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Environmental benefits of canola production in 2010 compared to 1990: A life cycle perspective

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ABSTRACT

The aim of this study was to investigate the changes in environmental performance over time of canola production due to changes to management and production practices on the Canadian prairies. Selected environmental impacts of canola production in 2010 and in 1990 in the Gray, Black, and Dark Brown/Brown soil zones of Western Canada were quantified (1990 analysis was limited to Alberta due to data availability). The life cycle assessment (up to the farm gate) was carried out on a per-tonne-of-canola basis. There were limited differences in impacts across soil zones for the 2010 production system. Differences across soil zones were generally more pronounced for the 1990 production system. The production and use of fertilizers (both production and field emissions) and the use of farm equipment (for tillage, harvest, etc.) were the major contributors, accounting for up to 95% of the environmental impacts of canola production in both time periods. Overall, the environmental impacts of producing one tonne of canola were reduced between the 1990 and 2010 time periods. Over the past two decades, the on-farm fuel use and fertilizer applied per tonne of canola decreased, which led to reduced greenhouse gas emissions and improved ecosystem quality (acidification being the exception). The improvements in the environmental profile of canola production between 1990 and 2010 were due to a combination of factors, particularly the advances in crop management practices including tillage and large-scale adoption of herbicide tolerant hybrid canola, that have led to increases in average yields and in efficiency of inputs use.

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1. Introduction

Canola, an oil-seed crop, the seed used as raw material for production of numerous food and industrial products such as cooking oil, animal feed, biodiesel, and lubricants. Globally, canola ranks second in oil-seed production (USDA ERS, 2012), and vegetable oil production (USDA FAS, 2014).

Canola was first developed in the Canadian prairies during the 1960s and 1970s to address dependence on imported edible oils (Statistics Canada, 2009). Canada and China have become the two largest single producers of the crop (USDA FAS, 2014). Between 1986 and 2006, total annual production of canola in Canada more than tripled to reach 14 million tonnes due to a combination of steady increases in yield as well as area planted (Statistics Canada, 2009; Supplementary Material [SM] Section 2). Over time, the importance of canola to the Canadian economy has increased to the point that it is now the most valuable Canadian crop (Statistics Canada, 2009). Canadian canola production is concentrated in the provinces of Saskatchewan, Alberta, and Manitoba (i.e. Western Canada), which accounts for 99% of Canadian production by tonnage.

There are several reasons for the increased yield and seeded canola acreage in Canada, but one of the most influential factors has been the development of transgenic, herbicide tolerant (HT) varieties of the oilseed (Stringam et al., 2003). HT canola was developed in Canada in 1995 (Smyth et al., 2011) and is resistant to non-selective herbicides. One of the main benefits of HT canola when compared to conventional canola is improved weed control. The technology presents other indirect benefits such as time- and labor-savings, reduced tillage requirements, and improved soil organic matter content and reduced erosion from reduced tillage (Shaw, 2014). However, concerns have been raised on the large-scale application of HT crops, such as impact on biodiversity and the potential risk of increased weed resistance to pesticides due to intensive use of the same active ingredient (Mortensen et al., 2012; Beckie et al., 2013).

Considering the recent substantive increases in canola acreage and changes to management practices for canola production on the Canadian prairies, the aim of this study was to investigate the resulting changes in selected environmental impacts over time in different soil zones. To achieve this goal, the impacts of canola production in 2010 and in

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1990 were examined primarily on a production basis, and secondarily on an area basis.

2. Methodology

2.1. Overall method

A cradle-to-farm gate life cycle assessment (LCA) of canola production in Western Canada circa 1990 and 2010 was conducted in accordance with International Organization for Standardization standards for LCA (ISO, 2006a, 2006b).

2.2. Goal and scope definition

Agricultural systems can have more than one function. Functional units are derived based on the functions of the system under study. In this study, the main function of the system is the "production of canola". Hence the main functional unit is defined as "1 tonne of canola". Some researchers advise that agricultural systems should be evaluated by at least two functional units, for example, production- and area-based functional units (e.g. Nemecek et al., 2011). Other functions of canola production may be to "properly manage agricultural land" or "minimize the environmental impacts of canola production". The second functional unit "1 hectare (ha) of land" is defined from these functions. The current analysis and discussion focus on the main functional unit, but the second functional unit is examined as part of the sensitivity analysis.

The system boundary (Fig. 1) begins with the production of the energy and materials required for the production of canola (e.g. seeds, fertilizers), and ends where canola has been harvested, dried, and is ready for sale on the market.

SimaPro (version 7.3.2, Pré, 2011) LCA modeling software was used for the analysis. Selected environmental impacts were calculated using the life cycle impact assessment (LCIA) IMPACT 2002 + midpoint method (Jolliet et al., 2003) as it allowed for examination of the impact categories of interest and is generally considered to be a high-quality method for impact assessment. Its selection was examined through sensitivity analysis. The 2007 global warming potential (GWP) factors from the Intergovernmental Panel on Climate Change (IPCC, 2007), consistent with (S&T)[2] Consultants Inc. (2010). Biodiversity is not available as an impact category in the IMPACT 2002 + method, and it was beyond the scope of this study to develop such method. It was therefore not examined.

2.3. Canola production systems

Where possible, the information used to define typical canola production was from canola grower surveys conducted in Western Canada. Otherwise, informed assumptions were made (presented in the text or SM). Production systems are described below and details are provided in Section 3 of SM.

2.3.1. Analysis by soil zones

The analysis was conducted for canola production in Western Canada (three provinces: Alberta, Saskatchewan, and Manitoba) in the Gray, Black, Dark Brown, and Brown soil zones (US taxonomic equivalents: Boralf, Udic Boroll, Typic Boroll, Aridic Boroll respectively). The analysis was conducted on a soil zone basis due to the climatic and

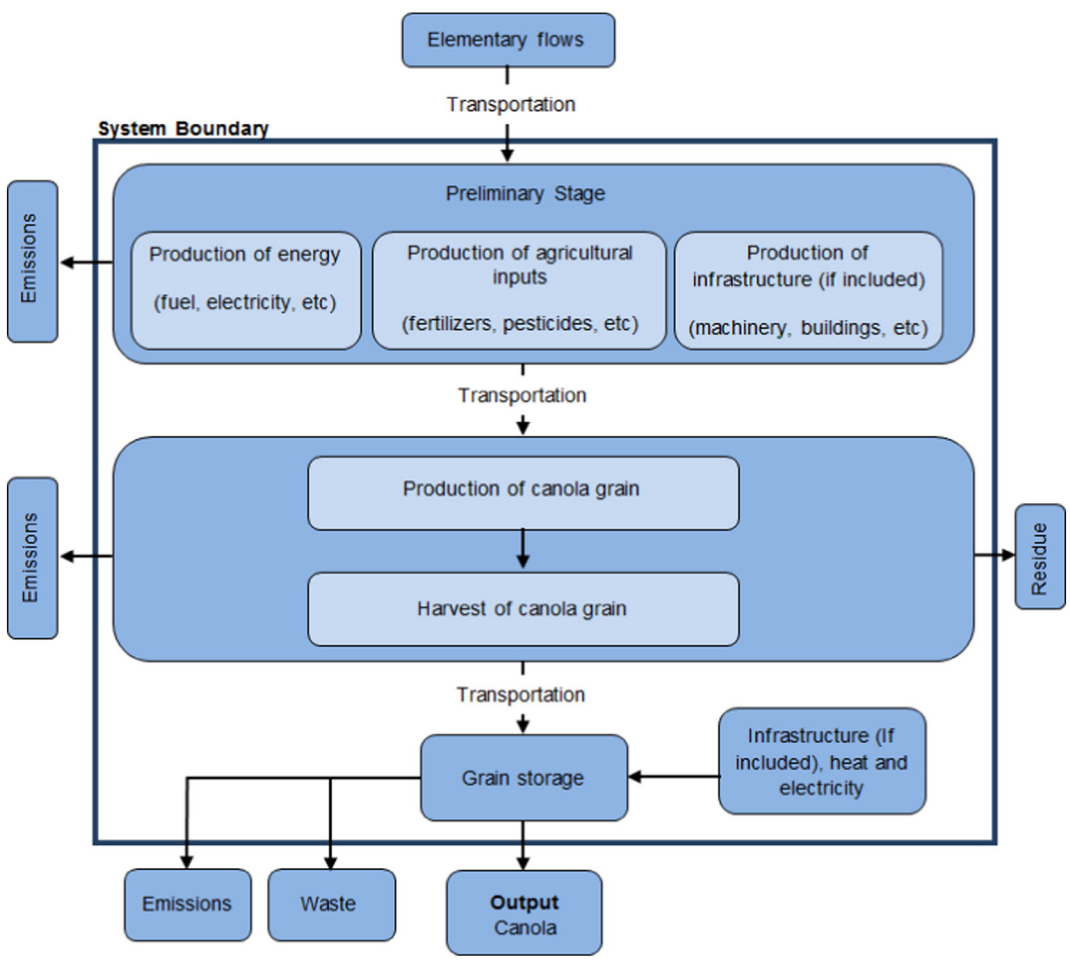

Fig. 1. System boundary of canola production.

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