Forage plus Grain Wheat versus Grain-Only Wheat

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Abstract

Winter wheat may be grown in the Southern Plains either to produce grain only, or as a dual-purpose crop to produce both fall-winter forage and grain. The objective of the research is to determine expected net returns for both production systems. The estimated expected net value of the dual-purpose system stocked with steers with an initial weight of 450 pounds is from $38 to $92 per acre greater than that of the grain-only system. The economic success of dual-purpose wheat depends on a number of management factors including stocking density.

Introduction

Winter wheat may be grown in the Southern Plains either to produce grain-only, or as a dual-purpose crop to produce both fall-winter forage and grain (Redmon et al., 1995). For dual-purpose forage and grain production, grazing may be initiated in the fall, after the plants have become anchored in the soil. If the plants are anchored they are less likely to be removed by grazing livestock. Grazing may be continued throughout the winter until the first hollow stem stage of plant growth that usually occurs in late February or early March (Taylor et al., 2010). If the livestock are removed at or prior to first hollow stem, the plants will mature and produce wheat grain.

Southern Plains winter wheat pastures produce nutritious forage available for grazing during a time period when most U.S. pastures are dormant. In a typical year, the quantity of wheat pasture forage would far exceed the level that could be consumed by locally produced calves. Young steers and heifers are imported to the region from across the country. Brorsen, Bailey, and Thomsen found that over the time period from 1987 to 1992, weaned calves were purchased in the late summer and fall from distant states including Montana, North Carolina, and Florida and transported to Oklahoma to graze on winter wheat pastures. Most Oklahoma calves are born in the spring, weaned in late summer, stocked on winter wheat pasture in the fall and winter, and then moved to feedlots in the region for finishing.




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The decision to purchase calves and 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 prior to the growing season. For dual-purpose wheat to be more profitable 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. Surveys conducted by True et al. and Hossain et al. found that between 49-66 percent of the wheat acres planted in Oklahoma are intended for dual-purpose, 25-31 percent are intended for grain-only, with the remaining acres intended for forage only. This result suggests that profit maximizing producers interpret the expected returns from dual-purpose to be at least as great as the expected returns from grain-only.

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. For the time period from 1998 through 2006, the USDA reported that the average acre of wheat in the Prairie Gateway region that includes Oklahoma returned from $2.08 to $8.56 per acre for the production of a secondary product, either wheat straw harvested after grain, or forage harvested by livestock prior to grain harvest (USDA). The USDA did not report estimates of the proportion of acres on which straw was harvested or the proportion that was 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.

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 purchase calves and produce dual-purpose wheat. Of course, the value of fall-winter forage and the price of wheat grain are not known prior to the end of the season. In addition, 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 forage and grain yields, expected livestock weight gain, expected prices of wheat, and expected values of livestock weight gain. Epplin, Krenzer, and Horn estimated the net value of steer gain from grazing dual-purpose wheat to be from $18 to $43 per acre (in 1999 dollars, $23 to $55 in 2009 dollars) depending on the number of days available for grazing and stocking density. This added value from the grazing component of dual-purpose must be sufficient to compensate for the lower expected grain yield and the higher production cost of dual-purpose. The production parameter estimates that Epplin, Krenzer, and Horn used to prepare their budgets were based on results of designed experiment station trials.

Expected grain yield is lower for dual-purpose because of a demonstrated planting date effect and an unknown grazing effect (Epplin, Hossain, and Krenzer; Hossain, Epplin, and Krenzer). Planting date trials conducted on plots that were not grazed found a planting date effect, but did not provide information regarding the grazing effect. For the past five years, wheat variety trials have been conducted under both a dual-purpose and grain-only management system, producing an estimate of the grain yield difference between early planted and grazed dual-purpose plots (capturing the combined planting date and grazing effect) and later planted but ungrazed grain-only plots (Edwards et al., 2005, 2006, 2007, 2008, 2009). The average yield obtained from the dual-purpose variety trial plots that were planted on average on September 9 and grazed was 23.4 bushels per acre (Edwards et al., 2005, 2006, 2007, 2008, 2009) (Table 1). This amount is 11 bushels less than the average yield of 34.4 bushels per acre produced during the same five years with the same varieties on the adjacent grain-only plots that were on average planted on October 20 and not grazed. By this measure, the dual-purpose system reduced grain yield by an average of 32 percent.

Given the low and high wheat prices from 1992 to 2008 of $2.31 and $7.93 per bushel, 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 average grazing value of $23 to $55 per acre and the additional costs required for growing dual-purpose rather than grain-only, a dual-purpose system that produced 11 bushels per acre less grain would have difficulty competing economically with a grain-only system. However, as noted, based on revealed production patterns, producers interpret the expected returns from dual-purpose to be at least as great as the expected returns from grain-only. This suggests that either the management system used in the variety trials is not consistent with the management system used by farmers, or one or more of the parameter values (such as initial weight of steers, average daily gain, or stocking density) used to estimate the value of grazing is incorrect. The objective of the research reported in this paper is to reconcile these inconsistencies and to determine expected net returns for both production systems. This study differs from prior studies including the Epplin, Krenzer, and Horn study in that distributions of key production parameters: grain yield, stocking density, and average daily gain, are constructed from survey responses provided by producers rather than from controlled experiments enabling the consideration of year-to-year variability. Historical price data are used to construct steer purchase price, steer sale price, and wheat sale price distributions.

Methods and Procedures

A phone survey of 31 producers who have experience in growing both grain-only and dual-purpose wheat was conducted. The direct elicitation method was used (Anderson, Dillon, and Hardaker). Subjective distributions were elicited for targeted planting dates for both dual-purpose and grain-only, grain-only wheat yields, dual-purpose wheat yields, initial weight of steers purchased to stock on dual-purpose wheat, stocking density of steers on dual-purpose wheat, and average daily gain of steers on dual-purpose wheat. The producers were asked to consider a six-year time horizon. They were then asked what their expected average, high, and low values would be over the next six years (Hull; Sonka and Patrick; Shapiro, Brorsen, and Doester). Covariance among yields was also elicited by asking expectations regarding average daily gain levels (low, average, or high) for each level of wheat yield (low, average, and high).

The questions were designed to enable the construction of triangular distributions for yield and average daily gain (Anderson, Dillon, and Hardaker; de Finetti; Hogarth; Norris and Kramer; Raiffa). Cumulative distribution functions (CDF) were formulated from the information provided (Schlaifer). Since the producers 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 occurred at the probability level of 0.16 on the CDF (84% of the time the average producer would expect higher yields). Similarly, the distributions were adjusted so that the average high value occurred at approximately the 0.84 probability level on the triangular distribution.

During the 1992 to 2008 time period, the average June cash wheat price was $3.61 per bushel with a standard deviation of 1.43 (NASS). The USDA loan rate provided an effective floor price for wheat. Therefore, the nominal wheat prices are assumed to be normally distributed but truncated at the 2008 loan rate of $2.75 per bushel (NASS). Wheat prices are assumed to be uncorrelated with yield since the grain yield on a specific field in the Southern Plains is assumed not to influence the global price of wheat.

Value of Fall-Winter Grazing of Dual-purpose Wheat

The assumption was that the fall-winter wheat pasture would be grazed by young steers. Two steer budgets were prepared, one with an initial steer weight of 450 and the other with an initial steer weight of 550 pounds. A 21-day receiving program and 112 days on wheat were assumed. The steers were assumed to have an average daily gain of one pound during the receiving program, 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.

Steer price data were obtained from databases maintained by the Livestock Marketing Information Center (LMIC). Oklahoma City 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 the steer purchase price is assumed to be normally distributed. Since the March sale price for steers is correlated with the previous October buy price, the sell price is assumed to be 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 (or 550) pound steers and the March 3 price for the heavier steers. Steer weight on March 3 depends not only on the initial weight but also on the stochastic average daily gain. Stochastic sale prices were simulated based on the average price margin and the standard deviation for the interpolated weights.

Simulations

Yield, stocking density, and average daily gain information provided by the growers were combined with budgeted cost estimates and price distributions to simulate expected net returns for each production system. Two steer purchase weights – 450 and 550 pounds – were considered for dual-purpose wheat, which enabled the comparison of two dual-purpose strategies: DP450 (dual-purpose wheat stocked with steers with an initial weight of 450 pounds) and DP550 (dual-purpose wheat stocked with steers with an initial weight of 550 pounds). For these simulations, production costs, buy weights, days owned, stocking density, buyer fees, shipping costs, veterinary costs, soybean meal based supplements, 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. Grain-only and dual-purpose wheat grain yields are assumed to be perfectly correlated. The SIMETAR Excel add-in was used to simulate each system 1,000 times to reflect 1,000 growing seasons (Richardson, Schumann and Feldman).

Results

Survey Results

The surveyed producers reported average targeted planting dates of September 13 for dual-purpose wheat and October 4 for grain-only wheat. Comparatively, True et al. reported a target date for dual-purpose of September 17 and for grain-only of September 27. Similarly, the Hossain et al. survey reported a target planting date of September 20 for dual-purpose and October 2 for grain-only wheat. The average planting date for the variety trials was September 9 for dual-purpose and October 20 for grain-only (Edwards et al., 2005, 2006, 2007, 2008, 2009) (Table 1). The dual-purpose planting date in the variety trials has been earlier than the farmer's reported target date and the average grain-only planting date has been later than the target reported by farmers in all three surveys.

Other survey results are reported in Table 2. The producers reported an expected average yield in a grain-only wheat system of 42.2 bushels per acre. The surveyed producers reported an expected average yield in a dual-purpose wheat system of 36.4 bushels per acre. 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 (rather than the average reported variety trial difference of 11 bushels per acre) and the cost of the additional inputs required to produce dual-purpose wheat.

The grain yield response to planting date function reported by Epplin, Hossain, and Krenzer predicts a 19.4 percent (6.8 bushels) decrease in grain yield from a September 13 planting date relative to an October 4 planting date. Similarly, the response function reported by Hossain, Epplin, and Krenzer predicts a 15.5 percent (6.2 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. However, it is substantially less than the reported yield difference of 32 percent (11 bushels) found in the variety trials (Edwards et al., 2005, 2006, 2007, 2008, 2009). Some of the yield difference can be attributed to differences in planting date. The dual-purpose variety trial plots were planted on average nine days earlier, and the grain-only plots 20 days later, than target planting dates reported by farmers. The grain yield response to planting date functions show that the earlier planting date is not good for grain yields (Epplin, Hossain, and Krenzer; Hossain, Epplin, and Krenzer).

Producers reported an overall average steer purchase weight of 464.5 pounds. True et al. and Hossain et al. reported purchase weights of 460 and 466 pounds, respectively. Kaitibie et al. (2003b) reported approximate purchase weights of 550 pounds for steers used in research trials at the Marshall Oklahoma Wheat Pasture Research Unit. 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 (DP450) and another with an initial steer purchase weight of 550 pounds (DP550).

The producers reported an average stocking density of 333 pounds per acre. The surveys of True et al. and Hossain et al. reported an average stocking density of 196 pounds per acre. Kaitibie et al. (2003a) 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, would have been 305 pounds per acre. To investigate the consequence of stocking density, one set of simulations was conducted with a stocking density of 333 and another with a stocking density of 196 pounds per acre.

The average reported low (1 in 6), average, and high (1 in 6) average daily gains were 1.54, 2.11, and 2.70 pounds. Producers surveyed by True et al. reported an average daily gain for steers of 1.9 pounds. In the more recent survey by Hossain et al., producers reported an average daily gain for steers of 2.3 pounds. Kaitibie et al. (2003b) 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.

To determine if grain yield is correlated with average daily gain, the producers were asked "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)?" The producers responded that years that result in high average daily gains do not necessarily produce high wheat grain yields. Based on the responses to this question, average daily gain was assumed to be uncorrelated with wheat grain yield.

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 in the region (in the absence of government subsidies) would lose $69 per acre.

Results of the simulations are provided in Table 3. The dual-purpose system generates the greatest net returns at both buy weights the majority of the 1,000 simulated seasons. The dual-purpose systems reflect a stocking density of 333 pounds per acre. Based on the growers distribution of average daily gains and yields combined with the distribution of historical wheat and cattle prices, DP450 wins 76.3 percent of the time and has an average net return of $18.34 per acre. DP550 wins 21.6 percent of the time with an average net return of negative $27.69 per acre. Grain-only wheat has an average net return of negative $73.69 per acre.

Based on budget and simulation results, DP450 at a stocking density of 333 pounds per acre generates an expected net return of $92 per acre more than grain-only wheat. Similarly, the expected net returns from DP550 and the same stocking density is $46 more per acre than the expected net returns from grain-only wheat. These findings support the revealed production patterns of producers.

The greatest discrepancy in findings between the current survey and the surveys reported by True et al. and Hossain et al. is for stocking density. The current survey finds an average stocking density of 333 pounds per acre versus an average stocking density of 196 pounds per acre reported by True et al. and Hossain et al. To determine the consequence of stocking density, a simulation was conducted with a stocking density of 196 rather than 333 pounds per acre. With the decrease in stocking density, the relative economics of the three production systems remains unchanged. DP450 produces the highest net returns per acre 73.8 percent of the time with an average net return of negative $36 per acre. The change in stocking density from 333 to 196 pounds per acre results in a decrease in expected net return of $53 per acre for the DP450 system. DP550 remains the runner-up, winning 18.4 percent of the time with an average net return per acre of negative $63, $35 per acre less than when the stocking density is assumed to be 333 pounds per acre. With the lower stocking density, the average advantage for DP450 relative to grain-only is $37 per acre, and the average advantage for DP550 relative to grain-only is only $10 per acre. Stocking density is clearly a key management decision.

To address the question of whether a high wheat price would mitigate the advantage of dual-purpose, a third set of simulations was conducted with the highest reported annual average wheat price from 1992-2008 of $7.93 per bushel, rather than the mean wheat price of $3.61. DP450 reports the highest net return per acre for 74.5 percent of the simulations and an average net return of $189. The average net return per acre for DP550 is $143, and for 19.6 percent of the simulations, DP550 produces the greatest net returns. Grain-only reports the highest net returns for only 5.9 percent of the simulations with an average net return of $124 per acre. For the relatively high wheat price of $7.93, the expected returns from DP450 are $65 per acre greater than the expected returns from grain-only. The expected returns from DP550 are $19 per acre greater than the expected returns from grain-only. For a 333 pound per acre stocking density, and a 5.8 bushel per acre average yield difference between grain-only and dual-purpose, the price of wheat would have to reach $18.34 per bushel before overtaking both dual-purpose systems.

Discussion

Revealed production patterns of producers suggest that the expected net returns of dual-purpose wheat exceed the expected net returns of grain-only wheat. However, average results from five years of experiment station variety trials that compared grazed dual-purpose wheat to ungrazed grain-only wheat reported an 11 bushels per acre greater average grain yield for grain-only than for dual-purpose. A $23-$55 per acre value of fall-winter grazing based on prior budget estimates would not be sufficient to offset the loss of 11 bushels of wheat. It is likely that the management system used in the variety trials is not consistent with the management system used by farmers, or that one or more of the parameter values (such as initial weight of steers, average daily gain, or stocking density) typically used to estimate the value of grazing is incorrect.

The management system could differ because the incentive structure differs between researchers and farmers. Researchers are rewarded for successful completion of experiments. In the case of dual-purpose wheat, there is an underlying incentive for the researcher to plant wheat early to increase the probability that the plants will become established and produce a substantial quantity of fall forage necessary to support fall-winter grazing experiments. Early planting will in most seasons result in lower grain yields. However, the researcher is more likely to incur negative feedback if the plots do not produce a substantial quantity of fall-winter forage necessary to support livestock grazing trials than if the grain yield is reduced from early planting. On the other hand, the economic incentive for the farmer is to maximize the combined net returns from both the forage and grain. The incentive for the farmer is to find the optimal planting date, recognizing that the outcome from planting as early as the researcher is likely to result in substantially lower grain yields and lower overall net returns.

A survey of producers was conducted to enable construction of triangular distributions of key production parameters. These data were combined with historical prices to simulate three systems: grain-only, DP450, and DP550. The main findings are 1) the estimated expected net value of the DP450 system is from $38 to $92 per acre greater than that of the grain-only system, which is consistent with revealed production patterns. 2) The planting dates used in the variety trials are not consistent with targeted planting dates used by producers. The dual-purpose plots were on average planted nine days earlier than producers target for dual-purpose; this earlier planting date explains some of the yield discrepancy. 3) The expected grain yield of grain-only wheat is 15.9 percent greater than the expected grain yield of dual-purpose wheat when both are seeded at their respective target planting dates. However, for most states of nature, the value of winter grazing more than compensates for the lower grain yield and additional production cost, and dual-purpose wheat generates greater expected net returns than grain-only wheat. 4) Stocking with steers with an initial weight of 450 pounds is a better strategy than stocking with steers with an initial weight of 550 pounds for most states of nature. 5) A high wheat price ($7.93 per bushel) reduces the advantage for dual-purpose, but does not eliminate it. 6) The economic success of dual-purpose depends critically on stocking density.

Earlier surveys reported an average stocking density of 196 pounds per acre. The survey conducted for this study finds an average stocking density of 333 pounds per acre, which is close to the optimal stocking density estimated by Kaitibie et al. (2003a) of 305 pounds per acre. However, the change in stocking density does not change the relative ranking among the three systems. Increasing the stocking density from 196 to 333 pounds per acre increases the expected net returns by $54 per acre for DP450, and by $35 per acre for DP550. One caveat is that this estimate is contingent on the assumption that the expected grain yield loss from grazing does not change when stocking density is increased from 196 to 333 pounds per acre.

No field trials have been conducted that enable the determination of the grazing effect on grain yield separate from the planting date effect. The variety trials that are referenced enable an estimate of the combined effects since the dual-purpose plots were planted early and grazed, and the grain-only plots were planted later and not grazed. The small plot planting date trials that are referenced enabled an estimate of the planting date effect, but since they did not have complementary plots that were grazed, they did not provide information regarding the grazing effect. To obtain a more precise estimate of the economics of dual-purpose relative to the economics of grain-only, a more precise estimate of the planting date and the grazing effect will be required. In addition, given the importance of stocking density for the economics of dual-purpose, future trials should consider designing studies to capture the planting date effect, and the grazing effect for several levels of stocking density.

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Table 1. Planting dates and average grain yield across all varieties obtained from the variety trials at the Marshall Oklahoma Wheat Pasture Research Unit for both dual-purpose and grain-only management (2004-2009)

	Dual-Purpose		Grain-Only	
Year	Planting Date	Yield (bu/ac)	Planting Date	Yield (bu/ac)
2004-05	31-Aug	16	29-Oct	30
2005-06	7-Sep	22	14-Oct	28
2006-07	5-Sep	16	9-Oct	30
2007-08	18-Sep	55	30-Oct	63
2008-09	17-Sep	8	20-Oct	21
Average	9-Sep	23.4	20-Oct	34.4

Source: Edwards et al., 2005, 2006, 2007, 2008, 2009

Table 2. Expected average, high, and low estimates for wheat yield, purchase weight, stocking density, and average daily gain

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
Average daily gain of Steers on Wheat	lbs/day	2.11	2.70	1.54

Estimates reported in this table are the averages found in a phone survey of 31 producers who have experience in growing both grain-only and dual-purpose wheat.

Table 3. Results of simulating net returns from 1,000 seasons of grain-only wheat, dual-purpose wheat stocked with steers with an initial weight of 450 pounds (DP450), and dual-purpose wheat stocked with steers with an initial weight of 550 pounds (DP550)

	Base Assumptions[a]		Base Assumptions Except for 196 lb/ac Stocking Density		Base Assumptions Except for Expected Wheat Price $7.93/bu	
Production System	"Wins"	Expected Returns[b] ($/ac)	"Wins"	Expected Returns ($/ac)	"Wins"	Expected Returns ($/ac)
Grain-only Wheat	2%[c]	-$74	8%	-$74	6%	$124
DP450; Dual-purpose Wheat Stocked with Steers with an Initial Weight of 450 pounds	76%	$18	74%	-$36	75%	$189
DP550; Dual-purpose Wheat Stocked with Steers with an Initial Weight of 550 pounds	22%	-$28	18%	-$63	20%	$143
	Expected Net Value of Dual-purpose Relative to Grain-only ($/ac)					
Difference (DP450 – Grain-only)		$92[d]		$38		$65
Difference (DP550 – Grain-only)		$46		$11		$19

[a] Base assumptions include October 21 purchase date; 21 day receiving program, 112 days on wheat, March 3 sale date, mean average daily gain of one during receiving program and 2.11 during wheat grazing; mean wheat yield of 36.4 for dual-purpose and 42.2 for grain-only, and stocking density of 333 pounds per acre.

[b] Indicates expected net return to land, overhead, and management. Income from government subsidies and insurance is not included.

[c] 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) are treated as stochastic variables. Under the base assumptions, grain-only wheat produces greater net returns that the other two alternatives two percent of the time.

[d] For the base assumptions including an expected grain yield advantage of 5.8 bushels per acre for grain-only, the expected net returns are $92 per acre more for DP450 than for grain-only.