Effects of Broad-Leaf Crops Frequency on Seed Yield, and Nitrate-N and Extractable P in Soil after Eight Years in a Dark Brown Chernozem in Saskatchewan

S. S. Malhi[1], S. A. Brandt[2] and R. H. Kutcher[1]

[1]Agriculture and Agri-Food Canada, P.O. Box 1240, Melfort, Saskatchewan, Canada S0E 1A0
(E-mail: sukhdev.malhi@agr.gc.ca);
[2]Agriculture and Agri-Food Canada, P.O. Box 10, Highway 374, Scott, Saskatchewan, Canada S0K 4A0

Background

- In many years, canola provides the best economic return to producers compared to other field crops grown in western Canada.
- For this reason production of canola is often intensive, meaning it is grown more than once every four years on the same field.
- Producers and industry need to understand the consequences of intensive canola rotations in order to prepare for unwanted outcomes such as pest problems (diseases, weeds, and insects).
- Growers frequently question whether improved weed control technology and cultivars with improved disease resistance can overcome these limitations.
- In addition to fertilizer input, accumulation and distribution of nutrients in the soil profile vary with crop intensity/type/species/diversity, yield potential, rooting characteristics (depth/volume/mass) of crop, placement of crop residue, soil type and climate.

Objective

- The main objective of this report is to determine the impact of frequency of broad-leaf crops canola and pea, and fungicide application in various crop rotations with wheat and flax using current technology including disease resistant and/or herbicide tolerant cultivars and new fungicides for disease control on accumulation and distribution of nitrate-N and extractable P in the soil profile after 8 years.
- Cumulative seed yields over 8 years from 1998 to 2005 are also reported, and discussed in relation to residual soil nutrients.

Materials and Methods

- An 8-yr field experiment was conducted from 1998 to 2005 on a Dark Brown Chernozem (Typic Boroll) loam at Scott, Saskatchewan.
- There were 12 crop sequences (main plots) and two fungicide (sub-plots) treatments (**Table 1**), with all phases of each rotation present every year.

- Growing season precipitation (from May to August) was substantially below average in 1998 and 2001, fairly below average in 2002, 2003 and 2004, slightly below average in 2000, above average in 1999, and really wet in 2005**.**
- N, P, K and S fertilizers at recommended rates were applied to all plots at seeding.
- Soil samples in each plot were obtained from the 0-15, 15-30, 30-60 and 60-90 cm depths, and analysed for nitrate-N (2M KCl) and extractable P (Melich extract).

Summary

- Seed yield of Westar was always much lower than that of the hybrid in the same rotation, and seed yield of Westar was much more reduced as rotation intensity increased compared to hybrid canola.
- The use of a blackleg resistant cultivar hybrid canola combined with a one in four year rotation provided the most effective increase in seed yield, although yield loss was not apparent among rotations of 2-years or longer.
- Fungicide application increased seed yield for Westar canola in all crop rotations/sequences, but for hybrid canola seed yield increase due to fungicide occurred only in the continuous monocrop rotation/sequence.
- Seed yield of pea was usually reduced in the continuous pea rotation compared to rotations of 2 years or longer, and there was little difference in seed yield between rotations of 2-years and longer.
- Fungicide application produced greater seed yield of most crops, but the magnitude of yield benefit of fungicide appeared to be associated with environmental conditions.
- The relative seed yield response to fungicide was usually in the order of pea > wheat > Westar canola > hybrid canola (small) > flax (little or none), depending on the crop sequence/rotation.
- Residual soil nitrate-N in most layers and extractable P in many layers were significantly affected by crop rotation and sequence, with the highest amounts after continuous monocrop rotations/sequences.
- Fungicide application resulted in decreased amount of residual soil nitrate-N, but it had no effect on soil extractable P.
- Crop phase had significant effect on soil nitrate-N in some crop sequences, for example residual soil nitrate-N tends to be highest after pea or Westar canola, and also after flax in the 4-yr rotation with flax.
- Crop phase had no effect on soil extractable P in any crop sequence/rotation.
- The amounts of soil nitrate-N usually associated with the crop yield/N removal in various crop rotations/sequences/phases.
- There was a significant negative correlation ($r = -0.416$; $P < 0.02$) between residual soil nitrate-N and seed yield.

Conclusion

- The findings suggest that seed yields can be improved, and soil residual nutrients, especially nitrate-N, can be reduced by extending crop rotations and using high yielding disease resistant canola cultivars in most cases, and by applying fungicides most likely in years with weather conditions conducive to diseases

Acknowledgements

- The authors would like to thank Z. Zhang and K. Strukoff for technical help, D. Leach for preparing and Erin Cadieu for printing the poster.

Table 1. Description of crop rotations/sequences in a field experiment from 1998 to 2005 at Scott Saskatchewan

Rotation duration (name)	Crop sequence
Continuous (1-yr)	Continuous Westar canola
Continuous (1-yr)	Continuous hybrid canola
Continuous (1-yr)	Continuous pea
2 (2-yr)	Westar canola-wheat
2 (2-yr)	Hybrid canola-wheat
2 (2-yr)	Pea-wheat
3 (3-yr)	Pea-Westar canola-wheat
3 (3-yr)	Pea-hybrid canola-wheat
4 (4-yr)	Westar canola-wheat-pea-wheat
4 (4-yr)	Hybrid canola-wheat-pea-wheat
4 (4-yr)	Westar canola-wheat-flax-wheat
4 (4-yr)	Hybrid canola-wheat-flax-wheat

Table 2. Influence of crop rotation x fungicide or crop sequence x fungicide interaction in 1-, 2-, 3- and 4-year rotations on cumulative seed yields over 8 years from 1998 to 2005 in a field experiment from 1998 to 2005 at Scott, Saskatchewan

Parameter	Cumulative seed yield (kg ha^{-1})		
	No fungicide	Fungicide	Mean
Crop rotation			
Continuous monocrop	9164	10941	10053
2-year rotation	14109	15353	14731
3-year rotation	14547	16624	15585
4-year rotation with pea	15260	17296	16278
4-year rotation with flax	13040	13664	13352
Mean	13736	15237	
$LSD_{0.05}$	Crop rotation = 1770***; Fungicide = 1050**; Crop rotation x Fungicide = ns		
Crop sequence			
Continuous Westar canola	5125	6247	5686
Continuous hybrid canola	9152	9879	9515
Continuous pea	13215	16699	14957
Westar canola-wheat	11753	12851	12302
Hybrid canola-wheat	14139	14246	14193
Pea-wheat	16433	18961	17697
Pea-Westar canola-wheat	14155	16299	15227
Pea-hybrid canola-wheat	14938	16948	15943
Westar canola-wheat-pea-wheat	14633	16992	15812
Hybrid canola-wheat-pea-wheat	15888	17599	16744
Westar canola-wheat-flax-wheat	13074	13473	13724
Hybrid canola-wheat-flax-wheat	13005	13855	13430
Mean	13736	15237	
$LSD_{0.05}$	Crop sequence = 2924***; Fungicide = 1036*; Crop sequence x Fungicide = ns		

Table 3. Distribution of nitrate-N in the soil profile in various crop rotations (averaged across fungicide treatments and crop phases) and fungicide treatment (averaged across crop rotations/phases) in 2005 in a field experiment from 1998 to 2005 at Scott Saskatchewan at Scott, Saskatchewan

Crop rotation	Nitrate -N (kg N ha $^{-1}$) in s oil layers (cm)				
	0-15	15-30	30-60	60-90	0-90
Continuous monocrop	18.1	12.0	11.8	13.8	55.7
2-year rotation	13.4	9.1	12.5	18.5	53.5
3-year rotation	14.3	9.7	9.5	13.4	46.9
4-year rotation with pea	13.4	8.8	8.2	13.9	44.3
4-year rotation with flax	14.1	8.5	9.7	22.7	55.0
$LSD_{0.05}$	2.6*	1.8**	3.7•	8.5*	ns

Table 4. Distribution of nitrate-N in the soil profile in relation to crop sequence (averaged across fungicide treatments and crop phases) in 2005 in a field experiment from 1998 to 2005 at Scott Saskatchewan at Scott, Saskatchewan

Crop sequence	Nitrate-N (kg N ha^{-1}) in soil layers (cm)				
	0-15	15-30	30-60	60-90	0-90
Continuous Westar canola	20.2	13.6	12.6	14.2	60.6
Continuous hybrid canola	14.6	9.5	9.5	9.1	42.7
Continuous pea	19.6	12.9	13.3	18.2	64.0
Westar canola-wheat	13.0	10.1	18.8	29.6	71.5
Hybrid canola-wheat	14.5	9.0	9.5	15.5	48.5
Pea-wheat	12.7	8.3	9.3	15.5	45.8
Pea-Westar canola-wheat	15.0	10.0	9.8	13.7	48.5
Pea-hybrid canola-wheat	13.6	9.4	9.1	13.0	45.1
Westar canola-wheat-pea-wheat	13.9	9.3	8.7	18.1	50.0
Hybrid canola-wheat-pea-wheat	12.9	8.4	7.7	9.6	38.6
Westar canola-wheat-flax-wheat	12.5	8.2	8.2	18.3	47.2
Hybrid canola-wheat-flax-wheat	15.7	8.8	11.3	27.0	62.8
$LSD_{0.05}$	4.2*	2.9*	6.0*	14.0*	21.7*

Table 5. Distribution of nitrate-N in the soil profile in relation to fungicide treatment (averaged across crop sequences/phases) in 2005 in a field experiment from 1998 to 2005 at Scott Saskatchewan at Scott, Saskatchewan

Fungicide treatment	Nitrate-N (kg N ha^{-1}) in soil layers (cm)				
	0-15	15-30	30-60	60-90	0-90
No fungicide	14.8	10.0	11.5	17.7	54.0
Fungicide	13.6	8.6	8.6	16.2	47.0
$LSD_{0.05}$	1.5•	1.0**	2.1**	5.0**	7.7•

Table 6. Influence of crop phase x fungicide interaction in 1-, 2-, 3- and 4-year sequences/rotations on nitrate-N in soil (0-90 cm) under two fungicide treatments in 2005 in a field experiment from 1998 to 2005 at Scott, Saskatchewan

Crop phase		No fungicide	Fungicide	Mean
		Nitrate-N (kg N ha^{-1})		
Continuous monocrop	Westar canola	66.4	54.1	60.3
	Hybrid canola	51.9	33.1	42.5
	Pea	71.2	57.2	64.2
	Mean	63.2	48.1	
2-year rotation	Westar canola	74.3	81.3	77.8
	Wheat	85.2	46.8	66.0
	Hybrid canola	33.1	56.6	44.8
	Wheat	44.8	49.9	47.4
	Pea	56.6	47.1	51.9
	Wheat	35.9	32.0	33.9
	Mean	55.0	52.3	
3-year rotation	Pea	59.4	62.5	61.0
	Westar canola	55.8	42.9	49.3
	Wheat	37.3	34.5	35.9
	Pea	57.7	53.5	55.6
	Hybrid canola	35.3	39.2	37.3
	Wheat	47.6	35.6	41.6
	Mean	48.9	44.7	
4-year rotation with pea	Westar canola	69.8	41.2	55.5
	Wheat	38.4	26.6	32.5
	Pea	77.4	74.8	76.1
	Wheat	46.0	24.9	35.5
	Hybrid canola	26.9	27.5	27.2
	Wheat	26.6	26.3	26.5
	Pea	79.9	56.3	68.1
	Wheat	40.6	27.2	33.9
	Mean	50.7	38.1	
4-year rotation with flax	Westar canola	66.1	61.7	63.9
	Wheat	34.2	36.4	35.3
	Flax	57.2	61.1	59.1
	Wheat	31.4	28.9	30.1
	Hybrid canola	45.7	86.6	66.1
	Wheat	71.7	41.5	56.6
	Flax	101.5	81.8	91.6
	Wheat	41.2	32.2	36.7
	Mean	56.1	53.8	

Table 7. Distribution of extractable-P in the soil profile in various crop rotations (averaged across fungicide treatments and crop phases) in 2005 in a field experiment from 1998 to 2005 at Scott Saskatchewan at Scott, Saskatchewan

Crop rotation	Extractable-P (kg P ha^{-1}) in soil layers (cm)				
	0-15	15-30	30-60	60-90	0-90
Continuous monocrop	9.7	8.6	3.4	1.8	23.5
2-year rotation	6.6	7.0	2.4	0.9	16.9
3-year rotation	7.7	6.9	4.2	1.2	20.0
4-year rotation with pea	7.5	7.0	4.2	0.9	19.6
4-year rotation with flax	8.6	7.6	4.5	2.4	23.1
$LSD_{0.05}$	1.9*	ns	2.0•	1.3*	4.1*

Table 8. Distribution of extractable-P in the soil profile in relation to crop sequence (averaged across fungicide treatments and crop phases) in 2005 in a field experiment from 1998 to 2005 at Scott Saskatchewan at Scott, Saskatchewan

Crop sequence	Extractable -P (kg P ha^{-1}) in soil layers (cm)				
	0-15	15-30	30-60	60-90	0-90
Continuous Westar canola	8.0	7.7	6.2	4.2	26.1
Continuous hybrid canola	7.7	8.4	1.0	0.8	17.9
Continuous pea	13.3	9.5	2.9	0.4	26.1
Westar canola -wheat	5.0	6.5	1.8	0.6	13.9
Hybrid canola -wheat	7.0	6.6	3.6	1.1	18.3
Pea-wheat	7.9	7.9	1.8	1.0	18.6
Pea-Westar canola -wheat	8.2	6.8	4.1	1.5	20.6
Pea-hybrid canola -wheat	7.2	7.1	4.3	0.9	19.5
Westar canola -wheat-pea-wheat	7.7	6.9	3.8	0.5	18.9
Hybrid canola -wheat-pea-wheat	7.4	7.0	4.7	1.4	20.5
Westar canola -wheat-flax-wheat	8.9	8.3	4.9	2.1	24.2
Hybrid canola -wheat-flax-wheat	8.4	6.9	4.1	2.6	22.0
$LSD_{0.05}$	3.2*	ns	ns	2.2*	6.9•