Soil Quality Attributes Five Years After the Establishment of Alberta Soil Quality Benchmark Sites

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Introduction

Predictive models have been used to evaluate probable soil quality change in Canada (Acton and Gregorich 1995, McRae et al. 2000). The Soil Quality Benchmark Sites were established in an attempt to validate the predictions. Twenty three sites were established across Canada to represent the range of soils and soil management typical of Canadian agriculture (Figure 1). Detailed charactarization of the sites was carried out when the sites were established in 1991-92 (Wang et al. 1994, Walker and Wang 1994, 1998, 1998). After 5 years the soils were resampled to monitor changes in dynamic soil properties.

Figure 1. Benchmark sites for monitoring soil health in Canada.

Objective

To compare soil quality attributes measured in 1991 - 92 with those measured in 1996 - 97 at four Alberta locations under soil management typical of the area where the study sites are located.

Materials and methods

- **For Landform low relief, hummocky moraine** used transect sampling design (Figure 2) – suited to terrain with relief as in other studies on soils in toposequences (Arnold and Wilding 1991)
- **For level landscapes** used a 10 by 10 grid at 25 m spacings (Figure 3).
- **Laboratory analyses** (Sheldrick 1984) on topsoil (Ap horizon) samples:
  - Organic carbon – total C (LECO induction furnace) minus inorganic C (manometric method).
  - Total Nitrogen – samples were digested using a semi-micro version of the Kjeldahl- Wilforth-Gunning method (AOAC 1955) .
  - pH ($CaCl_2$) – measured by pH meter in a 1:2 soil to $CaCl_2$ solution.
- Available potassium (K) – by the pH7, 1M, NH_4OAc extraction method and for Non-calcareous samples - cold, 0.05M, H_2SO_4 extraction.
- **Comparative analysis** – via paired t-tests ($P \leq 0.05$) on the selected parameters.

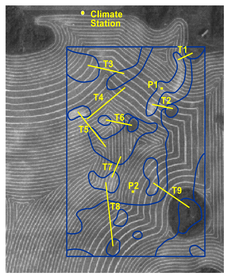

Figure 2. Transect sampling Method - Provost

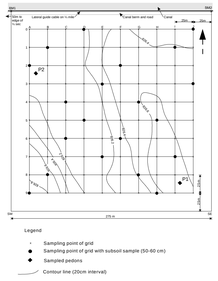

Figure 3. Grid sampling method - Bow Island

Results

Bow Island - Irrigated Site, Brown Lacustrine Landscape

There is a significant increase in organic carbon and available potassium in the 5 years from 1991 to 1996. The increase in C:N corroborates the improved management over the past 15 years.

Falher - Dark Gray Chernozemic, Lacustrine Landscape

There is a significant decrease in pH and a significant increase in available potassium.

Provost - Dark Brown Morainal Landscape

Increases in organic carbon occurred in the mid slope positions and decreased in the lower slopes and depressions. Total nitrogen decreases occurred in both mid and lower slope positions along with an increase in the C:N ratio.

Mundare - Black Chernozemic Morainal Landscape

There is little evidence of change in the soil attributes measured on either the conventional tillage or the direct seeded fields. A small significant reduction in total nitrogen occurred in the crest and mid slope positions on the conventionally tilled fields.

Bow Island Soil Attributes

	Baseline (1991)		Repeat (1996)		Change
	Mean	SdDev (No.)	Mean	SdDev (No.)	over 5 yrs
pH_{CaCl_2}	7.2	0.4 (102)	7.1	0.4 (60)	-0.1
Organic Carbon (%)	1.2	0.1 (102)	1.3	0.1 (60)	0.1*
Total Nitrogen (%)	0.12	0.01 (102)	0.13	0.01 (59)	0.01
C:N Ratio	9.8	0.9 (102)	10.4	0.5 (60)	0.7
Available K (ug g^{-1})	462	115 (102)	617	123 (60)	154*

* Significant difference by t-test (<0.05)

Falher Soil Attributes

	Baseline (1991)		Repeat (1996)		Change
	Mean	SdDev (No.)	Mean	SdDev (No.)	over 5 yrs
pH_{CaCl_2}	5.3	0.13 (100)	5.1	0.12 (40)	-0.2*
Organic Carbon (%)	3.2	0.3 (100)	3.2	0.2 (40)	0.0
Total Nitrogen (%)	0.33	0.12 (100)	0.27	0.04 (40)	-0.06*
C:N Ratio	10.2	1.6 (100)	12.1	1.6 (40)	1.9*
Available K (ug g^{-1})	273	42 (102)	234	38 (40)	-39*

* Significant difference by t-test (<0.05)

Conclusions

1. There has been relatively minor changes in the soil attributes monitored in the Alberta Soil Quality Benchmark Sites over the 5 years. The small changes occurring are at the limit of sensitivity of most of the measurements. These changes may become significant for the next generation.
2. The increase in organic carbon and available potassium at Bow Island indicate the management there is doing well.
3. The decrease in pH at Falher is significant and if the trend continues could affect productivity before long.

Mundare Soil Attributes

	Baseline (1991)				Repeat (1996)				
	Conventional Tillage		Direct Seeding		Conventional Tillage		Direct Seeding		Change over 5 Yrs
	Mean	SdDev (No.)	Mean	SdDev (No.)	Mean	SdDev (No.)	Mean	SdDev (No.)	CT(R1-BS) / D-S(R1-BS)
Whole field									
pH_{CaCl_2}	5.8	0.7 (32)	5.7	0.6(36)	5.8	0.7(32)	5.5	0.6(36)	0.0 / -0.2
Organic Carbon (%)	3.6	1.4 (32)	4.0	0.9 (36)	3.4	1.5 (32)	4.0	1.0 (36)	-0.2 / 0.0
Total Nitrogen (%)	0.29	0.11(32)	0.31	0.07 (36)	0.27	0.11 (32)	0.31	0.07 (36)	-0.02* / 0.00
C:N Ratio	11.9	0.7 (32)	12.5	0.6 (36)	12.4	1.1 (32)	12.7	0.8 (36)	0.5* / 0.2
Available K (ug g^{-1})	219	155 (32)	201	130(37)	202	91(32)	196	73(37)	-17 / -5
Crest									
pH_{CaCl_2}	6.5	1.1 (6)	5.6	0.7 (7)	6.3	1.2 (6)	5.5	0.7 (7)	-0.2 / -0.1
Organic Carbon (%)	2.2	0.9 (6)	3.2	1.2 (7)	2.2	1.0 (6)	3.0	1.0 (7)	0.0 / -0.2
Total Nitrogen (%)	0.2	0.08 (6)	0.26	0.09 (7)	0.18	0.08 (6)	0.24	0.08 (7)	-0.02* / -0.02*
C:N Ratio	11.2	0.5 (6)	12.0	0.7 (7)	11.9	0.9 (6)	12.1	0.9 (7)	0.7* / 0.1*
Available K (ug g^{-1})	211	106 (6)	240	198 (7)	200	78 (6)	250	98 (7)	-11 / 10
Upper Slope									
pH_{CaCl_2}	5.3	0.3 (2)	5.3	0.4 (3)	5.4	0.1 (2)	4.9	0.3 (3)	0.1 / -0.4
Organic Carbon (%)	5.8	0.1 (2)	4.0	0.6 (3)	5.8	0.3 (2)	4.0	0.8 (3)	0.0 / 0.0
Total Nitrogen (%)	0.5	0.08 (2)	0.32	0.04 (3)	0.44	0.03 (2)	0.32	0.05 (3)	-0.06 / 0.00
C:N Ratio	11.5	0.5 (2)	12.5	0.6 (3)	13.2	0.2 (2)	12.7	0.7 (3)	1.7 / 0.2
Available K (ug g^{-1})	372	105 (2)	171	91 (3)	412	87 (2)	153	7 (3)	40 / -18
Mid Slope									
pH_{CaCl_2}	5.6	0.5 (17)	5.4	0.4 (17)	5.5	0.6 (17)	5.3	0.4 (17)	-0.1 / -0.1
Organic Carbon (%)	3.6	1.3 (17)	3.8	0.7 (17)	3.7	1.5 (17)	3.9	0.8 (127)	0.1 / 0.1*
Total Nitrogen (%)	0.3	0.11 (17)	0.38	0.06 (17)	0.28	0.11 (17)	0.3	0.06 (17)	-0.02* / -0.08
C:N Ratio	11.9	0.7 (17)	12.9	0.5 (17)	12.8	1.1 (17)	13.0	0.7 (17)	0.9* / 0.1
Available K (ug g^{-1})	195	135 (17)	160	84 (16)	183	76 (17)	158	47 (16)	-12 / -2
Lower Slope									
pH_{CaCl_2}	5.9	0.5 (7)	6.3	0.6 (9)	6.1	0.4 (7)	6.1	0.6 (9)	0.2 / -0.2
Organic Carbon (%)	3.9	0.9 (7)	4.8	0.4 (9)	3.2	1.4 (7)	4.8	0.4 (9)	-0.7 / 0.0
Total Nitrogen (%)	0.31	0.08 (7)	0.38	0.03 (9)	0.27	0.11 (7)	0.38	0.03 (9)	-0.04 / 0.00
C:N Ratio	12.5	0.4 (7)	12.9	0.7 (9)	11.8	0.9 (7)	12.6	0.6 (9)	-0.7 / -0.3
Available K (ug g^{-1})	243	234 (7)	236	137 (9)	187	70 (7)	214	49 (9)	-56 / -22

* Significant difference by t-test (<0.05)

Provost Soil Attributes

	Baseline (1990)		Repeat (1996)		Change
	Mean	SdDev (No.)	Mean	SdDev (No.)	over 6 yrs
Whole Field					
pH_{CaCl_2}	6.1	1.1 (64)	6.2	1.1 (64)	0.1
Organic Carbon (%)	2.8	0.8 (64)	2.6	0.9 (64)	-0.2*
Total Nitrogen (%)	0.25	0.07 (64)	0.22	0.06 (64)	-0.03*
C:N Ratio	10.9	1.0 (64)	11.6	1.5 (64)	0.7*
Available K (ug g^{-1})	474	213 (64)	487	204 (64)	13
Crest & Upper Slopes					
pH_{CaCl_2}	7.5	0.4 (15)	7.4	0.3 (15)	-0.1
Organic Carbon (%)	1.8	0.3 (15)	1.8	0.8 (15)	0.0
Total Nitrogen (%)	0.18	0.03 (15)	0.18	0.05 (15)	0.00
C:N Ratio	10.0	0.5 (15)	10.2	2.4 (15)	0.2
Available K (ug g^{-1})	282	59 (15)	314	100 (15)	32
Mid Slopes					
pH_{CaCl_2}	6.2	1.1 (24)	6.3	1.1 (24)	0.1
Organic Carbon (%)	2.6	0.6 (24)	2.5	0.5 (24)	0.1*
Total Nitrogen (%)	0.24	0.04 (24)	0.21	0.04 (24)	-0.03*
C:N Ratio	11.1	0.8 (24)	11.7	0.5 (24)	0.6*
Available K (ug g^{-1})	450	189 (24)	450	188 (24)	0
Lower Slopes & Depressions					
pH_{CaCl_2}	5.2	0.4 (25)	5.3	0.5 (25)	0.1
Organic Carbon (%)	3.5	0.3 (25)	3.2	0.7 (25)	-0.3*
Total Nitrogen (%)	0.31	0.04 (25)	0.27	0.06 (25)	-0.04*
C:N Ratio	11.3	1.1 (25)	12.2	0.5 (25)	0.9*
Available K (ug g^{-1})	613	199 (25)	627	172 (25)	14

* Significant difference by t-test (<0.05)

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