PREDICTING DECOMPOSITION OF CANOLA RESIDUE

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Abstract

The Residue Recommendation System (RESREC), a decision support system, was used to predict levels of crop residue in crop rotations containing canola. Effects of decomposition and tillage on canola residue were simulated in conventional F-C-W-B and C-P-FL-B, and zero-till C-P-FL-B to provide estimates of temporal changes and formulate statistical hypotheses for field research currently conducted on the later two rotations at Melfort. Crop residue in the fallow phase of the F-C-W-B rotation was less than that required to control soil erosion. Canola residue in conventional C-P-FL-B was rapidly reduced to less than 100 kg ha^{-1} by the combined effects of decomposition and tillage, but was maintained at a minimum level of 500 kg ha^{-1} in zero-till. Total rninimum crop residue in zero-till C-P-FL-B was estimated at 3000 kg ha^{-1} but was near zero kg ha^{-1} in conventional tillage.

Introduction

New innovative cropping systems which incorporate continuous cropping, broadleaf crops, new in-crop, preseeding, and preharvest herbicides and direct seeding have been adopted by producers in the Parkland in response to reduced prices for cereal crops. Producers in the Saskatchewan Parkland are seeding a high proportion of acres to canola, and are increasing the acreage of broadleaf crops such as peas. Canola acreage for crop insurance districts located in the Saskatchewan Parkland ranged from 29.3% to 41.3% of seeded acres, while peas varied from 4 - 8% in 1994 (Saskatchewan Crop Insurance Corporation 1994). Concurrent with this shift to broadleaf crops is the increased adoption of no-till (6%), and conservation tillage (2 1%) in the Saskatchewan Parkland (Statistics Canada 1991). As a result demand has increased for information on rotations with a high frequency of broadleaf crops, in zero, minimum and conventional tillage.

The adoption of conservation tillage in the Saskatchewan Parkland has occurred at a rate faster than the remainder of the prairies. This is attributed to the need to reduce costs of production and improve the timeliness of farm operations. In the absence of any loss in grain yields, reduced fuel consumption, machinery depreciation and labor requirements mean a lower cost of production and increased net returns provided that they are not offset by increased herbicide costs.

Barriers to the adoption of conservation tillage include the concern that excessive cereal residues will adversely affect germination and emergence of crops due to soil moisture conditions and high fertilizer N requirements. Although this may be the case for cereal crops, residue of broadleaf crops such as canola, peas and flax under conventional tillage may be insufficient to control erosion and increase the incentive for conservation tillage. If high levels of broadleaf residues persist, then residue borne crop diseases such as sclerotinia stem rot may increase the probability of yield loss.

Residue management is a primary concern of producers who direct seed annual crops in the Parkland. Surface-placed residues affect emergence, germination, soil cover, nutrient availability, soil structure, soil temperature, water infiltration and evaporation, pest populations, and microbial activity (Douglas et al. 1980; Stroo et al. 1989; Collins et al. 1990). The goal of effective residue management in conservation tillage systems is to maintain sufficient crop residues at or near the soil surface to minimize erosion, yet not in excessive amounts that impede planting operations or subsequent crop seedling emergence and establishment.

A new tillage by rotation study was initiated at Melfort in order to study agronomic and soils variables in conventional, minimum and zero till rotations with 25%, 50%, and 75% broadleaf crops at Melfort in 1994. The objective of the study is to evaluate the agronomic, environmental and economic impact of reduced tillage seeding systems and broadleaf crop intensity in rotation on crop yields, residue management, plant disease and weed abundance, soil fertility status and cost of production.

The objectives of this paper are three fold:

1. To simulate temporal trends in canola and crop residue for rotations and tillage systems in a new tillage by rotation study at Melfort.
2. To evaluate the rotations with respect to erosion control.
3. To develop research hypotheses for the tillage by rotation study.

Materials and Methods

The Residue Recommendation System (RESREC) was used to simulate production of crop residues in a new tillage by rotation study at Melfort. RESREC is a prototype of a decision support system which includes an empirical equation for decomposition of crop residue, effects of tillage on residue, and costs based on field operations in Western Canada. The program calculates changes in residue due to decomposition, based on an equation developed by Douglas and Rickman (1992). In the program, decomposition of residues is based on cumulative degree days (CDD). The Douglas Rickman model has been evaluated for a number of cereals and broadleaf crops in chemical and tillage fallow systems at the Melfort Research Station (Moulin and Beckie 1994). Over winter losses of residue are based on coefficients calculated from field data. Decreases in residue due to tillage are calculated with a series of coefficients specific to different implements and residue classes.

Crop residue levels were simulated for treatments (Table 1) selected from rotation and tillage treatments of a study at Melfort, and a conventional F-C-W-B cropping system. Yield, harvest date, tillage and seeding operations, residue removal, and over winter loss were combined in the model to simulate changes in crop residue over time. All simulations are reported in Julian days from initiation of the rotation. Temperature data were based on 30 year long-term means which are calculated over a thirty year period from 1960 to 1989 for the Melfort Research Station. Simulated rates were corrected with coefficients for over winter loss from field data as the model does not simulate this process.

The study of rotation by tillage was initiated in 1994 at the Agriculture Canada Research Station at Melfort, Saskatchewan. Crop rotations are C-W-B-B, C-P-W-B, and C-P-FL-B, while the tillage treatments are zero, minimum and conventional. Gram yields, dates and numbers of tillage operations used in simulations are from the study (Table 1).

Table 1. Tillage operations used in simulated crop rotations.

Rotation	Tillage System	Cultivator passes			Harrow Pack	Seeding
		Fallow	Broadleaf	Cereal		
F-C-W-B	Conventional	6	3	4	1	1
C-P-FL-B	Conventional	na	3	4	1	1
C-P-FL-B	Zero-till	na	0	0	0	1

F=Fallow; C=Canola, W=Wheat, B=Barley, P=Peas, FL=Flax
na=not applicable

Results and Discussion

Decomposition of canola residue

Decomposition of canola residue at the surface in chemical fallow (Figure 1) was similar to that simulated with the Douglas Rickman model. The model has previously been reported to accurately simulate decomposition of wheat, barley, flax and alfalfa (Moulin and Beckie 1994) under fallow conditions.

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Figure 1. Simulated and measured decomposition of canola at the surface in chemical fallow. Error bars indicate one standard error (n=4) of the sample means for each sample date. Canola and Total Crop Residue in a Conventional F-C-W-B Rotation

Rotations which include tilled fallow in rotation are susceptible to erosion as crop residue levels (Figure 2) fall below those levels required to control erosion (Table 2) in the fallow year. Tilled fallow was often used in the Parkland prior to 1980 to control weeds though this practice has decreased with the advent of new in-crop, preseeding and preharvest herbicides, and direct seeding.

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Figure 2. Total residue (kg ha^{-1}) in the second cycle of a conventional F-C-W-B rotation.

Crop residue in conventional F-C-W-B falls below 1500 kg ha^{-1} required to control wind erosion on clay soils and 800- to 1150 kg ha^{-1} to reduce water erosion. Residue levels are low throughout the fallow year, and in the following year when canola is planted (Figure 2) due to preseeding tillage.

Table 2. Levels of crop residue required to control erosion (Brandt 1987).

Wind Erosion (texture)	Residue required (kg/ha)
loam	1000
clay	1500
sandy	2000
Water erosion (slope)	
6-9%	800-1150
10-15%	1150-1700
16-30%	continuous cover
30%+	continuous cover

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Figure 3. Canola residue (kg ha^{-1}) in the canola phase of the second cycle of a conventional F-C-W-B rotation.

Canola and Total Crop Residue in Conventional and Zero-Till C-P-FL-B Rotations

Canola residues in conventional C-P-FL-B rotations (Figure 4) rapidly decrease to less than 100 kg ha^{-1} due to preseeding tillage. Simulated values of canola residue at seeding are well below those required to control soil erosion, furthermore they rapidly decrease to low levels by the middle of the flax phase in the rotation. Erosion can be a significant problem at seeding in the canola phase of this rotation before the development of the crop canopy.

In contrast canola residue in the zero-till C-P-FL-B rotation, increases to higher levels after harvest due to carry over from previous years. Canola residue also decreases slowly to a minimum of 500 kg ha^{-1} (Figure 4) which may affect the incidence of plant diseases such as sclerotinia stem rot.

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Figure 4. Canola residues (kg ha^{-1}) in the canola phase of the second cycle of a zero-till and conventional C-P-FL-B rotations.

Total crop residue in the conventional C-P-FL-B rotations after preseeding tillage falls below those levels required to control erosion (Figure 5). In contrast total crop residue in the zero-till C-P-FL-B rotation reaches a minimum of 3000 kg ha^{-1} well above those levels required to control erosion. Although the decomposition equation used in RESREC accounts for decomposition in crop. predicted levels of residue in the zero-till rotation are high and will require validation with field data in future research. In addition the accumulation of high levels of crop residue may result in low soil temperatures which may affect emergence and germination of the crop.

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Figure 5. Total crop residues (kg ha^{-1}) in the second cycle of conventional and zero-till C-P-FL-B rotations.

Conclusions and Future Research

Crop residue in the fallow phase of a conventional F-C-W-B was less than that required to control soil erosion. Canola residue in conventional C-P-FL-B was rapidly reduced to levels less than 100 kg ha^{-1} by the combined effects of decomposition and tillage, but was maintained at a minimum level of 500 kg ha^{-1} in zero-till. Total minimum crop residue in zero-till C-P-FL-B was estimated at 3000 kg ha^{-1}, but was near zero under conventional tillage. Rotations with a high proportion of broadleaf crops will require reduced or zero-tillage in order to maintain sufficient residue to control erosion.

Additional field research is being conducted at Melfort, and in cooperation with Dr. G. Lafond at Indian Head, to measure decomposition in crop canopies. Fields which have been in long-term zero-till, will be surveyed to determine if simulated levels accurately estimate accumulated surface residue. Crop disease is being monitored in the new tillage by rotation study at Melfort, and the use of foliar sprays has been included as a factor. Soil temperature and moisture will be monitored in the study to determine if they are significantly lower in zero-till than conventional systems.

Acknowledgments

This study was supported by the National Soil Conservation Fund, the Environmental Sustainability Initiative, the Parkland Agricultural Research Initiative, and the Canada Saskatchewan Agricultural Green Plan. Roy Beimuts of the Melfort Research Station provided programming support.

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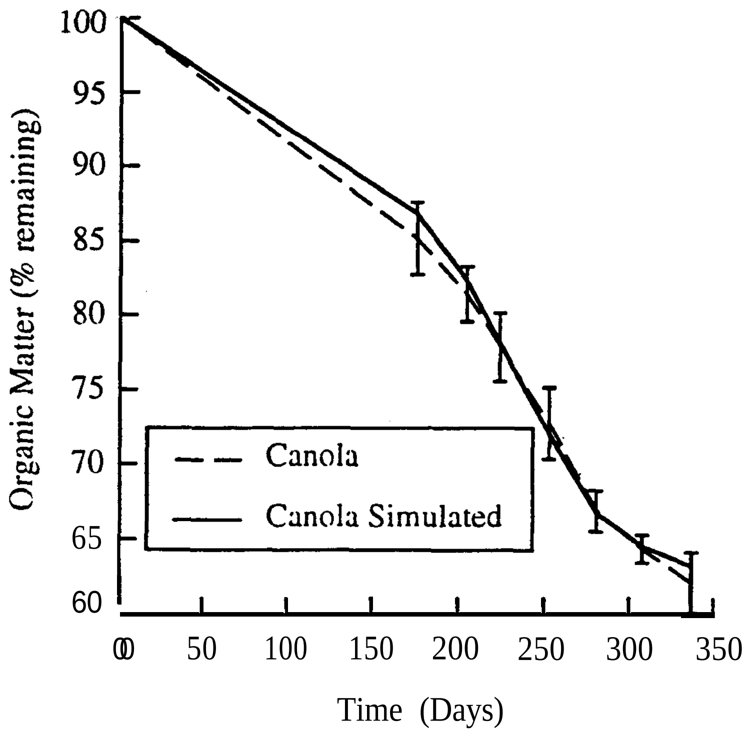

Figure 1. Simulated and measured decomposition of canola at the surface in chemical fallow. Error bars indicate one standard error (n=4) of the sample means for each sample date.

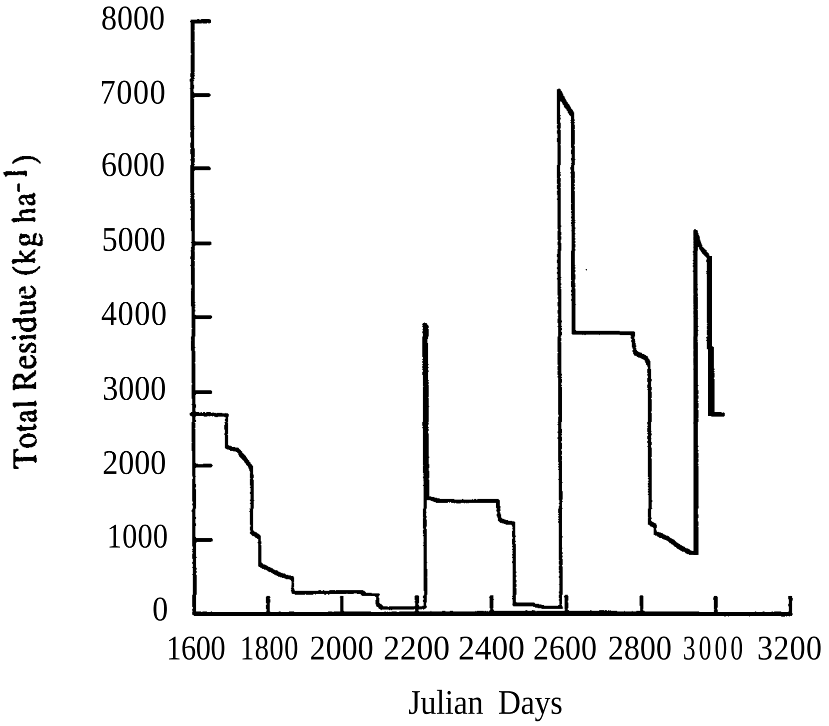

Figure 2. Total residue (kg ha-l) in the second cycle of a conventional F-C-W-B rotation_

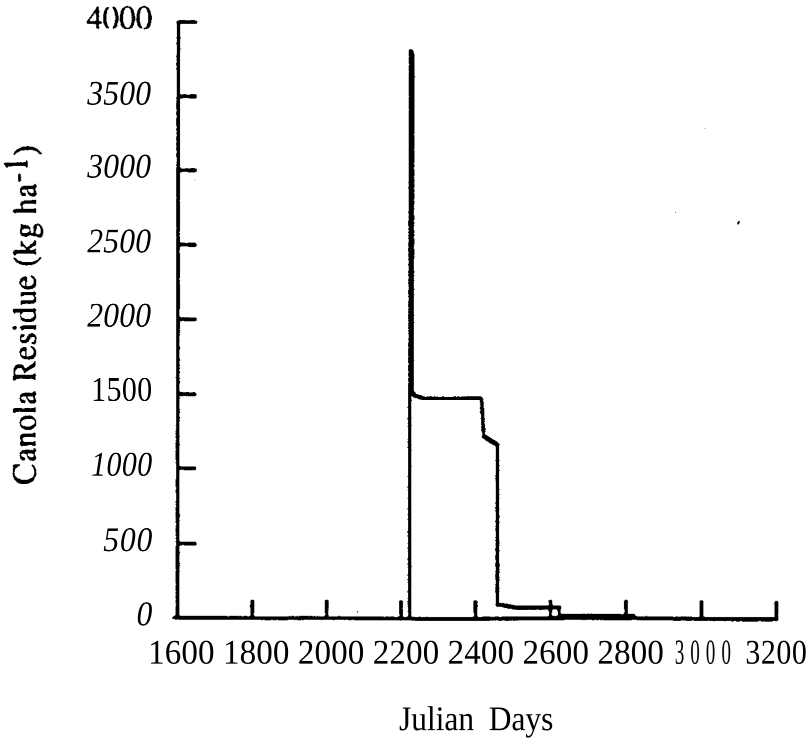

Figure 3. Canola residue (kg ha^{-1}) in the canola phase of the second cycle of a conventional F-C-W-B rotation.

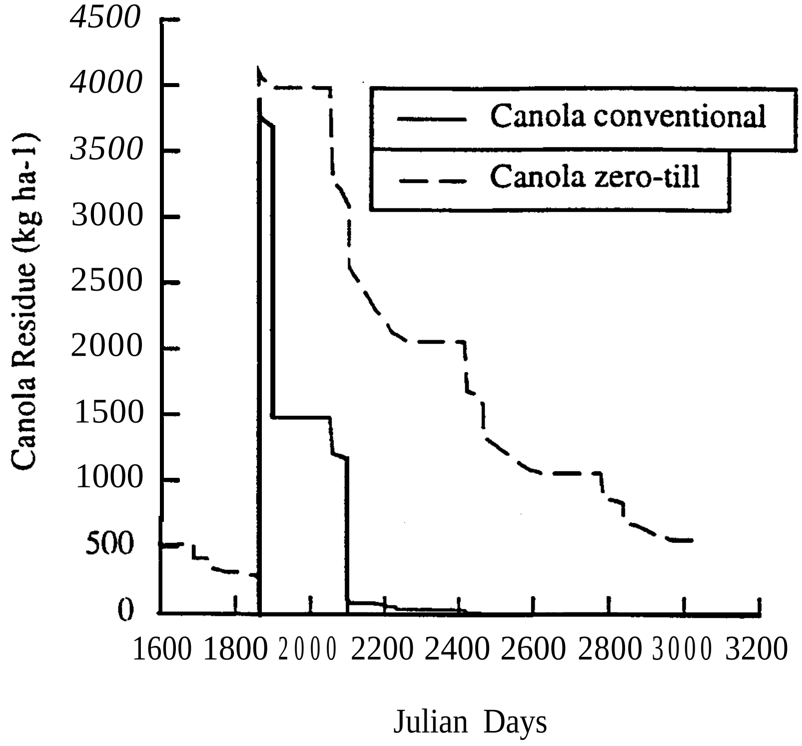

Figure 4. Canola residues (kg ha^{-1}) in the canola phase of the second cycle of a zero-till and conventional C-P-FL-B rotations.

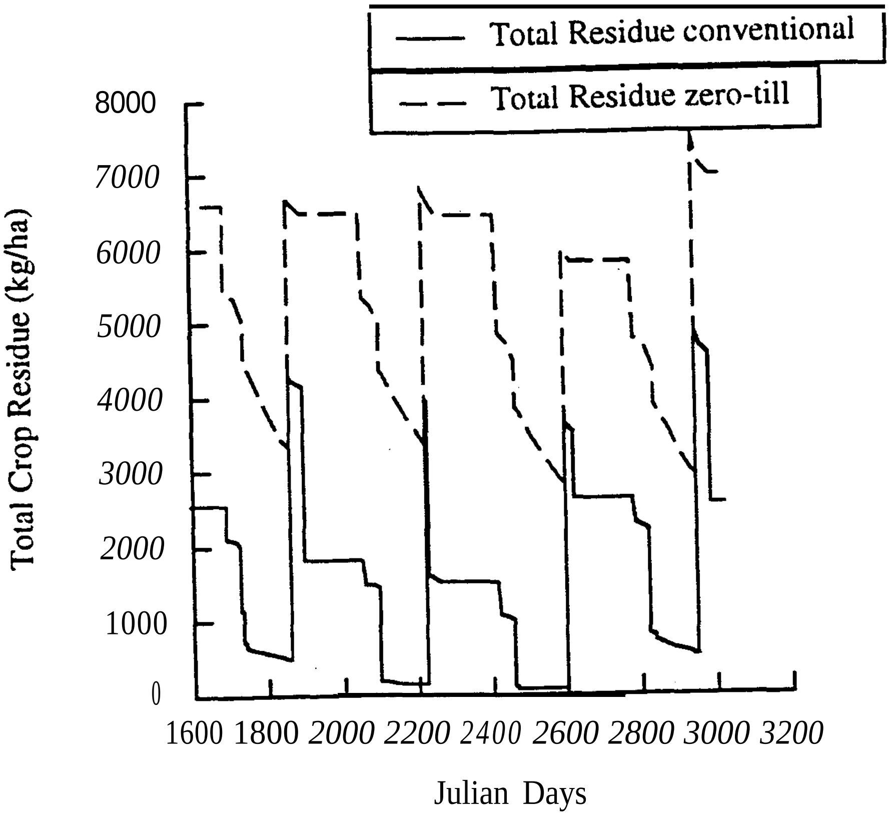

Figure 5. Total crop residues (kg ha-l) in the second cycle of conventional and zero-till C-P-FL-B rotations.