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Zero tillage: a greener way for Canadian farms

By Attah K. Boame

Zero tillage is associated with 'greener' farms, in more than one sense of the word. And it's breaking new ground by breaking less ground.

Zero tillage is a relatively recent innovation on Canadian farms however, it may not always be suitable for all crop and soil conditions. Zero till practices matched appropriately to crop and field conditions have the potential to reduce agriculture's impacts on the environment and lower energy and labour costs.

'Zero tillage' or 'no tillage' is the farmer's least labour-intensive option for growing crops. It's a one-pass operation that places seed and fertilizer in a relatively undisturbed seedbed, and packs the furrow while retaining surface residue to prevent soil erosion. Zero tillage is a system where mechanical tillage of the soil of any kind is avoided and seeding and fertilizing is done in this one pass operation with as little soil disturbance as possible. Zero tillage seeding systems also allow farm operators to seed with fewer tractor hours, thereby reducing operating expenditures.

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Symbols

The following standard symbols are used in Statistics Canada publications :

.	not available for any reference period
-	not available for a specific reference period
…	not applicable
p	preliminary
r	revised
x	confidential
A	excellent
B	very good
C	good
D	acceptable
E	use with caution
F	too unreliable to be published

Canada had some 4.1 million hectares of agricultural land under zero tillage in 1996[1], the fourth highest land area in the world (Climate Change Central 2002)[2]. Only the United States (19.3 million hectares) Brazil (11.2 million hectares) and Argentina (7.3 million hectares) had more area under zero till (Derpsch 2001)[3]. By 2001 zero tillage had become a common practice on about 30% of the cultivated farmland in Canada. However, a study by Agriculture and Agri-Food Canada in 2003 found that only 14% of agricultural producers with seeded cropland use zero till technology.[4]

Several factors increase the likelihood of Canadian farms using zero till practices. The study found that young and middle-aged farmers, high farm sales, and the hiring of a custom operator increase an operator's likelihood of adopting zero tillage practices in crop production. Farmers in the Prairie Provinces and Ontario used zero till more than farmers in other provinces.

Cereals, pulses, vegetables and oilseeds tend to be the most prominent crops grown on farms reporting zero tillage. On the other hand, the presence of livestock on a farm operation, in particular, cattle and poultry, reduces an operator's likelihood of using zero tillage.

1. Most recent internationally comparable statistics.
2. Climate Change Central (2002) Carbon Credits Could be Next Cash Crop, *Climate Change Central Newsletter*, Issue 3. //www.climatechangecentral.com/info_centre/C3Views/c3views_apr02.html
3. Derpsch, Rolf (2001) *Keynote: Frontiers in Conservation Tillage and Advances in Conservation Practice* In D. E. Stott, R. H. Mohtar and G. C. Steinhardt (eds.), 2001, Sustaining the Global Farm, Selected papers from the 10th International Soil Conservation Organization Meeting held May 24-29, 1999 at Purdue University and the USDA-ARS National Soil Erosion Research Laboratory, pp. 248-254.
4. Agriculture and Agri-Food Canada (2003) *Agricultural Policy Framework*.

Zero tillage: helping make agriculture sustainable

Appropriate tillage practices not only reduce the impact of agriculture on the environment; they help make agriculture sustainable.

Sustainable agriculture protects the natural resource base, prevents the further degradation of soil, water, air quality and conserves biodiversity. Conservation farming practices used over the past 15 to 20 years have now stabilized the organic matter in many Canadian agricultural soils. This has been done by increasing the amount of organic matter added to soil, such as adding manure, fertilizer, and returning unharvested material to the soil. Other practices include reducing losses of organic matter and carbon by managing crop residues and controlling erosion.[5]

Conservation farming practices capture carbon dioxide from the atmosphere, bind carbon in organic matter, and return some of it to the soil where it can be stored. A benefit of accumulating carbon in the soil is the reduction of atmospheric carbon dioxide. Carbon dioxide is a greenhouse gas (GHG) that is building up in the atmosphere, contributing to global warming, and a serious environmental issue.

With the ratification of the Kyoto Protocol (KP), Canada has made a commitment to reduce its GHG emissions between 2008 and 2012 to 94% of the 1990 emission levels. Agricultural production activities are a significant source of Canada's GHG emissions responsible for about 10% of those emissions, not including the use of fossil fuels or indirect emissions from fertilizer production (Agriculture and Agri-Food Canada 2003).[6]

5. McRae T., C.A.S. Smith, and L.J. Gregorich (eds), (2000) Environmental Stability of Canadian Agriculture, Report of the Agri-Environmental Indicator Project Agriculture and Agri-Food Canada, Chapter 9. www.agr.gc.ca/policy/environment/pubs_aei_01_e.phtml.
6 Agriculture and Agri-Food Canada (2003) *Climate Change and Greenhouse Gas Awareness Study*.

Zero tillage both reduces GHG emissions and contributes to the accumulation of carbon in agricultural soils.

Data sources

The main sources of data are from Statistics Canada's 2001 Farm Environmental Management Survey (FEMS) and the 2001 Census of Agriculture. FEMS, conducted in March 2002, was carried out on behalf of Agriculture and Agri-Food Canada to measure current farm environmental initiatives and farming practices. With the permission of respondents, records from FEMS have been linked to the 2001 Census of Agriculture in order to make use of a richer set of information. The data set has 16,053 observations. The unit of analysis is the farm level, which facilitates detailed analysis. The Census of Agriculture has data for up to three operators per agricultural operation. Our analysis is based on Operator 1 who is responsible for the day-to-day management decisions of the farm.

www.agr.gc.ca/policy/spb/rad-dra/publications/climat/climat_e.php.

One of several tillage options for farmers

Tillage is the practice of working the soil for the purpose of bringing about more favourable conditions for plant growth. Farmers have several tillage options and they can all be classified into one of three tillage systems. The three primary tillage systems are zero or no tillage, conservation tillage and conventional tillage.

Zero or no-till includes direct seeding into stubble or sod as well as ridge tillage. Conventional tillage (clean till) incorporates most of the crop residue into the soil, while conservation tillage (minimum till) retains most of the crop residue on the surface. Compared to other tillage practices, zero tillage offers several economic, environmental and agronomic benefits.

Zero till reduces erosion, labour costs

Zero tillage seeding is a one-pass operation that places seed and fertilizer into an undisturbed seedbed, packs the furrow and retains adequate surface residue to prevent soil erosion. Zero till increases soil organic matter, enhances water filtration, conserves moisture and reduces runoff and soil erosion due to wind and water. Zero tillage contributes to increasing soil organic matter because it reduces the rate of decomposition of the organic matter. Carbon represents a substantive proportion of all organic matter.

Composition of Organic Matter in Soils

Soil organic matter makes up about 5 to 10% of most agricultural soils. Similar to the plants and animals from which it is derived, organic matter is composed of carbon chains and rings to which other atoms are attached. The terms soil organic matter and soil organic carbon are often used interchangeably, because carbon, the key component of organic matter, is readily measured in the laboratory. Soil organic matter typically contains about 50% carbon, 40% oxygen, 5% hydrogen, 4% nitrogen and 1% sulphur. (Environmental Stability of Canadian Agriculture, Report of the Agri-Environmental Indicator Project Agriculture and Agri-Food Canada, Chapter 9. www.agr.gc.ca/policy/environment/pubs_aei_01_e.phtml.)

Farm operators can achieve significant labour savings with zero tillage. Zero tillage seeding systems allow producers to seed with fewer tractor-hours and hence reduce fuel consumption and extend the life of their tractors. This reduces overhaul, replacement and operating expenses. Canadian farmers can save on average an estimated 5.9 litres/hectare of diesel for every tillage pass that they eliminate. Since the average farm is 274 hectares, this translates into an annual savings of 1617 litres of diesel using minimum tillage and 3233 litres using zero tillage[7]. The 39% increase in the use of reduced-tillage practices between 1991 and 2001 led to an estimated savings of 3052 terajoules in 2001. This translates into a reduction of 227 kilotonnes of GHG emissions.[8]

Furthermore, studies conducted throughout the Prairies have shown that zero tillage seeding systems can provide higher spring soil moisture and lower evaporation losses compared to conventional tillage systems (PFRA 2003).[9]

Some farmers reluctant to use zero till

Despite the environmental and financial advantages of this practice, several factors currently discourage the use of zero tillage.

The main drawback with zero tillage systems is that farmers have to acquire new seeding machinery. As a result, initial capital costs can be high. In addition, the machines that are currently available may not all be able to handle the levels of vegetation residues remaining on the field under zero tillage conditions and the fertilizer placement. Also, zero till is still a relatively recent innovation and may not be suitable for all crop and field conditions.

Almost all farmers with cropland now use a number of proven practices to minimize the impact that agriculture can have on the environment. These practices include tillage management, soil tests for nutrient management, shelter belts, field belts and wind breaks. Agriculture and Agri-Food Canada has stated in its Agricultural Policy Framework[10] however that decreasing the number of bare-soil days on farmland and increasing no-till or conservation tillage are major issues that still merit further attention.

A study by Agriculture and Agri-Food Canada 2003 found that only 14% of agricultural producers with seeded cropland use zero till technology despite its proven favourable effect on the environment. Two thirds of the producers reported that they were still using conventional tillage as the main tillage practice while the remaining 30% reported conservation tillage.[11]

These findings raise a number of agricultural policy questions. What are the characteristics of the farmers and farm operations that use zero till technology? What sort of information might be useful in promoting the practice of zero tillage among Canadian farmers?

Zero tillage practices around the world

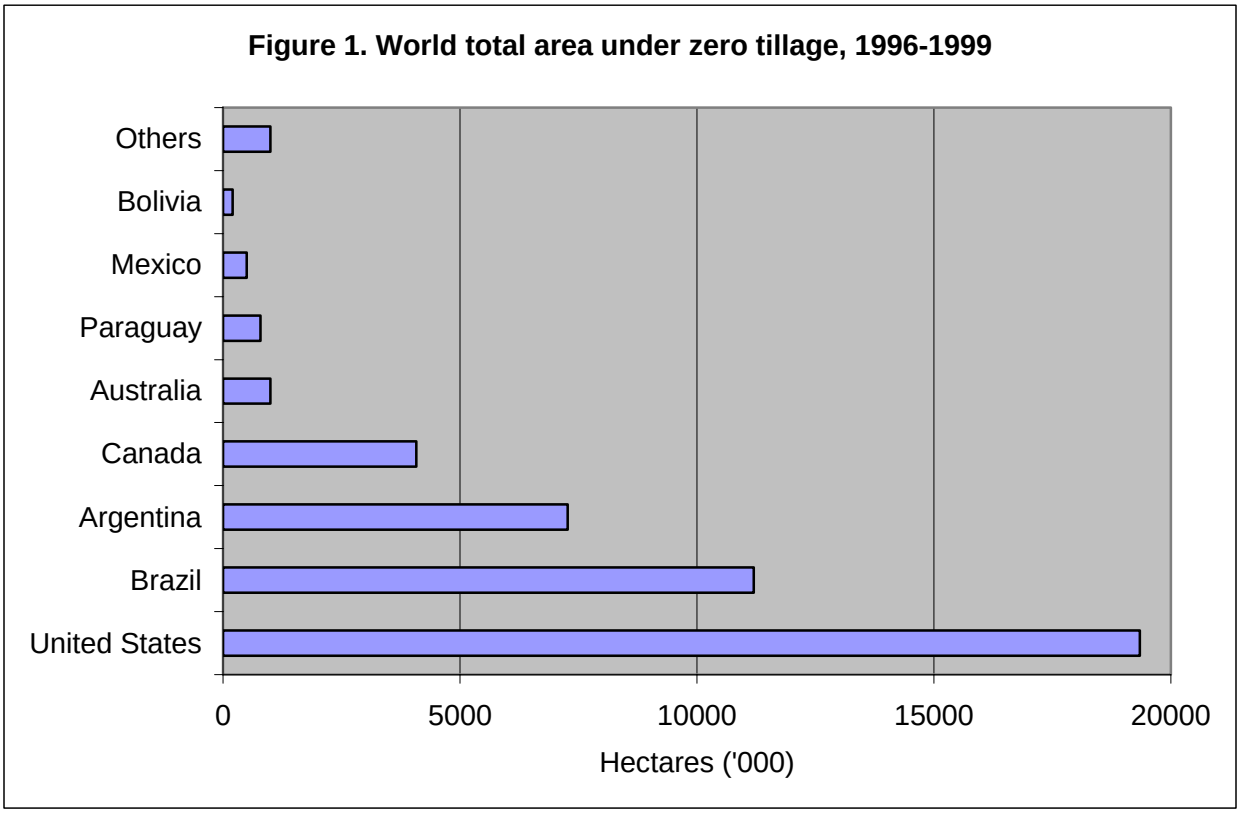
Zero tillage systems are not new to North America. Zero tillage has been the focus of research in the United States as early as the 1940s and more intensively in the 1950s. In Europe, research into zero tillage began in the 1960s and in Brazil and Latin America

7. Natural Resources Canada (2003) *Energy Efficiency Trends in Canada, 1990 to 2001*, June. www.oee.nrcan.gc.ca/neud/dpa/data_e/Trends/chapter_7.cfm.
8. Ibid.
9. Prairie Farm Rehabilitation Administration (2003) *Economics of Zero Tillage*. www.agr.gc.ca/pfra/soil/swork1.htm .
10. Agriculture and Agri-Food Canada (2003) *Agricultural Policy Framework*. www.agr.gc.ca/cb/apf/index_e.php.
11. Agriculture and Agri-Food Canada (2003) *Climate Change and Greenhouse Gas Awareness Study*, www.agr.gc.ca/policy/spb/rad-dra/publications/climat/climat_e.php.

research into the technology began in the early 1970s. Today, zero tillage technology is widespread.

Canada had some 4.1 million hectares of agricultural land under zero tillage in 1996, the fourth highest land area in the world (Climate Change Central 2002). Only the United States (19.3 million hectares) Brazil (11.2 million hectares) and Argentina (7.3 million hectares) had more area under zero till (Derpsch 2001) (Figure 1). By 2001 zero tillage had become a common practice on about 30% of the cultivated farmland in Canada. However, a study by Agriculture and Agri-Food Canada in 2003 found that only 14% of agricultural producers with seeded cropland use zero till technology.

Figure 1. World total area under zero tillage, 1996-1999



Source: Derpsch (2001, Table 1)

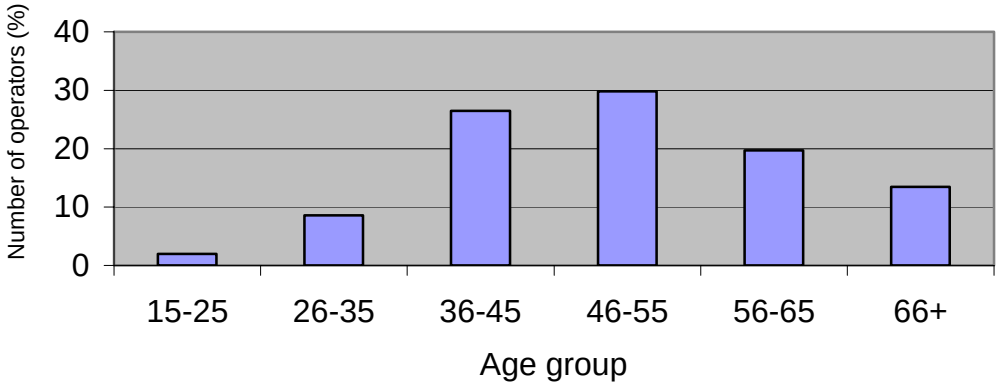
Younger, middle-aged farmers most likely to practice zero till

Younger farm operators are the most likely to adopt zero till practices. This likelihood decreases as operator's age increases beyond 56 years.[12] Figure 2 shows the age distribution of the operators and the adoption of zero till technology.

12. This is confirmed by the Spearman correlation coefficient of -0.0545, which falls within the 95% confidence interval limits (-0.0589, -0.0501). The correlation coefficient measures the strength or degree of linear association between two variables, in this case, between operator's age and the likelihood of adopting zero tillage practice. The value of the correlation coefficient lies between -1 and +1. The closer the correlation coefficient approaches -1 or +1, the stronger the linear association between variables.

A binomial logistic regression model was used to identify the relationships between the characteristics of the farmers and farms where zero tillage was practiced and where it was not. This model found the operator's likelihood of using zero tillage technology peaks between age 36 and 55, then declines. These farmers may be those who are most likely to have a long-term business perspective. On the other hand, being male or female does not seem to play an important role as to an operator's likelihood of adopting a zero tillage technology.

Figure 2. Percent of operators using zero tillage by age group, 2001



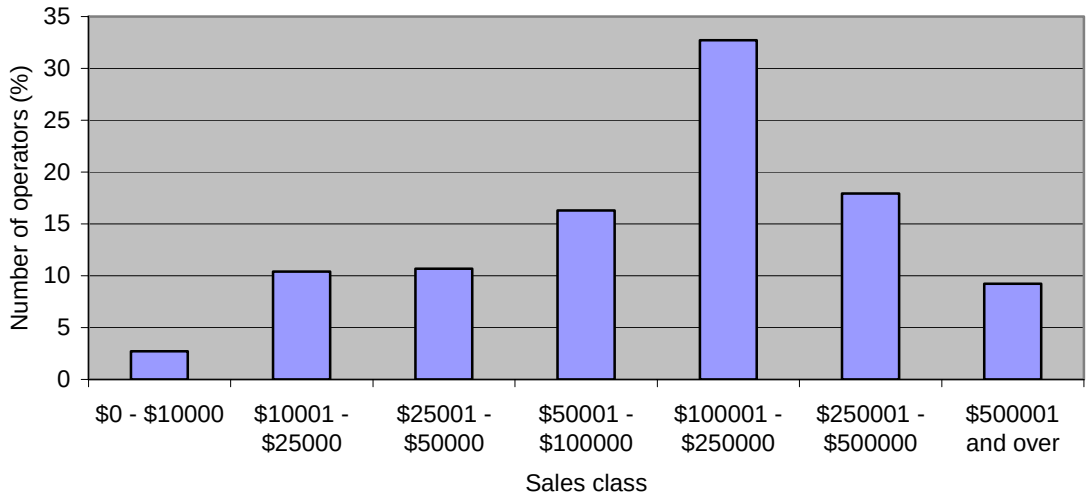
Source: 2001 Census of Agriculture

As sales increase, so does zero tillage

Zero tillage conserves soil and moisture and is, at the same time, labour-saving and cost-cutting, i.e., it reduces operating costs over time. Higher sales operations are most likely to incur higher operating costs. In order to reduce costs, it is reasonable to assume large operations will be among the first to adopt zero tillage. Indeed, figure 3 shows that higher sales operations tend to use zero till practices in their crop production process.

The operators of large farms are more likely to use zero tillage than those operating smaller farms as they may see zero tillage as a means of cutting costs. Similarly, farm operations that make use of custom operators are more likely to apply zero tillage technology. Since zero tillage tends to reduce costs, custom operators have been quick to adopt the technology to reduce their costs.

Figure 3. Percentage distribution of zero tillage operators in each sales class, 2001

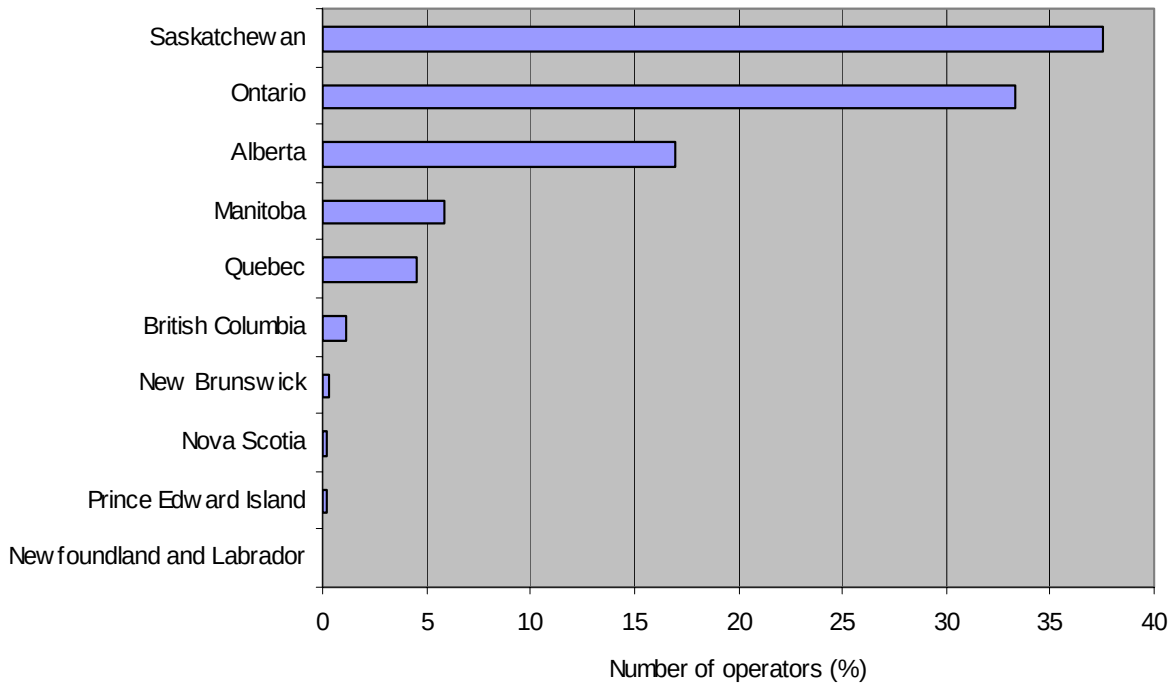


Source: 2001 Census of Agriculture

Prairie farmers most likely to practice zero till

Climate, soil characteristics and geographical factors also influence the types of crops that are grown in different regions of the country. It is thus of interest to examine how zero tillage technology varies among the Canadian provinces. The data presented in Figure 4 show that, with the exception of Ontario where 33% of all operators use zero till, zero tillage is a Prairie practice. Saskatchewan leads all provinces with 38% of them practicing zero till on all or some of their land, followed by Ontario at 33%, Alberta at 17% and Manitoba at 6%.

Figure 4. Provincial distribution of zero tillage operators, 2001



Source: 2001 Census of Agriculture

Pulses and other crops associated with zero till

The results show that farmers that grow pulse crops, such as peas, are the farmers that are most likely to adopt zero tillage practices. This confirms that pulses and oilseeds, which at early growth stages are susceptible to hot winds and abrasion from wind blown soil particles will benefit from zero tillage. Vegetable and cereal growers are also more likely than others to use zero tillage practices.

It does not come as a surprise to find that farmers that summerfallow are unlikely to have adopted zero tillage. Farm operators interested in zero tillage are less likely to use summerfallow because it can contribute to soil erosion, soil salinity and organic-matter losses. As well, zero till replaces some of the need for summerfallow.

Farm operations that have poultry and cattle are also less likely to produce crops under zero tillage technology. On the other hand, the presence of "other livestock" (e.g., elk, bison, goats, llamas) increases the likelihood of an operator using zero tillage practices, other things being the same. The presence of sheep and pigs does not appear to influence farm operators' likelihood of using zero tillage.

Some crops such as cereals appear to lend themselves to the use of zero tillage practices. Some, such as potatoes do not. Whether this is the result of the practice being unsuitable for a particular crop or field conditions or whether it is the result of resistance to change or the economic costs of change is not clear and represents an issue for more investigation.