SOIL CONSERVATION COUNCIL OF CANADA
CONSEIL DE CONSERVATION DES SOLS CANADA

Global Warming and Agriculture

The Carbon Cycle

In this, the second in a series of information sheets aimed at discussing global warming and its relationship with agriculture in Canada, we'll look at carbon dioxide (CO_2). Specifically, we'll explore the role CO_2 plays in the global warming scenario and the affect agriculture can have on global CO_2 levels.

Carbon dioxide - what is it?

Carbon dioxide is considered the largest contributor to global warming. What is it? Where does it come from?

There are vast amounts of carbon (C) in global circulation. The oceans hold most of the C while the atmosphere and the world's soils and forests hold much of the rest.

Of these C pools, the atmosphere holds the smallest amount, but is the most active. Atmospheric C combines with oxygen to form CO_2. This CO_2 is continually on the move. Some of it is absorbed and released by oceans. Some is used by plants and other photosynthetic organisms on land and water. They absorb CO_2 from the atmosphere, and use energy from the sun to combine it with water into organic matter (composed of carbon, hydrogen and oxygen). As well, CO_2 is continually being released into the atmosphere through respiration, organic matter decay and burning.

This give-and-take has been going on for centuries and things have stayed pretty much in balance.

The problem started a relatively short time ago with the advent of the industrial revolution. For centuries, Earth had been packing excess C away deep below its surface, and in its forests and soils. The industrial revolution required energy. Coal and oil resources were extracted and burned, releasing their stored C into the atmosphere in the form of CO_2. This situation was aggravated by the clearing of forests for industrial and agricultural purposes. Agriculture worsened the situation by breaking the land thereby releasing centuries old soil-stored C into the atmosphere in the form of CO_2. Our Earth's system of balance, that kept CO_2 levels relatively constant for 10,000 years, has been thrown out of whack with CO_2 levels rising 30% in a mere 140 years and becoming a major contributor to global warming.

The carbon cycle

As discussed in the previous information sheet all segments of society will have to do something if the CO_2 imbalance is to be effectively turned around. Agriculture will be no exception.

Within the agricultural C cycle, CO_2 is absorbed from the atmosphere by plant leaves and is transformed via photosynthesis into C-containing compounds like carbohydrates, sugars, cellulose and lignin. A portion of this is used by the plant for its own energy and released back into the atmosphere as CO_2. Some of the C remaining in the plant is removed during harvest with the rest returning to the soil as plant residue. This residue, along with the roots, becomes part of the soil organic matter. Soil microorganisms decompose the organic matter returning some of the C to the atmosphere in the form of CO_2. While rates of transformation vary due to such things as climate, soil and crop type, this cycle is essentially the same in all cropping systems.

Livestock adds another variable into this situation. The carbon in crops that might otherwise be harvested and exported can be fed to livestock and used as bedding. Some of the carbon is released into the atmosphere through animal respiration and some carbon is removed as meat products. Most of the C can be returned to the soil as manure.

What farmers can do - increasing soil carbon

The farming community has a lot to offer in terms of reducing C emissions. While no one knows for certain the amount of CO_2 that could be stored (sequestered) in agricultural soils, some predict that by using best

management practices, approximately 763 million tonnes of CO_2 could be sequestered in Canadian agricultural soil over a 20 year period. There are basically two ways farmers can reduce $C0_2$ emissions, one is to increase the amount of C stored, the other is to use less fossil fuel energy.

Farmers can influence the amount of C taken from the atmosphere to be stored in the soil. Management practices that accomplish this must concentrate on adding as much C to soil as possible and on slowing the rate of CO_2 release by decomposition.

Carbon dioxide in the air enters the soil by way of photosynthesis. It is trapped in organic forms and enters the soil as residue (including roots). Practices that encourage higher levels of photosynthesis enhance C accumulation, in other words, practices that increase plant yields. This can be done by using higher yielding crops and varieties, and by reducing water stress, where possible, through practices such as irrigation, water conservation or drainage. As well, any action that improves soil quality and thus promotes higher yields helps in this area. Another key goal is to keep plants actively growing, and thus photosynthesizing, on the land as much and as long as possible.

Increased photosynthesis helps build soil C only if some of the trapped C is returned to the soil. The more of the plant that's removed the more C is removed. Using practices that leave a maximum amount of residue in the field and including in crop rotations, forages that store much of their C in their roots, can promote soil C accumulation.

Slowing the rate of organic matter decomposition is another way to increase soil-stored C. Carbon dioxide is released from organic matter through microbial activity. A managerial goal is to make conditions less favorable for these microbes. For example, crop residue left on the soil surface slows microbial activity. As well, keeping growing plants on the surface as long as possible slows decay. Decay can also be reduced by shielding soil organic matter from microbes. Soils are usually granulated and organic matter is often protected inside the granule (or aggregates). Intensive tillage can break these aggregates open and expose the organic matter to soil microbes.

Farming practices that increase stored carbon

Specifically, the following managerial practices will encourage C sequestration.

- Reduce tillage. Tillage hastens the release of soil carbon into the atmosphere and practices such as summerfallow reduce inputs into the soil during the year when no crop is growing. Reducing tillage also protects soil resources from erosion.
- Apply more nutrients. Fertilizers, animal manures or green manure increase yields leading to higher inputs of C. Manure can also improve soil tilth adding further yield increases and residue additions.
- Grow more perennial forage crops. Perennial crops can trap more CO_2 than annual crops because they continue growing more months of the year. As well, many have extensive root systems that place C below ground.
- Remove land permanently from cultivation. This could mean removing marginal land from cultivation by establishing woodlots, planting shelterbelts, creating pastures, grassing waterways, etc.
- Eliminate summerfallow. During a fallow year, virtually no residue is added and the soil remains warm and moist hastening organic matter decay.
- Grow cover crops. When the season allows, a winter cover crop can be sown after the main crop. This practice can add residue and prevent erosion.
- Avoid burning of crop residues. When residues are burned almost all their C is returned to the atmosphere.
- Use crops and varieties that yield higher volumes of residue.
- Improve water management. Irrigation, snow trapping, etc. increase yields and thus residue returned to the soil.
- Restore wetlands. By putting previously drained wetlands back under water, oxygen is cut off, preventing organic matter decomposition.
- Integrate livestock into farm management plans.
- Improve grazing management. Overgrazing can result in large losses of C via erosion.

Agriculture also adds CO_2 into the atmosphere through direct or indirect use of fossil fuel energy. The next information sheet will investigate agricultural fossil fuel use and what can be done to reduce it.

Sources

Agriculture and Agri-Food Canada, Research Branch. 1998. The health of our air. Ottawa, Ontario.

The Soil Conservation Council of Canada. 1998. Carbon sequestration and trading implications for Canadian agriculture, discussion paper. Saskatoon, Saskatchewan.

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