INTERNATIONAL
SOIL AND WATER
CONSERVATION RESEARCH

The development and adoption of conservation tillage systems on the Canadian Prairies

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Abstract

One of the major agricultural innovations on the Canadian Prairies over the last 40 years has been the introduction of conservation tillage (CT). Conservation tillage-a system that includes minimum and zero tillage (ZT) -was introduced as an alternative to traditional (conventional) tillage (TT) to control soil degradation and to promote agricultural sustainability. The development and adoption of CT systems involved pioneer farmers, engineers, scientists, and farmer associations. By the end of the 1970s, CT started to take shape on the Prairies, but for a number of economic, technical, political and social reasons, the adoption of CT did not occur on any major scale before the 1990s. Today, more than 75% of the Prairie's cropland is under some form of CT with more than 50% under ZT. In this paper, the factors behind the development and adoption of conservation tillage technology on the Prairies in the period between 1930 and 2011 are reviewed. Then, some of the benefits of the adoption of CT on the Prairies are highlighted. The data show that CT and ZT became profitable for the majority of farmers during and after the 1990s, and that the increased use of CT contributed to the dramatic decrease in the area under summerfallow and to the increase in the area sown to canola and pulse crops. These changes contributed to the reduction of all forms of land degradation and to decreases in agricultural greenhouse gas (GHG) emissions.

Key Words: Conservation tillage, Zero tillage, Land degradation, Innovation development and adoption, Economic and environmental benefits

1 Introduction

Canada has about 38 Mha of arable land; of this, about 32 Mha is located in the Prairies (Campbell et al., 2002; Zentner et al., 2002). The Prairies area covers the south of Alberta, Manitoba, and Saskatchewan, and is divided into five soil-climate zones, Brown, Dark Brown, Black, Dark Grey, and Grey (Fig. 1). The Brown soil zones are located in the southern part and the Black and Grey soil zones are located in the northern part of the Prairies (Fig. 1). About 57% of the Prairies' arable land is located in the Black, Dark Grey, and Grey soil zones; 22% in the Dark Brown soil zone; and the rest in the Brown soil zone. The soil colour notation is an indication of the soil organic matter content that accumulated within the topsoil. The organic matter content of the surface 30 cm is about 2%, 4%, and 7% in the Brown, Dark Brown, and Black soil zones, respectively, and ranges between 1% and 10% in the Grey soil zones (Campbell et al., 1990).

In general, Black and Grey soil zones are cooler and receive more precipitation than Brown soil zones. Annual precipitation increases from 350 mm in the Brown soil zone to 475 mm in the Black and Grey soil zones. Mean annual temperatures are higher in the Brown soil zones than in the Black and Gray soil zones. Annual mean temperatures on the Prairies range, on average, between 0.3℃ and 5℃ (Campbell et al., 1990).

The main crops grown on the Prairies are: wheat, oats, barley, tame hay, flaxseed, canola, mustard, lentil,

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and peas. In 2011, the Prairies produced about 22.5 Mt of wheat, 2.7 Mt of oats, 7.4 Mt of barley, 16.5 Mt of tame hay, 0.4 Mt of flaxseed, 14.5 Mt of canola, 0.13 Mt of mustard, 1.4 Mt of lentil, and 2.5 Mt of peas (Statistics Canada, 2011).

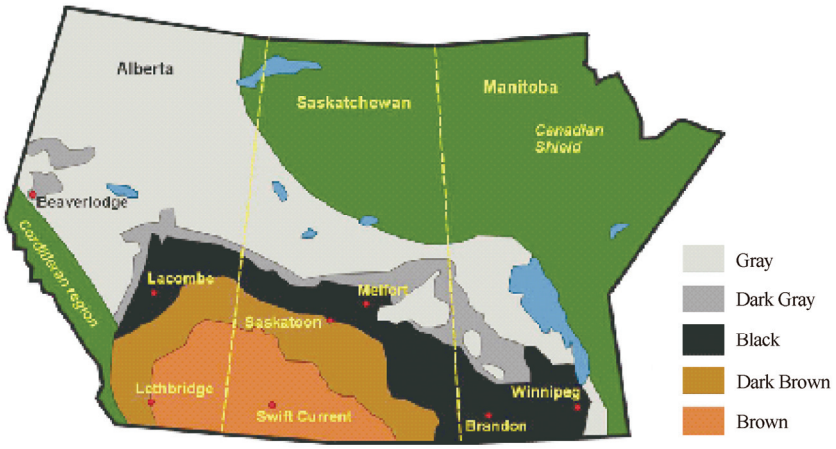

Fig.1 Soil zones of the Canadian Prairies

Source: Agriculture and Agri-Food Canada (Canadian Soil Information Service) Soil map of Canada.

On the Canadian Prairies, conservation tillage (CT) was introduced as an alternative to traditional tillage (TT) to combat soil degradation and promote agricultural sustainability. Soil degradation negatively impacts crop production through losses in nutrients, water-storage capacity, and soil organic matter, and can contributes to increases in greenhouse gas (GHG) emissions［Campbell et al., 1988, 1990; Agriculture and Agri-Food Canada (AAFC), 2010］.

By the end of the 1970s, conservation tillage technology, through the effective integration of crop residue management, chemical weed control, and specialized seeding equipment, -started to take shape on the Prairies. Today, more than 75% of the arable land on the Prairies is under some form of conservation tillage, with zero tillage (ZT) accounting for more than 50% (Statistics Canada, 2011).

The development and adoption of conservation tillage (CT) systems on the Prairies involved pioneer farmers, engineers, scientists, and farmer associations who worked together and interacted for a period of more than five decades. During this time, the innovation activities of different contributors were guided by a set of environmental, economic, technological, policy, and social factors.

The aims of this paper are to review the factors behind the development and adoption of conservation tillage systems on the Canadian Prairies in the period between 1930 and 2011. The paper will also highlight some of the economic and environmental benefits of this dramatic transformation of the Prairie landscape.

This paper is structured as follows. Section one is the Introduction. Section two describes some of the issues of world food security, population growth, and land degradation, and confirms the need for greater agricultural sustainability. Section three describes the factors underlying the development and adoption of the conservation tillage innovation on the Canadian Prairies. In particular, this section describes how environmental factors such as land degradation and climate were key drivers in the development of conservation tillage technology, while economic, technical, political, and social factors delayed its development and adoption between the 1930s and 1980s. Then, a review is presented of the driving factors that resulted in the development and adoption of conservation tillage technology between 1990 and 2011. Section four highlights some of the benefits of the adoption of conservation tillage systems on the Prairies. Finally, Section five concludes the paper.

2 Population growth, land degradation, and agricultural sustainability

The concept of sustainable agriculture (i. e., the ability of agriculture to provide continuous satisfaction of human needs for present and future generations in an economically and environmentally acceptable manner), has gained considerable global attention as the world population continues to grow. Each year, the global population increases by about 80 million people and it is expected to exceed 9 billion by the year 2050 (United Nations, 2005).