Quantifying Changes in Soil Organic Carbon Levels in Saskatchewan Crop Production

Event

In the late-1990s, Saskatchewan farmers began adopting more sustainable soil and land management practices. Significant reductions in two specific practices, soil tillage and taking land out of production for a full crop year or summerfallowing, have helped improve soil organic carbon (SOC) levels by decreasing soil disturbances and increasing the amount of post-harvest crop residues.

Significance

Agriculture accounts for about 10% of total Canadian greenhouse gas (GHG) emissions. Canada's commitment to the 2015 Paris Accord requires emission reductions of 30%, based on 2005, by 2030. Carbon sequestration transfers carbon through photosynthesis, from the atmosphere into soil storage pools, reducing net emissions. The challenge is that Saskatchewan farmers' contributions to Canada's climate goals through adoption of carbon capturing practices are minimized in policy discussions. Policies using a 2005 baseline grossly discount farmers' contributions, as by the early 2000s adoptions of these practices had already occurred on a broad scale.

Analysis

Saskatchewan farmers were surveyed on their land management practices. Sixty-four farmers completed questions regarding 1991-94 and 126 completed questions regarding 2016-19. Results found hectares managed with summerfallow decreased from 44% to 1% between 1991-94 and 2016-19. Land managed by conventional tillage as the main form of weed control decreased from 51% to 3%, while the use of minimum-till and no-till increased from 35% to 42% and 14% to 55%, respectively. Farmers identified several contributing factors to these management changes, with the introduction of herbicide tolerant (HT) crops, especially HT canola in 1995, being the most significant. The adoption of other genetically modified (GM) HT crops like corn and soybeans and mutagenic HT crops like wheat and lentils have also contributed to farmers' ongoing ability to practice minimum-till and no-till.

Carbon accounting results show that in 1991-94, the average Saskatchewan hectare (ha) was a net carbon emitter, releasing 0.02 tonnes(t)/year(yr) from tillage. By 2016-19, the average hectare became a net sink, storing 0.12 t/yr from the combination of carbon no longer released from tillage and increased carbon storage from continuous crop production. Similarly, soil carbon storage from summerfallow reductions increased from 0.03 t/ha/yr in 1991-94 to 0.42 t/ha/yr in 2016-19. Summerfallow reductions increase SOC levels by reducing soil emissions from decomposition and increasing crop residues from continuous cropping. By 2016-19, only 1% of land included summerfallow, indicating that significant emission reductions from summerfallow elimination have been achieved.

Applying these values to total Saskatchewan crop production (15.2 million ha) indicates that reductions in tillage between 1991-94 and 2016-19 caused soils to go from being a net carbon emitter of 0.28 million t (Mt)/yr to a net sink of 1.81 Mt/yr. From reductions in summerfallow, Saskatchewan carbon storage increased from 0.51 Mt/yr to 6.40 Mt/yr. Canadian agriculture emits about 73 Mt CO_2 equivalents, or 20 Mt of carbon, each year. Carbon accounting results show that from 2016-19, Saskatchewan soils were annually storing 9-32% of total agricultural emissions from reductions in tillage and summerfallow. Results also indicate that Saskatchewan soils are currently storing 3-11% of Canada's required emission reductions of 219 Mt CO_2 equivalents in the Paris Accord each year.

Farmers' carbon storage can be valued using three pricing scenarios: the Nori carbon removal marketplace; the 2019 federal carbon tax; and the Canadian social cost of carbon. The 2019 value of the increase in annual carbon storage between 1991-94 and 2016-19 ranges from C$10-$23 per ha from the adoption of conservation tillage, and C$28-$65 per ha from the removal of summerfallow. Applying these estimates to total Sask. crop production, the increase in annual carbon storage from changes in tillage practices is valued from C$152 – $351 million, and from the removal of summerfallow, C$429 - $992 million. The wide range in valuation results from the spread in values used as upper and lower estimation bounds, which increases the confidence level of the estimates.

Conclusion

Reductions in tillage and summerfallow practices are key drivers of Saskatchewan agricultural sustainability improvements. These adoptions, facilitated by technologies including GM and HT crops and their related chemicals, are essential to Canada's ability to increase, and sustain, its carbon storage capacity. It is estimated that Saskatchewan soil sequesters up to 8.5 Mt/yr of carbon, potentially valued at over C$1.3 billion.