The Economic, Agronomic and Environmental Impact of No-Till on the Canadian Prairies

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Executive Summary

No-till or zero-till (ZT) *(planting of a crop into the untilled stubble of a previous crop with little or no soil disturbance)* is a conservation practice, that is economical (saving on fuel, farm machinery-life and reduced labor costs, while maintaining or improving crop yields); and it is environmentally friendly (increased soil-organic matter, improved soil tilth, improved moisture conservation and use efficiency, and reduced soil erosion). No-till seeding also has the potential to sequester atmospheric carbon dioxide, an important factor in the mitigation of green house gas emissions.

No-till adoption rate – The adoption of no-till in western Canada experienced a pronounced upward trend since 1991. The planted acres using no-till practices are estimated to be growing at an annual rate of 626,000 acres in Alberta. Since the mid 1980s, considerable research has been done on the characterization of no-tillage on the Canadian Prairies. The main objective of this report is to examine the value of no-till practices on the prairies.

Economic of no-till – Adoption of no-till on the farm depends on the assumption that it will maximize net farm income and/or reduce risk taking. Factors that contribute to the net farm income include yield, cost of inputs used in crop production (labor, fuel, fertilizer, pesticide, seed and machinery), and expected output (commodities) prices.

Grain yield – On average crop yields are generally higher in no-till systems (wheat: 3.5%; barley: 6.2%; flax: 7.9%; peas: 4.6% and lentils: 13%).

Labor cost – There is a lower cost for labor in no-till (ZT): 3.5 passes; minimum tillage (MT): 5.8 passes, and conventional tillage (CT): 7.5 passes).

Fertilizer use – There is no agreement in the literature on the effects of no-till on fertilizer needs and nutrient availability. Some researchers have suggested that, over the long haul, fertilizer use decreases under no-till because it is injected (side or mid-row banded) below the soil surface, resulting in more efficient use of nutrients, while others have suggested that the fertilizer requirement increases or stays the same for both no-till and conventional tillage systems. A study in southern Alberta has shown that no-till wheat tied up nitrogen in residue and soil organic matter, resulting in reduced yields. No-till, accompanied by appropriate nutrient management, increased net returns by 5% for canola, 30% for wheat, and 25% for peas, but in canola, it raised fertilizer costs by 14%.

Fuel consumption – There is a significant reduction in fuel consumption with reduced and no-till as compared to conventional tillage (peas – ZT: 18.8 L/ha; MT: 23.7 L/ha; CT 32.3 L/ha; flax – ZT: 18.6 L/ha; MT: 23.7 L/ha; CT: 30.3 L/ha; wheat on fallow – ZT: 23.5 L/ha; MT: 30.6 L/ha; CT: 47.1 L/ha; wheat on stubble: ZT: 19.9 L/ha; MT: 24.0 L/ha; CT: 30.2 L/ha).

Pesticide use – There are conflicting reports on the relative use and cost of herbicides across tillage systems in western Canada. An Alberta Agriculture study showed no difference in herbicide cost between no-till and conventional tillage systems. However, the cropping practices survey in Saskatchewan showed that herbicide cost for minimum – no-till was slightly higher than for conventional tillage.

Seed use – Studies in western Canada have shown that growers do not vary the seeding rate by tillage practices.

Machinery use – No-till and minimum tillage require fewer trips across the field, allow two or more activities to be combined into one, and permit the use of machines with greater capacity and lower draft.

Cost comparisons – generally, the production costs for no-till are lower as compared to those for conventional tillage. However, there is a considerable variability in the economics of no-till among various soil zones. In the dry Brown Soil of Alberta and Saskatchewan, conservation tillage (minimum and no-till) systems are less profitable, especially in continuous cereal and cereal-fallow rotations, whereas, in the Dark Brown soils, no-till is equal to or marginally more profitable than in conventional tillage. In the Black and Gray soils of western Canada, no-till and minimum tillage are superior to conventional tillage. This cost advantage in the Black and Gray soils is due to higher grain yields and better cost of production for no-till.

The economic analysis of the cereal-fallow rotations in no-till and conventional tillage systems in the Brown and Dark Brown soils zones was carried out in the early 1990s when glyphosate prices were high ($25.00 /L) and application of N was broadcast on the soil surface rather than side banded below the soil surface. Since then there has been a significant drop in glyphosate price (< $8.00/L), more efficient fertilizer placement, a substantial increase in fuel prices, and a majority of farmers in these soil zones are now practicing diversified cropping rotations. If the economic comparison were made now between no-till and conventional tillage, by taking current glyphosate, fuel and lack of fallow into the economic benefit equation, the profit picture for no-till would be either equal or superior to conventional tillage.

Soil Conservation – On the prairies, the on-farm cost of soil erosion in 1980 was estimated to be nearly $430 million in Alberta, Saskatchewan $560 million, and nearly $44 million in Manitoba. Studies on the prairies have shown that soil losses were greatest from conventional tillage and least from no-till management systems. Since the early 1990s, ZT and MT along with other soil conservation practices have resulted in a significant decline in soil losses, and, as a result, only a small proportion of agricultural land is now susceptible to soil erosion (water erosion: < 14%; wind erosion 30%).

No-till reduces run-off – No-till increases runoff infiltration by slowing the flow of rainwater or snowmelt from the field. In no-till fields, there is also more infiltration as compared to tilled fields; consequently this results in fewer pollutants entering the streams and open water bodies. Reduced runoff in no-tillage is also associated with decreased flooding and an increase in soil moisture. However, by not tilling the soil, there is a concern that it may increase leaching of water, nutrients and pesticide to the ground water. There are conflicting reports in the literature about the role of no-till in enhancing leaching. Some studies have found little or no difference in leaching of water and nutrients between no-till and tilled fields while others report greater leaching in no-till soils than in tilled soils

No-till reduces sediment loss – The most common pollutants in environmentally impaired waterways are sediment, nutrients, and bacteria. No-till practices reduce the amount of sediment by 60 – 90%.

No-till reduces phosphorus loss – No-till practices typically reduce soil erosion and sedimentation losses and may result in less phosphorus lost in runoff. Information on the effects of tillage systems on phosphorus loss is contradictory. Some studies have reported significantly lower dissolved phosphorus losses under no-till as compared to conventional tillage, while other studies have demonstrated that no-till reduced the loss of particulate and total phosphorus in surface runoff; however, it does increase the loss of soluble phosphorus to ground water.

No-till reduces nitrogen losses – No till may reduce runoff resulting in less nitrogen loss. Several studies have shown that no-till reduces sedimentation up to 97 % (relative to conventional tillage), and this results in a 75 to 90 % reduction in total nitrogen loss for soybeans planted following corn and 50 to 73 % reduction in nitrogen loss for corn following soybeans. No-till crop production also increases the amount of soil macropores and allows for greater water infiltration, increasing potential for nitrate leaching compared to conventional systems. However, more recent studies have shown no difference in nitrogen leaching between tillage types.

No-till reduces runoff of pesticides – No-till farming practices leave a large amount of crop residue on the soil surface rather than ploughing it under; these practices can reduce runoff of sediments, nutrients and chemicals into streams by more than 90%.

In western Canada, some of the residual herbicides (2,4-D, MCPA, trifluralin) have often been detected in surface and ground water. Transgenic crops such as glyphosate (Roundup Ready crops) and glufosinate-tolerant varieties (Liberty Link crops) have the potential to significantly reduce herbicide losses and concentration in runoff. Planting herbicide-tolerant varieties such as Roundup Ready crops and Liberty Link crops, and replacing some of the residual herbicides with glyphosate or glufosinate herbicides, can reduce herbicide losses and concentrations in runoff. Such herbicides are thought to be more environmentally benign.

No-till impact on weeds, diseases and insect population – Adoption of no-till has an impact on weeds, diseases, and insect species diversity and numbers. Many broad-leaf weeds decrease in no-till; however, some grassy weeds and perennial weeds increase. Studies in Alberta and Saskatchewan have shown that year-to-year variation in climatic conditions and crop rotations have a greater impact on weeds than tillage systems.

There are conflicting reports in the literature on the incidence and severity of plant diseases in minimum and no-till systems. Some of the earlier studies documented an increased incidence and severity of disease levels in conservation tillage as compared to cultivation, while others showed a decrease or no effect.

Similar to weeds and plant diseases, insect pests respond differently to tillage practices. Populations of some species increase under minimum and no-till while others decrease.

No-till sequesters atmospheric CO_2 – In Canada, conservation tillage practices on the farmland offer a large opportunity to sequester carbon and consequently enhance the soil carbon sink. Over the years, various models have been developed to estimate the national potential of CO_2 sequestration on the cultivated land.

- Agriculture and Agri-Food, Canada Sink Table model: a national potential to sequester 18.3 Mt CO_2 per year on cultivated land by 2012.
- McConkey (1999) the Prairie Provinces model: estimates 14,734,408 tonnes of carbon dioxide per year could be sequestrated on the cultivated land by 2008 – 2011.
- Goddard (2001) has estimated the Alberta potential to sequester 5.9 Mt CO_2 per year on cultivated land by 2011.

No-till enhances wildlife habitat – Studies in Canada and the United States have shown that no-till farming practices, especially fall-seeded winter cereals, have greater abundance and diversity of songbirds, ducks, small mammals and soil arthropods.

No-till enhances the physical, chemical and biological properties of the soils – Tillage practices affect soil quality indicators in a complex way. No-till, retains large qualities of residues**,** resulting in an increase in organic matter content, improved soil structure, buffered soil temperatures, and allows soil to hold more water. All these changes regulate plant growth processes and crop yields. Some of the important effects of no-till on soil qualities are:

- Increased soil organic matter: 2.9 ± 1.3 Mg ha^{-1} yr^{-1}
- Increased available plant nutrients: increase in mineralizable N. No-till also increases N immobilization. However, $N - NO_3$ or "available" nitrogen levels are not affected by no-till. P and K levels also increase under no-till
- No-till soils have higher microbial biomass and earthworm populations

- Improved physical qualities: no-till soils resulted in greater aggregate stability and/or aggregate size distribution, decreased soil compaction, improved soil tilth and structure, less run-off and increased water infiltration, and soil moisture content. No-till soils also have greater bulk density in the surface horizon (0-10 cm)
- No-till soils have moderate soil temperatures and significantly less heat stress as compared to tilled soils throughout the growing season.