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Soil health scorecard developed for Saskatchewan

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A Saskatchewan Assessment of Soil Health (SASH) scorecard was developed to help assess soil health from soil tests. The most important factors in determining soil health from soil tests were soil carbon and nitrogen factors of soil organic C, active C, total N, and soil protein, along with total phosphate.

Soil health has been defined as "the capacity of soil to function as a vital living system, within the ecosystem and land-use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health" (Doran and Zeiss, 2000). While some countries have developed soil health tests to monitor changes in soil over time, in western Canada, there was no standardized, Prairie-based system for assessing soil health.

The objective of this research was to develop a soil health scoring framework for Saskatchewan soils that integrates biological, physical, and chemical indicators. This framework would use these soil attribute values to develop meaningful scores and use a weighting system to calculate the overall soil health score.

Soil samples were taken from 55 fields at 26 sites at Agri-Arm locations, producer fields, and Agriculture and Agri-Food Canada (AAFC) long-term sites in the fall of 2018. These sites included 4 in the Gray soil zone, 13 in the Black zone, 21 in the Dark Brown zone, and 17 from the Brown zone. Composite soil samples were collected from the 0 to 6, 6 to 12 and 12 to 24 inch depths (0-15, 15-30, and 30-60 cm).

Forty-four per cent of fields were cropped to canola, 29% to wheat, 15% to pulse crops, with 3 sites in green manure, and 1 site each in flax, barley and potato. One native prairie grassland and one woodland site were also included.

The samples were analyzed for range of soil chemical, physical and biological attributes. Chemical attributes included pH, EC, and total soil concentrations of phosphate, potassium, sodium, magnesium, calcium, manganese, iron, copper, zinc, boron, and sulfur. Soil nitrate (NO_3^-), ammonium (NH_4^+), soil organic carbon (SOC), total carbon (TC), total N (TN) and potentially mineralized N were also calculated.

Soil physical attributes were determined for soil texture, field capacity (FC) and wet aggregate stability. Soil biological attributes measured were soil protein, active carbon, soil respiration (CO_2), and nitrous oxide (N_2O) production.

Data analysis determined the weighting factors in order to integrate each soil attribute into a soil health scorecard called the Saskatchewan Assessment of Soil Health (SASH).

Soil carbon, soil N and total P most important factors

The importance of soil attributes varied by sampling depth. At 0 to 6 inch sampling depth, the top 6 attributes with the greatest weighting and influence on soil health score were phosphate, total carbon, active carbon, soil organic carbon, total N and N_2O.

For the 6 to 12 inch depth, the attributes that have the most influence on the soil health score are were total carbon, soil organic carbon, field capacity, phosphate, total N and wet aggregate stability. For the 12 to 24 inch depth soil organic carbon, field capacity, total N, zinc, and total carbon have the greatest influence.

Soil protein, active carbon, total N, total carbon, and soil organic carbon were responsible for the most variations in soil health. Carbon and N are important parts of soil organic matter, which is important for nutrient supply and cycling, water supply and cycling, climate regulation, and supporting plant growth. However, changes in soil organic matter are detected over a longer period of time, making it difficult to assess changes in soil health in short timeframes. The SASH framework offers a way to measure soil health changes more quickly, since it measures both labile (active carbon and soil protein) and stable forms (total carbon, total N and soil organic carbon) of soil organic matter.

The SASH score was lower in the 0 to 6 inch depth than deeper depths. The SASH score was 56.97% in the 0 to 6 inch depth, and an average score of 63.88% at the 6 to 12 inch depth, and 64.33% in the 12 to 24 inch depth.

The overall SASH score in the 0 to 24 inch depth ranged from 41.24% to 77.05%. The highest score was on native prairie. This overall SASH score did not differ between soil zones, with a median ranging from 60.17 to 65.68%.

The researchers also compared soil health scores to crop productivity by looking at cereal crop yields in the rural municipalities where the samples were collected over the previous 10 years. During dry years, a positive relationship was observed between higher soil health and higher yields.

A case study was conducted on three sites. The native grassland site had a SASH score of 76%. Farm 1 in the Black soil zone had a history of no-till cereal and oilseed production and a crop rotation that included a cover crop mixture that was periodically grazed by livestock. This farm had a SASH score of 70%, which was close to that of native grassland. Farm 2 had a SASH score of 48%, and had a history of intensive potato production with frequent tillage.

Overall, the research found that soil C- and N-indices and total P are the main drivers of soil health differences. Management decisions that support biogeochemical cycling, C and N sequestration, and P retention may also improve soil health scores. The SASH framework provides a foundation to help convert soil test data into a soil health scorecard. An online SASH tool is under development and will help inform on-farm management decisions to improve soil health.

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