A Single Measurement to Predict Mineralizable Nitrogen

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Introduction

Since the early 1970's, soil test nitrate nitrogen (NO_3-N) has been used as a basis for N fertilizer recommendations in the prairie provinces of Canada. However, soil test NO_3-N only represents nitrate N concentration at the time of soil sampling. Soil test NO_3-N changes from time to time, and soil test NO_3-N, therefore, does not represent the true supply power of soil N for plant uptake in a growing season.

Stanford and Smith (1972) used a first order kinetics model ($Nt=No(1-e^{-kt})$) to quantify the mineralizable N in soil, where No is potential mineralizable N, Nt is mineralizable N for a given time period, k is the rate constant, and t is time. To estimate the impact of soil water content on Nt, Olness (1984) used a y factor in the above model, $Nt=No(1-e^{-kt})y$. By determining Nt experimentally, No can be obtained by graphical extrapolation. Chemical extraction is an other approach to estimate No. However, its results are still in debate due to inconsistent correlations with other reliable methods such as incubation. Nevertheless, hot KCl (35°C) extractable N was found to be a good chemical method to estimate No in western Canada (Campbell et al., 1997). In contrast, we think that the hot KCl extracted N is Nt for a year but not No in the model. The potential mineralizable N, No is a fraction of the total organic N, and that fraction can be as high as 2.6% in prairie provinces of Canada based on historic soil test results and field experiments.

Based on soil and climate, the arable area of Alberta has classified into 109 ecodistricts. In 1998, 42 benchmark sites with three slope positions were established to monitor soil quality as affected by the current agricultural practices in these ecodistricts (Figure 1).

Our objectives are 1) to evaluate hot KCl extraction as a method for soil test N; and 2) demonstrate the spatial variability of mineralizable N in a field and regional scale.

Materials and Methods

Benchmark sites

Forty two benchmark were chosen to represent soil and agricultural practices in Alberta. Each site includes three landscape positions (upper, middle and lower). Soil samples at 0-15 cm depth were taken annually at the fall since 1998. The soil test results in 1998 was summarized in Table 1.

Model used

Nt = $No(1-e^{-kt})y$ (Olness, 1984)

- Nt - mineralizable N in a year mg/kg soil
- No - potential mineralizable N, 2.6% of total organic N, mg/kg soil
- k - rate constant, $week^{-1}$
- t - time, week
- y - moisture factor, dimensionless, annual precipitation divided by optimal water use for crops (460 mm).

Table 1. Soil characteristics in the benchmark sites

	Available N	Available P	Available K	Available S	No. of sites
			mg /kg soil		
Aspen Parkland	10.4	20.7	303	11.0	9
Boreal Transition	7.3	14.7	124	9.6	8
Fescue Grassland	9.2	18.8	496	3.1	2
Mixed Grassland	11.4	13.9	459	17.3	7
Moist Mixed Grassland	18.1	25.2	413	34.9	5
Peace Lowland	22.9	21.7	236	18.9	9

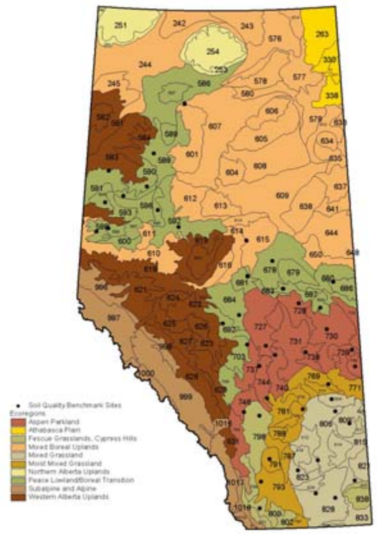


Figure 1. Location of Benchmark Sites, Ecoregions and Ecodistricts in Alberta

Results and Discussion

Mean growing season temperature in Alberta is 13.2 °C, there are only about 13.5°C difference between minimum (6.5°C) and maximum (20.0°C) temperature. The annual precipitation mean is 431 mm. Based on weekly average temperature and using equations developed by Stanford et al. (1973) and Campbell et al. (1988), we calculated the rate constant k as affected by temperature (Table 2).

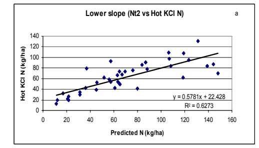
Table 2. Change of rate constant as a function of temperature.

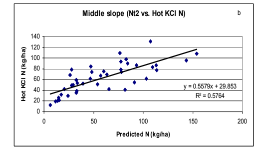
	Rate constant, k[1]	Rate constant, k[2]
	wk^{-1}	
Minimum value	0.0122	6.65×10^{-5}
Maximum value	0.0154	1.6×10^{-4}
Average	0.0135	9.9×10^{-5}

1 log k=6.16-2299/T, Stanford et al. (1973)
2 log k =27.33-8973/T, Campbell et al. (1988)

The rate constant calculated from Campbell's approach is very small, while the constant from Stanford's approach gave a k value with narrow difference. We used a k value, 0.028 wk^{-1} derived from western Canada by Campbell et al. (1988) to calculated Nt. The R^2 from regression of calculated Nt and the hot KCl extractable N was found to be significant ($p<0.05$) (Fig 2.) for each slope position.

The spatial distribution of Nt was greater in the lower slope position as compared to the higher slope position (Table 3). The difference in N content between higher and lower slope positions is about 46 kg N/ha, a N rate nearly equal to the entire year of N application in farm land. This strongly indicates the need to adopt variable N rate management in farm land.





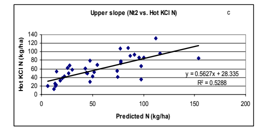


Figure 2. Regression of Nt from each slope position against hot KCl extracted N.

Table 3. Variation of Nt at different landscape position.

	Lower slope	Middle slope	Upper slope
		mg N kg^{-1} soil	
Minimum	5.22	6.26	6.00
Maximum	412.95	154.17	153.93
Mean	75.39	58.20	52.14

On a regional base, the mineralizable N is also different among the ecoregions. The Mixed Grassland , even with higher temperature, had lowest mineralizable N in soil (Table 4). The mineralizable N was high in the Boreal Transition.

Table 4. Mineralizable N in different ecoregions.

	Peace Lowland	Boreal Transition	Aspen Parkland	Moist Mix Grassland	Fescue Grassland	Mixed Grass-land
			mg kg^{-1} soil			
Lower slope						
Minimum	22.81	28.75	2.61	15.55	31.59	5.59
Maximum	65.73	206.48	72.15	39.93	44.13	18.11
Mean	38.49	65.88	34.08	25.82	37.86	10.08
Middle slope						
Minimum	16.32	12.96	5.54	12.10	28.40	3.13
Maximum	77.08	28.33	71.67	40.85	38.66	10.28
Mean	41.15	54.75	36.07	12.88	33.53	7.04
Upper slope						
Minimum	15.15	3.63	5.95	12.80	23.85	7.04
Maximum	55.99	27.36	58.07	48.96	48.78	11.26
Mean	57.33	15.22	28.34	29.00	36.32	7.16

Conclusions

Hot KCl extractable N can be used as a single soil test to predict mineralizable N in the prairie provinces of Canada. Therefore, a more realistic soil N test method can be developed for N management on arable land.

Acknowledgement

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References

Campbell, C.A. et al. 1988. Can. J. Soil Sc. 68:537-552; Campbell, C.A. et al. 1984. Can. J. Soil sci. 64:333-343; Olness, A. 1984 Agron. J. 76:171-172; Stanford, G. et al. 1973. Soil sci. 115:311-323; Stanford, G. and S.J. Smith. 1972. Soil Sci. soc. Amer. Proc. 6:465-472.