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Using a plant bioassay approach to estimate soil nitrogen contribution to potato crop

Judith Nyiraneza, Danielle Murnaghan, Aaron Mills, and Yefang Jiang

The price of nitrogen (N) fertilizer continues to rise and applying N fertilizer above the crop N requirement results in economic and environmental losses. Along with N fertilizer, the soil organic matter (SOM) is an important source of N to crop N nutrition.

Prince Edward Island's coarse-textured soil, cold and wet springs, and short growing seasons make it difficult to confidently estimate the N credits from soil organic matter and preceding crops and thus can result in an over-application of N, especially when a legume forage is the preceding crop. This over application enhances soil nitrate leaching risk, increases greenhouse gas emissions, and negatively affects potato yield (Jiang et al. 2019; Nyiraneza et al. 2021; Whittaker et al. 2022) and quality. In Prince Edward Island, current N recommendations for potatoes range from 112 kg N ha^{-1} to 207 kg N ha^{-1} depending on the potato variety (Government of PEI 2017).

Based on past research trials conducted over 10 years by Agriculture and Agri-Food Canada, the soil N contribution using a plant bioassay approach under potato crop was assessed. This consists of quantifying the amount of N accumulated in the entire potato crop (vines, tubers, recoverable roots and stolons) at the onset of vine senescence in the absence of N fertilizer as a proxy of net soil N mineralization (Zebarth et al. 2005). This estimates the amount of N supplied by the soil alone, and integrates preceding crops, soil properties and climatic conditions in a given growing season.

The main objective of this factsheet was not to assess statistical significance among tested treatments but to provide a range of soil N contribution values across different growing seasons under two or three year potato rotation systems with different preceding crops and management practices.

A research trial located in Harrington, Prince Edward Island, in which half of the potato plots have received recommended nutrients (NPK) while the other half of the potato plots have received recommended nutrients with the exception of N fertilizer (PK).

The cover crop seeding rates were within the range recommended in the region.

Results demonstrated that the soil N contribution was variable over growing seasons and confirm the importance of soil N input and that current N credits following a two-year of a legume crop to subsequent potato may be underestimated (Table 1). Averaged across trials, soil N contribution was 115 kg N ha^{-1} following two years of red clover. Manure application one year prior to growing potatoes at 20 metric tons/ha increased soil N contribution by an average of 44 per cent compared to no manure incorporation (Nyiraneza et al. 2021). Our trials were conducted at plot-scale and need to be validated at field-scale. Growers interested in validating these results can do this easily by leaving a strip (i.e. four potato rows) without N fertilizer. Research is underway to estimate soil N contribution using soil properties and climatic data.

Crop Sequence	Average soil N contribution to potato using a plant bioassay approach ± Standard Deviation (kg N/ha)	
Three year potato rotation at two sites (2015-2018), soil pH = 6.1, 6.0; SOM = 3.0%, 2.7%		
Barley u/s Red Clover - Red Clover - Potato	83 ± 14	
Grain Corn - Sorghum Sudan Grass - Potato	75± 15	
Soybean - Brown Mustard (double cropping) - Potato	98 ± 26	
Three year potato rotation (2009-2011), soil pH = 5.8; SOM = 3.5%		
Barley - Barley - Potato	82 ± 28	
Barley u/s Timothy - Timothy - Potato	84 ± 5	
Barley u/s Red Clover - Red Clover (early fall plowing) - Potato	116 ± 17	
Barley u/s Red Clover - Red Clover (late fall plowing) - Potato	99 ± 29	
Barley u/s Red Clover - Red Clover (spring plowing) - Potato	127 ± 25	
Three year potato rotation at two sites (2012-2015), soil pH = 5.3, 5.6; SOM = 3.4%, 3.3%		
Barley u/s Red Clover - Red Clover - Potato	123 ± 34	
Barley u/s Red Clover - Red Clover (mowed before fall plowing) - Potato	121 ± 41	
Barley u/s Red Clover - Red Clover (sprayed before fall plowing) - Potato	136 ± 29	
Barley u/s Red Clover - Red Clover (spring plowing) - Potato	124 ± 21	
Three year potato rotation (2014-2016), soil pH = 6.5; SOM = 3.1%		
Barley u/s Red Clover - Red Clover (fall plowing) - Potato	113 ± 32	
Barley u/s Red Clover Red Clover (spring plowing) - Potato	109 ± 27	
Two year potato rotation at two sites (2012-2014), soil pH = 5.9; SOM = 3.1%		
(sprayed and unsprayed before fall plowing)	**No Spray**	**Spray**
Negative Control (bare soil/weeds) - Potato	59 ± 13	57 ± 12
Red Clover - Potato	84 ± 20	56 ± 13
Rye - Potato	95 ± 33	68 ± 21
White Clover - Potato	96 ± 36	84 ± 36
Two year potato rotation (2017-2018), soil pH = 5.9; SOM = 2.6%		
Grasses, legumes, or a mixture of both with and without 20 metric tons/ha (fresh weight) of cow manure	Averaged across all treatments, manure increased soil N contribution by 44% **(Nyiraneza et al. 2021)**	

Note: Values are an average of 3 to 4 replicates for one cycle of rotation, and an average of 6 to 8 replicates for two cycles of rotation. After each cover crop was cut, biomass was left on the field. To convert kg/ha to lb/acre divide by 0.89.

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For more information, visit www.agr.gc.ca or contact judith.nyiraneza@agr.gc.ca