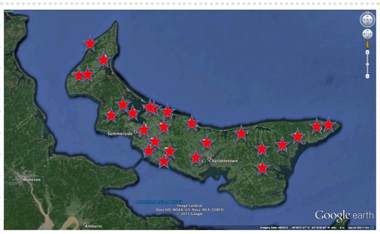

Figure 1: Location of sampling sites for soil nitrogen supply survey in PEI.

On each farm four replicate samples were collected from a field in the fall of 2014 and the spring of 2015. Approximately 1 kg of soil was sampled from the 0-15 cm depth, air-dried and passed through a 2mm sieve.

The Soil Nitrogen Supply test was performed on all 104 samples. This test measures the soil mineral (NO_3^- + NH_4^+) nitrogen (SMN) content of the soil following air-drying of the soil and the amount of mineral nitrogen released during a 2-week aerobic incubation (N Flush). The sum of these two measures is referred to as soil nitrogen supply (SNS).

The Soil Nitrogen Supply test was performed by combining 30g of soil with 30g of washed Ottawa sand, placing in a Buchner funnel and leaching with 200 mL of 0.01 M $CaCl_2$. Following the first leaching the soil contained in the funnel was incubated at 25 °C for 2 weeks. Following incubation the soils were leached a second time with 200 mL of 0.01 M $CaCl_2$. Leachates were analyzed for NH_4^+, NO_2^-+NO_3^-, and total soluble nitrogen (persulfate digestion).

Nitrogen mineralization potential (N_o) was estimated from soil total N, and N flush (Dessureault-Rompré et al. 2011a & 2012) and nitrogen mineralization was estimated for a 130-day growing season using estimated N_o and the biophysical water function (Dessureault-Rompré et al. 2011b) based on climatic normals for each location.

Results

Soil mineral nitrogen (SMN) in the fall of 2014 and spring of 2015 averaged 5.2 & 3.0 mg N kg^{-1} soil, with a range of 0 to 16 and 1 to 12 mg N kg^{-1} soil and a coefficient of variation 68% and 57% respectively (Fig. 2). The average coefficient of variation within fields was 64% and 27%.

Nitrogen flush during a two-week aerobic incubation in the fall of 2014 and spring of 2015 averaged 8.2 & 12.8 mg N kg^{-1} soil, with a range of 0 to 16.3 and 3.9 to 45.9 mg N kg^{-1} soil and a coefficient of variation 41% and 53% respectively (Fig. 2). The average coefficient of variation within fields was 30% and 16%.

Soil nitrogen supply (SNS; the sum of SMN and N flush) in the fall of 2014 and spring of 2015 averaged 13.4 & 14.8 mg N kg^{-1} soil, with a range of 1.1 to 32.0 and 5.1 to 51.1 mg N kg^{-1} soil and a coefficient of variation 40% and 49% respectively (Fig. 2). The average coefficient of variation within fields was 23% and 17%.

The value for the estimated N_{min} over a 130-day period averaged 33.3 mg N kg^{-1} (70 kg N ha^{-1}) soil with a range of 12.0 to 60.2 mg N kg^{-1} soil (25 to 125 kg N ha^{-1}). The coefficient of variation in estimated N mineralization across all soils was 23% where as the average coefficient of variation at an individual site was 10%.

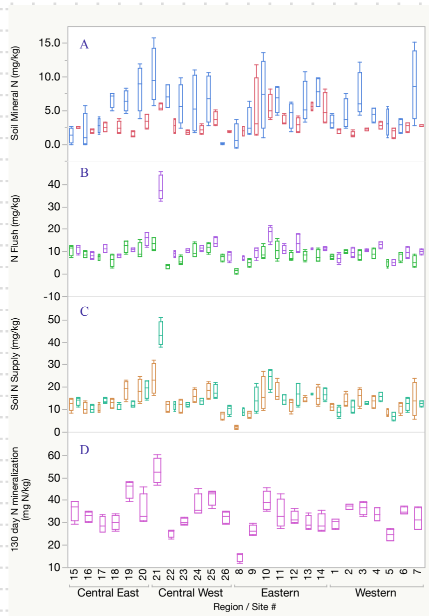

Figure 2: Mean, standard deviation and range of values for soil mineral N content (SMN), N flush, soil nitrogen supply (SNS) and estimated N mineralization over a 130-day period. Values are provided for the fall of 2014 (blue, green red and purple) and the spring of 2015 (red, purple and green)

Statistically significant differences between fields were observed for each of the measures of soil N status and estimated N mineralization.

When examined on a regional basis, statistically significant difference were only apparent for N_o and estimated N mineralization (Table 1). Mean values for the more dynamic measures of soil N status were not statistically different between regions.

Table 1: Regional mean values (kg N ha^{-1}) for soil mineral nitrogen (SMN), N flush, soil nitrogen supply (SNS), nitrogen mineralization potential (N_o) and estimated N mineralized over a 130-day period. Means followed by different letters are statistically different at $p \leq 0.05$.

Region	SMN	N Flush	SNS	N_o	N_{min}[1]
	(kg N ha^{-1})				
Western	10.1	16.4	26.5	140 ab	75 ab
Central West	12.4	18.5	31.3	152 a	77 a
Central East	9.7	19.5	29.2	142 ab	79 ab
East	10.9	15.1	26.3	130 b	68 b

Discussion

There was significant variation in all dynamic measures of soil N status from field to field and less variability within fields than between fields. Soil mineral N had the greatest variability both within and between fields and also from fall to spring.

Nitrogen flush was more consistent within a field and from spring to fall, with significant differences between fields.

Soil N supply demonstrated even greater stability than N flush from fall to spring and within fields. There were significant variation between fields. This suggests that some of the mineral N appearing in the soil is a result of decrease in the mineralizable N pool.

The soil N supply accounted for 64% and 34% of the variation in estimated N mineralization over 130 days (Fig. 3).

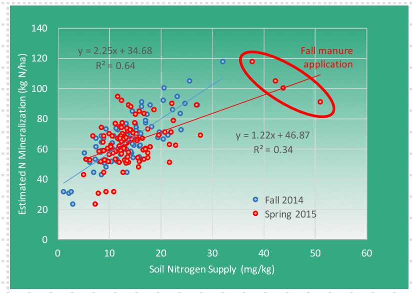

Figure 3: Correlation between soil nitrogen supply (mg N/kg soil) and estimated soil N supply (kg N/ha) in the fall of 2014 and spring of 2015.

The measured variation in all of the measures of soil N dynamics points to the opportunity to use site specific measures of soil N supply in determining the "right rate" for N fertilizer application. Measure of N mineralization (N flush, N_o) showed greater uniformity within the field and temporal stability (fall to spring) than measures of mineral N content. Soil N supply, which included both mineral N and N mineralization estimates provided the most spatially and temporally stable estimate. Field to field and regional estimates in of N mineralization potential and/or soil N supply suggest that significant improvements in N use efficiency could be realized by measured site-specific measures of soil N supply.

Conclusion

- ✓ Significant spatial variation in measures of soil nitrogen dynamics were measured. There was greater variation between fields than within fields.
- ✓ Measures of soil N mineralization (N flush) showed greater spatial and temporal stability than soil mineral N.
- ✓ Much of the variation in estimated N mineralization was explained by measured soil N supply.
- ✓ There is a opportunity to adjust N fertilizer application rate to reflect field to field differences in soil N supply.

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