COMPARISON OF PRODUCTION SYSTEMS INVOLVING GRAIN-ONLY WHEAT, DUAL-PURPOSE WHEAT, AND CANOLA

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TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

Figure Page

PAPER I

CANOLA-WHEAT-WHEAT ROTATION VERSUS CONTINUOUS WHEAT FOR THE SOUTHERN PLAINS

Abstract

In some Oklahoma counties wheat (*Triticum aestivum*) 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 and winter wheat is economically competitive with continuous monoculture winter wheat in the region. Data from experiment station trials that include winter canola in a rotation with winter wheat are not available. A phone survey of producers that have had at least three years experience with both crops was conducted. Information provided by the growers was used to produce 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 is similar to the fixed interval or judgmental fractile approach. The yield distributions were 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 generated 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 $21.41 per acre per year. Based on the expected yields reported by growers and the simulated net returns, the canola-wheat-wheat rotation dominates continuous wheat. It remains to be seen if the growers' estimates of canola and wheat yields when grown in a rotation were overly optimistic.

Introduction

In the United States hard red winter wheat (*Triticum aestivum*) is the largest wheat class produced and exported (Hossain et al. 2003). Kingfisher County, Oklahoma has approximately 77 percent of crop acres seeded to wheat, and in Garfield County, Oklahoma approximately 83 percent the crop acres are seeded to wheat. Canadian County, Oklahoma has had an average of 87 percent of total crop acres seeded to wheat from 1998 to 2007 (National Agriculture Statistics Service 2008). Figures I-1, I-2, and I-3 show the proportion of total crop acres seeded to wheat from 1960-2007 in Kingfisher, Garfield, and Canadian counties, respectively. These graphs show the importance of wheat in Oklahoma relative to other field crops for these counties.

Winter wheat is grown 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 9-20 percent of the wheat acres planted in Oklahoma were intended for forage-only; 49-66 percent were intended for dual-purpose; and 25-31 percent for grain-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.

A unique combination of climate and soils in the region enable the production of dual-purpose winter wheat. In a dual-purpose system where fall forage and grain are both economically important, growers traditionally plant wheat in mid-September (Epplin et al. 2000). Grazing of fall winter wheat forage typically begins in mid November. Fall forage production is a function of planting date with more forage produced from early planted wheat. However, wheat grain yield is also a function of planting date and expected yield from early planted wheat is less than the expected yield from wheat that is planted in early October. Most dual-purpose wheat is stocked with young steers and heifers (referred to as stockers in the region). Returns to both cattle and wheat must be considered to maximize net returns in the dual purpose wheat enterprise.

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. Net 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 (Tembo et al. 1999).

Grain-only wheat, as the name implies, is planted to produce only grain. Producers will optimally plant wheat intended for grain-only use later than wheat intended for dual-purpose. Hossain et al. (2003) found that the optimal planting date for grain-only wheat is in early October. The expected grain yield from the later planted grain-only wheat is higher than the expected grain yield of the earlier planted dual-purpose wheat as a result of the later planting date (Hossain et al. 2003).

Weeds, especially the introduced invasive species, ryegrass, make it increasingly difficult to grow monoculture continuous wheat for grain. Other grasses and weeds such as closely related brome species, and jointed goat grass can also become a problem in monoculture continuous wheat for grain. Most ryegrass seed germinates in the first season it grows; therefore, control of ryegrass and other weeds is a very important factor that can affect wheat yield (Scott 2005).

Ryegrass was first introduced into the region as pasture grass and eventually became a wheat field invader (Barnes et al. 2001). Ryegrass is a prolific seed producer and adapts quickly to a number of stimuli (Smith 2003). Many times, during harvest, the ryegrass is still green when the wheat has already matured. This makes it especially difficult for combines to run smoothly through the wheat. Wheat grain yield is negatively affected by ryegrass (Appleby et al. 1976). The control of ryegrass infestations in the current year will have a direct effect on the stand of ryegrass the following year (Appleby et al. 1976). Herbicides registered to control ryegrass in a continuous wheat environment are expensive and often provide less than 100 percent control. One potential solution is to use a crop rotation that includes a glyphosate tolerant crop such that the broad spectrum glyphosate herbicide may be used to control the ryegrass. For traditional monoculture Oklahoma winter wheat fields that have become infested with ryegrass, glyphosate-tolerant winter hardy canola is a potential candidate as a rotation crop with winter wheat (Smith 2003).

When a crop is grown continuously, 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. The profitability of wheat production can then be reduced by these wheat diseases and insects.

A well-planned crop rotation can help with insect and disease control and can aid in maintaining or improving soil structure and organic matter levels (OMAFRA 2002). Crop diversification provides more control opportunities and disrupts the life cycle of weeds and thus can result in reduced weed densities over time, therefore, increasing yields.

Continuous wheat cropping in Oklahoma has increased wheat production problems (Peeper et al. 2008). Crop rotations, that might be used to manage weeds and diseases, are not common in the region. 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. 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 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 (NASS 2008).

Public research efforts have been successful in developing a few winter hardy canola varieties. A few glophosate-tolerant winter canola varieties have also recently been released. A crop rotation that includes canola and wheat may be an economically viable alternative to continuous wheat. Herbicides that are available for use on canola would provide growers with more options for managing weeds if a crop rotation is used. As noted, herbicides registered to control ryegrass in a continuous wheat environment are expensive and often provide less than 100 percent control in part because they require moisture after application that may not be forthcoming. This control may be easier to obtain for Oklahoma producers by switching from continuous winter wheat to a crop rotation that includes winter canola in a rotation with winter wheat.

One of the motivations for evaluating winter canola is because once established it is a strong competitor with weeds. Canola in a rotation with wheat could potentially break weed and disease cycles and improve wheat yields. 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 enables of the use of glyphosate for the soybeans crop. Conventional herbicides may be used for the corn crop.

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 would enable the in-season use of glyphosate, allowing a wide spectrum of weeds to be controlled. If necessary, conventional herbicides could 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).

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 Canola Growers Association 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 expected average, highest, and the lowest yield 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 (Shapiro et al. 1992). Covariance among yields was also elicited. During the phone conversation, answers to the following questions were sought.

1. What rotation that includes both wheat and canola do you expect to be most successful?
2. What is your expected low, average, and high yields over a six year period from:
    a. Wheat after wheat (continuous wheat)
    b. Wheat after canola
    c. 2nd year wheat in a wheat-wheat-canola rotation
    d. Canola after wheat
3. If the yield of wheat is (low, average, and high) in a particular year, what yield level would you expect for canola (low, average, or high)?

The third question was designed to determine the subjective correlation between canola and wheat yields. Together the second and third questions were designed to enable the construction of triangular yield distributions (Shapiro et al. 1992). The triangular distribution is a probability distribution with a lower limit, average, and upper limit. Mathematically, the triangular distribution is:

$$f(x|a,b,c) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)} & \text{for } a \leq x \leq c \\ \frac{2(b-x)}{(b-a)(b-c)} & \text{for} c \leq x \leq b \end{cases} \quad (1)$$

Where: *a* is the adjusted minimum estimate; *b* is the adjusted maximum estimate; *c* is the adjusted mode estimate; and *x* is the random variable.

Wheat and Canola Prices

North Dakota leads the U.S. in canola production (NASS 2008). North Dakota is the only U.S. state for which the USDA provides both historical canola and wheat prices. Similar to Oklahoma, North Dakota has a canola processing plant and exports most of its wheat. For the purposes of this study it is assumed 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 (NASS 2008). These prices can be used to calculate the realized canola-wheat price ratio for each growing season.

$$PRx = Cpx / Wpx \quad (2)$$

Where: *x* is the specified year; *Cpx* is the price of canola in year *x*; *Wpx* is the price of wheat in year *x*; and *PRx* is the price ratio in year *x*.

The historical average price ratio, as well as the lowest and highest ratio can be determined. The historical ratio, canola price per pound divided by the wheat price per bushel, of prices received by North Dakota farmers ranged from a low of 0.02178 to a high of 0.03366. The average ratio over the 16 years for which data are available was 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. Expected returns are computed for each of these three sets of prices. These prices are calculated by:

$$W_p = C_{bp} / PR_x \tag{3}$$

Where: W_p is the wheat price; C_{bp} is the canola base price (set at $0.15 per pound); and PR_x is the specified price ratio.

Value of Fall-Winter Grazing of Dual-Purpose Wheat

As noted, in addition to grain yield, the economics of dual-purpose wheat depends on the value of the fall-winter grazing. It was 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 included in Table I-3. This budget was used to determine the value of fall-winter grazing to the dual-purpose wheat enterprise. The value of fall-winter grazing of dual-purpose wheat is determined as follows:

$$NR (\$/acre) = [(Ps*Ws)*(1-DL)-(Pp*Wp)-C]*[SD] \tag{4}$$

where: Ps is the selling price ($/cwt); Ws is the selling weight (cwt); DL is the death loss (%); Pp is the purchase price ($/cwt); Wp is the purchase weight (cwt); C is the total of other costs per head ($/hd); and SD is the stocking density (head/acre).

Steer price data were collected from the LMIC (2008). Since 1992, the USDA has been reporting Oklahoma City steer prices in 50 pound increments (USDA 2006). The buy price for the budgeted 475 pound steer was set at the 2007 level of $1.2582 per pound. With sixteen years of data, the ratio of sell to buy price was used in determining the price to use in the stocker budget. The ratio was then applied to the buy price of a 475 lb steer in 2007. The spring sell price for the 774 pound steer was set at the historical average of 84 percent of the fall buy price for the 475 pound animal. The sell price for the 774 pound steer was linearly interpolated between the prices reported for 725 and 775 pound animals. The interpolation was done by subtracting the actual weight from the lower weight and multiplying it by higher weight price subtracted from the lower weight price. The product was then subtracted from the lower price. Then that value was divided by 50 due to the price report in 50 pound increments.

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. R1620 contains 1620 grams of monensin per ton and has an expected daily intake of 0.15 pounds per head. The expected cost of R1620 is $1,100 per ton. The steers are assumed to have an average daily gain of one pound during the receiving program and 2.48 pounds during the 112 days on wheat (Taylor et al. 2007). The ending weight was calculated based on an assumed buy weight of 475 lbs, 21 pounds for gain during the receiving period and then adding the pounds from grazing 112 days gaining on average 2.48 lbs per day:

(475 lbs + (1 lb/day * 21 day receiving program) + (2.48 lbs/day * 112 grazing) = 774 lbs) (5)

Budgets

Production practices budgeted for each of the crop production systems (grain-only wheat, dual-purpose wheat, Roundup Ready® (RR) canola, and conventional canola) are reported in Table I-1. Table I-2 includes a copy of the base enterprise budget for each crop. The wheat intended for grain-only is assumed to be seeded in early October and the dual-purpose wheat is assumed to be seeded around September 13. Custom application of fertilizer, herbicide, and insecticide are assumed and included in the budgets. Research results and experiences from wheat and canola producers were used to assemble the 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 RR canola seed includes the cost of the seed treatment and technology fee. A seed treatment is included in the conventional canola budget. These seed treatments include both an insecticide and a fungicide. The wheat budgets do not include seed treatments.

Each of the crop budgets includes the cost of two herbicide applications. Several grass and broadleaf herbicides are available for wheat. Some herbicides that are labeled for continuous wheat are persistent in the soil and have a time requirement prior to safe planting of canola. Herbicides must be selected carefully to target the weeds prevalent in the specific field and that will 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.

The budgeted fertilizer requirements for both crops include 44 pounds per acre of 11-52-0. The intent is 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 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, it is recommended that no more than a third of the nitrogen 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 2008).

Simulations

Yield information provided by the growers was 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). As noted these three wheat prices were based on the historical canola to wheat price ratio. For these simulations, production costs, and expected stocker steer returns were held constant. Wheat and canola yields were simulated based on the distribution information provided by the surveyed growers. Distributions were 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. Dual-purpose wheat yields were assumed to be 90 percent of grain-only wheat yields based on findings from previous studies (Hossain et al. 2003). Each cropping system was simulated 100 times to reflect 100 growing seasons for each of the three price levels.

Results

Survey Results

Each of the ten growers contacted by phone was cooperative and provided responses to the designed questions. However, the first question, “What rotation that includes both wheat and canola do you expect to be most successful?” did not identify a consensus. The responses confirmed that growers in the region are struggling to identify crop rotations that are economically viable. For example, one producer hypothesized that a three year rotation, wheat-wheat-double cropped soybeans-corn, may work. However, he has had only limited experience with the rotation. In some years, summer moisture in the region is insufficient to support double-cropped soybeans after wheat. One grower posited that a wheat-wheat-grain sorghum-sunflower rotation might help to manage weeds and diseases, but was concerned about its economic viability. One general consensus across the ten growers was that at least one full year out of wheat would be necessary to break the weed and disease cycles. The sample of growers was provided by the Canola Growers Association and all have experience with canola. They indicated that as they learn more about canola they plan to adjust their canola production systems. Several expressed concern about the difficulties of incorporating winter canola into a no-till production system.

Results from the second question on the survey, “What are your expected low, average, and high yields over a six year period”, are reported in Table I-4. 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). They also reported that expected wheat yields increased after a year of canola to 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 were 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 yet provide estimates of canola yields for the state. The third survey question, “If the yield of wheat is (low, average, and high) in a particular year, what yield level would you expect for canola (low, average, or high)?” was designed to determine the subjective correlation between canola and wheat yields. Based on their experience, the producers reported that the expected yields for the two crops would 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 was 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 was 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 grower’s low estimate. Similarly, the average upper value reported by the growers was assumed to occur at approximately the 0.84 probability level on the triangular distribution. The lower and upper limits were iteratively adjusted so that the probability level of 0.16 on the resulting distribution occurred at the average low (1 in 6 year) yield reported by the 10 growers, and the probability level of 0.84 occurred at the average high (1 in 6 years) yield reported. The lower, average, and upper values used for the triangular distribution in continuous grain-only wheat were 1.0, 38.8, and 73.0 respectively. For first year wheat after canola the values were 8.0, 47.65, and 89.0. The values for second year wheat after canola were 9.0, 42.5, and 72.0. The lower, average, and upper limits for canola were 450, 1825, and 3090. A cumulative distribution function (CDF) chart of the elicited wheat yields is shown in figure 7.

Simulation Results

Figures I-4, I-5, and I-6 show the average net returns per acre for each of the four production systems for each of the three sets of wheat and canola prices. Estimated production costs are very similar for conventional and glyphosate-tolerant canola. 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 cost estimates from the glyphosate-tolerant canola budget were used to compute the net returns. The farmers reported a substantial yield advantage for wheat in the rotation relative to continuous wheat. This yield advantage contributes to an average net returns advantage for wheat in the crop rotation.

Price required to breakeven given the yields included in the budgets of 38 bushels per acre for grain-only wheat, and 1,825 pounds per acre for RR canola, are approximately $5.66 per bushel and $0.15 per pound, respectively.

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. At a canola price of $0.15 and a wheat price at $4.46, the rotation of canola followed by two years of dual-purpose wheat wins 100 percent of the time. The same is true with a canola price of $0.15 and a wheat price of $5.41. When the canola price is held the same with a wheat price of $6.89, 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 $59.87, $20.30, and $-5.13 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 at the $4.46 wheat price. At the highest wheat price (where the ratio of canola to wheat was the lowest, .021782) the system of canola followed by two years of grain-only wheat brought the highest net returns 0 out of 100 times. The expected average net returns for this system are $53.98, $10.02, and $-18.25 per acre per year for the respective $6.89, $5.41, and $4.46 wheat prices and $0.15 canola base price. On average the rotation of canola followed by two years of grain-only wheat produces $5.89, $10.28, and $13.12 per acre less than the canola-dual-purpose wheat-wheat rotation for the $6.89, $5.41, and $4.46 wheat prices and $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 $9.75, $21.41, and $28.91 per acre per year, with respect to the $6.89, $5.41, and $4.46 wheat prices and $0.15 canola base 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 $3.13, $13.63, and $20.39 per acre per year with respect to the $6.89, $5.41, and $4.46 wheat prices and $0.15 canola base price.

Also determined was the scenario of choosing the system with the highest net returns every time over the 100 trials. At the low price ratio of canola to wheat (high wheat price of $6.89 per bushel with canola at $0.15 per pound), the producer could gain $.33 more per acre by having the ability to choose the system with the highest net returns. For the average and high price ratio (for wheat prices of $5.41 and $4.46 per bushel) the rotation of canola followed by two years of dual-purpose wheat won 100 percent of the time, the producer would be best off choosing the canola-dual-purpose wheat-dual-purpose wheat rotation. Results of the computer simulations are reported in Tables I-5, I-6, and I-7.

Figure I-8, includes the CDFs for a wheat price of $5.41 per bushel and a canola price of $0.15 per pound for each of the four production systems. At the budgeted input and output prices, the continuous grain-only wheat system has an estimated 57 percent probability of resulting in negative net returns ($/acre). The system of canola followed by two years of grain-only wheat has an estimated 42 percent probability of resulting in negative net returns ($/acre). Continuous dual-purpose wheat and the system of canola followed by two years of dual-purpose wheat each have a respective estimated 44 percent and 34 percent probability of resulting in negative net returns ($/acre).

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 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 Oklahoma and Kansas. The cropping systems included:

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 showed that on average over 100 trials, the canola-dual-purpose wheat-dual-purpose wheat rotation had 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 (shown in Tables I-5, I-6, and I-7) The average net returns produced 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 \$0.15 canola base price (shown in Figures I-4, I-5, and I-6). At the \$5.41 wheat price (average price ratio), the rotation of canola followed by two years of dual-purpose wheat dominates the other systems by first order stochastic dominance. 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.

Given "perfect" information producers will select the cropping system that maximizes expected net returns to their fixed resources. This simulation was meant to "represent" or "mimic" the actual economic system. It is meant only to provide information. By identifying and examining these key factors that can affect net return per acre of production systems, producers can further understand and manage their operations, thus maximizing their return.

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Table I-1. Budgeted field operations for grain-only wheat, dual-purpose (fall-winter grazing plus grain) wheat, Roundup Ready canola, and conventional canola.

Field Operations	Date	Grain-Only	Dual-Purpose	Roundup Ready Canola	Conventional Canola
Tillage					
Primary	June	✓	✓	✓	✓
Secondary Tillage	August	✓	✓	✓	✓
Secondary Tillage	September	✓	✓	✓	✓
Seedbed Preparation	September		✓	✓	✓
Seed Treatment	September				✓
Seedbed Preparation	October	✓			
Seeding					
Plant Wheat	September		✓		
Plant Canola	September			✓	✓
Plant Wheat	October	✓			
Fertilizer					
Apply Fertilizer	August	✓	✓		
Apply Fertilizer	September		✓	✓	✓
Apply Fertilizer	October	✓			
Apply Fertilizer	February		✓	✓	✓
Herbicide					
Apply (Herbicide)	October	✓			✓
Apply (Roundup & AMS)	October			✓	
Apply (Hebicide)	February	✓	✓		✓
Apply (Roundup & AMS)	February			✓	
Pesticide					
Insecticide (Warrior) 1 of 3 yrs	October			✓	✓
Apply Pesticide (Dimethoate)	April	✓			
Apply Pesticide (Warrior)	April			✓	✓
Foliar Fungicide (1 of 3 yrs)	April	✓	✓		
Harvest					
Combine Wheat Grain	June	✓	✓		
Swath Canola	June			✓	✓
Combine Canola	June			✓	✓

Table I-2. Grain-only Wheat, Dual-purpose Wheat, Conventional Canola, and Roundup Ready Canola Budgets.

			Production System							
			Grain-Only Wheat		Dual-Purpose Wheat		Roundup Ready Canola		Conventional Canola	
Item	Unit of Measure	Price per unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Production										
Wheat	Bu	5.41	38	205.58	34	183.94				
Canola	Lbs	0.15					1825	273.75	1825	273.75
Net Value of Steer Gain	acre					61.23				
Gross Returns	$/acre			205.58		245.17		273.75		273.75
"Cash" Costs										
Wheat Seed	Bu.	15.00	1	15.00	1.5	22.50				
Canola Seed (RR + tech fee)	Lbs	5.20					5	26.00		
Canola (Conventional)	Lbs	2.00							5	10.00
Anhydrous Ammonia (82-0-0)	Lbs.	0.45	68	30.73	59	26.34				
Fertilizer Application	acre	12.00	1	12.00	1	12.00				
Urea (46-0–0)	Lbs.	0.45			65	29.35	155	69.70	155	69.70
MAP (11-52-0)	Lbs.	0.61	44	26.84	44	26.84	44	26.84	44	26.84
Sulfur (0-0-0-90S)	Lbs.	0.36					6	2.16	6	2.16
Fertilizer Application	acre	4.00	1	4.00	1	4.00	2	8.00	2	8.00
Herbicide (broadleaf)	acre	5.00	1	5.00	1	5.00				
Herbicide (grass)	acre	16.00	1	16.00	1	16.00				
Herbicide (e.g. Select®)	oz	0.92							6	5.52
Herbicide (e.g. Assure II®)	oz	1.15							8	9.20
Herbicide Additive (Crop Oil Concentrate)	ac	1.00							2	2.00
Herbicide (e.g. Roundup® (glyphosate)	oz	0.48					36	17.28		
Herbicide Additive (ams)	units	0.125					2	0.25		
Herbicide Application	acre	4.00	2	8.00	2	8.00	2	8.00	2	8.00
Seed Treatment (e.g. Prosper FX®)	acre	6.00							1	6.00
Insecticide (e.g. dimethoate)	pint	5.38	0.75	4.04						
Insecticide (e.g. Warrior®) Fall = 1/3	oz	2.45					1	2.45	1	2.45
Insecticide (e.g. Warrior®) Spring = Full	oz	2.45					3	7.35	3	7.35
Foliar Fungicide (1 of 3 years)	acre	12.50	0.33	4.13	0.33	4.13				
Aerial Pesticide Application	acre	5.00	1.33	6.65	0.33	1.65	1.33	6.65	1.33	6.65
Wheat Crop Insurance	acre	7.00	1	7.00	1	7.00				

Table I-2. Grain-only Wheat, Dual-purpose Wheat, Conventional Canola, and Roundup Ready Canola Budgets.

			Production System							
			Grain-Only Wheat		Dual-Purpose Wheat		Roundup Ready Canola		Conventional Canola	
Item	Unit of Measure	Price per unit	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Canola Crop Insurance	acre	14.00					1	14.00	1	14.00
Fuel	gallon	4.70	4.92	23.12	4.92	23.12	4.92	23.12	4.92	23.12
Lube	acre			3.47		3.47		3.47		3.47
Repair	acre			7.12		7.12		7.12		7.32
Annual Operating Capital	$	0.07	86.55	6.06	98.26	6.88	111.20	7.78	105.89	7.41
Wheat Custom Harvest & Haul										
Base Charge	acre	23.00	1	23.00	1	23.00				
Excess for > 20 bu/a	bu	0.23	18	4.14	14	3.22				
Hauling	bu	0.23	38	8.74	34	7.82				
Canola Custom Harvest & Haul										
Swathing	acre	12.00					1	12.00	1	12.00
Combining	acre	16.00					1	16.00	1	16.00
Excess for > 20 bu/a	bu	0.24					17	3.96	16.5	3.96
Hauling	bu	0.24					37	8.76	36.5	8.76
Total "Cash" Costs	$/acre			215.03		237.43		270.90		259.92
Return to Mach. and Equip. Fixed Cost, and Labor, Land, Management, and Overhead	$/acre			-9.45		7.74		2.85		13.83

Table I-3. Stocker Steer Enterprise Budget for Dual-Purpose Wheat (head).

Assumed Death Loss	1.5%	
Days on Wheat	112	
Days owned	133	
ADG	2.48	lb/hd
Purchase Weight	4.75	cwt
Purchase Price	125.82	$/cwt
Sell Price	93.26	$/cwt
Stocking Density	0.58	hd/ac

Item	Unit	Price	Quantity	Value
Gross receipts:				
Steers (based on death loss of 1.5%)	cwt	105.689	7.62	$805.51
Operating costs:				
Steer calves	cwt	125.82	4.75	$597.65
Order buyer fee	cwt	0.5	4.75	$2.38
Shipping to pasture	head	10	1	$10.00
Receiving program (21 days):				
Veterinary and medicine	head	15	1	$15.00
Hay (2% of initial purchase weight in lb/hd/day)	lb	0.04	199.5	$7.98
Soybean meal based supplement (2 lb/hd/day)	lb	0.20	42	$8.40
Other:				
Shipping to market, sales commission, etc	cwt	2	7.62	$15.24
Machinery fuel, lube, and repairs	$			$10.00
Hay during bad weather	lb	0.04	24	$0.96
High calcium mineral mixture (including R-1620)	lb	0.55	16.8	$9.24
Interest on steer calves	$	0.07	217.77	$15.24
Interest on other operating expenses	$	0.07	28.86	$2.02
Total operating costs, $/head:	$			$694.11
Fixed costs for steer production:				
Machinery and equipment – Depr., taxes and insurance	$			$5.50
Machinery and equipment – Interest	$	0.07	2.00	$0.14
Total fixed costs, $/head				$5.64
Total costs, $/head				$699.75
Return to land, labor, and management, $/head				$105.76
Return to land, labor, and management, $/acre				$61.23

Table I-4. 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 I-5. Results of Simulating 100 years of each of the Four Production Systems at a canola price of $0.15 and a wheat price of $4.46.

Production System	Number of Years Out of 100 that System "Wins"
Continuous grain-only wheat	0
Continuous dual-purpose wheat	0
Three year rotation of canola followed by two crops of grain-only wheat	0
Three year crop rotation that includes canola followed by two years of dual-purpose wheat	100

Table I-6. Results of Simulating 100 years of each of the Four Production Systems at a canola price of $0.15 and a wheat price of $5.41.

Production System	Number of Years Out of 100 that System "Wins"
Continuous grain-only wheat	0
Continuous dual-purpose wheat	0
Three year rotation of canola followed by two crops of grain-only wheat	0
Three year crop rotation that includes canola followed by two years of dual-purpose wheat	100

Table I-7. Results of Simulating 100 years of each of the Four Production Systems at a canola price of $0.15 and a wheat price of $6.89.

Production System	Number of Years Out of 100 that System "Wins"
Continuous grain-only wheat	5
Continuous dual-purpose wheat	31
Three year rotation of canola followed by two crops of grain-only wheat	0
Three year crop rotation that includes canola followed by two years of dual-purpose wheat	64

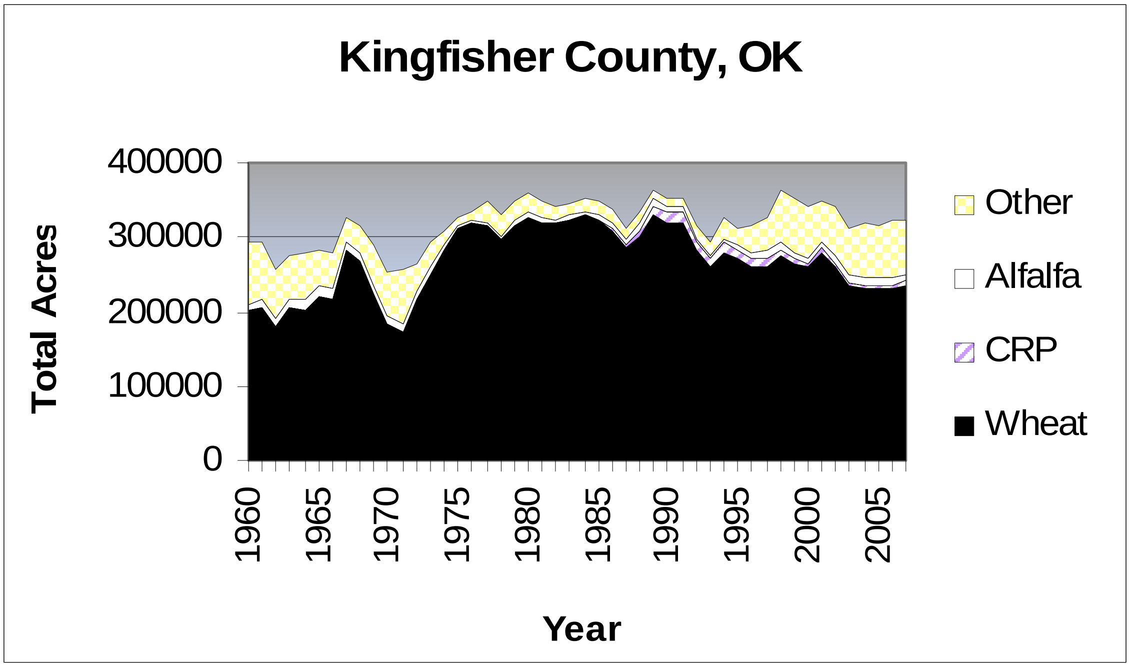

Figure I-1. Kingfisher County, Oklahoma cropland acres seeded to wheat, alfalfa, and other crops, and acres in the conservation reserve program (CRP), 1960-2007.

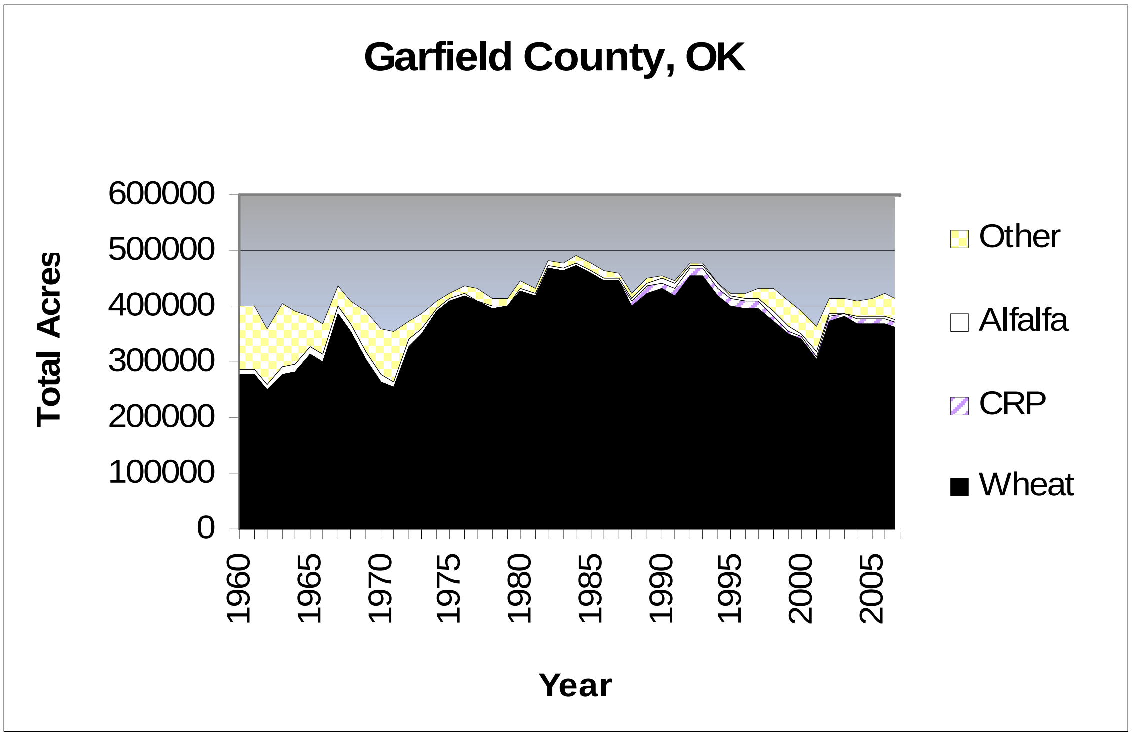

Figure I-2. Garfield County, Oklahoma cropland acres seeded to wheat, alfalfa, and other crops, and acres in the conservation reserve program (CRP), 1960-2007.

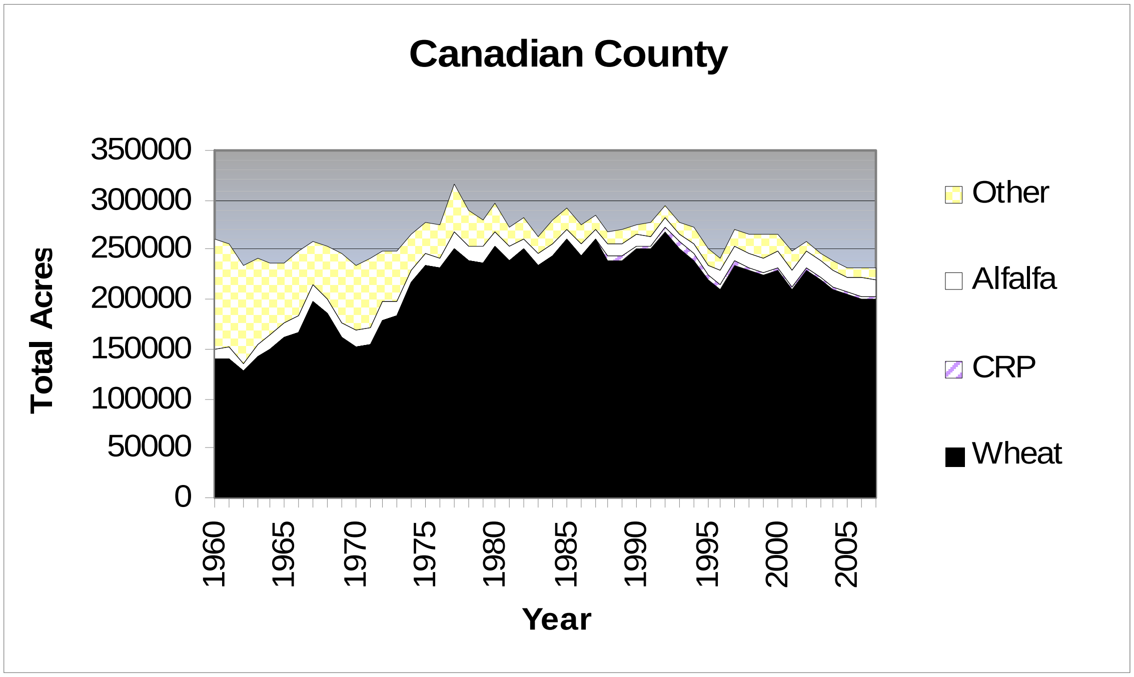

Figure I-3. Canadian County, Oklahoma cropland acres seeded to wheat, alfalfa, and other crops, and acres in the conservation reserve program (CRP), 1960-2007.

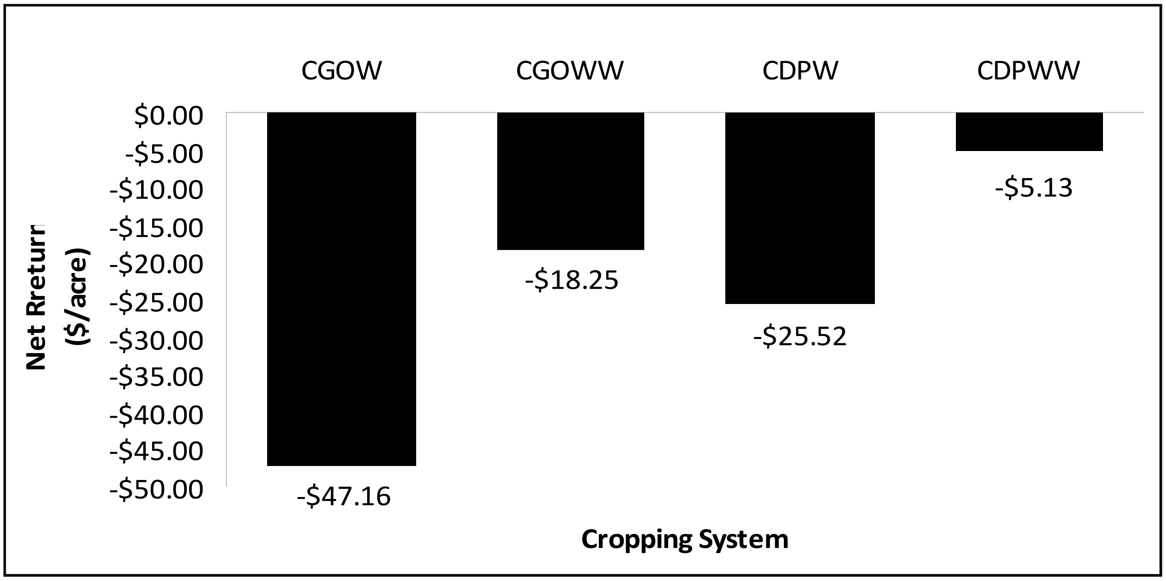

Figure I-4. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat (CGOW), Continuous Dual-purpose Wheat (CDPW), a Canola-Grain-only Wheat-Grain-only Wheat Rotation (CGOWW), and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation (CDPWW), Averaged across 100 years of Simulated Yields for a wheat price of $4.46 and a canola price of $0.15 per pound.

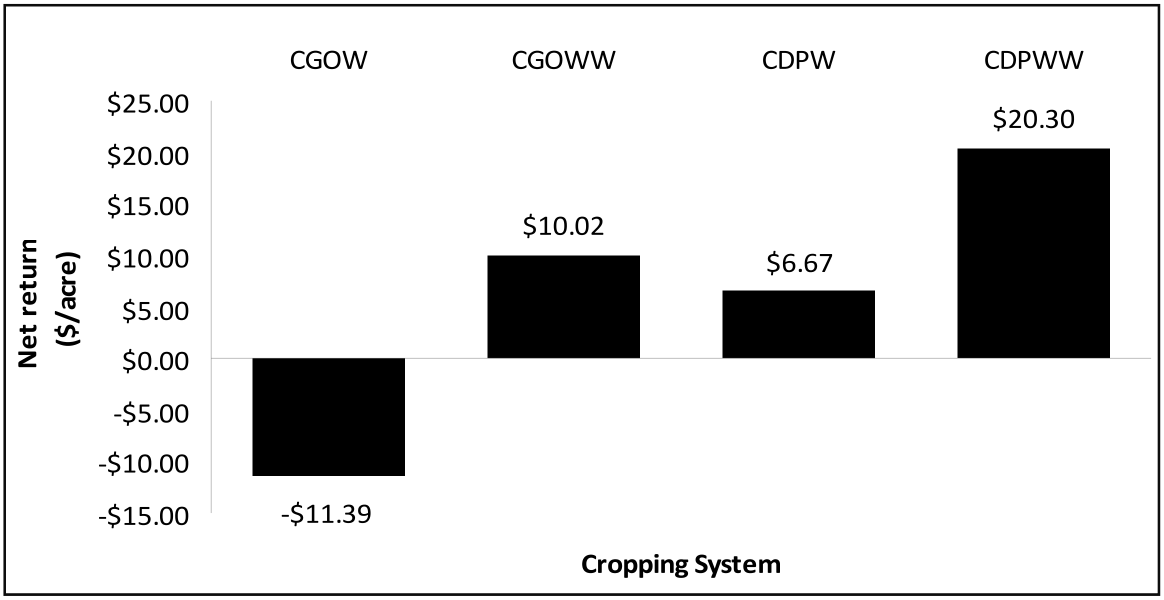

Figure I-5. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat, Continuous Dual-purpose Wheat, a Canola-Grain-only Wheat-Grain-only Wheat Rotation, and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, Averaged across 100 years of Simulated Yields for a wheat price of $5.41 and a canola price of $0.15 per pound.

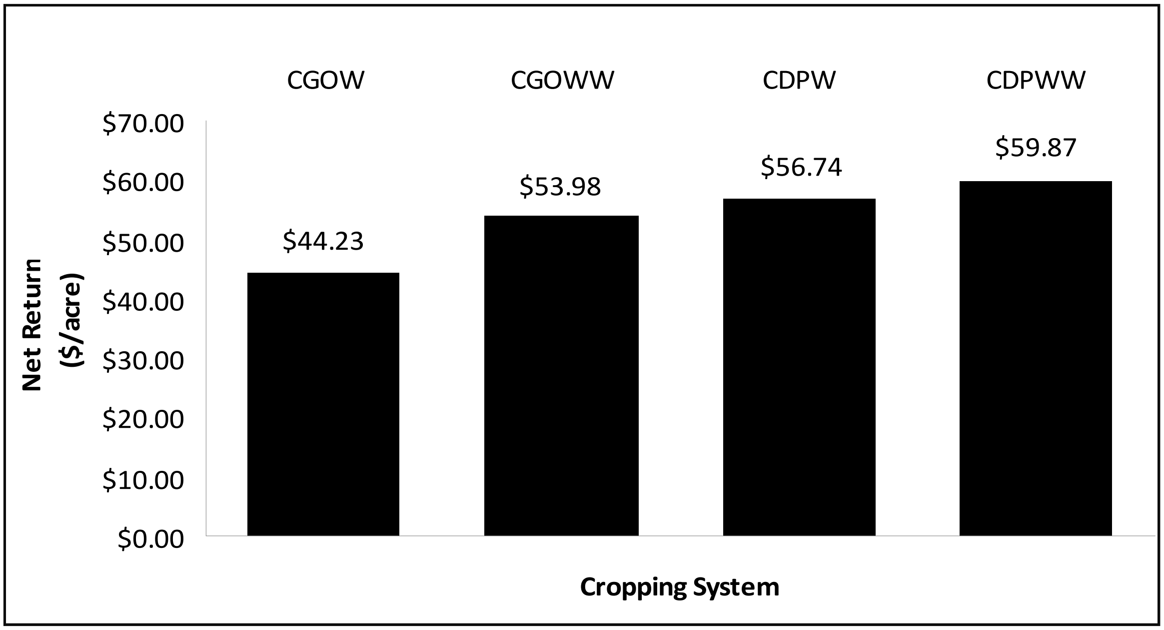

Figure I-6. Estimated Annual Net Returns to Land, Machinery Fixed Costs, Labor, Overhead, and Management for Continuous Grain-only Wheat, Continuous Dual-purpose Wheat, a Canola-Grain-only Wheat-Grain-only Wheat Rotation, and a Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, Averaged across 100 years of Simulated Yields for a wheat price of $6.89 and a canola price of $0.15 per pound.

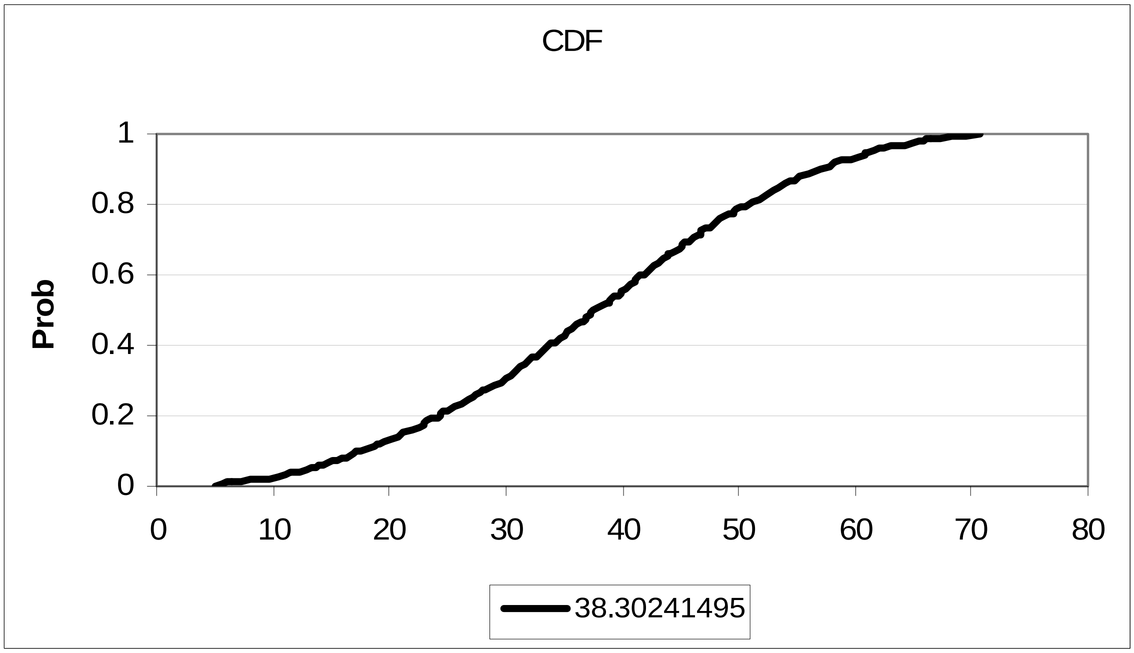

Figure I-7. The cumulative distribution function for continuous wheat for an average yield of 38.3, an average low yield in one of six years of 21, and an average high yield in one of six years of 55.5 bushels per acre.

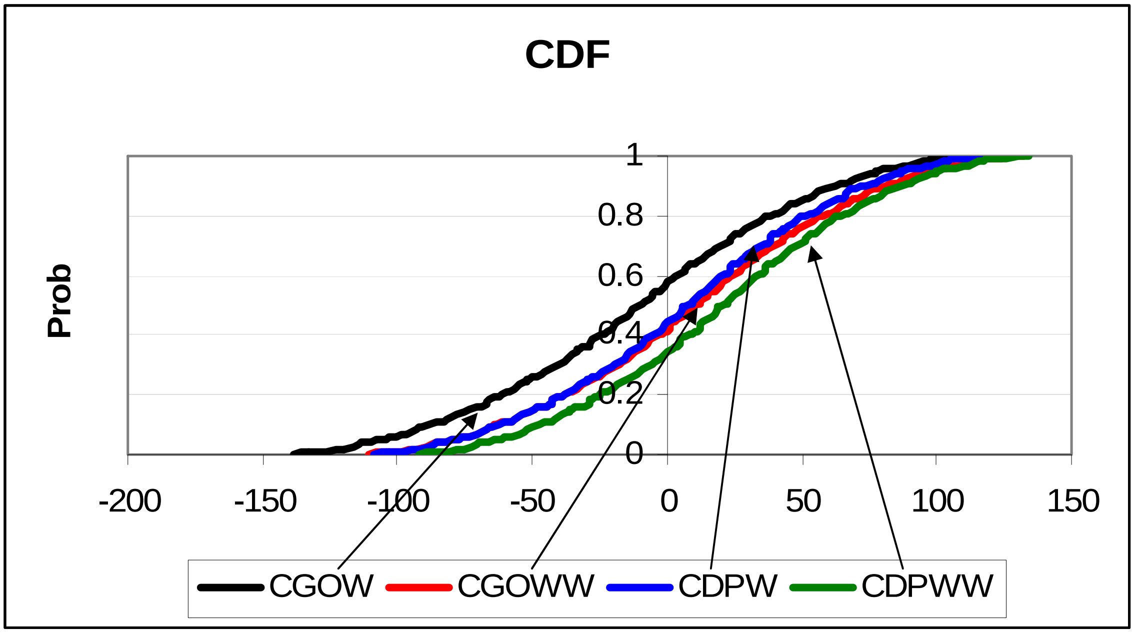

Figure I-8. Cumulative distribution functions for four production systems (Continuous Grain-only Wheat, CGOW; Continuous Dual-purpose Wheat, CDPW; Canola-Grain-only Wheat-Grain-only Wheat Rotation, CGOWW; Canola-Dual-purpose Wheat-Dual-purpose Wheat rotation, CDPWW) for a wheat price of $5.41 and a canola price of $0.15 per pound.

PAPER II

COMPARISON OF GRAIN-ONLY AND DUAL-PURPOSE WHEAT BASED ON KEY PARAMETERS ELICITED FROM GROWERS

Abstract

Winter wheat (*Triticum aestivum*) may be grown in the Southern Plains either to produce only grain, or as a dual-purpose crop to produce both fall-winter forage and grain. The decision to produce dual-purpose wheat is not straightforward in part because the expected grain yield from dual-purpose wheat is less than the expected grain yield from grain-only wheat. Prior research of the difference in expected grain yield between dual-purpose and grain-only wheat have not been consistent, with a group of studies reporting a seven percent lower expected grain yield from dual-purpose, and another group reporting an expected 28 percent lower grain yield from dual-purpose. For typical yields, these differences translate into approximately eight bushels per acre. Given a wheat price of $5 per bushel, the difference in the estimated yield forgone from dual-purpose production would be $40 per acre. Estimates of the relative economics of the two systems depend critically on this assumed difference in grain yield. This study was conducted to determine the net returns of dual-purpose wheat and grain-only wheat. A phone survey of producers that have experience producing both dual-purpose wheat and grain-only wheat was conducted. The fixed interval or judgmental fractile approach was used to elicit production parameters. Information provided by the growers was used to reconcile differences in

results of prior research and to produce subjective distributions of grain yield for both systems and average daily gains of steers grazing wheat. The production parameters were used in combination with distributions of wheat price and steer prices, and cost estimates to simulate distributions of expected net returns. Dual-purpose wheat stocked with steers with an initial weight of 450 (550) pounds produced greatest net returns 76 percent (22 percent) of the time with grain-only wheat winning two percent of the time. The discrepancies of the findings of prior studies of the grain-yield forgone by dual-purpose relative to grain-only wheat can be explained in large part by differences in planting dates.

Introduction

Winter wheat (*Triticum aestivum*) may be grown in the Southern Plains either to produce only grain, or as a dual-purpose crop to produce both fall-winter forage and grain. A unique combination of climate and soils in the region enable the production of dual-purpose winter wheat. Dual-purpose wheat is important to the agriculture economies of southwest Kansas, eastern New Mexico, western Oklahoma, southeastern Colorado, and the Texas Panhandle (Epplin et al. 2000; Pinchak et al. 1996; Redmond et al. 1995; Hossain et al. 2004). The decision to produce dual-purpose wheat is not straightforward since (a) the expected grain yield from dual-purpose wheat is less than the expected grain yield from grain-only wheat; (b) dual-purpose wheat is more expensive to produce since it requires more fertilizer and seed; and (c) prices of wheat and the value of the fall-winter forage are not known precisely a prior. For dual purpose wheat to be more economical than grain-only wheat, the value of the fall-winter forage must be sufficient to offset both the additional production costs and the value of the reduced grain yield.

The USDA provides annual estimates of wheat acres planted and harvested for grain. However, the USDA does not differentiate among uses and historical estimates of acres used to produce dual-purpose wheat (fall-winter grazing plus grain) are not available (Hossain et al. 2004). For the time period from 1998 through 2006, a USDA study reported that the average acre of wheat in the region returned from $2.08 to $8.56 for the production of a secondary product, either wheat straw harvested after grain, or forage harvested by livestock prior to grain harvest (USDA 2006). The USDA does not report estimates of the proportion of acres on which straw was harvested or the proportion that were grazed. The estimates as reported fail to adequately capture either the returns from grain-only wheat or the returns from dual-purpose wheat. Similarly, the USDA does not report average daily gain or stocking density of livestock grazing on wheat pastures.

Surveys conducted by True et al. (2001) and Hossain et al. (2004) 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 were intended for forage-only. The surveys also found that several important management practices including planting date, fertilization strategy, and seeding rate differ between dual-purpose and grain-only wheat. Farmers in the region have a choice to manage for either one or the other. Ideally, in years when realized wheat grain prices are high relative to the realized value of livestock weight gain, the decision would have been made to produce grain-only wheat. Alternatively, when the value of the fall-winter forage is high relative to the value of wheat grain, the decision would have been made to produce dual-purpose wheat. Of course, the value of fall-winter forage and price of wheat grain are not known prior to the end of the season. And, the optimal planting date, fertilizer strategy, and seeding rate is different for the two systems. Farmers must make the decision to produce either grain-only or dual-purpose wheat based on expected yields, expected prices of wheat, and expected value of livestock weight gain.

Figure II-1 includes a bar chart of Oklahoma June cash wheat prices from 1992 to 2008. The nominal wheat price has ranged from a low of $2.31 per bushel in 1999 to a high of $7.93 per bushel in 2008. Over this sixteen year period the average June cash price was $3.61 per bushel with a standard deviation of $1.43.

In addition to the variability in wheat grain price farmers are confronted with variability in the value of the livestock weight gain of animals that graze the fall-winter wheat forage. Figure II-2 includes a bar chart of one estimate of the historical gross value ($/acre) of the fall-winter forage component of dual-purpose wheat. The estimated values are based on production parameters obtained from surveys of producers reported by True et al. (2001) and Hossain et al. (2003). The key assumptions are that the fall-winter forage would be grazed by steers with an initial weight of 450 pounds, average daily gain of one pound for a 21 day receiving period, a stocking density of 196 pounds per acre (2.3 acres per steer) and an average daily gain of 2.1 pounds for 112 days of grazing on wheat for a sale weight of 719 pounds. It was assumed that the steers would be purchased on October 21 and sold prior to the first hollow stem stage of winter wheat plant growth on March 3. Historical Oklahoma City (1992-2008) steer prices for 450 and 719 pound steers for the appropriate purchase and sale dates were obtained from the data base maintained by the Livestock Marketing Information Center (LMIC).

The chart in Figure II-2 illustrates the variability in the value of gain strictly based on price differences. There was a $79 gross return per acre from steers in the 1992-1993 grazing season while only a $44 gross return per acre from steers in the 1995-1996 grazing season. Over this 16 year period, gross returns per acre from steers grazing dual-purpose wheat during the fall-winter season have averaged $64 per acre with a standard deviation of $14. These estimates depend critically on the assumptions regarding stocking density and average daily gain.

Planting Date

As noted, planting date is a key management decision. The purpose of this section is to present findings of prior studies that have addressed the planting date issue. Two of the studies (True et al. 2001; Hossain et al. 2004) report the findings of comprehensive random surveys of Oklahoma wheat producers. Two of the studies (Epplin et al. 2000; Hossain et al. 2003) report wheat grain yield response to planting date functions estimated from designed small plot experiments. Four studies (Edwards et al. 2005; 2006; 2007; 2008) report results of wheat variety test plots conducted at the Marshall Wheat Pasture Research Unit. The varieties were tested under both an early planted fall-winter grazed system, and a later planted grain-only system.

The True et al. (2001) random survey of Oklahoma wheat producers reported a target planting date of September 17 for dual-purpose wheat and September 27 for grain-only wheat (Table II-1). Similarly, the Hossain et al. (2004) survey reported a target planting date of September 20 for dual-purpose and October 2 for grain-only wheat. The average target planting date across these two surveys is September 18 for dual-purpose and September 29 for grain-only. The average planting date for the variety trials at Marshall from 2005-2008 was September 7 for dual-purpose and October 20 for grain-only. On average, the Marshall dual-purpose variety trials were planted 11 days earlier than the target date for dual-purpose reported by producers. And, the Marshall grain-only variety trials were on average planted 21 days later than the producer's target date for grain-only wheat.

Based on the wheat grain yield response to planting date functions reported by Epplin et al. (2000) and Hossain et al. (2003), the expected grain yield from a September 18 (dual-purpose) planting date is approximately 39 bushels per acre. Similarly, the expected yield is 42 bushels per acre for the average survey reported grain-only target planting date of September 29. By this measure a dual-purpose system could be expected to reduce grain yield by three bushels per acre (7.4 percent). Both the Epplin et al. (2000) and Hossain et al. (2003) response functions estimate that over approximately a three week period from planting in late September to early October the predicted grain yield is within one bushel per acre from the maximum. The response function estimated by Epplin et al. (2000) predicts a maximum grain yield from an October 8 planting and that over the range from September 29 to October 19, grain yield would be within one bushel of the maximum. Similarly, the response function reported by Hossain et al. (2003) predicts that over the range from September 27 to October 15 grain yield would be within one bushel of the maximum achieved by planting on October 6.

For four years of variety trails conducted at the Marshall Wheat Pasture Research Unit, the average wheat yield obtained from the dual-purpose wheat plots that were planted on average on September 7, was 27 bushels per acre (Edwards et al. 2005; 2006; 2007; 2008). This is 11 bushels less than the average yield of 38 bushels per acre produced during the same four years with the same varieties in the Marshall grain-only plots that were on average planted on October 20. By this measure a dual-purpose system could be expected to reduce grain yield by 11 bushels per acre (28 percent). This finding is consistent with the differences in yields predicted by the Epplin et al. (2000) and Hossain et al. (2003) response functions for September 7 and October 20 planting dates. The Epplin et al. (2000) predicted yield of 28 from a September 7 planting date is 22 percent less than the predicted yield of 36 from the October 20 planting date. Similarly, the Hossain et al. (2003) predicted yield of 38 from a September 7 planting date is 19 percent less than the October 20 predicted yield of 47.

Based on the combined information from the two comprehensive surveys of Oklahoma farmers and the two planting date studies, a dual-purpose system could be expected to reduce grain yield by three bushels per acre (7.4 percent) relative to a grain-only system. However, based on four years of variety trials at the Marshall Wheat Pasture Research Unit, the dual-purpose system reduced grain yield by 11 bushels per acre (28 percent). Much of the yield difference can be attributed to the fact that the dual-purpose plots at Marshall were planted on average 11 days earlier and the grain-only plots 21 days later than target planting dates reported by farmers. Given the low and high wheat prices from 1992 to 2008 of $2.31 and $7.93, a difference of 11 bushels would amount to $25 to $87 per acre in lost potential revenue from grain that must be overcome by the dual-purpose system. Given the estimated low and high gross returns of $44 and $87 per acre for grazing over the same time period, 11 bushels per acre difference in additional yield loss given the Marshall Wheat Pasture Research Unit production system would be critical to the economics of dual-purpose production.

Clearly, planting date matters, and conclusions regarding the economics of a dual-purpose system relative to a grain-only system may depend critically on the assumptions regarding planting dates. Given the importance of the planting date issue and that the surveys by True et al. (2001) and Hossain et al. (2004) are slightly dated, another survey of producers is warranted to determine if targeted planting dates have changed in response to changes in agricultural input and commodity markets.

Stocking Density

The True et al. (2001) survey of Oklahoma producers found an average stocking density of 173 pounds per acre, while the Hossain et al. (2004) survey reported an average stocking density of 219 pounds per acre. The surveys conducted by True et al. (2001) and Hossain et al. (2003) reported an average stocking density of 196 pounds per acre (2.3 acres per steer). (A stocking density of 196 pounds per acre was used to prepare the gross returns estimates charted in Figure II-2.) Kaitibie et al. (2003) used data produced at the Marshall Wheat Pasture Research Unit from 1989 to 2000 to estimate an optimal stocking density. They found that the optimal stocking density, given the planting dates used at Marshall would have been 305 pounds per acre. This is 56 percent more than the average reported by growers in the two surveys and would add 56 percent to each bar reported in Figure II-2. Given the importance of stocking density to the overall economics of a dual-purpose system, another survey of producers may be warranted to determine if stocking density has changed in response to changes in steer and wheat prices.

Average daily gain is also a critical production parameter. Producers surveyed by True et al. (2001) reported an average daily gain for steers of 1.9 pounds. In the more recent survey by Hossain et al. (2004) producers reported an average daily gain for steers of 2.3 pounds. Kaitibie et al. (2003) reported that the average daily gain for steers at the

Marshall Wheat Pasture Research Unit from 1989 to 2000 across all stocking densities was 2.22 pounds.

The overall objective of the research reported in this chapter is to determine which wheat production system (dual-purpose wheat or grain-only wheat) would be most appropriate for Oklahoma producers. Specifically, the objective is to determine expected net returns distributions for grain-only wheat; dual-purpose wheat stocked with steers with an initial weight of 450 pounds; and dual-purpose wheat stocked with steers with an initial weight of 550 pounds. Distributions of key production parameters, grain yield, stocking density, and average daily gain, will be constructed from survey responses provided by producers in the region. Historical price data will be used to construct steer purchase price, steer sale price, and wheat sale price distributions.

Methods and Procedures

Wheat Prices

The National Agriculture Statistical Services reports prices received by farmers including Oklahoma June cash wheat prices. These historical nominal 1992 to 2008 prices are charted in Figure II-1. During this 16 year time period the average June cash price was \$3.61 per bushel with a standard deviation of 1.43 (NASS 2008). The USDA loan rate provides an effective floor price for wheat. Therefore, the nominal wheat prices are assumed normally distributed but truncated at \$2.75 per bushel, the 2008 loan rate (NASS 2008).

$$W_p = \overline{X_{W_p}} + (\sigma_{W_p} * N(0,1)) \qquad (1)$$

Where: W_p is the distributed wheat price greater than or equal to \$2.75; $\overline{X_{W_p}}$ is the average historical nominal wheat price, \$3.61; and σ_{W_p} is the standard deviation of the historical nominal wheat prices, 1.43.

Value of Fall-Winter Grazing of Dual-Purpose Wheat

It was assumed that the fall-winter wheat pasture would be grazed by young steers. Steer price data were obtained from data bases maintained by the LMIC. Since 1992, LMIC has been reporting Oklahoma City steer prices in 50 pound increments (LMIC 2008). Weekly cattle prices were available from 1992 to 2007. Observations for the appropriate week and weight were used to compute the nominal mean and standard deviation. For the price simulations it was assumed that the steer purchase price is normally distributed.

$$B_p = \bar{X} + (\sigma_x * N(0,1)) \tag{2}$$

Where: B_p is the buy price; $\bar{X}$ is the average historical buy price; and σ_x is the standard deviation of the historical buy prices.

The mean prices for 450 and 550 pound steers purchased the week of October 21 were \$103.52 and \$93.72, respectively with standard deviations of \$22.94 and \$19.77. The mean March 3 price of 700 (800) pound steers was \$87.11 (\$81.81). Over the time period from 1992 to 2008, the correlation coefficient between the October 21 price of 450 (550) pound steers and the March 3 price of 700 (800) pound steers the following calendar year was 0.96 (0.94). The average difference (price slide or average price margin) was \$16 (\$22) per cwt for steers with an initial weight of 450 (550) pounds.

Since the March sale price is correlated with the previous October buy price, it is assumed that the sell price is normally distributed with respect to the interpolated average price slide and standard deviation from 1992 to 2008. The price margin is the difference between the October 21 price of 450 (550) pound steers and the March 3 price for the heavier steers. The weight of the steers on March 3 depends not only on the initial weight but also on the stochastic average daily gain. Stochastic sale prices can be simulated as described by equation 3.

$$S_p = \overline{PM} + (\sigma_{PM} * N(0,1)) \tag{3}$$

Where: S_p is the sell price that is linked to the buy price; $\overline{PM}$ is the interpolated average price margin; and σ_{PM} is the interpolated standard deviation of the price margin.

Interpolation within the 50 pound weight brackets for which LMIC prices are reported was done by subtracting the actual ending weight from the lower weight and multiplying it by higher weight price subtracted from the lower weight price. The product was then subtracted from the lower price. Then that value was divided by 50 due to the price report in 50 pound increments as described by equation 4.

$$\mathrm{P_I} = \mathrm{W_{L_p}} - [(\mathrm{W_A} - \mathrm{W_L}) * (\mathrm{W_{L_p}} - \mathrm{W_{H_p}})/50] \tag{4}$$

Where: P_I is the interpolated price; W_{L_p} is the price of the lower weight boundary; W_A is the actual ending weight; W_L is the lower weight boundary; and W_{H_p} is the price of the higher weight boundary.

A modified stocker steer budget developed by Taylor et al. (2007) is included as an example in Tables II-4 and II-5 for purchase weights of 450 and 550 pounds, respectively. These budgets were used to determine the value of fall-winter grazing to the dual-purpose wheat enterprise. The value of fall-winter grazing of dual-purpose wheat is determined using equation 5:

$$\text{NR (\$/acre)} = [(Ps*Ws)*(1-DL)-(Pp*Wp)-C]*[SD] \tag{5}$$

where: Ps is the sell price ($/cwt); Ws is the sell weight (cwt); DL is the death loss (%); Pp is the purchase price ($/cwt); Wp is the purchase weight (cwt); C is the total cost per head ($/hd); and SD is the stocking density (cwt/acre).

True et al. (2001) and Hossain et al. (2004) reported producer's target purchase weights of 460 and 466 pounds, respectively. Kaitibie et al. (2003) reported approximate purchase weights of 550 pounds. As a result, two steer budgets were prepared, one with initial steer weight of 450 and the other with initial steer weight of 550 pounds. A 21-day receiving program and 112 days on wheat are assumed. The budget assumes that the steers have free choice access to an R-1620 high calcium mineral supplement. R1620 contains 1620 grams of monensin per ton and has an expected daily intake of 0.15 pounds per head. The expected cost of R1620 is $1,100 per ton. Another supplementation program could be used, but in general, the price per ton will be similar. The steers are assumed to have an average daily gain of one pound during the receiving program (Taylor et al. 2007), a mean gain of 2.11 pounds per day during the 112 days on wheat, and a 1.5 percent death loss (Taylor et al. 2007). The ending weight was calculated for each of the two buy weights of 450 and 550 pounds by adding the 21 pounds of assumed gain during the receiving period and the weight gain during the 112 days of grazing. Gain during grazing is assumed to be stochastic. Equation 7 illustrates the computation of a steer's ending weight assuming a buy weight of 450 pounds and an average daily gain of 2.11 pounds during wheat grazing.

$$(450 \text{ lbs} + (1 \text{ lb/day} * 21 \text{ day receiving program}) + (2.11 \text{ lbs/day} * 112 \text{ grazing}) = 707 \text{ lbs}) \quad (7)$$

Procedures for Obtaining Estimates of Key Production Parameters

A phone survey of producers that have experience with both wheat production systems was conducted. Names were provided by personnel from the Oklahoma

Cooperative Extension Service. A total of thirty-one producers that have experience in growing both grain-only wheat and dual-purpose wheat stocked with steers were surveyed.

A direct elicitation method was used. The questions were directly asked to producers regarding their perceptions for the probability of their estimates (Anderson, Dillon, and Hardaker 1977). Subjective distributions of expected future yields were constructed by asking the growers to consider a six year time horizon. They were then asked what their expected average, high, and low average daily gain, buy weight, and stocking density would be over the next six years (Sonka and Patrick 1984; Hull 1976). The method used is similar to the fixed interval or judgmental fractile approach (Shapiro, Brorsen, and Doester 1992). Covariance among yields was also elicited. During the phone conversation, answers to the following questions were sought.

1. What is your targeted planting for dual-purpose wheat (fall-winter grazing plus grain)?
2. What is your targeted planting date for grain-only wheat?
3. The third question pertained to the producers expected low, average, and high values over six years for each of the following:
    a. Grain-only wheat yield
    b. Dual-purpose wheat yield
    c. Initial weight of steers purchased to stock on wheat pasture
    d. Stocking density of steers on dual-purpose wheat
    e. Average daily gain of steers on dual-purpose wheat
4. At each level of wheat yield (low, average, and high) what would you expect the average daily gain levels to be (low, average, or high)? This question was

designed to determine the correlation between average daily gain of steers stocked on dual-purpose wheat and wheat grain yield.

Together the third and fourth questions were designed to enable the construction of triangular yield and average daily gain distributions (Raiffa 1968). The probability that the producer attaches to his estimate is the degree of belief or certainty that it will be true (Hogarth 1975). Personal probabilities are only required to be “honest” (Anderson, Dillon and Hardaker 1977). The producer’s probability is subjective because it is a function of the producer’s feelings. One producer’s value estimates would be a point estimate, but the subjective probability distribution assigns probabilities to all values within a range (Norris and Kramer). The producer’s belief in the estimated values depends on the information available to him or her, background, and interpretation of information, therefore, the estimates may vary across producer (de Finetti 1964; von Holstein 1970). Equation 6 is the mathematical form of the triangular distribution.

$$f(x|a,b,c) = \begin{cases} \frac{2(x-a)}{(b-a)(c-a)} & for\ a \leq x \leq c \\ \frac{2(b-x)}{(b-a)(b-c)} & forc \leq x \leq b \end{cases} \tag{6}$$

Where: a is the adjusted minimum estimate; b is the adjusted maximum estimate; c is the adjusted mean estimate; and x is the random variable.

A cumulative distribution function (CDF) can be formulated from the information provided by the surveyed producers. When estimating a CDF, the producers provide values for a few specific probabilities and a curve is fitted to those points (Schlaifer 1969). These methods determine the fractiles of the CDF by asking producers to equally consider the low and high values in one of six years (Norris and Kramer 1990). The growers were specifically asked to provide expected low, average, and high yields over a six year time horizon. The distribution values were adjusted so that the average low value reported by the growers occurred at the probability level of 0.16 on the cumulative probability function. This means 84 percent of the time the producer would expect higher yields. Similarly the distributions were adjusted so that the average high value reported by the growers occurred at approximately the 0.84 probability level on the triangular distribution; the producers will expect lower yields 84 percent of the time. Information from the survey can be used to prepare distributions of key production parameters including grain-only wheat yield, dual-purpose wheat yield, and average daily gain.

Budgets

Production practices budgeted for both wheat production systems (grain-only wheat and dual-purpose wheat) will be prepared. The enterprise budgets will be based on production parameters provided by agronomy and animal science experts and by Oklahoma producers. Examples of wheat and stocker enterprise budgets can be found in the Oklahoma State University Cooperative Extension Service data base (Oklahoma State University 2008).

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

For the grain production activities, inputs consist of seed, fertilizer, pesticide, insecticide, custom harvest, fuel, oil, lubricants, and repairs. Each of the crop budgets includes the cost of two herbicide applications. The cost of a spring aerial insecticide application is included. A spring aerial foliar fungicide application is budgeted for one of three growing seasons.

The budgeted fertilizer requirements include 44 pounds per acre of 11-52-0. For grain-only wheat the remainder of the nitrogen requirement is met with anhydrous ammonia applied pre-plant. 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, Raun, and Hattey 2006).

Simulations

Yield, stocking density, and average daily gain information provided by the growers was combined with budgeted cost estimates to simulate expected net returns for each production system. Two steer purchase weights of 450 and 550 pounds were considered for dual-purpose wheat. For these simulations production costs, buy weights, days owned, stocking density, buyer fees, shipping costs, veterinary costs, soybean meal based supplement, and interest costs were held constant. Wheat yield, average daily gain during the 112 day fall-winter grazing season (and thus steer sale weight), wheat price, steer purchase price, and the margin between steer sale and steer purchase price (and thus the steer sale price) were treated as stochastic variables. Wheat harvest and hauling cost and the cost of nitrogen fertilizer were adjusted with the stochastic wheat yields. Based on responses to the survey, average daily gain and grain yield are assumed to be independent.

Specifically, above (below) average daily gains during the fall-winter grazing season are not necessarily followed by above (below) average dual-purpose wheat grain yields. The average daily gain values are listed at random in the simulation so that they are uncorrelated to respective 450 and 550 buy weights. Grain-only and dual-purpose wheat grain yields were assumed to be perfectly correlated. Wheat prices are uncorrelated with yield and a normal distribution of Oklahoma June cash prices (1992-2008) was truncated at the loan rate (price floor) set at $2.75. Specifically, a yield on a specific field in Oklahoma is assumed to not influence the global price of wheat. The SIMETAR Excel Add-in was used to simulate each system 1,000 times to reflect 1,000 growing seasons.

Results

Survey Results

Production practices budgeted for both wheat production systems (grain-only wheat and dual-purpose wheat) are reported in Table II-2. Table II-3 includes a copy of the base enterprise budgets for both systems.

Each of the thirty-one growers contacted by phone was cooperative and provided responses to the designed questions. Figure II-3 displays the locations of the surveyed producers by county, as well as the number surveyed in each. The first and second questions asked the producer's targeted planting date for each system (dual-purpose wheat and grain-only wheat). Overall, there was a general consensus among producers for targeted planting dates. The average targeted planting date was September 13 for dual-purpose wheat and October 4 for grain-only wheat. Comparatively, True et al. (2001) reported a target date for dual-purpose of September 17 and for grain-only of September 27 (Table II-1). Similarly, the Hossain et al. (2004) survey reported a target planting date of

September 20 for dual-purpose and October 2 for dual-purpose wheat. The average planting date for the variety trials at Marshall from 2005-2008 was September 7 for dual-purpose and October 20 for grain-only. The dual-purpose planting date at Marshall is earlier than the farmer's reported target date and in most years the grain-only target planting date at Marshall has been later than the target reported by farmers in all three surveys. Actual planting date is subject to weather, and researchers, like farmers cannot always plant when they would prefer to do so.

Results for the third question on the survey, "What are your expected low, average, and high yield (in 1 of 6 years), purchase weight, stocking density, and average daily gain" are reported in Table II-6. The producers reported an expected average yield in a grain-only wheat system of 42.2 bushels per acre. A CDF of the triangular distribution constructed from the responses averaged across the 31 producers is included in Figure II-4. For comparison, the average winter wheat yield across Oklahoma from 2004 to 2008 was 31.4 bushels per acre (NASS 2008). The surveyed producers reported an expected average yield in a dual-purpose wheat system of 36.4. By this measure, the expected yield from grain-only wheat is 15.9 percent greater than the expected yield of dual purpose wheat. The net returns from winter grazing must be sufficient to offset both the expected yield loss of 5.8 bushels per acre and the cost of the additional inputs required to produce dual-purpose wheat.

The response function reported by Epplin et al. (2000) predicts a 19.45 percent (6.81 bushels) decrease in grain yield from an October 4 planting date relative to a September 13 planting date. Similarly, the response function reported by Hossain et al. (2004) predicts a 15.5 percent (6.18 bushels) decrease. The average finding of 15.9 percent

(5.8 bushels) as reported by the surveyed producers is consistent with the findings of the prior studies based on small plots.

For every bushel of wheat yield in the grain-only system, producers expect dual-purpose wheat to yield 0.88, 0.86, and 0.83 bushels, for good, average, and poor years. The 2008, 2007, 2006, and 2005 wheat variety performance tests at the Marshall Wheat Pasture Research Unit reported dual-purpose to grain-only wheat yield ratios of .87, .53, .79, and .53, respectively.

Producers reported an overall average steer purchase weight of 464.5 pounds. True et al. (2001) and Hossain et al. (2004) reported purchase weights of 460 and 466 pounds, respectively. Kaitibie et al. (2003) reported approximate purchase weights of 550 pounds. Rather than treating purchase weight as a stochastic variable, two dual-purpose wheat systems were evaluated, one based on an initial steer weight of 450 pounds and another with an initial steer purchase weight of 550 pounds.

The question regarding stocking density did not elicit a consensus. Some producers reported stocking density in head per acre and others reported in pounds per acre. For those reporting in head per acre, adjustments were made based on their average reported purchase weights to pounds per acre. According to producers, a weight of 332.84 pounds per acre was the average stocking density. The surveys of True et al. (2001) and Hossain et al. (2004) reported an average stocking density of 196 pounds per acre. This difference could be a result of the two previous surveys being of random sample of producers across the entire state. Kaitibie et al. (2003) used data produced at the Marshall Wheat Pasture Research Unit from 1989 to 2000 to estimate an optimal stocking density. They found that the optimal stocking density, given the planting dates used at the Marshall would have been 305 pounds per acre.

The average reported low (1 in 6), average, and high average daily gains were 1.54, 2.11, and 2.70 pounds. Producers surveyed by True et al. (2001) reported an average daily gain for steers of 1.9 pounds. In the more recent survey by Hossain et al. (2004) producers reported an average daily gain for steers of 2.3 pounds. Kaitibie et al. (2003) reported that the average daily gain for steers at the Marshall Wheat Pasture Research Unit from 1989 to 2000 across all stocking densities was 2.22 pounds.

The fourth survey question, “If the yield of wheat is (low, average, or high) what level would you expect the average daily gain levels to be (low, average, or high)?” was designed to determine the subjective correlation between average daily gains and wheat yields. This was not an easy question for the producers to answer. The enumerator concluded after conversations with the 31 producers that often included “sometimes”, “it depends”, and “not necessarily” that grain yield and average daily gain are not perceived to be correlated.   Factors such as planting date, weather, stocking density, and supplementation strategies were cited as being important. However, the general consensus was that years that result in high average daily gains do not necessarily produce high wheat grain yields. One producer held that is was better to have a little dry weather after the wheat is established so the cattle will not tromp the wheat in the mud. Based on the responses to this question, average daily gain was assumed to be uncorrelated with wheat grain yield.

The growers were specifically asked to consider a six year time period. As a result, the average low value reported by the growers was assumed to occur at the probability level of 0.16 on the cumulative triangular probability function. Similarly, the average upper value reported by the growers was assumed to occur at approximately the 0.84 probability level on the triangular distribution. The lower and upper limits were iteratively adjusted so that the probability level of 0.16 on the resulting distribution occurred at the average low (1 in 6 year) yield reported by the 31 growers, and the probability level of 0.84 occurred at the average high (1 in 6 years) yield reported. The low, average, and high limits were adjusted to allow for opportunity of achieving the low and high estimates in one of six years. The CDF for grain-only wheat is shown in Figure II-4. The low, average, and high values used for the triangular distribution of each variable are displayed in Table II-7.

Simulation Results

The estimated pre-harvest cash costs for the average budgeted yield of 42.2 bushels per acre for grain-only wheat is $222 per acre. Dual-purpose wheat requires more nitrogen and more seed and has budgeted cash costs of $241 per acre for the average dual-purpose wheat yield of 36.4. The price required to break-even for the grain-only system given the average yield of 42.2 bushels per acre is $5.26 per bushel. At the budgeted prices and input levels, and a nominal mean wheat price of $3.61 (the 1992-2008 average), grain-only wheat producers would lose $69 per acre and dual-purpose wheat producers would lose $61 per acre.

The dual-purpose wheat system with the added value of grazing generated the greatest net returns at both buy weights the majority of the 1,000 simulated seasons. Results of the simulations are provided in Table II-8. Figure II-5 includes a chart of the average net returns per acre for each system. The dual-purpose systems reflect a stocking density of 332.84 pounds per acre. Based on the growers distribution of average daily gains and yields combined with the distribution of historical wheat and cattle prices, dual-purpose wheat wins 76.3 percent of the time at a purchase weight of 450 pounds. Dual-purpose wheat at a purchase weight of 450 pounds has an average net return over the 1,000 simulations of $18.34 per acre at budgeted input prices. For a purchase weight of 550 pounds, dual-purpose wheat remains second in net returns, winning 21.6 percent of the time. Dual-purpose wheat at a purchase weight of 550 pounds has an average net return of negative $27.69 per acre at budgeted input prices. As shown in Figure II-5, grain-only wheat has an average net return of negative $73.69 per acre at budgeted input prices.

Based on budget and simulation results, dual-purpose wheat stocked with steers with an initial weight of 450 pounds at a stocking density of 332.84 pounds per acre, generates an expected net return of $92.03 per acre more than grain-only wheat. Similarly, the expected net returns from dual-purpose wheat stocked with steers with an initial weight of 550 pounds and the same stocking density is $46.01 more per acre than the expected net returns from grain-only wheat. Also determined was the scenario of choosing the system with the highest net returns every time over the 1,000 trails. A producer could gain $7.74 per acre by choosing the "best" system from each of the 1,000 simulations rather than choosing the dual-purpose systems and stocking with 450 pound steers each season.

Figure II-6 includes a chart of the CDFs for the distributions of net returns per acre from the simulations for each production system. Given the budgeted input prices and simulated wheat prices, the grain-only wheat system has an expected probability of 0.92 of resulting in negative net returns. The dual-purpose system stocked with 550 pound steers has an expected probability of 0.69 of producing negative net returns. The dual-purpose wheat system 450 pound steers has an expected probability of 0.46 of resulting in negative net returns.

Also considered was the scenario of having the highest reported wheat price from 1992-2008 of $7.93 combined with the current input prices and historical cattle price slide. The relationship of the production systems remained the same with dual-purpose wheat stocked with steers with an initial weight of 450 pounds reporting the highest net return per acre 745 of 1,000 simulations and an average net return of $188.63. Dual-purpose wheat stocked with steers with an initial weight of 550 pounds remained the runner-up with 196 wins and an average net return per acre of $142.58. Grain-only won 59 times with an average net return per acre of $124.29. The explanation for the relationship of the production systems remaining similar is due to the surveyed producers expecting only a 5.8 bushel decrease with respect to the production systems, therefore, the price of wheat would have to reach $18.34 per bushel before overtaking both dual-purpose systems.

Furthermore, the average surveyed stocking density of 196 pounds per acre observed by True et al. (2001) and Hossain et al. (2004) was considered. With the decrease in stocking density from 332.84 pounds to 196 pounds per acre, the relationship of the production systems stay the same. Dual-purpose wheat stocked with steers with an initial weight of 450 pounds remained the frontrunner, bringing the highest net returns per acre 738 out of 1,000 simulations with an average net return of negative $36.01. This is a decrease in net return of $53.35 per acre with respect to stocking density. Dual-purpose wheat stocked with steers with an initial weight of 550 pounds remained the runner-up with 184 wins and an average net return per acre of negative $63.13. This is a decrease in net return of $34.55 per acre with respect to stocking density. Average daily gain was assumed to be the same for both stocking densities evaluated. Based on the stocking densities and the average daily gains reported by the 31 surveyed producers, stocking density is a key management decision.

Conclusion

Wheat is the primary crop grown in the southern plains and 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 allowed to mature in the spring and produce a grain crop. Research in this area is essential to further understand the industry and keep it successful. Research was conducted to determine which wheat production system (dual-purpose wheat or grain-only wheat) produces the highest net returns. Field operations and operating inputs were obtained from agronomy and animal science experts.

Yield, average daily gain, and stocking density data were obtained from Oklahoma producers that have experience producing grain-only and dual-purpose wheat. The low, average, and high estimates of these producers were elicited and used to prepare triangular distributions. Cattle price data were obtained from data bases maintained by the LMIC. Wheat price data were obtained from the National Agricultural Statistics Service.

Simulations revealed that on average over 1,000 trials, the dual-purpose wheat produced the highest net returns. Based on the simulation, the dual-purpose wheat stocked with steers with an initial weight of 450 (550) pounds produced higher net returns 763 (216) of 1,000 trials (shown in Table II-8). Dual-purpose wheat produced higher average net returns over the 1000 trials with an average net return of $18.34 (-$27.68) when stocked with steers with an initial weight of 450 (550) pounds (Figure II-5).

Given “perfect” information producers will select the cropping system that maximizes expected net returns to their fixed resources. This simulation was meant to “represent” or “mimic” the actual economic system. It is meant only to provide information. Producers are always faced with changing input, operating, and opportunity costs. By identifying and examining these key factors that can affect net return per acre of production systems, producers can further understand and manage their operations, thus maximizing their return. Additional research is warranted to use the distributions to determine which system would maximize utility for producers with different levels of risk preference.

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Table II-1. Differences in Planting Date and Estimated and Actual Differences in Wheat Grain Yield between Dual-Purpose and Grain-Only Wheat

	Dual-Purpose	Grain-Only	Estimated Grain Yield Difference
True et al.(2001)	**17-Sep**	**27-Sep**	
Predicted Wheat Yield			
Based on Epplin et al. (2000)	33.72	37.02	3.30
Based on Hossain et al. (2003)	42.85	46.16	3.31
Hossain et al.(2004)	**20-Sep**	**2-Oct**	
Predicted Wheat Yield			
Based on Epplin et al. (2000)	34.96	37.78	2.82
Based on Hossain et al. (2003)	44.04	47.10	3.06
Results from Marshall Variety Trials (Edwards et al. 2005,2007, 2008)			
2005			
Actual Planting Date	**31-Aug**	**29-Oct**	
Average Yield Across all Varieties	16.00	30.00	14.00
Predicted Wheat Yield			
Based on Epplin et al. (2000)	22.70	31.69	8.99
Based on Hossain et al. (2003)	32.84	43.95	11.10
2006			
Actual Planting Date	**7-Sep**	**14-Oct**	
Average Yield Across all Varieties	22.00	28.00	6.00
Predicted Wheat Yield			
Based on Epplin et al. (2000)	28.07	37.20	9.13
Based on Hossain et al. (2003)	37.63	47.41	9.78
2007			
Actual Planting Date	**5-Sep**	**9-Oct**	
Average Yield Across all Varieties	16.00	30.00	14.00
Predicted Wheat Yield			
Based on Epplin et al. (2000)	26.65	37.86	11.20
Based on Hossain et al. (2003)	36.36	47.62	11.26
2008			
Actual Planting Date	**18-Sep**	**30-Oct**	
Average Yield Across all Varieties	55.00	63.00	8.00
Predicted Wheat Yield			
Based on Epplin et al. (2000)	34.16	31.13	-3.03
Based on Hossain et al. (2003)	43.26	43.56	0.30

Table II-2. Budgeted field operations for grain-only wheat and dual-purpose (fall-winter grazing plus grain) wheat.

Field Operations	Date	Grain-Only	Dual-Purpose
Tillage			
Primary	June	✓	✓
Secondary Tillage	August	✓	✓
Secondary Tillage	September	✓	✓
Seedbed Preparation	September		✓
Seedbed Preparation	October	✓	
Seeding			
Plant Wheat	September		✓
Plant Wheat	October	✓	
Fertilizer			
Apply Fertilizer	August	✓	✓
Apply Fertilizer	September		✓
Apply Fertilizer	October	✓	
Apply Fertilizer	February		✓
Herbicide			
Apply (Herbicide)	October	✓	
Apply (Herbicide)	February	✓	✓
Pesticide			
Apply Pesticide (Dimethoate)	April	✓	
Foliar Fungicide (1 of 3 years)	April	✓	✓
Harvest			
Combine Wheat Grain	June	✓	✓

Table II-3. Grain-only wheat and dual-purpose wheat budgets

Item	Unit of Measure	Price per unit	GOW Quantity	GOW Value	DPW Quantity	DPW Value
Production						
Wheat	bu	$ 5.28	42	222.82	36	192.19
Net return from grazing						49.19
Gross Returns				**222.82**		**241.38**
"Cash" Costs						
Wheat Seed	Bu.	$ 15.00	1	15.00	1.5	22.50
Anhydrous Ammonia (82-0-0)	Lbs.	$ 0.45	79	35.34	64	28.98
Fertilizer Application	acre	$12.00	1	12.00	1	12.00
Urea (46-0--0)	Lbs.	$0.45			65	29.35
MAP (11-52-0)	Lbs.	$0.61	44	26.95	44	26.95
Fertilizer Application	acre	$4.00	1	4.00	1	4.00
Herbicide (broadleaf)	acre	$5.00	1	5.00	1	5.00
Herbicide (grass)	acre	$16.00	1	16.00	1	16.00
Herbicide Application	acre	$4.00	2	8.00	2	8.00
Insecticide (e.g. dimethoate)	pint	$5.38	0.75	4.04		
Foliar Fungicide (1 of 3 years)	acre	$12.50	0.33	4.13	0.33	4.13
Aerial Pesticide Application	acre	$5.00	1.33	6.65	0.33	1.65
Wheat Crop Insurance	acre	$7.00	1	7.00	1	7.00
Fuel	gallon	$4.70	4.92	23.12	4.92	23.12
Lube	acre			3.47		3.47
Repair	acre			7.12		7.12
Annual Operating Capital	$	$0.07	88.91	6.22	99.63	6.97
Wheat Custom Harvest & Haul						
Base Charge	acre	$23.00	1	23.00	1	23.00
Excess for > 20 bu/a	bu	$0.23	22.2	5.11	16.4	3.77
Hauling	bu	$0.23	42.2	9.71	36.4	8.37
Total "Cash" Costs	**$/acre**			**$221.85**		**$241.38**
Return to Machinery and Equipment Fixed Cost, and Labor, Land, Management, and Overhead	$/acre			$0.97		$0.00

Production Systems: GOW and DPW.

Table II-4. Stocker Steer Enterprise Budget for Dual-Purpose Wheat with a 450 Pound Purchase Weight and Historical Average Buy Prices, Sell Prices, and Average Daily Gains.

Stocker Steer Enterprise Budget for Dual-Purpose Winter Wheat:

Assumed Death Loss	1.5%	
Days on Wheat	112	day
Days owned	133	
ADG	2.11	lb/hd/d
Purchase Weight	4.5	cwt
Purchase Price	103.52	$/cwt
Sell Price	98.76	$/cwt
Actual Stocking Density	0.70	hd/ac

Item	Unit	Price	Quantity	Value
Gross receipts:				
Steers (based on death loss of 1.5%)	cwt/hd	98.76	6.97	$688.07
Operating costs:				
Stocker calves	cwt	103.52	4.5	$465.84
Order buyer fee	cwt	0.5	4.5	$2.25
Shipping to pasture	head	10	1	$10.00
Receiving program (21 days):				
Veterinary and medicine	head	15	1	$15.00
Hay (2% of initial purchase weight in lb/hd/day)	lb	0.04	189	$7.56
Soybean meal based supplement (2 lb/hd/day)	lb	0.20	42	$8.40
Other:				
Shipping to market, sales commission, etc	cwt	2	6.97	$13.93
Machinery fuel, lube, and repairs	$			$10.00
Hay during bad weather	lb	0.04	24	$0.96
High calcium mineral mixture (with R-1620)	lb	0.55	16.8	$9.24
Interest on Stocker calves	$	0.07	169.74	$11.88
Interest on other operating expenses	$	0.07	28.18	$1.97
Total operating costs, $/head:	$			$557.04
Fixed costs for steer production:				
Machinery and equipment – Depr., taxes & insurance	$			$5.50
Machinery and equipment – Interest	$	0.07	2.00	$0.14
Total fixed costs, $/head				$5.64
Total costs, $/head				$562.68
Return to land, labor, and management, $/head				$125.39
Return to land, labor, and management, $/acre				$87.86

Table II-5. Stocker Steer Enterprise Budget for Dual-Purpose Wheat with a 550 Pound Purchase Weight and Historical Average Buy Prices, Sell Prices, and Average Daily Gains.

Stocker Steer Enterprise Budget for Dual-Purpose Winter Wheat:

Assumed Death Loss	1.5%
Days on Wheat	112 day
Days owned	133
ADG	2.11 lb/hd/d
Purchase Weight	5.5 cwt
Purchase Price	93.72 $/cwt
Sell Price	90.76 $/cwt
Actual Stocking Density	0.70 hd/ac

Item	Unit	Price	Quantity	Value
Gross receipts:				
Steers (based on death loss of 1.5%)	cwt/hd	90.76	7.95	$721.73
Operating costs:				
Stocker calves	cwt	93.72	5.5	$515.46
Order buyer fee	cwt	0.5	5.5	$2.75
Shipping to pasture	head	10	1	$10.00
Receiving program (21 days):				
Veterinary and medicine	head	15	1	$15.00
Hay (2% of initial purchase weight in lb/hd/day)	lb	0.04	231	$9.24
Soybean meal based supplement (2 lb/hd/day)	lb	0.20	42	$8.40
Other:				
Shipping to market, sales commission, etc	cwt	2	7.95	$15.90
Machinery fuel, lube, and repairs	$			$10.00
Hay during bad weather	lb	0.04	24	$0.96
High calcium mineral mixture (with R-1620)	lb	0.55	16.8	$9.24
Interest on Stocker calves	$	0.07	187.83	$13.15
Interest on other operating expenses	$	0.07	29.70	$2.08
Total operating costs, $/head:	$			$612.18
Fixed costs for steer production:				
Machinery and equipment – Depr., taxes and insurance	$			$5.50
Machinery and equipment – Interest	$	0.07	2.00	$0.14
Total fixed costs, $/head				$5.64
Total costs, $/head				$617.82
Return to land, labor, and management, $/head				$103.91
Return to land, labor, and management, $/acre				$72.81

Table II-6. Expected Average, High, and Low Estimates For Grain-Only Wheat and Dual-Purpose Wheat

Item	Units	Expected Average	Expected High (1 of 6 years)	Expected Low (1 of 6 years)
Grain-Only Wheat Yield	bu/acre	42.2	60	28
Dual-Purpose Wheat Yield	bu/acre	36.4	52.9	23.2
Purchase Weight	lbs/hd	464.5	551.8	375.3
Stocking Density	lb/acre	332.84	475.69	236.41
ADG of Steers on Wheat	lbs/day	2.11	2.70	1.54

Estimates reported in this table are the averages as reported by a surveyed group of Oklahoma wheat producers.

Table II-7. Parameters for Simulated Variables.

Item	Units			
Parameters for triangular distributions		Adjusted Minimum	Adjusted Mode	Adjusted Maximum
Grain-Only Wheat	bu/acre	8.5	38.7	84.0
Dual-Purpose Wheat	bu/acre	5.0	34.8	73.0
ADG of Stocker Steers	lbs/day	0.78	2.11	3.45
Parameters for normal distributions (For illustration only, final weight varied)		Mean	Standard Deviation	
450 lb Steer Price Week of October 21	$/cwt	103.52	22.94	
550 lb Steer Price Week of October 21	$/cwt	93.72	19.77	
Oct 21 - March 3 Price Margin for 450 lb to 700 lb Steers	$/cwt	16	10	
Oct 21 - March 3 Price Margin for 550 lb to 800 lb Steers	$/cwt	22	11	
June Wheat Price truncated at $2.75	$/bu	3.61	1.43	

Table II-8. Results of simulating 1000 years of grain-only wheat, dual-purpose wheat at a 450 pound purchase weight, and dual-purpose wheat at a 550 pound purchase weight.

Production System	Number of Years Out of 1000 that System “Wins”
Grain-Only Wheat	21
Dual-Purpose Wheat - 450	763
Dual-Purpose Wheat - 550	216

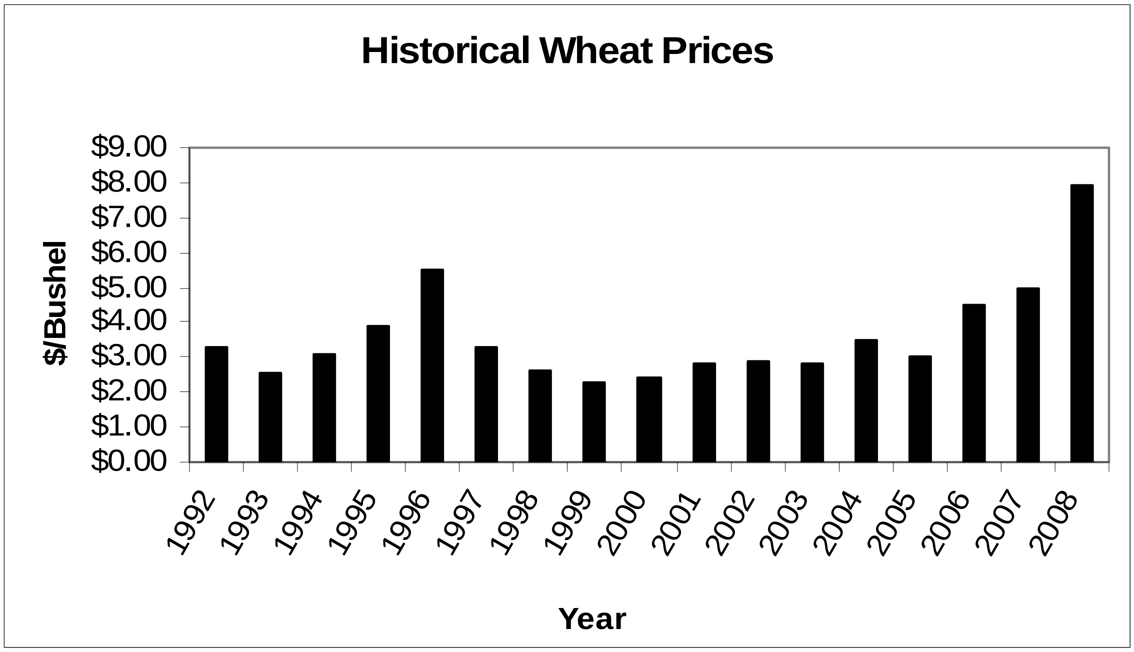

Figure II-1. Oklahoma June cash wheat prices received by farmers, 1992-2008 ($ per bushel).

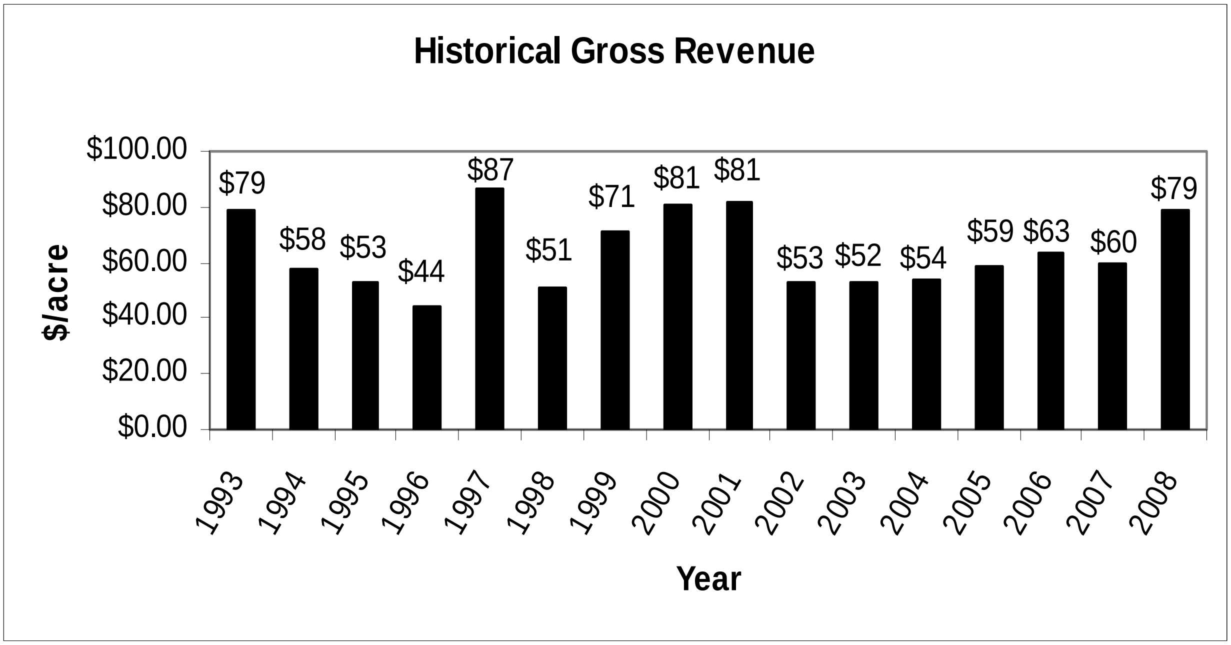

Figure II-2. Gross revenue from grazing fall-winter wheat forage by steers with an initial weight of 450 pounds, average daily gain of one pound for a 21 day receiving period, a stocking density of 196 pounds per acre (2.3 acres per steer) and an average daily gain of 2.1 pounds for 112 days of grazing on wheat for a sale weight of 719 pounds, 1993-2008 ($ per acre).

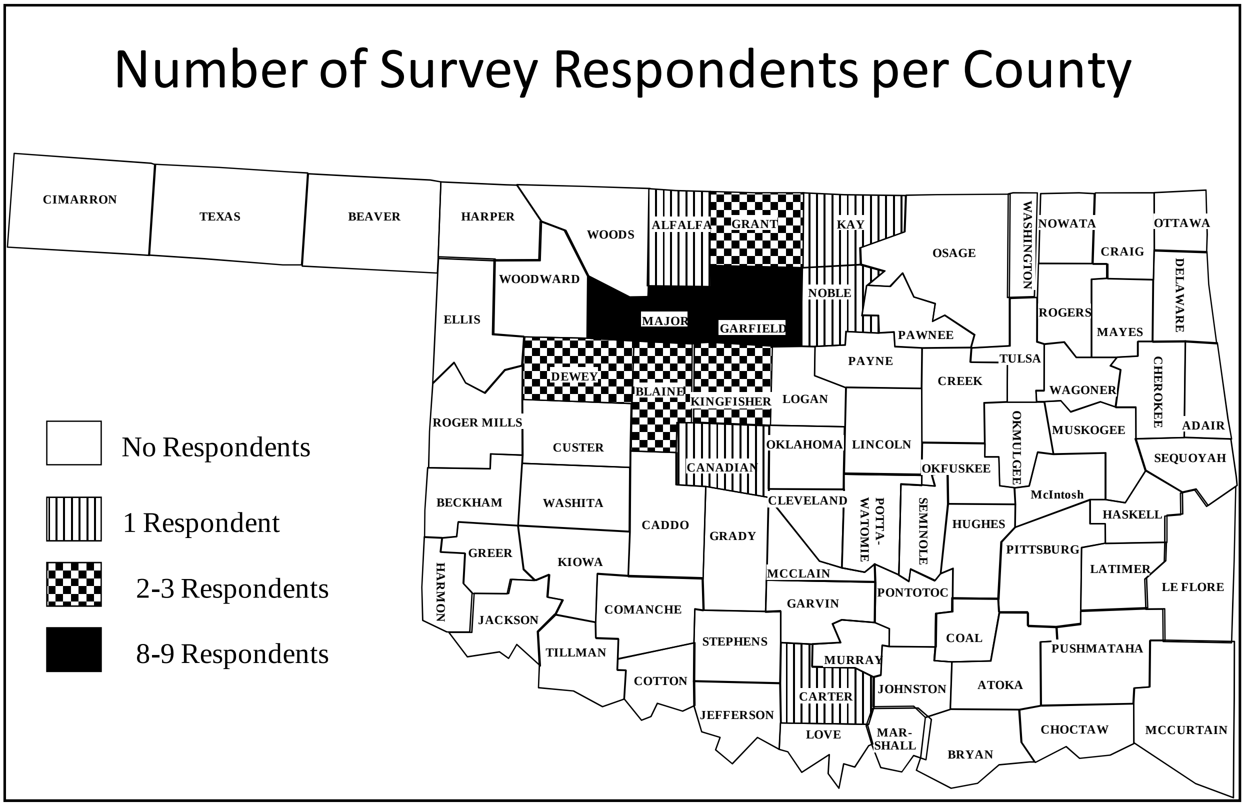

Figure II-3. Locations of Surveyed Producers in Oklahoma Reported by County

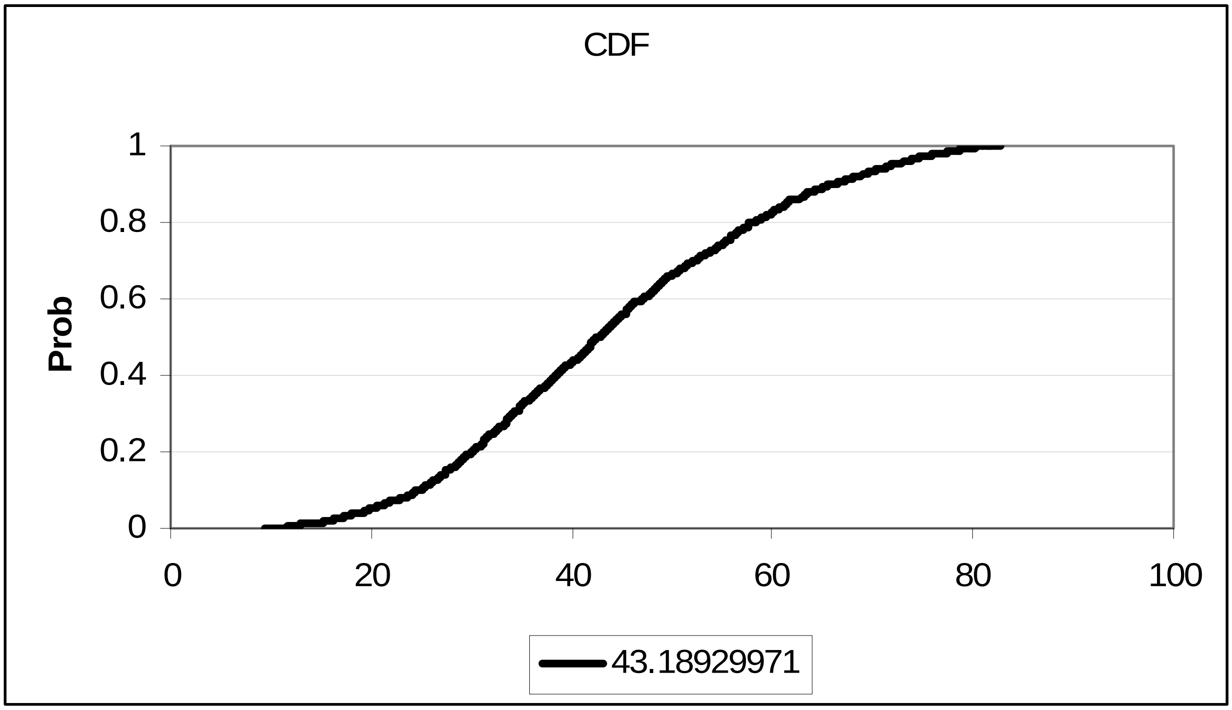

Figure II-4. Cumulative distribution function of grain-only wheat yields estimated with a triangular function based on survey responses (an average yield of 42.2, low yield of 28.0, and high yield of 60.0 bushels per acre).

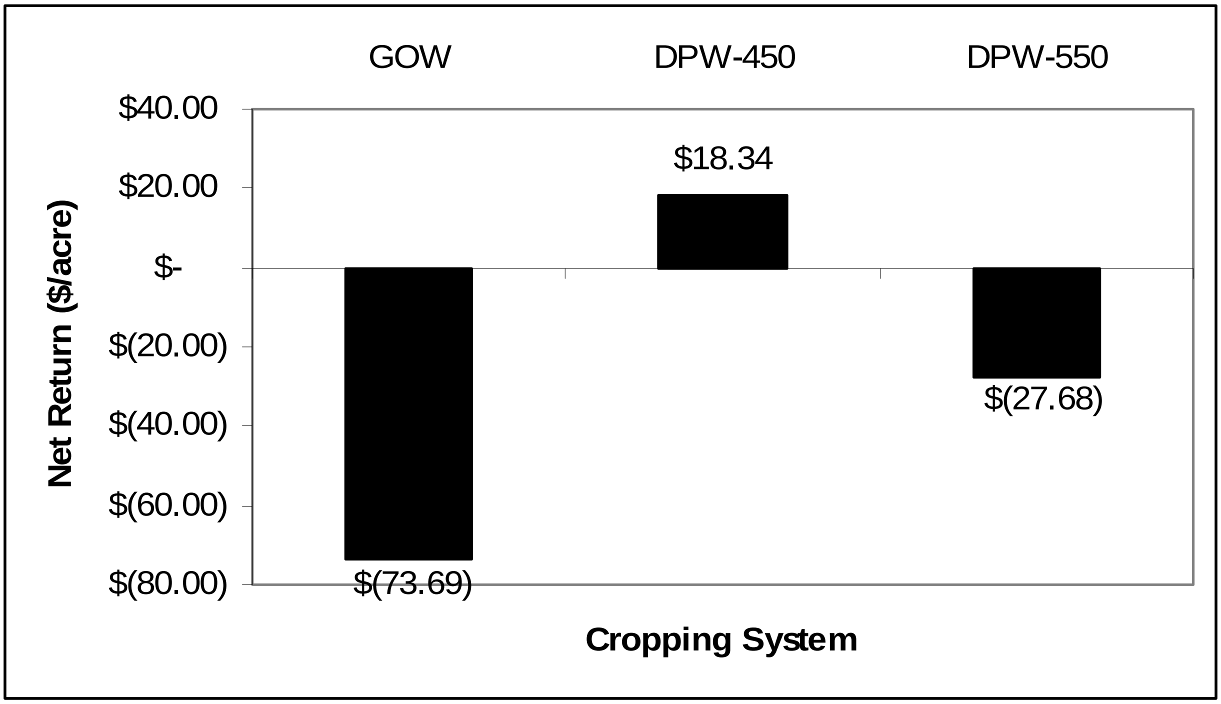

Figure II-5. Estimated annual net returns to land, machinery fixed costs, labor, overhead, and management for grain-only wheat, dual-purpose wheat grazed by steers with an initial weight of 450 pounds, and dual-purpose wheat grazed by steers with an initial weight of 550 pounds averaged across 1000 years of simulated yields, average daily gains, wheat prices, and cattle prices.

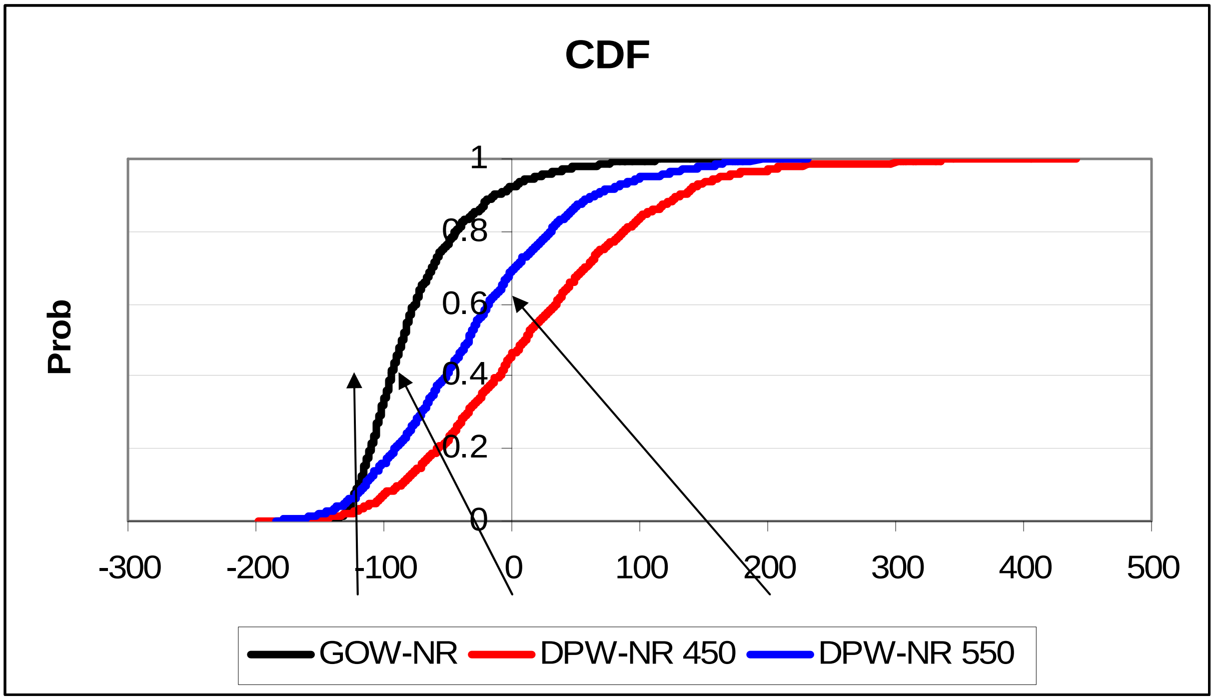

Figure II-6. Cumulative distribution function of net returns for grain-only wheat, dual-purpose wheat grazed by steers with an initial weight of 450 pounds, and dual-purpose wheat grazed by steers with an initial weight of 550 pounds averaged across 1000 years of simulated yields, average daily gains, wheat prices, and cattle prices ($ per acre).

VITA

Jason Chance Duke

Candidate for the Degree of

Master of Science

Thesis: Comparison of Production Systems Involving Grain-Only Wheat, Dual-Purpose Wheat, and Canola

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Title of Study: Comparison of Production Systems Involving Grain-Only Wheat, Dual-Purpose Wheat, and Canola

Pages in Study: 78 Candidate for the Degree of Master of Science
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Scope and Method of Study: This study consisted of two papers. The research reported in the first paper was conducted to determine if a crop rotation that includes winter hardy canola and winter wheat is economically competitive with continuous monoculture winter wheat in Oklahoma. A phone survey of producers that have experience producing both wheat and canola was conducted. Yield distributions were 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 research reported in the second paper was conducted to determine distributions of expected net returns for grain-only wheat; dual-purpose wheat stocked with steers with an initial weight of 450 pounds; and dual-purpose wheat stocked with steers with an initial weight of 550 pounds. A phone survey of Oklahoma producers that have experience producing both dual-purpose wheat and grain-only wheat was conducted to obtain distributions of key production parameters including grain yield and average daily gain. The production parameters were used in combination with distributions of wheat price, steer prices, and cost estimates to simulate distributions of expected net returns.

Findings and Conclusions: A three year crop rotation that includes canola followed by two years of dual-purpose wheat generated 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 $21.41 per acre per year. Based on the expected yields reported by growers and the simulated net returns, the canola-wheat-wheat rotation dominates continuous wheat.

Simulations of net returns for grain-only wheat and dual-purpose wheat found that dual-purpose wheat stocked with steers with an initial weight of 450 (550) pounds produced greatest net returns 76 percent (22 percent) of the time. The discrepancies in findings of prior studies of the grain-yield forgone by dual-purpose relative to grain-only wheat can be explained in part by differences in planting dates.

ADVISOR’S APPROVAL Dr. Francis Epplin