Intensifying Canola and Pea Crop Rotations

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Introduction

Canola production in Western Canada has enjoyed steady and rapid growth since introduction of it's ancestral crop, rapeseed more than 60 years ago. Since that time, production has almost doubled each decade. Innovation with this crop was and continues to be the driving force behind this growth. It began with agronomic improvements that made cultivars more suited to our climate, but was quickly followed by improvements to oil and meal quality. The introduction of herbicide tolerant cultivars allowed the crop to be grown on fields previously considered too weedy. It is now often used as a weed 'clean up' crop, and has eliminated the need to delay seeding as a weed control measure. Early seeding enhances yield because the crop typically avoids heat stress at the critical flowering stage.

Hybrids cultivars represent a major advance in yield potential and yield stability because they typically provide greater stress tolerance. These advancements also mean that inputs of nutrients like nitrogen fertilizer and energy are used more efficiently. These developments have positioned this crop where it could begin to enjoy a status similar to corn and soybean, which are considered to be major global crops.

However, the major influence emerging today is driven my market forces. Canola oil is very well suited for use in bio-diesel. It recently was approved for a US health claim, and specialty oil types are increasingly used to substitute for hydrogenated oils and for other oils in the fast food industry. The emphasis has clearly moved from trying to expand markets to absorb ever increased production to trying to increase production to meet ever increasing demand. However, to do so will require that we grow the crop more frequently in rotations than we have done in the past. This could present new challenges, particularly with pest control since crop rotation has been a highly effective means of reducing impacts of pests on this and other crops. To investigate the implications of more intensive canola rotations we initiated studies at the AAFC research farms at Scott and Melfort Saskatchewan.

Materials and Methods

A crop rotation experiment was initiated in 1999 at the AAFC farms at Scott and Melfort to address whether cultivar improvements would allow canola to be grown more frequently than once every 4 years. Rotations used in the study were:

Continuous canola	[Cont C]
Continuous pea	[Cont P]
Canola-wheat	[C-W]
Wheat-Pea	[W-P]
Canola-wheat-pea	[C-W-P]
Canola-wheat-pea-wheat	[C-W-P-W]
Canola-wheat-flax-wheat	[C-W-F-W]

Because of poor performance of flax in the last rotation listed, data for that rotation was not included in this report.

Duplicate canola rotations were used. One with a conventional non herbicide tolerant cultivar that was highly susceptible to blackleg [Westar], typical of cultivars used when rotation recommendations were developed. The second used hybrid herbicide tolerant cultivars that were resistant to blackleg [various InVigor hybrids]. Plots were split with half of each receiving

no fungicide, while the other was treated for control of leaf diseases using an appropriate fungicide for diseases considered to threaten each crop. Fertilizer application was based on soil tests at each location each year. At each location year, the fertilizer rate was the same for all rotations where the same crop was grown, but rates did differ between crops. For each crop, similar herbicide treatments were used in all rotations except canola. With Westar, we typically applied Edge in fall, followed by in crop applications of Muster, Poast or Lontrel as needed based on weed numbers. With InVigor, we typically applied Liberty with or without an additional grass herbicide depending on grassy weed pressure.

Economic analyses were made using costs as reported for 2008 by Saskatchewan Agriculture and Food [SAF] [www.agriculture.gov.sk.ca/crop-planning-guides] with some exceptions. Westar seed was valued at $4.40/kg, and InVigor seed at $15.40/kg. Consequently rotations with a high frequency of Invigor canola had the highest costs, while costs decreased where Westar canola or where canola was grown less frequently (Table 1). Herbicide costs of $67.30/ha as reported for canola by SAF were used although our actual costs were higher for Westar canola, and lower for Invigor. Base crop prices of $312/ t for canola; $144/t for wheat; and $160/t for pea reflected 10 year (1997-2006) average prices as reported by SAF. Our fertilizer costs were lower than those used by SAF, but because they were the same for each crop independent of rotation used, no adjustment was made in this analysis. We also examined the effect that changing canola, wheat and pea prices would have on relative economic performance of rotations.

Table 1. Mean variable costs* for rotations at Scott and Melfort.

	Variable costs [$/ha]		Total costs [$/ha]	
Rotation	**Invigor**	**Westar**	**Invigor**	**Westar**
Continuous canola	374	310	533	469
Canola-wheat	336	304	499	463
Canola-wheat-pea	311	290	476	455
Canola-wheat-pea-wheat	308	292	471	455
Continuous pea	261		438	
Pea-wheat	280		448	

* based on data from SAF and include seed, fertilizer, pesticides, machinery operation, custom work, crop insurance and interest costs.

Results and Discussion

With the blackleg susceptible cultivar [Westar], blackleg incidence and severity increased substantially with each decrease from the recommended practice of growing canola only once every four years [Table 2]. Where blackleg resistant canola [InVigor] was used incidence and severity of the disease was much lower, but a rotation effect was still evident. Thus genetic resistance has replaced some, but not all the requirement for rotation to manage this disease.

Applying a fungicide decreased blackleg severity by 37% with the susceptible but only 23% with the resistant cultivar. Fungicide increased yield by 5% with the susceptible and had little effect on yield of the resistant cultivar averaged over all rotations. Generally the impact of fungicide was greater for the continuous rotations, but did not restore yield in either continuous rotation to that of the 1 in 4 rotations. Overall, genetic resistance and rotation were the most effective means of managing this disease.

Table 2. Blackleg severity [based on the Newman 0-5, lowest to highest scale] in rotations of blackleg susceptible [Westar] and blackleg resistant [InVigor hybrid] varieties of canola over 14 site-years at Scott and Melfort, SK (2000-2006).

Rotation	Westar	InVigor
Continuous canola	2.2	0.5
Canola-wheat	1.8	0.3
Canola-wheat-pea	1.4	0.3
Canola-wheat-pea-wheat	1.1	0.1

With the blackleg susceptible cultivar Westar during the first 4 years of the study, yield declined sharply in Cont C, but differed relatively little where canola was grown every 2, 3 or 4 years (Table 3). With the resistant cultivar, yield was highest for the rotation with canola every 3 years, lower for the rotations with canola every second or 4th year, and lowest for Cont C. During 2000-04 conditions were relatively dry, and the rotation treatments had recently been imposed. Both factors may have masked some detrimental effects of more intensive canola production. During the most recent 3 year period, Westar yield in the C-W rotation was much lower than in rotations where canola appeared less frequently, and was almost as low as for Continuous Westar. Canola yield in the C-W-P [Westar] also tended to be lower that for the C-W-P-W and C-W-F-W rotations. Both these indicators suggest that more intensive rotations of canola than the recommended 1 in 4 are likely to incur yield loss if practiced for any extended period of time when older blackleg susceptible cultivars are grown.

With InVigor canola, the highest yielding rotation was C–W-P during both time periods. With InVigor, C-W provided yield similar to C-W-P-W during both time periods. This would suggest that cultivar improvements have overcome at least some of the limitations on more intensive rotations with canola.

Yield of the resistant cultivar was 30 to 70% higher than for the susceptible one, with the largest differences typically occurring in more intensive rotations. This reflects the higher genetic yield potential of the hybrid cultivar, as well as better disease resistance and to some extent better weed control associated with herbicide tolerance of the cultivar. To date, differences in weed competition between the 2 herbicide systems [conventional with Westar and Liberty Link with Invigor] have not been large, but there are indications that wild mustard, wild buckwheat, Canada thistle and stinkweed are becoming more troublesome with the conventional system.

Table 3. Canola yield [kg/ha] in rotations of blackleg susceptible [Westar] and blackleg resistant [InVigor hybrid] varieties of canola at Scott and Melfort, SK.

	8 location years 2000-03 [dry]		6 location years 2004-06 [moister]	
Rotation	**Westar**	**InVigor**	**Westar**	**InVigor**
Continuous Canola	520b*	890b	1150c	1750c
Canola-Wheat	870a	1330a	1260b	2120b
Canola-Wheat-Pea	950a	1450a	1560a	2320a
Canola-Wheat-Pea Wheat	900a	1280a	1630a	2230ab

* yields in a vertical column followed by a different letter are statistically different at P=0.05.

Growing pea every year increased mycosphaerella severity [Table 4]. Rotation effects on mycosphaerella were relatively small, and were apparent even with just a one year break between pea crops. Pea yield also increased where there was at least a one year break between pea crops, reflecting reduced disease severity. Interestingly, relatively large pea yield

responses to fungicides averaging 360 kg/ha were noted in all rotations during years when moisture was favorable, while fungicides did not benefit yield during dry years. This would suggest that rotation had less impact on this disease than climatic conditions. It is probable that much of the inoculum causing yield loss is introduced from nearby fields, thus rotation has less impact. It may be feasible to use moisture conditions up to the time when fungicide application is required as an aid to ensure that they are applied only when there is a high probability that yield responses would more than offset costs. We also observed a small improvement in pea yield for C-W-P-W compared with C-W-P, but C-W-P was not better than W-P. To date we have been unable to relate this yield difference to differences in weed or disease levels.

Wheat yield was not generally affected by canola cultivar grown the preceding year in 3 of 4 rotations [table 5]. It would be reasonable to expect that yield of succeeding crops would be reduced in rotation with a very high yielding crop. This did occur during 2005 (by 8-10%), but was not observed during any other year. This suggests that cropping systems that are conducive to high yield of one crop may positively affect all crops in the rotation. It should be noted that residual soil N was similar following either canola cultivar, and rates of N applied to wheat were the same in all rotations. Under these conditions it would be expected that residual soil N would be reduced following the higher yielding cultivar. The fact that we have only observed a yield difference one time in the past 7 years suggests that the higher yielding cultivar used N that would otherwise have been lost to the system. If this is the case, it would be a very positive development that would suggest that higher yield could be environmentally beneficial.

Table 4. Severity of mycosphaerella* and yield of pea in rotations with different pea intensities over 8 site-years at Scott and Melfort, SK during 2000-03 and 6 site years during 2004-06.

Rotation	**mycosphaerella severity [0-9]**	**yield 2000-03 [kg/ha]**	**yield 2004-06 [kg/ha]**
Continuous pea	5.0	1260b**	1680c
Pea-wheat	4.2	1570a	2030b
Pea-canola-wheat	4.2	1530a	2040b
Pea-wheat-canola-wheat	4.2	1630a	2330a

* mycosphaerella severity based on the Xue 0-9 [lowest to highest]scale

** yields in a vertical column followed by a different letter are statistically different at P=0.05.

Table 5. Yield [kg/ha] of wheat in rotations averaged over 8 site-years at Scott and Melfort, SK during 2000-03 and 6 site years during 2004-06.

Rotation phase*	**2000-03**	**2004-06**
Canola-**wheat**	1970	3070
Canola – **wheat**- pea	2260	3170
Canola – **wheat** – pea - wheat	2140	3140
Canola – wheat – pea – **wheat**	2280	3240
Pea– **wheat**	2240	3070

*yield is for the wheat phase noted in bold.

Economic analyses confirmed that with older cultivars like Westar, growing canola once every 4 years provided the higher net returns (Table 6) Results also showed that newer high yielding hybrids were much more profitable than older cultivars. With the newer hybrid (InVigor), growing canola more frequently was sometimes favored. This was particularly evident during the most recent period when moisture was more favorable. During the relatively dry period 2000-03

InVigor rotations of C-W-P were favored followed by C-W-P-W and C-W. With more favorable moisture confounded with other cumulative rotation effects during 2004-07, C-W, C-W-P and C-W-P-W performed very well with a slight advantage for C-W. In terms of overall economic performance, there was relatively little difference between C-W, C-W-P and C-W-P-W, suggesting that there is not a large incentive to take additional risk with shorter rotations.

We examined if the there were large differences between locations where the studies were conducted. Scott was much drier, with lower yields that at Melfort, so it was not surprising to find that net returns were lower at Scott. Rotation responses were generally similar at both locations, where continuous canola or continuous pea were least favored, while the differences between C-W, C-W-P, and C-W-P-W were relatively small. At Melfort, the P-W rotation did perform relatively well, while it's performance at Scott was not as good.

Table 6. Net return [$/ha] above variable expenses for crop rotations with 2 canola cultivars.

	2000-03 8 loc yr		2004-07 7 loc yr		2000-07 15 loc yr	
Rotation	**Westar**	**InVigor**	**Westar**	**InVigor**	**Westar**	**InVigor**
Cont C	-151	-96	49	172	-51	38
C-W	-40	6	113	216	36	111
C-W-P	-4	28	135	190	66	109
C-W-P-W	-3	16	159	188	78	102
Cont P	-48		8		-20	
W-P	7		103		55	

Table 7. Net return [$/ha] above variable expenses for crop rotations at Scott and Melfort with InVigor canola during 2000-06.

Rotation	**Scott**	**Melfort**
Cont C	16	59
C-W	45	172
C-W-P	51	163
C-W-P-W	45	159
Cont P	-14	-44
W-P	2	121

Crop prices can influence rotation decisions, so we looked at several price scenarios for both canola and pea. Not surprisingly, at low canola prices the C-W-P-W rotation was favored, but as canola prices increased more frequent production of canola was favored (Figure 1). However, the more diverse rotations of C-W-P and C-W-P-W provided much more stable net returns over a broad range of canola prices. Overall, the C-W-P rotation performed quite well across most scenarios.

Regardless of whether pea was priced relatively low or high, the P-C-W and P-W-C-W rotations were favored (Figure 2). At high pea prices, the C-W and even the Continuous pea performed well, but even small decreases in pea prices resulted in large reductions in net returns. Again, overall the C-W-P rotation was usually favored.

While there were no continuous wheat rotations in the study, those that had 50% wheat were somewhat more affected that the one with only 33% wheat [C-W-P], and as for other scenarios, it performed well (Figure 3).

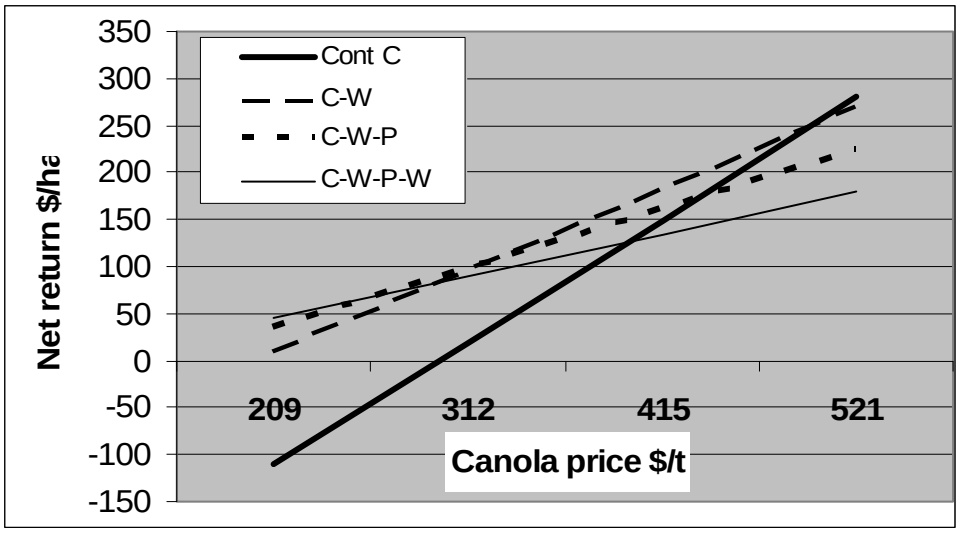

Figure 1. Influence of canola price on net returns [$/ha] with 4 InVigor canola rotations based on 14 location year yield means for Scott and Melfort 2000-2006.

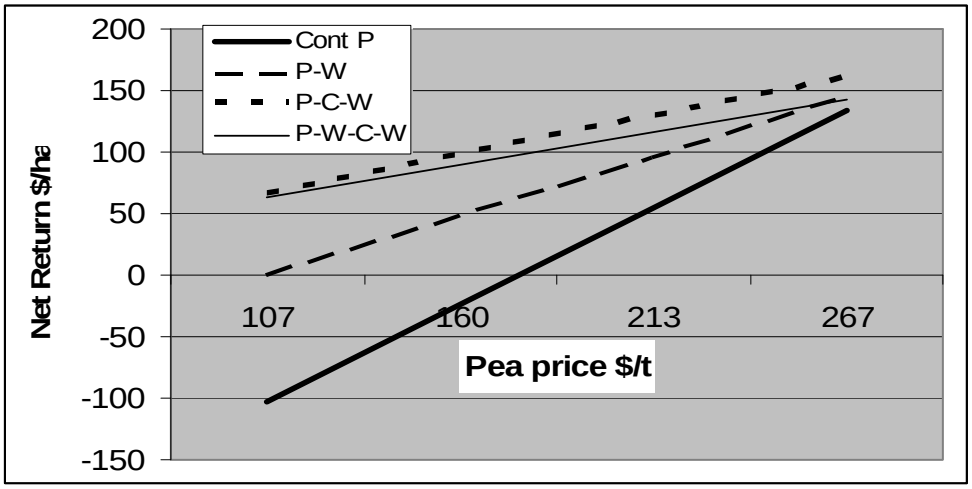

Figure 2. Influence of pea price on net returns [$/ha] with 4 rotations based on 14 location year yield means for Scott and Melfort 2000-2006.

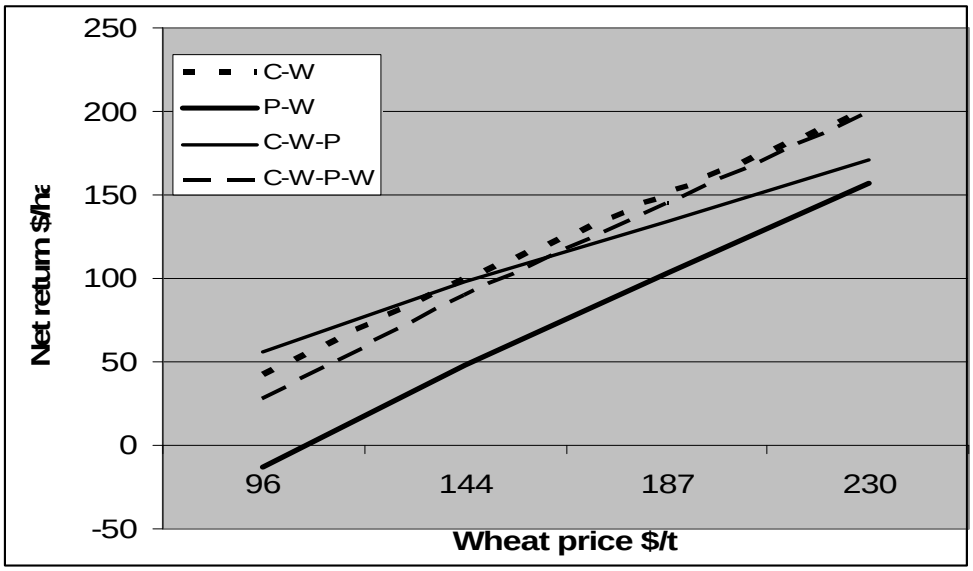

Figure 3. Influence of wheat price on net returns [$/ha] with 4 rotations based on 14 location year yield means for Scott and Melfort 2000-2006.

Summary

In summary, it appears that new canola cultivars may facilitate more frequent production of canola than one time every 4 years. At normal or above normal canola prices, there likely is an economic incentive to move to rotations with canola every 3 years, and at high canola prices, possibly every 2 years. Growing canola more frequently may pose a slightly elevated risk of blackleg. How this risk compares with using cultivars with lower resistance is not known, but would shed some light into relative importance of various risk factors. What does appear clear is that resistant cultivars presently provide the most effective means of controlling this disease, while appropriate rotation is also useful. Fungicides may be of some benefit where these fail.

We have not experienced serious yield loss from sclerotinia in these trials to date. Thus it is difficult to speculate how this disease may be affected by more intensive canola in our rotations. In regions where this disease is problematic, it would be prudent to be cautious about growing canola more frequently until the risk is more clearly understood.