Saskatchewan Soil Enhancement Project

G. Padbury, B. McConkey
Saskatchewan Soil Survey
University of Saskatchewan, Saskatoon, Sask.
Semiarid Prairie Agricultural Research Centre, Swift Current, Sask.

Objectives

1. To quantify changes in soil carbon for land that changed from conventional tillage to reduced tillage systems in 1996, including that due to the concurrent changes in the crop rotation and crop management.

2. To improve our understanding and capacity to estimate changes in soil carbon for agricultural land in Saskatchewan.

3. To develop baseline soils data and precise measurement locations for a network of fields representing the dominant soil-landscapes across Saskatchewan for measuring future changes in soil quality.

Background

In a stable ecosystem soil carbon inputs and outputs are equal over the medium to long term, and the soil is neither a source nor a sink of atmospheric CO_2. The extent to which soils function as a source or sink of atmospheric CO_2 depends on the initial steady state soil conditions, the imbalance between carbon inputs and outputs, and the duration of the imbalance before a new balance is established. An imbalance is created when the amount of crop residue returned to the soil is changed by the adoption of a new cropping system and/or the amount of decomposition of soil organic carbon is changed by adopting new tillage practices. Since annual inputs and outputs of carbon are small relative to the total amount of carbon stored in the soil, detecting short-term changes in soil carbon levels requires careful measurement.

Research Activities

In general, this project involves the establishment of a number of experimental sites throughout the agriculture region of the Province associated with a integrated set of research activities. Regarding the question of carbon sequestration, the information obtained from this project together with pertinent data from related research sites (e.g. long term rotation plots) will be used to validate or calibrate an appropriate soil carbon simulation model such as Century, which in turn will be used to predict soil carbon change and to effect the extrapolation both spatially and temporally from the research sites, to the region or province as a whole. The experimental sites and associated research activities can be grouped roughly as follows:

Level 1 Sites

The Level 1 sites will be used to measure the actual change in soil carbon associated with the adoption of minimum tillage technologies over a wide range of soil-management-climate combinations throughout the Province. About 125 of these sites, selected from a list of potential cooperators supplied by the Saskatchewan Soil Conservation Association, have been established in order to provide good representation of major soil and cropping sequences. Soil carbon levels will be measured at one site in each field initially (1996), after 3 years (1999), and, pending future funding support, at specified intervals thereafter.

Level 2 Sites

The Level 2 sites provide a direct comparison between the effect of minimum and conventional tillage technologies on soil carbon sequestration, particularly over the short term. Farmer-cooperators carry out tillage operations, representative of their previous conventional tillage system, on a small (5 ha) area within a minimum-till field. Three microsites were established in both the tilled and adjacent minimum tilled areas. Twenty five of these sites were established throughout the Province.

a) **Site selection.** The Level 1 and Level 2 sites were selected from a list provided by the Saskatchewan Soil Conservation Association. Each site was under conventional tillage prior to sampling (fall 1996), and then converted to minimum tillage either in 1996 or 1997. Sites were located in a relatively level part of the landscape so as to minimize the effect of erosion. Pertinent information concerning the soil-landscape characteristics of the field as well as the profile characteristics and the horizon depths of each core were recorded. Information was also solicited from the farmer cooperator concerning the past history of the field, including the cropping and management history and yearly information regarding the type of crop, the yield (above-ground biomass yields are measured in the vicinity of each microsite for Level 2 sites), the tillage practices used, fertilizer and pesticide applications, precipitation etc.

b) Sampling protocol. The sampling protocol was designed to minimize the confounding influence of the lateral or spatial variability in soil carbon. Each microsite consisted of a 2 x 5 m rectangular grid. Six soil cores, about 7 cm in diameter and at least 40 cm deep, were taken at 2 m intervals along each side the grid of a using a hydraulic, truck-mounted soil coring machine. Each core was divided into 10 cm segments (0- 10, 1 O-20,20-30, and 30-40 cm) and composited according to depth. Subsequent cores will be offset about 1 m from the initial cores. The sampling grid was aligned by compass in a north-south direction, and its exact location was identified by EMS markers buried at the northeast comer of the microsite. The general location of the microsite within the field was recorded relative to a known benchmark using a compass and tape.

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Research Sites

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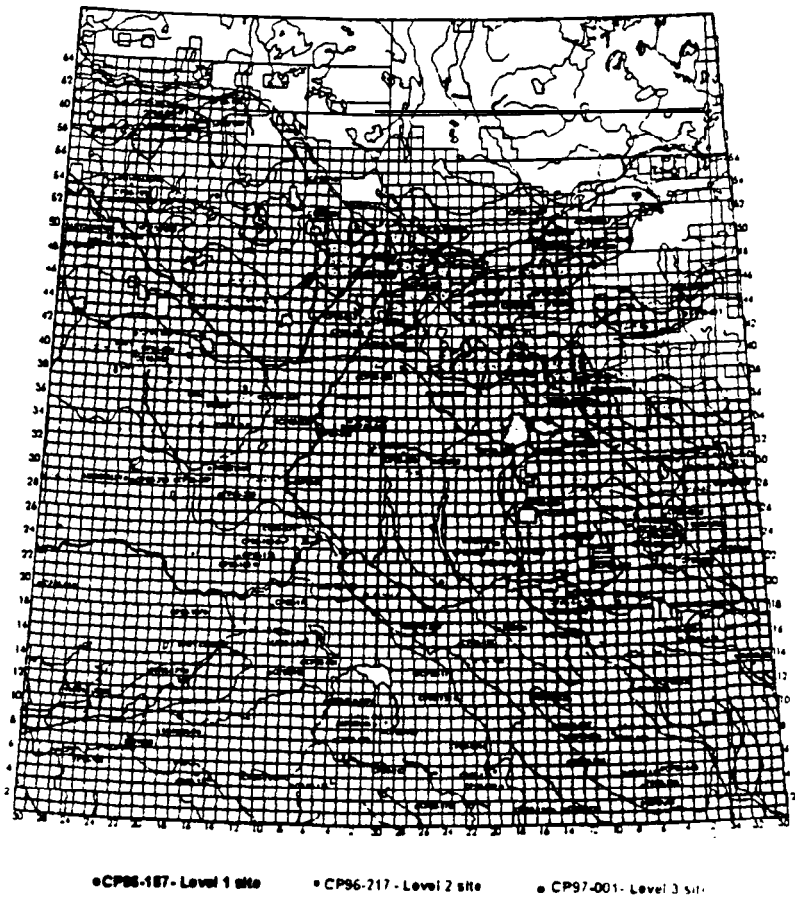
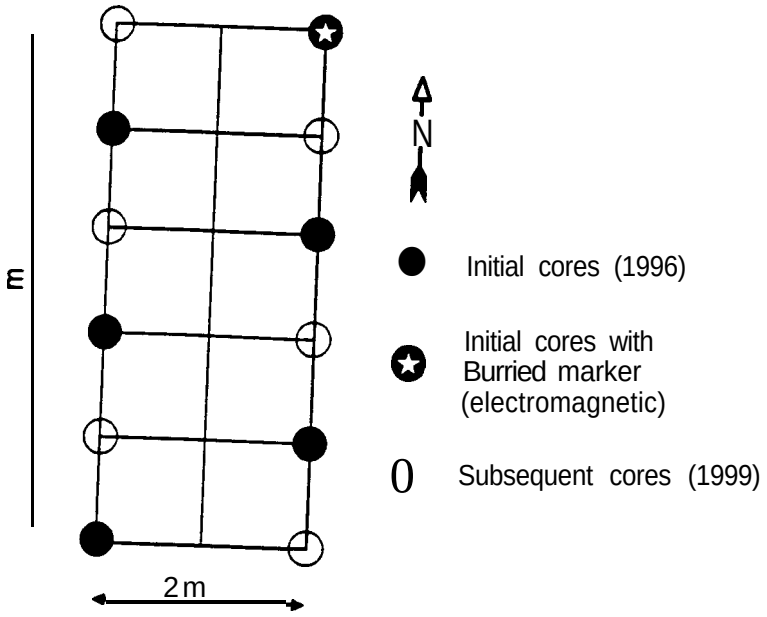


Location of Soil Cores Within Microsite



Level 3 Sites

1) **Paired-system comparison sites.** The objective of these sites is to demonstrate and confirm the anticipated relationship between the adoption of a direct-seeded cropping system and increasing soil carbon levels under management by farmers. Five paired-system sites; consisting of two adjacent fields, one that has been under a no-tillage system for six years or more, and the other that has been under a conventional tillage system have been be selected from across the Province. Soil carbon will be measured at several landscape positions from each field. Soil organic carbon levels will also be measured at neighboring native sites in order to establish the maximum carbon storage or sequestration capacity.

2) **Tillage system research sites.** Long term tillage-system comparison research plots across the prairies will also be resampled for soil carbon change for situations for which, otherwise, this measurement would not have been made. In addition, several tillage-system research sites will be sampled 3 or 4 years after experiment initiation to determine short-term changes in soil organic C and other soil quality parameters (in most cases, these latter experiments will not be long-term experiments).

3) Landscape sites. To minimize the current and past influence of erosion, the Level 1 and Level 2 sites were located in a level part of the field. However, there are sometimes large differences in the rate of SOC change from place to place within the landscape depending upon whether initial SOC levels are low as is commonly the case on the knolls and upper slopes, or high as is the rule on the lower slopes. At an additional 6 locations, microsites were placed on the upper, mid and lower slopes in order to help extrapolate the findings from the Level and 1 and 2 sites . These sites are in conjunction with variable-rate input or "precision farming" experiments so that reasons for differences in residue production among landscape positions is also being investigated.

4) **Soil quality indicators.** Other studies have shown that several indicators are more sensitive to a change in cropping or tillage systems than is total soil organic carbon. These include light fraction organic C, biomass C and N, water soluble C, aggregation and C associated with different aggregate classes, potential C mineralization (respiration), selected enzymes, and potential mineralizable N. By measuring these indicators, soil improvement (foreshadowing the eventual increase in total organic C) produced by a cropping system change may become evident before a change in total soil organic carbon can be clearly identified. Moreover, these parameters in themselves are important indicators of the sustainability of the cropping system in terns of soil fertility and soil erosion susceptibility. These parameters will be measured for the paired-field comparisons and selected research plots and, in 1999, for Landscape sites and for selected Level 1 and 2 sites.

Expected Results

The project will produce extensively verified estimates of soil carbon changes for the land converted to direct seeding in 1996. These changes will be estimated using an appropriate computer simulation model (e.g. CENTURY) linked to a Geographical Information System (GIS). It is expected while existing simulation models are not particularly well developed for predicting the effect of tillage systems on soil organic carbon, data from this study will provide an extraordinarily thorough and comprehensive data set by which to improve and validate these models.

References

B.H. Eliert and H.H. Janzen. 1996. Soil Sampling Procedure to Estimate Changes in Carbon Storage.
Project No 1113-9301. Soil Carbon Workshop, Regina, Sask.

Partners

The project involves the combined efforts of the Semiarid Prairie Agricultural Research Centre (SPARC), the Saskatchewan Soil Conservation Association (SSCA), and TransAlta Corporation.