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# Long-Term Productivity and Economic Performance of Spring Wheat Production Systems in Southwestern Saskatchewan

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## Introduction

- Producers in semiarid regions have relied on frequent summerfallowing (F) to conserve water and to maximize available soil N (reduce fertilizer requirements), but this practice has been shown to result in significant soil degradation (Campbell et al. 2002).
- Changes in market conditions, together with the development of new crop types and management methods, may offer wheat (W) producers new opportunities for enhancing farm income or reducing financial risk, while at the same time improving environmental sustainability of their cropping systems.
- A crop rotation experiment was initiated at Swift Current, SK, to determine the most ideal cropping frequency for wheat in this region and whether flexible rotations in which fallowing is decided each year based on criteria such as available soil water in spring (if water), or the need to control perennial weeds (if weeds), would be more effective than fixed rotations such as F-W-W. The study also compares the effects of including a legume green manure (LGM) crop in the rotation, and the production of Canada Western Red Spring (CWRS) wheat with the higher-yielding Canada Prairie Spring (CPS) wheat class.

## Objective

- To determine the effects of wheat class, summerfallow frequency, legume green manure, and flex cropping on production costs, net returns, and riskiness for wheat-based cropping systems managed with conservation tillage practices in the Brown soil zone of southwestern Saskatchewan.

## Materials and Methods

- Data were obtained from an on-going crop rotation experiment established in 1987 at the Semiarid Prairie Agricultural Research Centre (Zentner et al. 2003).

- We evaluated 7 cropping systems, five fixed and two flex-crop rotations, over the 1988 to 2002 period (Table1). All rotations have three replicates, with all phases of each rotation present every year. The soil is a Swinton loam and had been under F-W cropping for the previous 80 years.
- The rotations were managed using minimum and zero tillage practices, using recommended methods and rates of pesticide application.
- All crops were fertilized with N and P based on soil tests (Zentner et al. 2003). The average rates of N applied to wheat grown on fallow or after LGM partial-fallow were 28 to 37 kg ha<sup>-1</sup>, while wheat grown on stubble received 41 to 52 kg N ha<sup>-1</sup>. Wheat plots also received P fertilizer applied with the seed at 9.6 kg P ha<sup>-1</sup>, while the LGM received only P at a rate of 4.9 kg ha<sup>-1</sup>.
- The LGM crop was Indianhead black lentil from 1987-98, and chickling vetch, cv >AC Greenfix=, thereafter. The legume seed was inoculated with commercial peat-based rhizobium culture prior to planting.
- The wheat stubble was cut as tall as possible (usually > 30 cm) to enhance over-winter snowtrapping and soil water conservation.
- For the economic analysis, all purchased inputs and machine operations were valued and held constant at their 2003 cost levels (Saskatchewan Agriculture, Food and Rural Revitalization 2003; University of Saskatchewan 2003).
- Participation in the Canada/Saskatchewan Crop Insurance Program was assumed to be at the 70% yield coverage for both wheat classes. The 2003 premium rates and payout criteria for Risk Area # 10 of Saskatchewan were assumed (Saskatchewan Crop Insurance Corporation 2003).
- The net farm-gate prices for CWRS and CPS wheat were taken at their respective 10-year (1992/93 - 2001/02) mean values, namely \$158 t<sup>-1</sup> (STD = \$27 t<sup>-1</sup>) for CWRS wheat (13.5% protein) and \$140 t<sup>-1</sup> (STD = \$29 t<sup>-1</sup>) for CPS wheat. The price for CWRS wheat was adjusted by treatment, replicate, and year for grain protein content in accordance with the 2003 protein price schedule as established by the Canadian Wheat Board.
- The economic performance of the cropping systems were also evaluated for a range of product prices (representing two standard deviations lower to two standard deviations higher than their respective mean values) to test the sensitivity of the findings to changes in these price conditions.
- All economic results are expressed on a per hectare basis for the complete rotation systems, which includes the costs and returns for all cropped and fallow portions of each rotation, and all data were subjected to analysis of variance for split-plot designs with rotation as main plot and year as sub-plot (SAS Institute Inc. 1985). Riskiness was assessed using stochastic dominance analysis to compare the

probability density functions of net returns from the rotation treatments for producers with low, medium, and high risk aversion (Zentner et al. 1992).

**Table 1.** Crop rotation systems at Swift Current.

<b>Crop rotation description</b>	<b>Abbreviation</b>
Fallow-CWRS Wheat-CWRS Wheat	F-W-W
Legume Green Manure-CWRS Wheat-CWRS Wheat	LGM-W-W
Fallow-CPS Wheat-CPS Wheat	F-HY-HY
Fallow-CWRS Wheat-CWRS Wheat-CWRS Wheat	F-W-W-W
Continuous CWRS Wheat	Cont W
Continuous CWRS Wheat (if water) <sup>1</sup>	Cont W (if water)
Continuous CWRS Wheat (if weeds) <sup>2</sup>	Cont W (if weeds)

<sup>1</sup> Continuous CWRS wheat unless available soil water in spring is < 7.5 cm, in which case the land is fallowed. The plots were fallowed in 1988 and 1992 due to inadequate spring soil water.

<sup>2</sup> Continuous CWRS wheat unless perennial weeds become a major problem, in which case the land is fallowed. The plots were fallowed in 1994 and 1996 due to high weed densities.

## **Results and Discussion**

### Weather Conditions

- Growing season (1 May - 31 August) precipitation over the 15-year study period averaged 231 mm, 9% higher than the long-term mean for this region.
- Precipitation levels were more than 20% above normal in 8 of 15 years, near normal in 2 years, and below normal in 5 years. Thus, 1988-2002 represents a period of generally favorable growing conditions for annual crops.

### Grain Yields and Wheat Protein Concentration

- Wheat yields during the study period (Table 2) were above the long-term average for this region, reflecting the above normal growing conditions.
- Yields of CWRS wheat grown on fallow averaged 2524 kg ha<sup>-1</sup> and were similar for the F-W-W and F-W-W-W rotations, while yields of CPS wheat grown on fallow averaged 3286 kg ha<sup>-1</sup> (or 30% more), reflecting that CPS wheat was developed to produce much higher yields but lower grain protein than CWRS wheat (Clarke and DePauw 1989).
- CWRS wheat grown on LGM partial-fallow averaged 2173 kg ha<sup>-1</sup> over the 15-year period, but in the last 9 years since the LGM crop underwent a change in management, wherein the legume was seeded earlier and turned down earlier in an effort to reduce soil water depletion, subsequent fallow wheat yields were generally similar for LGM-W-W and F-W-W (Zentner et al. 2004).
- Cropping frequency also did not influence yields of CWRS wheat grown on stubble (Table 2). Stubble wheat yields averaged 1896 kg ha<sup>-1</sup>, or 79% of comparable fallow wheat yields. CPS wheat grown on stubble yielded 68% of comparable CPS fallow wheat yields and about 18% more than CWRS wheat grown on stubble.

- Grain protein concentrations were highest for CWRS wheat grown on partial fallow and on stubble in the LGM-W-W rotation, and were consistently higher for CWRS than for CPS wheat (Table 2). The higher grain protein in the LGM system was attributed to a gradual improvement in the N supplying power of the soil (Zentner et al. 2004).

**Table 2.** Yield and protein content of wheat grown in rotations at Swift Current (1988-2002).

<b>Rotation</b>	<b>Grain yield (kg ha<sup>-1</sup>)</b>	<b>Grain protein (%)</b>
<u>Wheat grown on fallow/partial fallow</u>		
F-(W)-W	2491	13.6
LGM-(W)-W	2173	14.9
F-(HY)-HY	3286	11.7
F-(W)-W-W	2556	13.7
Mean	2627	13.5
S <sub>x</sub>	70	0.18
<u>Wheat grown on stubble</u>		
F-W-(W)	1920	12.9
LGM-W-(W)	1977	14.1
F-HY-(HY)	2240	11.4
F-W-(W)-W	1892	13.1
F-W-W-(W)	1910	12.9
Cont W (if water) <sup>a</sup>	2021	12.2
Cont W (if weeds) <sup>b</sup>	1659	13.9
Cont W	1892	13.2
Mean	1946	13.0
S <sub>x</sub>	44	0.17

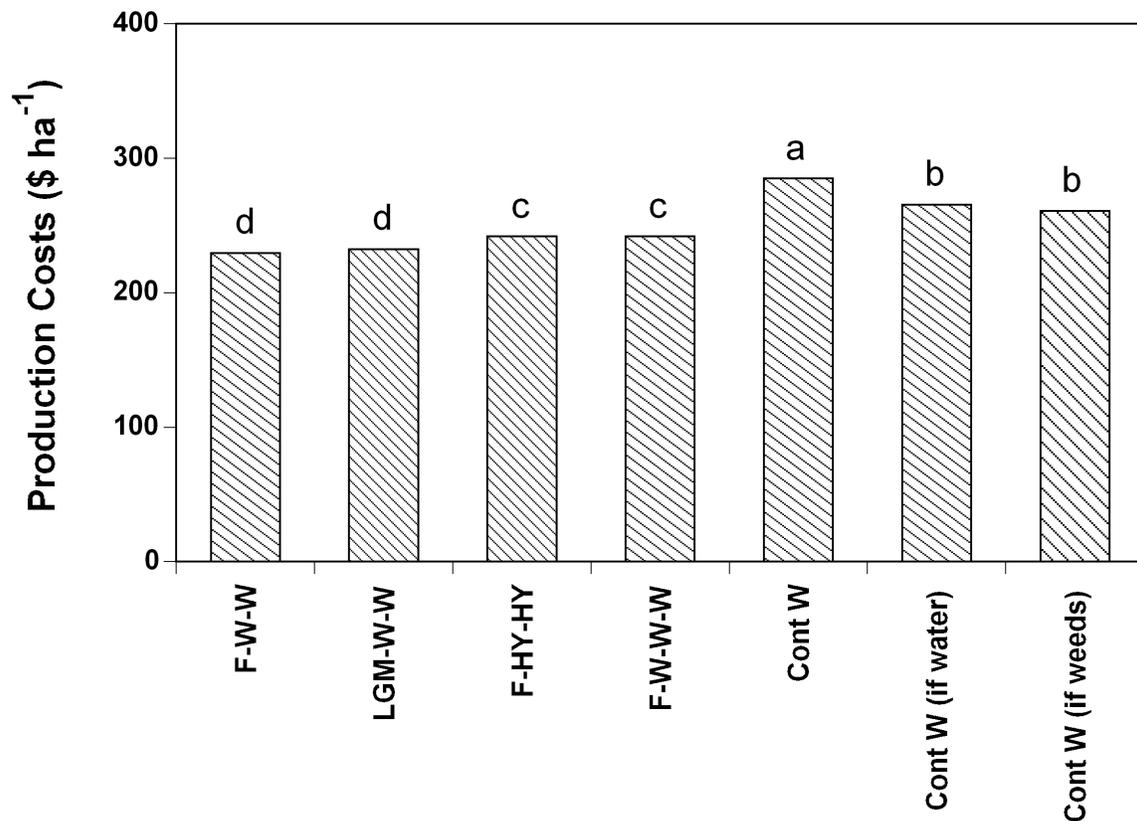
<sup>a</sup> Plots were fallowed in 1988 and 1992 due to inadequate spring soil water. Data for 1989 and 1993 were excluded from the mean values shown.

<sup>b</sup> Plots were fallowed in 1994 and 1996 due to high weed densities. Data for 1995 and 1997 were excluded from the mean values shown.

#### Production Costs and Breakeven Conditions

- Production costs for the complete rotation systems increased with cropping frequency; they averaged about \$231 ha<sup>-1</sup> for F-W-W and LGM-W-W, \$242 ha<sup>-1</sup> for F-HY-HY and F-W-W-W, and \$285 ha<sup>-1</sup> for Cont W (Fig. 1).
- The fact that average total costs were generally similar for F-W-W and LGM-W-W indicates that the added costs for seed and managing the LGM crop were largely offset by the savings in N fertilizer applied to the subsequent wheat crops plus savings in costs for weed control (tillage and herbicides) required on partial- fallow versus the full-fallow areas.

- Total costs for the flex-cropping systems were significantly lower (about \$22 ha<sup>-1</sup> less) than for Cont W, reflecting that summerfallowing the land (2 in 15 years) requires lower resource expenditures than cropping it.
- The unit cost of producing CWRS wheat on fallow averaged \$159 t<sup>-1</sup>, and \$193 t<sup>-1</sup> when it was grown on LGM partial-fallow (including the cost of summerfallow or LGM partial fallow). By comparison, the average unit cost for CWRS wheat grown on stubble ranged between \$141 t<sup>-1</sup> and \$151 t<sup>-1</sup>, with the cost being lowest for the LGM system. The unit cost of producing CPS wheat averaged \$130 t<sup>-1</sup> and \$103 t<sup>-1</sup> when grown on fallow and stubble, respectively. These values represent 'breakeven prices', or the minimum wheat prices needed to recover production costs.

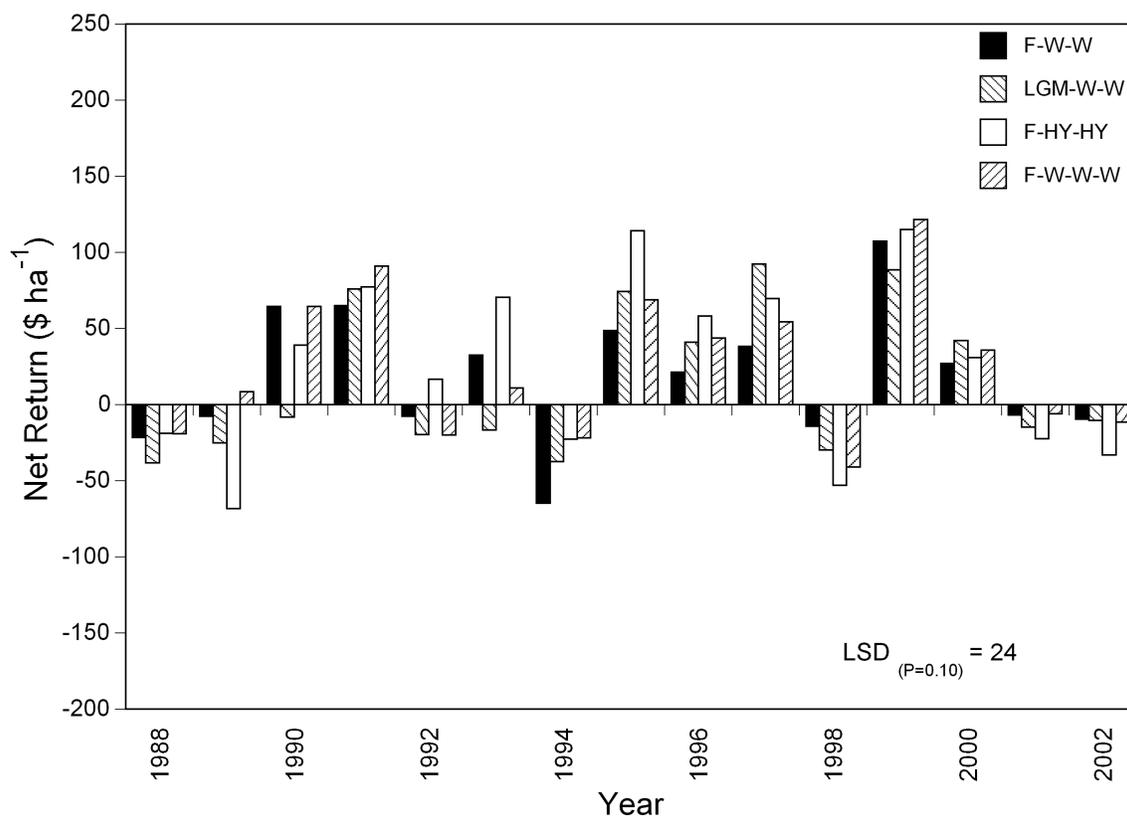


**Figure 1.** Mean production costs for cropping systems at Swift Current (1988-2002).

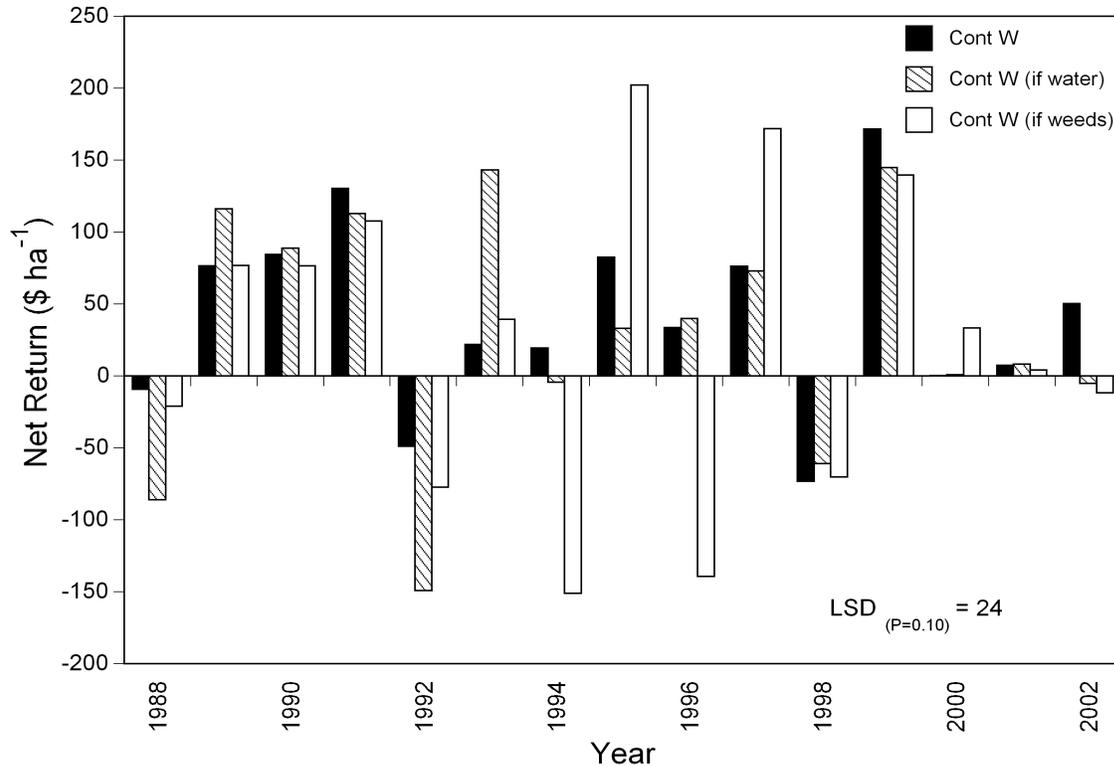
#### Net Returns

- Mean net returns (income remaining after paying for all production costs) were highest for Cont W (\$41 ha<sup>-1</sup>); intermediate for F-W-W-W, F-HY-HY, and the flex crop rotations (about \$15 ha<sup>-1</sup> less); and lowest for F-W-W and LGM-W-W (about \$25 ha<sup>-1</sup> less). These results contrast to those reported by Zentner and Campbell (1988) for another study at Swift Current conducted during the much drier 1967-1984 period wherein F-W and F-W-W were generally more profitable than Cont W.

- On an annual basis, the economic performance of Cont W and the flex-crop rotations was significantly higher than for the other cropping systems in 7-8 of 15 years, mainly those years with above average growing season rainfall. In the drier years, F-W-W and F-HY-HY generally performed best (Fig. 2 and Fig. 3).
- Net returns for LGM-W-W were significantly higher than for F-W-W in 5 of 15 years, similar in 6 years, and significantly lower in 4 years, the latter years occurred mainly prior to the change in management of the LGM crop in 1993 (Fig. 2).
- Net returns for F-HY-HY were higher than for F-W-W in 5 of 15 years, but they were significantly lower in 4 other years.
- Increases in the price for CWRS or CPS wheat favored the more intensively cropped systems, while lower wheat prices favored the rotations that included fallow (data not shown).



**Figure 2.** Annual net returns for fallow-based cropping systems at Swift Current.

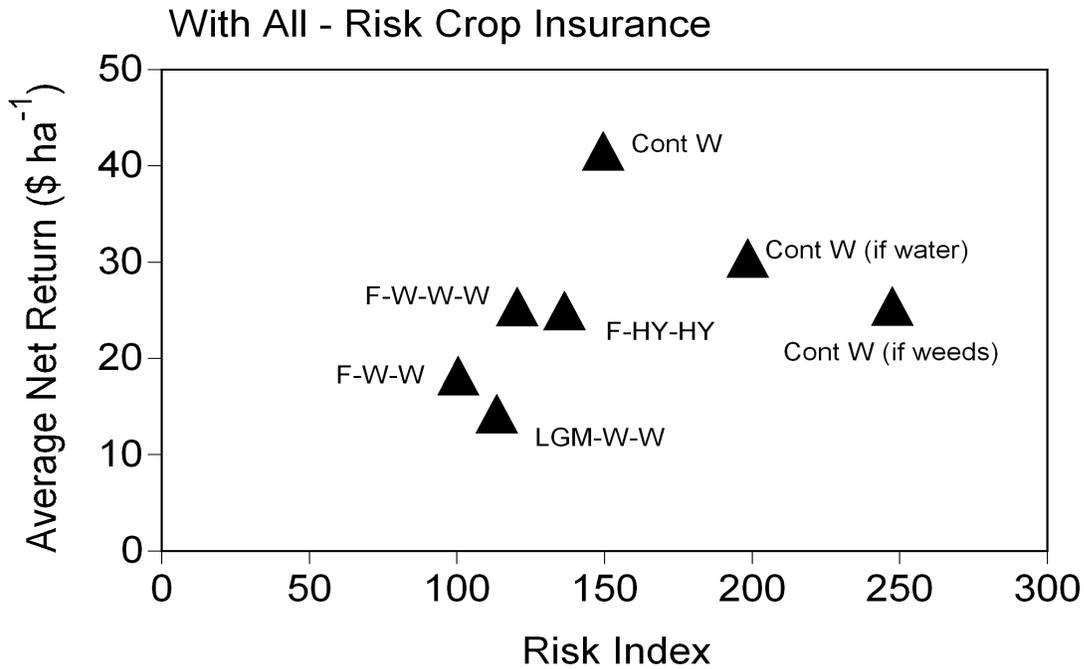


**Figure 3.** Annual net returns for continuously cropped systems at Swift Current.

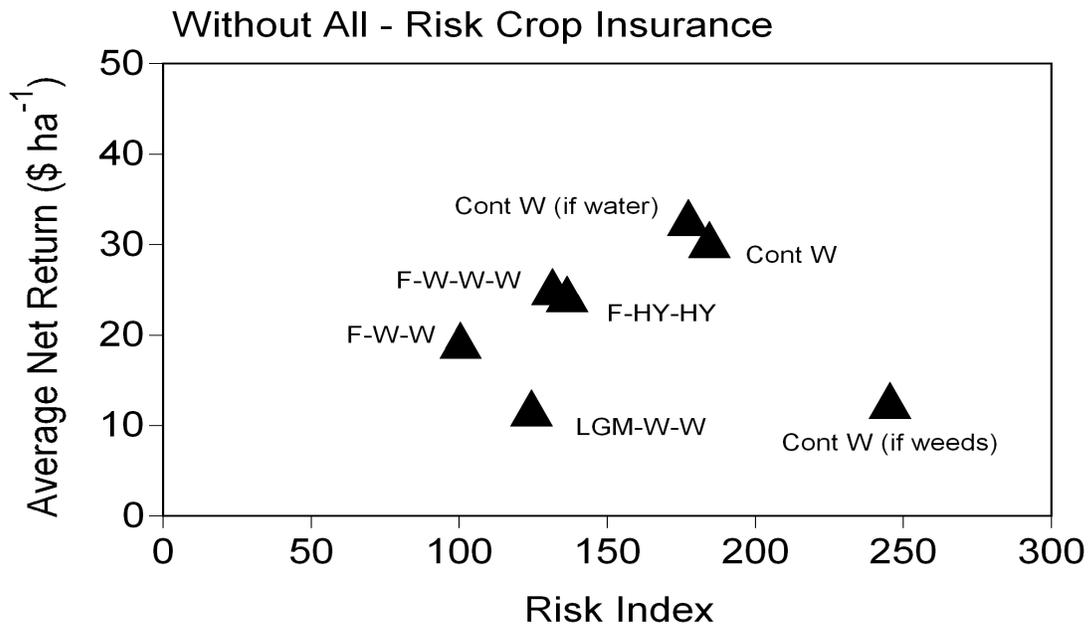
### Riskiness

- Income variability increased as cropping frequency increased (Fig.4). Riskiness was lowest for F-W-W and highest for the continuously crop systems.
- Surprisingly, the flex-crop systems displayed higher income variability than Cont W, in part because no income is generated in years when the land is summerfallowed due to inadequate spring soil water or high weed infestations, and in part due to the all-risk crop insurance program which offsets years with low grain yields (and income), thereby helping to increase and stabilize income (or minimize the losses) in these years.
- Producers face a tradeoff between the potential to earn higher net returns and the need to accept higher risk or income variability (Fig. 4).
- Based on a risk analysis of the probability distributions of net returns for the cropping systems (and with all-risk crop insurance), producers with low risk aversion (i.e., those most willing to gamble or accept risk) would choose Cont W, while more conservative producers (i.e., those less willing to gamble) would choose the F-HY-HY or F-W-W-W systems (Fig . 4).

- Without all-risk crop insurance, producers with low to moderate risk aversion would choose F-W-W-W or Cont W (if water), while producers with higher risk aversion would choose F-W-W (Fig. 5).



**Figure 4.** Tradeoff between increases in net return and increases in riskiness, assuming participation in the Canada/Saskatchewan all-risk crop insurance program.



**Figure 5.** Tradeoff between increases in net return and increases in riskiness, without all-risk crop insurance.

## Conclusions

- Wheat yields for these N and P fertilized systems, managed using conservation tillage practices, were above normal for the region, reflecting the generally favorable growing conditions during the study period.
- Wheat yields were not influenced by cropping frequency, with yields of CWRS wheat grown on stubble averaging 79% of fallow CWRS wheat yields, and with yields of CPS wheat grown on stubble averaging 68% of fallow CPS wheat yields.
- Grain protein content of CWRS wheat was highest when grown in the LGM system, and was little affected by cropping frequency.
- Total production costs increased with cropping frequency; however, the cost per unit of wheat produced displayed the reverse trend.
- Net returns were generally highest for Cont W, intermediate for the flex-crop rotations and for F-HY-HY and F-W-W-W, and lowest for F-W-W and LGM-W-W, again reflecting the good growing conditions which favored more intensive cropping systems.
- Net returns from the production of CPS wheat, with its higher yield but lower grain protein content and market price, averaged about \$10 ha<sup>-1</sup> higher than from the production of CWRS wheat grown in comparable fallow-based rotations.
- The use of a legume green manure crop as a summerfallow replacement was generally more profitable than full-fallow, but to be successful the LGM crop must be planted early (mid to late April) and its growth terminated in early July (before reaching full bloom) to minimize soil water depletion by the legume.
- The economic performance of the flex-crop rotations was superior to the fallow-based fixed rotations, but lower than for Cont W when participation in all-risk crop insurance was assumed.
- But, without all-risk crop insurance, Cont W (if water) was the preferred cropping system by producers with low to moderate risk aversion, while producers with high risk aversion would choose F-W-W.

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