EVALUATION OF A SOIL QUALITY TEST KIT IN ALBERTA [1]

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ABSTRACT

The purpose of this investigation was to assess the Unites States Department of Agriculture-Agricultural Research Service (USDA-ARS) Soil Quality Test Kit in three areas of Alberta with a variety of management systems. Results indicate that the test kit was able to detect differences between management practices and results compared well to standard laboratory analysis of the same soil. The test kit has the potential to be a valuable tool to raise the awareness of soil quality issues in Alberta.

INTRODUCTION

One popular definition of soil quality is the "capacity of a specific soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (Karlen et al. 1997). Soil quality is a dynamic interaction between various physical, chemical and biological soil properties, which are influenced by many external factors such as land use, land management, the environment and socio-economic priorities. Soil quality is considered a key element of sustainable agriculture (Warkentin 1995) because it is essential to support and sustain crop, range and woodland production and helps maintain other natural resources such as water, air and wildlife habitat.

Soil quality evaluation is a tool to assess changes in dynamic soil properties caused by external factors. The assessment of soil quality is a management tool for agricultural producers to identify problem areas and assess differences between management systems and is valuable to measure the sustainability of land and soil management systems now and in the future (Doran and Parkin 1994). Evaluation of the quality of a soil can be carried out through various methods which include the use of basic soil indicators, an index method which weights the importance of those indicators or by using qualitative or quantitative measures such as a soil quality scorecard or soil quality field test kit. All methods make use of indicators, which are measurable soil or plant properties that indicate the capacity of a soil to function for a specific land use, climate and soil type.

A quantitative assessment kit has been developed by the USDA-ARS to measure agricultural soil quality in the field (USDA 1999). The Soil Quality Test Kit is a simple, low cost assessment tool, which can provide immediate results to compare management systems, monitor changes in soil quality over time and to diagnose possible soil problems. It enables the user to perform *in situ* soil tests, which cannot be effectively conducted by an analytical laboratory. The kit uses a minimum dataset of indicators, which include 12 quantitative tests for physical, chemical and biological properties of the soil ecosystem.

Previous evaluations of the soil quality test kit used comparative assessment approaches, which compared the same soil subjected to different management practices (Seybold et al 2001; Evanylo and McGuinn 2000), and also determined the accuracy of the test kit results by comparing them to standard laboratory procedures (Liebig et al 1996; Evanylo and McGuinn 2000).

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[1] Proceedings of the 40th Annual Alberta Soil Science Workshop, February 18-20, 2003, Edmonton, Alberta
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OBJECTIVES

The AESA Soil Quality Program designed a study in 2002 to test the performance of the soil quality kit in agricultural soils across Alberta. This study had three main objectives 1) apply the kit in a variety of management systems and soils 2) compare the test kit results to standard laboratory analysis of the same soil and 3) determine if the field kit was easy to use and if the results could be interpreted in the Alberta context.

MATERIALS AND METHODS

The Soil Quality Test Kit

The kit consists of a portable toolbox, which includes most of the equipment needed to complete the tests. A guide is included in the kit, which provides step-by-step instructions and offers an interpretation of typical results seen in the United States, which may or may not be applicable in Alberta (USDA 1999).

Field Evaluation

Evaluations took place during the early growing season at three locations across Alberta (Foremost-April 30, Bentley-May 13, DeBolt-May 28). Sampling occurred before cultivation/seeding at the Foremost and Bentley sites, with the exception of the NT/CT field, which was seeded into a winter cereal. Seeding had already taken place at the DeBolt site. Soil samples were taken from the upperslope position at each site and occurred away from headlands, in an area representative of the entire field. Samples were taken inter-row where applicable and obvious field implement tire tracks were avoided. Three replicates of all tests were performed in each management system and location. Sampling positions within each management system were selected at random but within a few meters of each other. The site characteristics of Foremost, Bentley and DeBolt were determined (Tables 1,2,3).

Soil was sampled based on the instructions given in the test kit manual (USDA 1999). Respiration, infiltration, bulk density, depth to resistance layer, and earthworm concentration were determined in-situ. Tests for pH, EC, soil nitrate levels, aggregate stability and soil water content were determined in the lab using the field test kit equipment. Complete analysis of samples (9-12 samples) from each of the three sites, took place over a two-day period as directed by the instruction manual.

Standard Laboratory Procedures

Standard laboratory procedures of Norwest Labs were used to analyze soil samples for pH, EC and nitrate content, for comparing the test kit results to those from standard laboratory analysis.

Statistical Analyses

Using SAS, least squares means (LSM) at $P \leq 0.05$ was applied to determine statistical differences between management systems at each of the three sample sites across the province. A paired comparisons t-test at $P \leq 0.05$ was used to determine if the test kit results compared well with results from standard laboratory analysis.

Table 1. Site characteristics of management systems at Foremost, AB.

	CT	**NT**	**Rangeland**
Soil Group	Brown Chernozem		
Landform	Undulating		
Soil Texture	Loam	Clay Loam	Loam
Organic Matter (%)	1.9	2.2	3.1
Management	Wheat-Fallow conventional cropping	No-till continuous cropping	Native rangeland

Table 2. Site characteristics of management systems at Bentley, AB.

	CT	NT after CT	NT after Forage	Pasture
Soil Group	Dk Gray Chernozem	Black Chernozem		
Landform	Rolling	Undulating		
Soil Texture	Loam	Loam	Loam	Sandy Loam
Organic Matter (%)	4.5	3.1	3.8	12.6
Management	20 yrs of conventional annual cropping	7 yrs direct seeding after conventional annual cropping	7 yrs direct seeding after forages	Permanent pasture

Table 3. Site characteristics of management systems at DeBolt, AB.

	CT	CT after Forage	Fescue after CT
Soil Group	Dark Gray-Gray Luvisol		
Landform	Undulating		
Soil Texture	Silt Loam	Silt Loam	Loam
Organic Matter (%)	3.5	2.9	4.2
Management	Long-term conventional tillage	2^{nd} year of conventional tillage after timothy in rotation	2^{nd} year of fescue after long-term conventional tillage

RESULTS AND DISCUSSION

Soil Respiration

The soil quality test kit was not able to detect any significant differences in soil respiration rate between the different management systems we looked at in the study (Table 4). Soil respiration is highly dependent upon soil temperature and moisture among other factors. Respiration rates ranged from very low (7.8 lbs CO_2/acre/day) to medium (20.4 lbs CO_2/acre/day) based on interpretations from the soil quality test kit guide.

Soil Water Content

Soil water contents were found to be statistically different at all three sites (Table 4). The pasture system at the Bentley site was situated on a discharge area, which may have contributed to the high result, while low moisture content of the NT after CT system was caused by an actively growing crop at the time of sampling. At DeBolt, the conventionally tilled soils, which were previously in forages, had the lowest moisture content while the long term conventionally tilled soils were the moistest.

Bulk Density

The only significant differences in bulk density were between management systems at the Bentley site (Table 4). With the exception of the CT soil at Foremost and the pasture soil at Bentley, all of the bulk densities across the three sites were determined to be within expected range of 1.0 to 1.7 g/cm^3, according to the test kit guide. The CT soil at Foremost, most likely had a lower bulk density due to annual cultivation, while the bulk density sample for the pasture soil at Bentley contained a thick thatch layer, which lowered the density measurement. The thatch layer was included in the bulk density measurement as directed by the test kit instruction manual.

Electrical Conductivity

Electrical conductivity was statistically different between management systems at Foremost and Bentley (Table 4). Although differences were detected, all of the samples were determined to have EC values below 2.0 dS/m, and would not be expected to affect general crop growth.

Table 4. Means for soil quality test kit indicators by site and management system

	Site									
	Foremost			Bentley				DeBolt		
Management	**CT**	**NT**	**Range**	**CT**	**NT/ CT**	**NT/F**	**Pasture**	**CT**	**CT/F**	**F/CT**
Soil Respiration (lbs CO_2-C/acre/day)	7.9	10.9	12.5	7.8	8.2	8.2	8.0	20.4	14.3	8.3
Soil Water Content (% Volume)	15a#	16a	12b	26b	18c	24bc	58a	29a	21b	28a
Bulk Density (g/cm^3)	0.82	1.20	1.40	1.12b	1.10b	1.30a	0.59c	1.14	1.14	1.24
EC (dS/m)	0.12a	0.07b	0.13a	0.06b	0.1b	0.09b	0.3a	0.18	0.13	0.03
pH	7.8a	6.5b	7.4a	5.7c	5.5c	6.0b	8.0a	5.5b	4.9c	6.1a
Estimated Soil NO_3-N (lb/ac)	1.4a	1.5b	6.7b	2.7bc	4.5a	3.7ab	2.1c	29.0	7.5	1.2
Exact Soil NO_3-N (lb/ac)	1.8a	2.0b	9.8b	3.5	5.9	4.6	5.3	52.0	12.4	2.0
Infiltration Rate (in/hr)	3.6	2.2	1.1	8.1	21.2	13.3	1.9	<0.5	2.8	1.8
Depth to Resistance Layer (cm)	11	15	21	12b	15a	10c	10c	11	11	7
Earthworms Observed	0	0	0	0	0	4.5	0	0	0	0
Water Stable Aggregates (% of soil >0.25mm)	24	39	45	52b	48b	49b	88a	32b	28b	47a

within site and management for each indicator, the means followed by different letters are significantly different at $P \leq 0.05$. Where no letter is indicated, there was no significant difference between the management systems for that particular soil indicator tested with the soil quality test kit.

pH

The test kit procedure to analyze soil pH detected significant differences between management systems at all locations (Table 4). The pH measurements ranged from 4.9 to 8.0. Alfalfa productivity would be suppressed at the lower pH values found.

Soil Nitrate

Differences between management systems for estimated nitrate content were found at Foremost and Bentley. The test kit detected differences in exact nitrate content (based on the actual weight of soil and volume of water used in the extraction) between management systems at Foremost (Table 4). The estimated values were consistently lower than the exact soil NO_3-N contents as measured by the soil quality kit. All exact values measured were considered low (1.8-12.4 lb/ac), with the exception of the conventional tillage site at DeBolt, which had a value of 52 lb/ac. This value may be a result of the effects of spring fertilization just prior to sampling.

Infiltration Rate

Although statistical differences between infiltration rates were not found at any site (Table 4), the results indicate that no-till and forage systems positively influence infiltration. We might expect forages and no-tillage systems to have the highest infiltration rates due to increased aggregation and undisturbed pore space. The rangeland at Foremost and the pasture site at Bentley had a much slower infiltration rate than we would expect. The pasture at Bentley was situated on a discharge area, which caused the lower infiltration rate, while the cause of the Foremost situation is unknown.

Penetration Resistance

Compaction layers may represent a plough layer or may be due to tillage when the soil is too wet or excessive traffic in an area. While a significant difference between depths to the resistance layer was found between management systems at the Bentley site (Table 4), the depths measured at all of the sites were within the traditional cultivation zone (up to 23 cm deep) and didn't correlate with organic matter content or soil water content as might be anticipated.

Earthworms

Very few earthworms were found during this study (Table 4). Soil temperature, soil properties, food source and soil disturbance have an effect on earthworm populations and may have influenced these three sites. Alternatively, it is possible earthworms have not been introduced to the area.

Aggregate Stability

As described in the test kit interpretation guide, the assessment of aggregate stability is based on clay and organic matter content. Based on these characteristics, a suitable range of aggregate stability for the soils at Foremost would be 69-76%, 69-86% at Bentley and 67-77% at DeBolt. The results show that the aggregate stabilities are lower than suitable in all the management systems analyzed except in the permanent pasture site at Bentley (Table 4). In general, the greater the aggregation of a soil, the less erodible the soil will be. Erosion could be a problem with all of these soils if they are not protected with plant cover or residue. Although the results were much lower than expected, they do follow a trend whereby soils supporting forage systems have an increased ability to withstand the forces of flowing water due to increased organic matter content.

Comparison of Analysis Methods

Means of three indicators measured by the test kit and standard laboratory analysis are given in Table 5. Generally, the test kit yielded values significantly lower than those produced using standard laboratory methods. This trend was also observed by Liebig et al (1996). Significant differences may be attributed to the method of analysis. The soil quality test kit uses a 1:1 soil to water solution for pH, EC and nitrate determination. Standard analysis requires a 2:1 soil to water ratio for pH and EC, while a saturated paste is used for nitrate determination. Although significant differences were detected between the two methods for all three indicators, they resulted in similar interpretations; pH and EC are within acceptable ranges and the nitrate content would be considered low using either method.

Table 5. Means of indicators measured by the soil quality test kit and standard laboratory analyses.

Soil Quality Indicator	**Mean**	
	Soil Quality Test Kit	**Standard Laboratory Analysis**
pH	6.3b[#]	6.6a
EC (dS/m)	0.12b	0.44a
Nitrate NO_3 – N (lb/ac)	9.9b	20.0a

[#] means for each evaluation method, followed by different letters are significantly different at $P \leq 0.05$.

Test Kit Critique

The soil quality test kit is unique because it is able to perform *in situ* tests such as respiration, infiltration, bulk density, penetration resistance and earthworm concentration, which cannot be performed in a laboratory. The test kit results for pH, EC and nitrate content compared well to the results from standard laboratory analysis. Another positive feature of the test kit was the relative ease of use. The instructions included with the test kit are straightforward and step-by-step pictures provide the user with assistance.

An obvious shortcoming of the kit is it's lack of a test to measure soil organic matter. Soil organic matter (SOM) is very important in many soil processes and should be included as part of the test kit. The AESA Soil Quality Program is currently investigating a method to measure SOM in the field. The time commitment to perform the tests and the cost associated with acquiring the kit may also be drawback as land managers may not be willing to invest the time and money required. The test kit also doesn't provide follow-up information about what should be done if the results from the test kit are unfavourable.

CONCLUSIONS

The USDA soil quality test kit was able to characterize soil quality in the fields we tested. Problem areas and differences between management systems were identified with the help of the kit. The kit is useful to measure important dynamic soil properties that can only be measured *in situ*. We feel it is a useful tool for land managers to monitor soil quality in the field as it familiarizes them with their soil and gives them relatively quick results, which may lead to improved management decisions in the future. The test kit is a valuable soil quality awareness tool, which will help advance environmentally sustainable agriculture in Alberta.

ACKNOWLEDGEMENTS

The authors would like to thank the cooperators, AESA conservation staff, AAFRD staff and Norwest Labs for their assistance throughout this project.

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