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

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Background

- In the Canadian prairies, canola usually provides best economic returns to producers compared to other field crops grown in in many years.
- For this reason production of canola is often intensive, i.e., 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, or insects).
- Growers frequently question whether improved weed control technology and varieties with improved disease resistance can overcome these limitations.
- In addition to fertilizer input, accumulation and distribution of nutrients in the soil profile vary with cropping intensity, crop 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 field pea, and/or fungicide application in various crop rotations on accumulation and distribution of nitrate-N and extractable P in the soil profile after four years.
- Cumulative seed yields over 4 years from 1999 to 2002 are also reported, and discussed in relation to residual soil nutrients.

Materials and Methods

- A field experiment was conducted in the Parkland region from 1999 to 2002 at Melfort, Saskatchewan.
- Treatments under NT direct seeding included 12 crop sequences (main plots) and two fungicide (sub-plots) (Table 1), with all phases of each rotation present every

year. Foliar fungicides were applied at the 2-4 leaf stage to control blackleg and at flowering for sclerotinia stem rot.

- Growing season precipitation (from May to August) was near or slightly above average in 1999 and 2000, but substantially below average in 2001 and 2002. Mean temperatures during the growing season were below normal in 1999 and 2000, near normal in 2002 and above normal in 2001.
- 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

- In canola the use of a blackleg resistant variety combined with a 1 in 4 year rotation provided the most effective increase in seed yield (Table 2).
- Seed yield of Westar was always lower than hybrid in the same rotation and was reduced as rotation intensity increased, unlike the hybrid (Table 3).
- Seed yield of Westar was increased by fungicide application in most cases, but the increases were not associated with any particular rotation.
- There was little seed yield benefit from fungicide application when a blackleg resistant hybrid canola was grown regardless of rotation.
- Application of fungicide to control sclerotinia stem rot did not result in a significant increase in seed yield of canola because the disease had a moderate impact in only one year (2000).
- The findings indicated that intensification of canola production by growing the crop more than once every four years on the same field may not cause immediate yield reduction if a blackleg resistant variety is grown.
- Seed yield of pea was usually reduced in the continuous pea rotation compared to rotations of 2 years or longer.
- There was little difference in pea yield between rotations of 2-years or longer. Fungicide increased seed yield of pea in all years of normal precipitation.
- Seed yield increases due to fungicide were not restricted to the continuous pea rotation, but included rotations of 2-years and longer.
- The magnitude of the yield benefit of fungicide in pea appeared to be associated with year (environmental conditions) rather than with rotation.
- The study indicated that field pea growers should have the flexibility in the short term to intensify field pea production to a 2-year rotation if farm management practices or market conditions warrant it.
- Wheat and flax were included as rotational crops for canola and field pea.

- The application of fungicide on wheat usually increased seed yield only in years when environmental conditions were conducive to disease (normal precipitation), which were the same years when crop yields were high.
- For flax, a yield increase was observed by fungicide application in 2000 when pasmo of flax was severe.
- Crop rotation/sequence had no significant effect on soil nitrate-N, though the amounts of soil nitrate-N in different soil depths was highest in the continuous monocrop rotation and lowest with 4-year rotation with flax (Table 4).
- Interaction effects of crop phase x crop sequence on soil nitrate-N were significant for all depths in the soil profile (Table 5).
- The lower amounts of nitrate-N in soil after canola, especially hybrid canola, in most crop sequences were most probably due to relatively higher N requirement and uptake of canola because of high yield and seed protein content and deeper taproots of canola extracting nutrients from deeper soil depths compared to other crop species/cultivars.
- This suggests that canola production, especially hybrid canola, effectively minimizes the downward movement of nitrate-N in the soil profile.
- Soil extractable P in the 0-15 cm depth was lowest with continuous monocrop rotation and highest with 4-year rotation with flax (Table 6).
- This was probably due to less crop residue produced and returned to soil, and subsequently reduced release of labile P during residue decomposition under continuous monocrop than other more diversified crop rotations.
- Soil extractable P did not vary with crop sequence. There was a significant effect of crop phase on soil extractable P, but soil P levels varied with crop phase in different sequences.

Conclusion

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

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Table 1. Description of crop rotations/sequences in a field experiment from 1999 to 2002 at Melfort, 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 4 years from 1999 to 2002 in a field experiment at Melfort, Saskatchewan

Parameter	Cumulative seed yield (kg ha^{-1})		
	No fungicide	Fungicide	Mean
Crop rotation			
Continuous monocrop	3356	3630	3493
2-year rotation	5503	6282	5892
3-year rotation	5434	6000	5717
4-year rotation with pea	5788	6495	6142
4-year rotation with flax	4742	5268	5005
Mean	5159	5764	
$LSD_{0.05}$	Crop rotation = 625***; Fungicide = 371**; Crop rotation x Fungicide = 371^{ns}		
Crop sequence			
Continuous Westar canola	2415	2659	2537
Continuous hybrid canola	3084	3389	3237
Continuous pea	4568	4842	4705
Westar canola-wheat	4732	5390	5061
Hybrid canola-wheat	5607	6346	5976
Pea-wheat	6170	7111	6640
Pea-Westar canola-wheat	5074	5650	5362
Pea-hybrid canola-wheat	5793	6350	6072
Westar canola-wheat-pea-wheat	5582	6315	5948
Hybrid canola-wheat-pea-wheat	5994	6676	6335
Westar canola-wheat-flax-wheat	4577	5191	4884
Hybrid canola-wheat-flax-wheat	4908	5345	5126
Mean	5159	5764	
$LSD_{0.05}$	Crop sequence = 1074***; Fungicide = 380*; Crop sequence x Fungicide = 1318^{ns}		

Table 3. Influence of crop phase in 1-, 2-, 3- and 4-year rotations on cumulative seed yields over 4 years from 1999 to 2002 in a field experiment at Melfort, Saskatchewan

Table 4. Distribution of nitrate-N in the soil profile in relation to crop sequence (averaged across fungicide treatments and crop phases) in autumn 2002 in a field experiment from 1999 to 2002 at Melfort, Saskatchewan

Crop sequence	Nitrate-N (kg N ha^{-1}) in soil layers (cm)		
	0-15	15-60	0-60
Continuous Westar canola	51.7	72.0	123.7
Continuous hybrid Canola	42.9	39.5	82.4
Continuous pea	48.1	96.0	144.1
Westar canola-wheat	41.8	70.1	111.9
Hybrid canola-wheat	41.1	57.8	98.9
Pea-wheat	42.1	78.8	120.9
Pea-Westar canola-wheat	46.6	80.4	127.0
Pea-hybrid canola-wheat	37.1	56.9	94.0
Westar canola-wheat-pea-wheat	40.5	66.1	106.6
Hybrid canola-wheat-pea-wheat	39.4	65.7	105.1
Westar canola-wheat-flax-wheat	46.1	64.6	110.7
Hybrid canola-wheat-flax-wheat	36.2	49.5	85.7
$LSD_{0.05}$	ns	30.9•	ns

Table 5. Influence of crop phase in 1-, 2-, 3- and 4-year rotations on nitrate-N in the soil profile in autumn 2002 in a field experiment from 1999 to 2002 at Melfort, Saskatchewan

Table 6. Distribution of extractable-P in the soil profile in relation to crop rotation (averaged across crop sequences and phases) in autumn 2002 in a field experiment from 1999 to 2002 in a field experiment from 1999 to 2002 at Melfort at Melfort at Melfort, Saskatchewan

Crop rotation	Extractable-P (kg P ha^{-1}) in soil layers (cm)		
	0-15	15-60	0-60
Continuous monocrop	30.9	15.6	46.5
2-year rotation	31.6	18.9	50.5
3-year rotation	35.8	18.3	54.1
4-year rotation with pea	34.7	19.3	54.0
4-year rotation with flax	38.0	18.2	56.2
$LSD_{0.05}$	6.5•	ns	ns