Canola-Wheat Rotation versus Continuous Wheat for the Southern Plains

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Canola-Wheat Rotation versus Continuous Wheat for the Southern Plains

Abstract

Crop rotations are not common in the wheat belt of the Southern Plains. After years of continuous wheat, weeds have become increasingly difficult and expensive to manage. Yield data were elicited from farmers and used to determine if canola-wheat-wheat rotations are economically competitive with continuous wheat in the region.

Extended Abstract

In some Oklahoma counties, wheat (*Triticum aestivum* L.) has been seeded year after year on 90 percent of the cropped land. After years of continuous wheat, weeds have become increasingly difficult and expensive to manage. This study was conducted to determine if a crop rotation that includes winter hardy canola (*Brassica napus* L.) and winter wheat is economically competitive with continuous monoculture winter wheat in the Southern Plains. Data from experiment station trials that include winter canola in a rotation with winter wheat are not available. A survey of producers that have had at least three years experience with both crops was conducted to elicit subjective distributions of expected future yields for continuous wheat, canola after wheat, wheat after canola, and second year wheat after canola in a canola-wheat-wheat rotation. The method used to estimate yield distributions is similar to the fixed interval or judgmental fractile approach. The elicited yield distributions are used in combination with cost estimates to simulate expected net returns for each of four production systems: continuous grain-only wheat; continuous dual-purpose (fall-winter forage plus grain) wheat; canola followed by two crops of grain-only wheat; and canola followed by two years of dual-purpose wheat. The

three year crop rotation that includes canola followed by two years of dual-purpose wheat generates the greatest net returns in the majority of 100 simulated growing seasons. Switching from a continuous grain-only wheat system to a canola-wheat-wheat rotation increases expected net returns on average by $21 per acre per year. It remains to be determined if the growers' yield estimates for canola and wheat when grown in a rotation were overly optimistic.

Introduction

The vast majority of acres cropped to annuals in Oklahoma are seeded to winter wheat. For example, in Canadian County from 1998 to 2007, 87 percent of total crop acres were seeded to wheat (National Agriculture Statistics Service 2008) (Figure 1). When a crop is grown continuously, weeds that compete with the crop, and diseases that infect the crop, may become established in the field and become difficult to manage. Continuous cropping of annuals can result in the buildup of yield-constraining diseases and insects specific to the crop. Italian ryegrass (*Lolium multiflorum* Lam.) that was introduced to the region as a pasture grass has invaded many wheat fields and is difficult to control (Appleby et al. 1976; Barnes et al. 2001). Cheat (*Bromus secalinus* L.), downy brome (*Bromus tectorum* L.), and jointed goatgrass (*Aegilops cylindrica* Host) are also commonly found in fields seeded continuously to monoculture winter wheat (Medlin et al., 2003). These weeds make it difficult to economically grow monoculture continuous wheat in the region.

One potential solution is to use a crop rotation to manage the weed, insect, and disease problems associated with continuous cropping to wheat. Crop diversification may provide more weed control opportunities through access to more families of herbicides and may disrupt the life cycle of weeds and diseases. However, crop rotations are not common in the region of the study. Alternative winter small grain crops such as oats, barley, and rye are not economically

competitive. In most cases, attempts to include summer crops such as corn, soybeans, and grain sorghum have not been successful because they do not fit well in a rotation with winter wheat. In addition, currently available varieties of corn and soybeans do not perform well in the climate, which is characterized by hot, dry, windy summers. On average, 16 percent of planted soybean acres and 17 percent of corn acres planted for grain in the state are not harvested (National Agriculture Statistics Service 2008).

Economically viable crop rotations include crops that fit well together in a cropping calendar, enable the sharing of machinery resources, and differ sufficiently so that alternative families of herbicides may be used for weed control. One example is the common corn-soybeans rotation of the U.S. Corn Belt. Except for different combine heads, much of the same machinery may be used for both corn and soybeans. However, different herbicides may be used across crops. For example, glyphosate-tolerant soybeans enable the use of glyphosate for the soybeans crop. Conventional herbicides may be used for the corn crop.

Research efforts have been successful in developing a few winter hardy canola varieties. Herbicides that are available for use on canola would provide growers with more options for managing weeds than currently available for continuous wheat. A crop rotation that includes winter canola and winter wheat may be an economically viable alternative to continuous wheat.

Similar to soybeans and corn, winter canola and winter wheat could fit well in a cropping calendar and could share machinery resources. However, canola harvest may require swathing and a pickup head for the combine. Glyphosate-tolerant canola can enable the in-season use of glyphosate, allowing a wide spectrum of weeds to be controlled. Conventional herbicides can be used for the wheat crop. Rotation of crops that includes rotation of herbicide chemistry can help to maintain the efficacy of herbicides over time (Boyles et al. 2005).

Winter wheat is grown in Oklahoma and elsewhere in the southern plains for either grain-only, or forage-only, or for both fall-winter forage and grain as a dual-purpose crop. Surveys conducted by Hossain et al. (2004) and True et al. (2001) found that between 49-66 percent of the wheat acres planted in Oklahoma were intended for dual-purpose; 25-31 percent for grain-only; and 9-20 percent for forage-only. Forage-only wheat is more prevalent in fields heavily infested with weeds and is more common in years when the value of forage is high relative to the value of grain.

In general wheat intended for dual-purpose includes a 50 percent greater seeding rate, and 30 pounds per acre more nitrogen, and it is planted about three weeks earlier than grain-only wheat. For example, Hossain et al. (2003) found that the optimal planting date for grain-only wheat is in early October, whereas the optimal planting date for dual-purpose wheat is in mid-September (Epplin et al. 2000).

Most dual-purpose wheat is stocked with young steers and heifers (referred to in the region as stockers). Stocker weight gain is a function of stocking density, planting date, grazing initiation date, grazing termination date (therefore length of grazing), forage production, weather, and supplements. Gross return to the grazing component is a function of both weight gain and the value of gain. In most years, stockers may be placed on wheat pastures after the young wheat plants have become anchored in the soil, usually in mid November. If livestock are removed at the first hollow stem stage of wheat plant growth, usually in late February or early March, the wheat will mature and produce grain (Redmon et al. 1995; True et al. 2001; Hossain et al. 2004).

The objective of the research is to determine if a crop rotation that includes winter hardy canola and winter wheat is economically competitive with continuous monoculture winter wheat for the wheat belt of the Southern Plains. Since both dual-purpose and grain-only wheat are

grown in the region, distributions of net returns will be computed for continuous dual-purpose wheat; continuous grain-only wheat; a three year crop rotation that includes winter canola followed by two years of grain-only winter wheat; and a three year crop rotation that includes winter canola followed by two years of dual-purpose wheat.

Methods and Procedures

Yields

Since winter hardy canola is a relatively new crop, data from experiment station trials that include winter canola in a rotation with winter wheat are not available. The Oklahoma Cooperative Extension Service initiated a demonstration program with a small group of growers in 2004. The cooperating growers were provided seed and technical assistance to grow canola on ten acres. In subsequent years, some of these growers continued to plant canola. Extension personnel identified ten producers that had at least three years experience with both winter wheat and winter canola. A phone survey of these producers was conducted.

Subjective distributions of expected future yields were constructed by asking the growers to consider a six year time horizon. They were then asked their average, highest, and lowest expected yields for the next six years. Yield information was obtained for wheat after wheat (continuous wheat), canola after wheat, wheat after canola, and second year wheat after canola in a canola-wheat-wheat rotation. The method used is similar to the fixed interval or judgmental fractile approach (Norris and Kramer 1990; Pease 1992; Shapiro et. al. 1992; Clop-Gallart and Juárez-Rubio 2007).

Covariance among yields was also elicited by asking the growers' expectations regarding the yield of canola (low, average, and high) in a particular year, given a specific level for wheat yield (low, average, or high). The covariance question was designed to determine the subjective

correlation between canola and wheat yields. The survey questions were designed to enable construction of triangular yield distributions (Shapiro et al. 1992; Clop-Gallart and Juárez-Rubio 2007).

Wheat and Canola Prices

Historical canola prices are not available for Oklahoma. North Dakota leads the U.S. in canola production and is the only U.S. state for which the USDA provides both historical canola and wheat prices (National Agriculture Statistics Service 2008). Similar to Oklahoma, North Dakota has a canola processing plant and exports most of its wheat. For the purposes of this study, the assumption is made that the price of canola relative to the price of wheat in Oklahoma would be similar to the historical relative prices of canola and wheat in North Dakota. Historical North Dakota canola and wheat prices are available from 1992 to 2007 (National Agriculture Statistics Service 2008). These prices are used to calculate the realized canola-wheat price ratio for each growing season.

The historical ratio, canola price per pound divided by the wheat price per bushel, of prices received by North Dakota farmers ranges from a low of 0.02178 to a high of 0.03366. The average ratio over the 16 years for which data are available is 0.02774. For a base canola price of $0.15 per pound, based on the historical ratios, the respective low, average, and high wheat prices would be $4.46, $5.41, and $6.89 per bushel. These three sets of prices are used to compute expected net returns.

Value of Fall-Winter Grazing of Dual-Purpose Wheat

For this study, it is assumed that the fall-winter wheat pasture would be grazed by young steers. A modified stocker steer budget developed by Taylor et al. (2007) is used to determine the value of fall-winter grazing to the dual-purpose wheat enterprise.

It is also assumed that steers with an average weight of 475 pounds would be purchased during the week of October 21 and sold at a weight of 774 pounds prior to the first hollow stem stage of winter wheat plant growth during the week of March 3. Historical Oklahoma City (1992-2008) steer prices for 475 and 774 pound steers for the appropriate purchase and sale dates are interpolated from the data base maintained by the Livestock Marketing Information Center (LMIC 2008; U.S. Department of Agriculture 2006.). The buy price for the budgeted 475 pound steer is set at the 2007 level of $1.2582 per pound. The March 3 sell price for the 774 pound steer is set at the historical average of 84 percent of the October 21 buy price for the 475 pound animal.

The stocker steer budget for the dual-purpose wheat system is based on an initial steer weight of 475 pounds, a stocking rate of 1.72 acres per steer, a 21-day receiving program, and 112 days on wheat. The budget assumes that the steers have free choice access to an R-1620 high calcium mineral supplement. R-1620 contains 1620 grams of monensin per ton and has an expected daily intake of 0.15 pounds per head. The expected cost of R-1620 is $1,100 per ton. The steers are assumed to have an average daily gain of one pound during the 21-day receiving program and 2.48 pounds during the 112 days on wheat (Taylor et al. 2007).

Budgets

Research results and experiences from wheat and canola producers are used to assemble a set of budgeted management practices. Machinery fixed costs, and costs for labor, land, management, and overhead are not included in the budgets. These excluded costs are very similar for wheat and canola. Conventional tillage and custom application of herbicide, insecticide, and fertilizer is budgeted for all systems. Custom harvest, which is typical for the region, is also budgeted.

The price for glyphosate-tolerant canola seed includes the cost of a seed treatment (both an insecticide and a fungicide) and a technology fee. The wheat budgets do not include seed treatments. Each of the crop budgets includes the cost of two herbicide applications. Herbicides must be selected carefully to target the weeds prevalent in the specific field and not prohibit the planting of the alternative crop in subsequent years. Crop rotations require careful attention to field herbicide histories. The cost of a spring aerial insecticide application is included on three of the budgets. A spring aerial foliar fungicide application is budgeted for wheat for one of three growing seasons.

Budgeted fertilizer requirements for both crops include 44 pounds per acre of 11-52-0 to provide 23 pounds per acre of P_2O_5. For grain-only wheat the remainder of the nitrogen requirement is met with anhydrous ammonia. The expected nitrogen requirement for wheat is based on expected yield and is computed by multiplying the expected yield (bushels per acre) by two pounds of nitrogen per bushel and subtracting the assumed level of soil nitrogen of 15 pounds per acre (carryover). The dual-purpose wheat budget includes an additional 30 pounds of nitrogen per acre applied as urea top-dressed in late winter (Zhang et al. 2006).

Nitrogen rates included in the canola budgets are based on an expected requirement of 0.05 pounds of nitrogen per pound of canola yield goal. For winter canola, no more than a third of the nitrogen is recommended to be applied pre-plant with the remaining two thirds applied as a top-dress in late winter. The canola budgets include five pounds per acre of sulfur that could be met with six pounds per acre of 0-0-0-90S (Great Plains Canola Production Handbook 2007).

Simulations

Wheat and canola yield distributions based on the expected yields provided by the growers are combined with budgeted cost estimates to simulate expected net returns for each of

the four production systems at a canola price of $0.15 per pound and each of three wheat prices ($4.46, $5.41, and $6.89 per bushel). SIMETAR is used to simulate each system 100 times to reflect 100 growing seasons for each of the three price levels (Richardson et al. 2006). Distributions are prepared for wheat after wheat (continuous wheat), canola after wheat, wheat after canola, and second year wheat after canola in a canola-wheat-wheat rotation. Production costs and expected stocker steer returns are held constant.

Results

Survey Results

Results from the yield questions are reported in Table 1. The producers reported an expected average wheat yield in a continuous wheat system of 38 bushels per acre. For comparison, the average winter wheat yield across Oklahoma from 2004-2008 was 31.4 bushels per acre (National Agriculture Statistics Service 2008). The producers also reported expected wheat yields of 48 bushels per acre in the first year after canola and 43 bushels per acre in the second year after canola. The growers were not asked to differentiate between grain-only and dual-purpose wheat yields. Dual-purpose wheat yields are assumed to be 90 percent of grain-only wheat yields based on findings from previous studies (Hossain et al. 2003).

The growers reported an expected average canola yield of 1,825 pounds per acre. The agricultural statistics service does not provide estimates of canola yields for the state. The question designed to determine the subjective correlation between canola and wheat yields finds that the producers expect yields for the two crops to be highly correlated. Years that result in above (below) average wheat yields are expected to produce above (below) average canola yields. Based on this response, the correlation between wheat yields and canola yields is assumed to be one.

The growers were specifically asked to consider a six year time period. So, the average low value reported by the growers is assumed to occur at the probability level of 0.16 on the cumulative triangular probability function, therefore 16 percent of the time yields are expected to fall below the average of the ten growers' low estimate. Similarly, the average upper value reported by the growers is assumed to occur at approximately the 0.84 probability level on the triangular distribution. The lower and upper limits are iteratively adjusted so that the probability level of 0.16 on the resulting distribution occurs at the average low (1 in 6 year) yield reported by the 10 growers, and the probability level of 0.84 occurs at the average high (1 in 6 years) yield reported.

Figures 2, 3, and 4 include charts of the average net returns per acre for each of the four production systems for the three sets of wheat and canola prices. The estimated pre-harvest cash costs for the budgeted yields are $215 per acre for grain-only wheat and $270 per acre for glyphosate-tolerant canola. The rotation yield advantage reported by growers contributes to an average net returns advantage for wheat in the crop rotation.

The three year crop rotation that includes canola followed by two years of dual-purpose wheat generated the greatest net returns in the majority of the 100 simulated growing seasons (Table 2). For a canola price of $0.15 and wheat prices of $4.46 and $5.41 per bushel the rotation of canola followed by two years of dual-purpose wheat wins 100 percent of the time. For a canola price of $0.15 and a wheat price of $6.89 per bushel, the system of canola followed by two years of dual-purpose wheat results in the highest net returns 64 out of 100 times.

For the crop rotation of canola followed by two years of dual-purpose wheat, a 900-acre farm would have 300 acres of canola, 300 acres of first year dual-purpose wheat, and 300 acres of second year dual-purpose wheat. In addition to the wheat and canola, the 600 dual-purpose

wheat acres on the 900-acre farm would be expected to support 348 stocker steers during the fall-winter grazing season. The expected average net returns to land, machinery fixed costs, labor, overhead, and management for this system are $60, $20, and -$5 per acre per year based on the $6.89, $5.41, and $4.46 wheat prices and $0.15 canola base price. This includes returns from wheat, canola, and stocker steers.

The three year crop rotation that includes canola followed by two years of grain-only wheat generated the second greatest net returns. On average, the rotation of canola followed by two years of grain-only wheat produces $6, $10, and $13 per acre less than the canola-dual-purpose wheat-dual-purpose wheat rotation for the $6.89, $5.41, and $4.46 wheat prices respectively and the $0.15 canola base price.

Based on the budgets and simulation results, switching from a continuous grain-only wheat system to a canola-wheat-wheat rotation increases expected net returns by $10, $21, and $29 per acre per year, for the $6.89, $5.41, and $4.46 wheat prices respectively and the $0.15 canola price. Switching from a continuous dual-purpose wheat system to a rotation that includes canola followed by two years of dual-purpose wheat increases expected net returns by $3, $14, and $20 per acre per year with respect to the $6.89, $5.41, and $4.46 wheat prices respectively and the $0.15 canola price.

Figure 5 includes the CDFs for a wheat price of $5.41 per bushel and a canola price of $0.15 per pound for each of the four production systems. At the budgeted input and output prices, the continuous grain-only wheat system has an estimated 57 percent probability of resulting in negative net returns. The system of canola followed by two years of grain-only wheat has an estimated 42 percent probability of resulting in negative net returns. Continuous dual-

purpose wheat and the system of canola followed by two years of dual-purpose wheat each have a respective estimated 44 percent and 34 percent probability of resulting in negative net returns.

Conclusion

Wheat is the primary crop grown in the Southern Plains. It is not typically rotated with other crops. Wheat is often grown for two (dual) purposes in Oklahoma: fall-winter forage for livestock grazing and grain. Dual purpose wheat is grazed by cattle during the winter months, and then is allowed to mature in the spring and produce a grain crop. Research was conducted to determine if crop rotations that include winter canola and winter wheat are economically viable alternatives to continuous wheat in the traditional wheat regions of the Southern Plains. The cropping systems include: continuous grain-only wheat, continuous dual-purpose wheat, canola grain-only wheat-grain-only wheat rotation, and a canola-dual-purpose wheat-dual-purpose wheat rotation. Field operations and operating inputs were obtained from agronomy experts. Yield estimates were obtained from Oklahoma producers that have grown both crops. The low, average, and high estimated yields of these producers were collected and used to construct triangular distributions.

The wheat and canola yield analysis shows that on average over 100 trials, the canola-dual-purpose wheat-dual-purpose wheat rotation has the highest net returns. Based on the simulation, the canola-dual-purpose wheat-dual-purpose wheat rotation produced higher net returns the majority of 100 trails with respect to each set of wheat and canola prices. The average net returns produces over the 100 trials was $53.98, $10.02, and $-18.25 with respect to the $6.89, $5.41, and $4.46 wheat prices and the $0.15 canola base price. Given the production parameters provided by the producers and the budgeted prices, the market is providing an incentive to incorporate winter canola into a rotation with winter wheat. However, it remains to

be seen if the growers' estimates of canola and wheat yields when grown in a rotation will be realized over time, or if these estimates, based on three growing seasons, are overly optimistic.

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Table 1. Expected Average, High, and Low Yields For Continuous Wheat, Wheat in a Canola-Wheat-Wheat Rotation, and Canola in a Canola-Wheat-Wheat Rotation.

Crop	Units	Expected Average Yield	Expected High Yield (1 of 6 years)	Expected Low Yield (1 of 6 years)
Wheat Yield in a Continuous Wheat System	bu/acre	38	56	21
Wheat Yield in Second Year of a Canola-Wheat-Wheat Rotation	bu/acre	48	67	29
Wheat Yield in Third Year of a Canola-Wheat-Wheat Rotation	bu/acre	43	56	28
Canola Yield in a Canola-Wheat-Wheat Rotation	lb/acre	1,825	2,355	1,250

Yields reported in this table are the averages as reported by a surveyed sample of Oklahoma wheat and canola producers.

Table 2. Results of Simulating 100 years of each of the Four Production Systems at a canola price of $0.15 per pound and three wheat prices.

Production System	Wheat Price ($/bu)		
	$4.46	$5.41	$6.89
Continuous grain-only wheat	0	0	5
Continuous dual-purpose wheat	0	0	31
Three year rotation of canola followed by two crops of grain-only wheat	0	0	0
Three year crop rotation that includes canola followed by two years of dual-purpose wheat	100	100	64

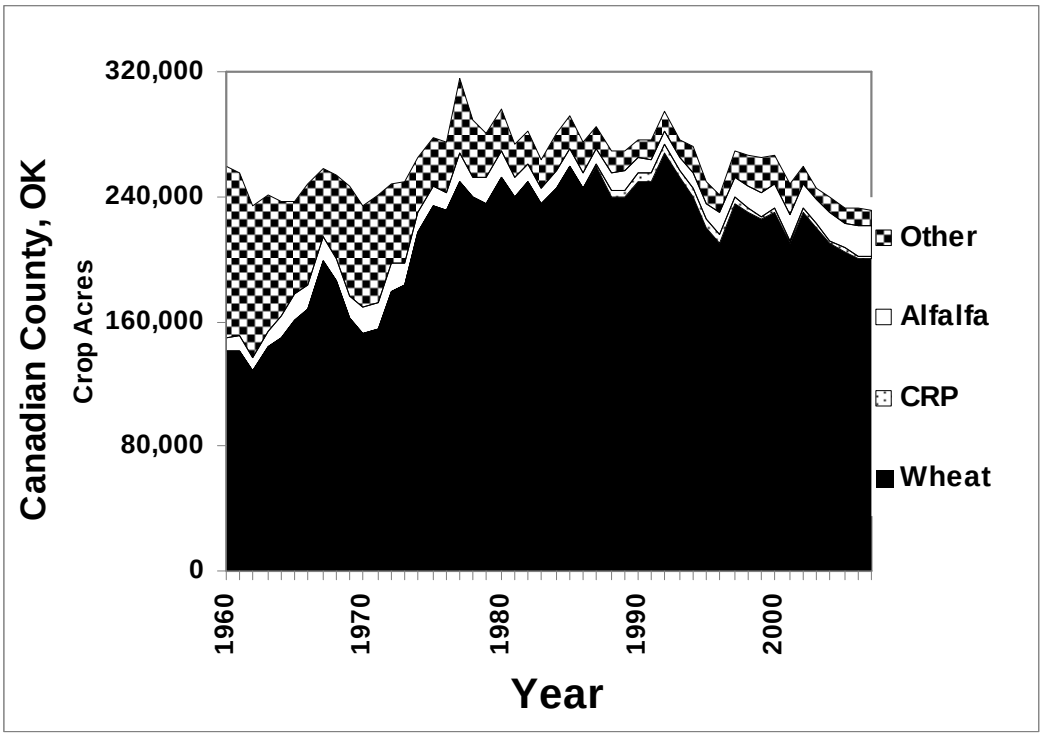

Figure 1. Canadian County, Oklahoma cropland acres seeded to wheat, alfalfa, and other crops, and acres in the conservation reserve program (CRP), 1960-2007.

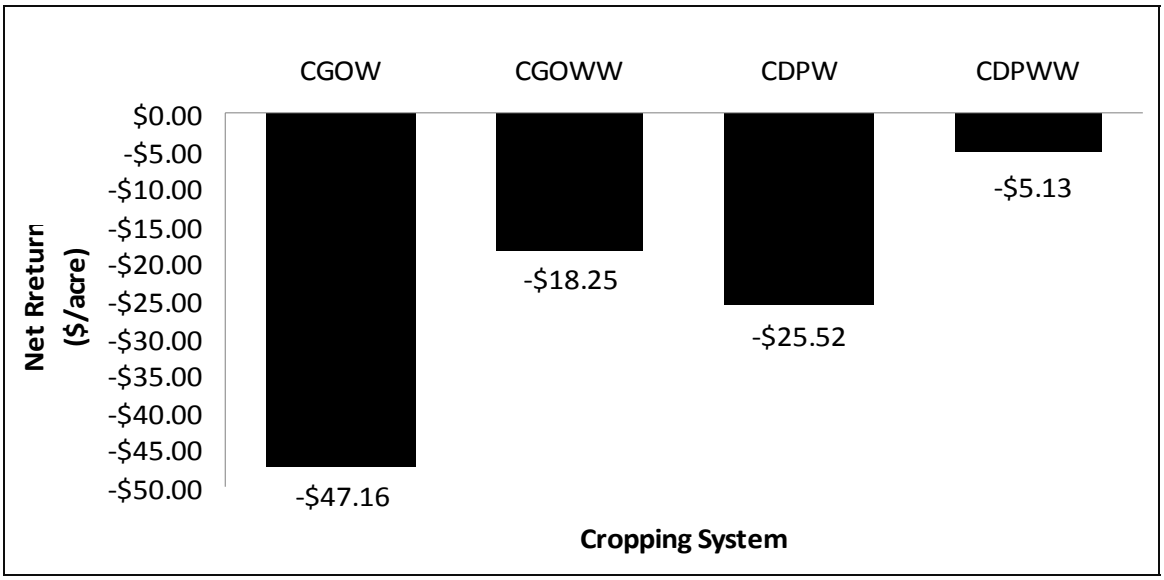

Figure 2. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat (CGOW), Continuous Dual-purpose Wheat (CDPW), a Canola-Grain-only Wheat-Grain-only Wheat Rotation (CGOWW), and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation (CDPWW), Averaged across 100 years of Simulated Yields for a wheat price of $4.46 and a canola price of $0.15 per pound.

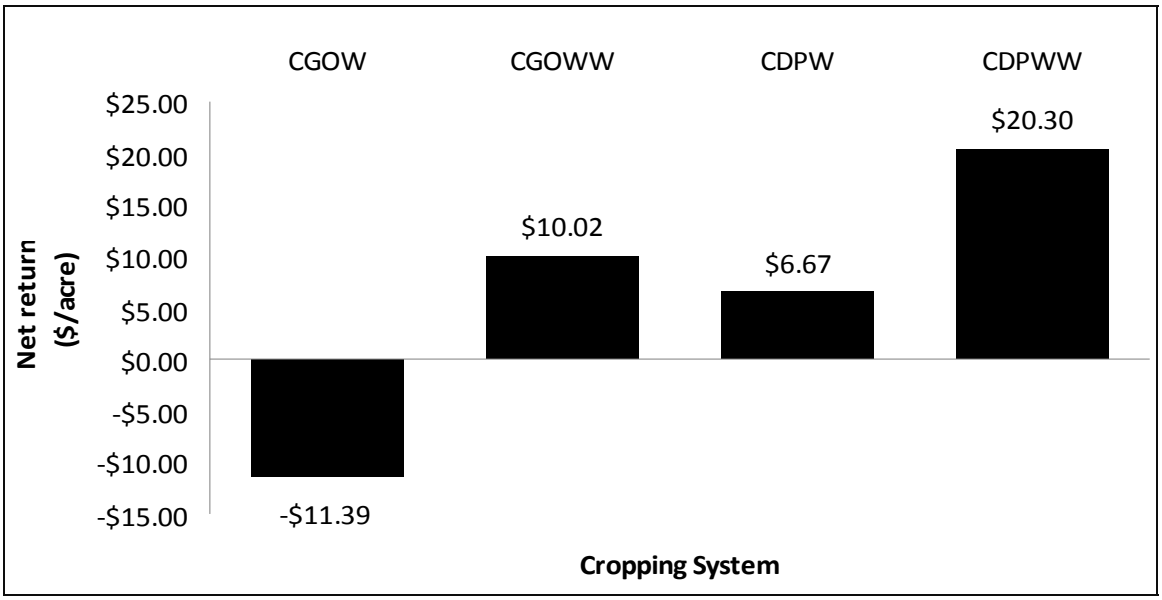

Figure 3. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat, Continuous Dual-purpose Wheat, a Canola-Grain-only Wheat-Grain-only Wheat Rotation, and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, Averaged across 100 years of Simulated Yields for a wheat price of $5.41 and a canola price of $0.15 per pound.

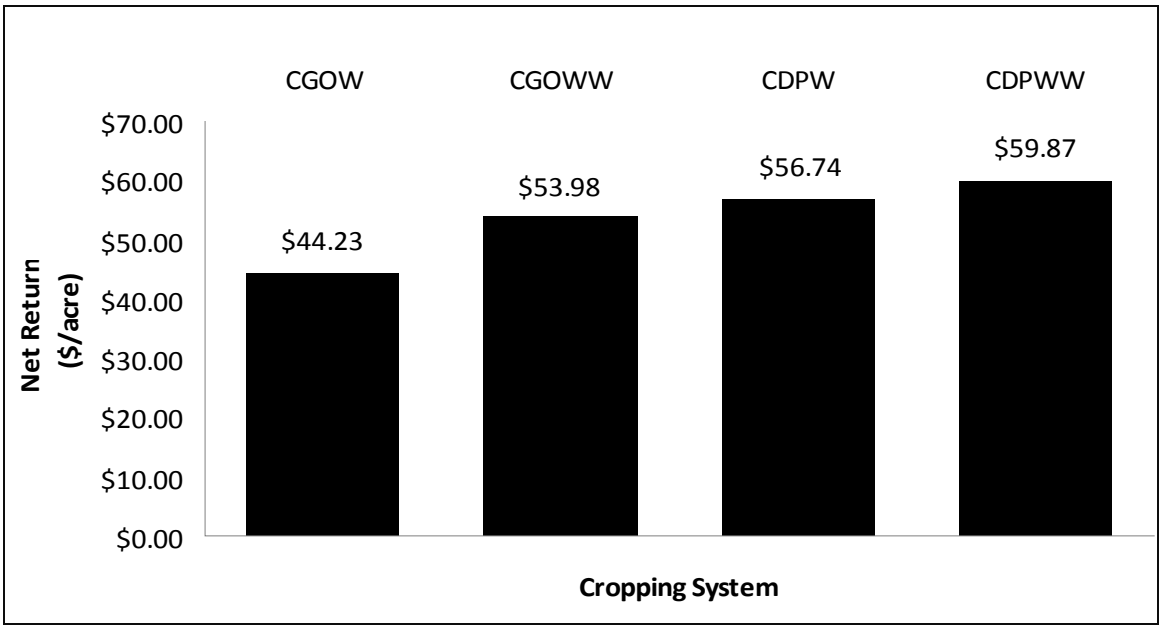

Figure 4. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat, Continuous Dual-purpose Wheat, a Canola-Grain-only Wheat-Grain-only Wheat Rotation, and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, Averaged across 100 years of Simulated Yields for a wheat price of $6.89 and a canola price of $0.15 per pound.

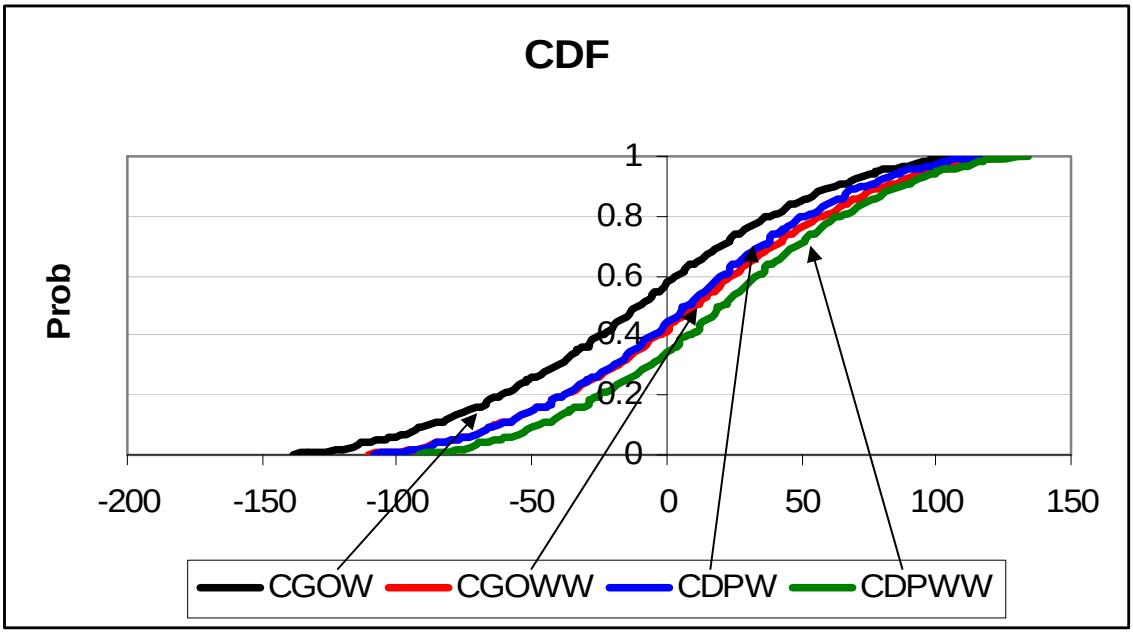

Figure 5. Cumulative distribution functions for four production systems (Continuous Grain-only Wheat, CGOW; Continuous Dual-purpose Wheat, CDPW; Canola-Grain-only Wheat-Grain-only Wheat Rotation, CGOWW; Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, CDPWW) for a wheat price of $5.41 and a canola price of $0.15 per pound.