Evaluating Dryland Crop/Livestock System Alternatives for Risk Management under Declining Irrigation in the Texas Panhandle

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ABSTRACT: Production budgets for dryland crop and crop/livestock systems are developed to estimate yields, costs and returns for dryland wheat and sorghum and for alternative dryland crop/livestock systems. A crop simulation model aids yield estimation. The yield and return distributions are used to estimate risk and relative risk for included alternatives.

Key Words: Relative Risk, Ogallala Aquifer, Crop-Livestock Systems, Wheat, Sorghum

Introduction

Agriculture is the largest industry in the Texas Panhandle region. Agriculture in the region relies upon irrigation. Irrigation increases yield by 2 to 7 times over non-irrigation. When risk is defined as a function of the variability in yield, irrigation reduces risk by 75% to 90%. The development of irrigation in the region is a relatively recent phenomenon, developing largely since the end of World War II. Between 1950 and 1980 irrigated acres increased from 19,315 to 1,754,560.

However, between 1980 and 1997 irrigated acres declined to 1,363,438 acres as the water availability in the Ogallala aquifer declined and pumping costs increased. In addition, aquifer recharge is negligible, and municipal, industrial, and conservation interests increasingly compete for Ogallala aquifer water. Irrigated acres in the region are therefore expected to continue to decline in the long-term due to economic or political forces. Decline in irrigated acreage will result in increasing acreage dedicated to dryland crop or crop/livestock production systems.

Precipitation in the region is highly variable. In Amarillo the annual average precipitation over the 120-year period from 1880 through 2000 is 20.53 inches (National Weather Service, 2000). However, the range in annual precipitation is from less than 9 inches to over 40 inches. There are pronounced year-to-year variations with as much as 15 to 20 inch differences in consecutive years. Major wet and dry cycles are observed. Short periods of significantly above average precipitation are usually followed by long periods of below average to average precipitation. A seasonal pattern adds to the variability. Over 50% of the annual precipitation is received during the summer growing season from May through October. May, June and August are the months with the highest average rainfall. Regional dryland systems face significantly increased yield risk due to the limited precipitation amounts and patterns. Risk assessment and management tools therefore provide benefits to regional producers.

Wheat, grain sorghum and corn are traditional crops grown in the Texas Panhandle under irrigation. Wheat and grain sorghum, along with sorghum-sudan and cotton, are predominant in in dryland systems. Livestock grazing of winter wheat pasture is also an important activity in the region. Development of alternative crop/livestock systems may offer reduced yield production risk in regional dryland systems. The objectives of this study are to estimate yield and expected return distributions for traditional dryland crops wheat and sorghum, and for experimental alternative crop/livestock systems for the Texas Panhandle, and; to compare the absolute risk and relative risk associated with the traditional dryland crops and the experimental crop/livestock systems.

Data and Methods

Yield distributions are determined for six primary Panhandle production alternatives: winter wheat harvested for grain only (WH); winter wheat grazed by steers and then harvested for grain (WHGRZ); winter wheat for grazeout only (WHGO); grain sorghum harvested for grain only (GS); grain sorghum harvested for grain, followed by residue grazing (GSGRZ); and sorghum-sudan raised for grazing (SS). Mean yields and distributions are then used in budget development in order to estimate net returns to land, labor, and management (NR) for these primary production alternatives and for additional alternatives.

Grain yields for wheat and sorghum are derived from simulations yields produced by the EPIC model which is incorporated into the CropMan crop simulation model (Gerik, 2006). These distributions are then adjusted to correspond with the average yields reported for Randall county between 1983 and 2005 by the Texas Crop and Livestock Reporting Service. The EPIC model utilizes daily weather data including precipitation, temperature, and radiation to simulate plant growth. Since crop yields in the region are highly related to weather, Amarillo is chosen as representative of the Texas Panhandle region. A 46-year precipitation record (1960-2005) for Amarillo serves as the key input to the CropMan model.

A similar approach is used to determine yield of wheat forage and grain sorghum residue available for grazing in the WHGRZ, WHGO, and GSGRZ production alternatives. The CropMan database includes biomass production for both wheat and grain sorghum, providing the most reliable and available long-term estimate of regional forage production for wheat and grain sorghum. A 100-yr CropMan simulation is reconciled with local estimates of wheat and grain sorghum forage production by Lust (2008) at the WTAMU Nance Ranch and the Texas AgriLife Extension Service at Bushland, Texas to determine the expected forage yields associated with WHGRZ and GSGRZ production alternatives. Expected forage yields are then transformed to steer gain based on National Research Council (NRC) nutrient requirements and forage nutrient values.

Steer gain per acre while grazing dryland wheat is estimated in Texas A&M University AgriLife Extension Crop and Livestock Budgets (AgriLife Budgets, 2008). The steer gain estimate from the District 1 AgriLife budget is chosen as representative of the region, as the district includes the Panhandle. The estimate in this budget is reconciled with forage yield estimates derived from the CropMan simulation to determine the expected steer gain used for the WHGRZ production alternative.

AgriLife budgets, unfortunately, do not estimate wheat forage production or steer performance for regional wheat grazed after March 1, the date associated with the first hollow stem stage of wheat maturity and generally accepted as the cattle removal date if grain is to be harvested. In addition, wheat forage growth during the typical March 1 – May 20 grazeout period does not have a linear relationship with forage growth prior to March 1, since increasing temperature, day length, and wheat maturity typically result in significantly increased forage growth rate during the grazeout period as compared to the winter grazing period. This is especially noticeable under dryland conditions. Therefore an alternative data source is required to estimate steer gain for this period. West Texas A&M University (WTAMU) researchers recorded steer gain on six plots of dryland wheat through grazeout during 2003-2007 (Lust, 2008). Mean steer gain per acre is calculated from this data set for the grazing period of March 1 – May 20. This gain is then combined with the steer gain estimate from the AgriLife budget for the winter grazing period to determine the gain used in the WHGO budget.

Yield and distributions for sorghum-sudan are determined through local data sets and CropMan simulation. McCuistion (2006) reports dryland sorghum-sudan forage production and steer gain while grazing replicated plots of dryland sorghum-sudan at the James Bush Research Farm in Bushland, TX. Lust (2008) determines steer gain grazing dryland sorghum-sudan at WTAMU during 2003-2007. Weighted means from these studies and the 2008 AgriLife budget for sorghum-sudan grazing are used to determine the expected mean steer gain for the SS production alternative budget. However, increased use of sorghum-sudan varieties in the Texas Panhandle has rapidly developed only during the last ten years. Since these data sources reflect a relatively short time period with limited precipitation variance, a 100-year CropMan simulation was used to estimate the variance of sorghum-sudan yield and steer gain over a longer time period and a more representative precipitation distribution.

Budgets are developed for each of the six primary production alternatives specified above. Budgets are based on four AgriLife budgets for WH, WHGRZ, GS and SS. Adjustments are made to reflect crop yields as described above. The budget for WHGO is developed by adding the steer gain for the grazeout period, as determined above, to the WHGRZ budget, so that grazing from November 1 through May 20 is reflected in a single budget. The budget for GSGRZ is similarly developed by adding steer gain from residue grazing to the GS budget to reflect the dual product alternative.

Each budget estimates the mean net return to land, labor and management (NR) for the production alternative specified. Net return for each budget is calculated by transforming the yield data to Total Returns (TR) based on 2008 prices, and subtracting the total specified expenses, which include variable and allocated fixed costs expressed on a per acre basis. Production costs and commodity prices are based on respective 2008 AgriLife budgets, and were held constant so that variance in TR is reflective of production risk, and not price risk. Dryland cropping operations incur few production costs that are correlated with yield. Only grain hauling costs are directly associated with yield, while the major costs are associated with planting, harvesting, or fixed assets are incurred regardless of relative crop success. Therefore total specified costs in the dryland budgets are not highly related to yield, and contribute negligibly to variance in TR. Additionally, commodity prices received in the region vary primarily in response to nationally prevalent conditions, rather than in response to local yields or supply. Therefore, specified costs and commodity prices are assumed constant, so that σ Yield = σ TR = σ NR. The standard deviation (σ) of NR is used as a measure of absolute risk, and the coefficient of variation (CV), which is the ratio of the standard deviation to the mean, measures relative risk for each production alternative.

A portfolio analysis is used to determine the NR, absolute risk, and relative risk of experimental production alternatives. Combinations of equally weighted pairs of the six primary production alternatives produced weighted mean NR for 15 additional production alternatives. The total variance of the portfolio is calculated as the sum of the proportional variances plus the covariance as described by Barry et al, (2000). Correlation coefficients between NR for each of the six production alternatives are determined in order to calculate covariance between paired production alternatives. A total of twenty-one single or combination production alternatives are then ranked by mean NR, absolute risk, and relative risk.

Results and Discussion

Budgets for each of the six primary production alternatives differ primarily due to the relative amount of grazing the alternative utilizes (Tables 1-6). No harvest or transportation costs are incurred for WHGO (Table 3) or SS (Table 6), since these alternatives rely solely on grazing. Dual product alternatives for WHGRZ (Table 2) and GSGRZ (Table 5) include additional income categories. Fuel costs for WHGO (Table 3) are increased relative to WH (Table 1) and WHGRZ (Table 2) budgets.

Mean NR for the six primary budgets ranged from $30.68 for WH to $71.60 for GSGRZ (Table 7). Means, correlation coefficients, standard deviations, and coefficients of variation of NR for all combinations of production alternatives analyzed are summarized and ranked. The addition of grazing to the grain production alternatives (WHGRZ and GSGRZ) resulted in a doubling of NR compared to the grain-only alternatives. Net Return increased from $30.68 for WH to $59.92 for WHGRZ, and from $34.10 for GS to $71.60 for GSGRZ (Table 7), indicating the effectiveness of dual product alternatives. The results for these two production alternatives indicate the significant increase in NR that is potentially realized through inclusion of secondary or dual products in a traditional grain production system. The grain portion of the WHGRZ and GSGRZ contributed 51.0% and 47.6% of the NR, respectively, to the total NR for the production alternatives. Forage produced in these two system alternatives is highly correlated with grain produced, since grain and grazing are produced by the same crop. Nevertheless, the results illustrate that harvest via grazing of the forage fraction of the crop may yield as much or more NR as the grain that is traditionally considered the primary crop. Total harvest of crop biomass through grazing may result in negative consequences not reflected in this analysis. Soil characteristics such as organic matter content, water-holding capacity, and susceptibility to wind and water erosion may be negatively affected by removal of forage or residue. This is especially a consideration for the GSGRZ system, since residue is removed after crop maturity and grain harvest. Wheat grazing on clay loam soils typical of the region may result in undesirable soil compaction, especially if grazed when the soil is wet. Inclusion of additional costs related to such potential problems may result in reduced NR.

The inclusion of grazing in the WHGRZ and GSGRZ alternatives suggests the desirability of grazing based production strategies. Two alternatives (WHGO and SS) describe grazing-only enterprises that harvest no grain. Such alternatives are attractive to some producers, especially those familiar with cattle and grazing systems. These alternatives produced NR that are \$12.81 (WHGO v WH) and \$7.74 (SS v GS) higher than the corresponding grain-only option. However, the grazing-only alternatives produce NR below that of the dual product systems WHGRZ and GSGRZ.

Wheat alternatives (WH, WHGRZ, WHGO) represent winter production systems, while the sorghum-based alternatives (GS, GSGRZ, SS) represent summer production. However, no seasonal advantage is clearly apparent based on the NR of the six primary alternatives. Sorghum-based summer production alternatives produce slightly higher total NR ($147.54) than wheat-based winter alternatives ($134.09). However, the winter system WHGO produces a slightly higher NR than SS.

The six primary production alternatives are paired to create 15 new crop/livestock production alternatives that are analyzed in a portfolio analysis. The NR for each of the combination alternatives is calculated as the weighted mean of the two alternatives that are paired, with equal weight (.50) given to each of the primary alternative systems. As expected, NR of the combination alternatives are intermediate to the NR of the two primary contributors. The twenty-one production scenarios are ranked by NR in Table 7. The overall mean NR for all production alternatives is $46.94. The advantage to NR gained by including both grazing and grain production in the production system becomes even more apparent when rankings are examined. The top eleven alternatives based on NR include both grain production and grazing, suggesting that diversified or dual product systems produce an advantage over single-product systems. Grazing-only systems (WHGO, WHGO-SS, SS) rank 12th, 13th and 14th for NR, slightly below the overall mean NR (Table 7). The distinct disadvantage of grain-only dryland production systems is clearly highlighted, as the three grain-only alternatives (WH, GS, WH-GS) rank 19th, 20th and 21st in NR. Results suggest that livestock grazing contributes significantly to maximum NR in Panhandle dryland production systems.

Correlation coefficients are calculated for NR of each pair of production alternatives. Correlations primarily indicate that NR are related by season. A correlation coefficient of .410 is calculated for WHGO:SS, indicating the least closely related production alternatives. Other summer:winter production system correlations were similar, with correlations of .432, .456, and

.480 determined for WH:SS, WHGO:GS, and WH:GS, respectively. Conversely, correlations of production alternatives in the same season were high, .901 for GS:SS, and .949 for WH:WHGO. Since forage production is a function of the respective grain crops, WH:WHGRZ and GS:GSGRZ were perfectly correlated. Correlations are as expected given the randomness of regional precipitation patterns and the dependence of yield and NR on precipitation.

The standard deviation of NR for each of the production alternatives provides a measure of absolute risk. Variation is lowest for grazing-only production options, with WHGO-SS producing the smallest distribution ($\sigma = 27.14$) followed by WHGO ($\sigma = 31.90$) and SS ($\sigma = 32.80$). This may be explained in part by the greater ability of the grazing regimes to harvest even marginal crop yields at a relatively low cost, resulting in reduced variation in grazing alternative outcomes.

The coefficient of variation of NR is calculated for each production alternative as an indication of relative risk. Production systems are ranked by CV of NR (Table 8). The top three production alternatives (for lowest relative risk) are the grazing-only production systems WHGO-SS, WHGO, and SS. The highest ranking alternative that includes a grain-only option is WHGO-GS, ranking tenth on the list of twenty-one alternatives. Grain-only production systems offer the greatest relative risk, with WH-GS, GS, and WH the three lowest ranking alternatives. The difference in relative risk between the grazing-only and grain-only systems is striking. The three grazing-only systems (WHGO-SS, WHGO, SS) have CV of .6366, .7335 and .7839 respectively, with a mean CV of .718. In contrast, the three grain-only production alternatives (WH-GS, GS, WH) have respective CV of 2.1022, 2.3625, and 2.5337, and a mean CV of 2.3328. Thus the three grain-only enterprises on average result in 324% more relative risk than the three grazing-only strategies. The most risky alternative (WH) produces almost 400% more risk to NR than the safest alternative (WHGO-SS). The difference in risk may be due to the greater sensitivity of dryland grain production systems to temporally and spatially variable local precipitation. Grain production requires threshold levels of soil moisture at specific stages of production, i.e. boot stage for sorghum and the grain-filling stage for wheat. The failure of dryland systems to meet these moisture thresholds results in drastic reductions in grain yield, or even crop failure. In contrast, forage production responds more positively to both the quantity and timing of any precipitation during the much longer forage growth season. In addition, stocking rates can be adjusted to harvest even marginal quantities of forage production, so that the harvest efficiency associated with grazing may be greater than that of grain-production systems, especially in times of drought or marginal precipitation. These factors may explain in part the lower relative risk associated with grazing system alternatives.

Producers have differing goals concerning NR and risk. In addition, goals and risk tolerance often change each year, or even within a production year due to various factors. Therefore no optimum production system is suggested by this study, since the risk tolerance and NR goals for each producer determine the optimum for that producer. A common strategy in semi-arid dryland production regions is to attempt to minimize the possibility of a negative NR, even at the expense of reduced maximum returns in a good year. Table 9 ranks the production alternatives by probability of negative NR. The production alternatives are ranked identically to the CV ranking, since both rely on the mean and variance of NR for derivation. However, this expression of relative risk offers a producer-friendly format for communicating risk. The least risky alternatives (WHGO-SS, WHGO, SS) have a mean probability of 8.166% of producing a negative NR. In contrast, the most risky alternatives (WH-GS, GS, WH) have a mean probability of 33.333% of producing a negative return, meaning that a producer can expect the grain-only alternatives to result in negative NR in one out of every three years. The combination alternative WHGO-SS has a 5.8% probability of NR, compared to a 34.7% probability for WH.

Conclusions

Agricultural producers in the Texas Panhandle will continue to face declining irrigated acreage and increasing dryland acreage due to declining availability of water from the Ogallala aquifer. Dryland systems are inherently risky in semi-arid regions due to the unpredictable nature of precipitation. Producers benefit from risk management tools and strategies. The dryland crop-livestock production systems evaluated by this study reveal the potential risk reduction attainable by including livestock grazing in production alternatives. Grazing systems provide lower risk to NR compared to grain-only production systems in this study. Portfolio analysis allows evaluation of combination systems. Systems that include grain production, grazing, and both summer and winter production offer potential for optimal tradeoffs between potential NR and relative risk, based on the risk tolerance of individual producers. Additional data is needed to verify dryland system yields and variation so that models for yield risk assessment can be further developed.

Bibliography

Barry, Peter J., Paul N. Ellinger, C.B. Baker and John A. Hopkin. 2000. Financial Management in Agriculture. Chapter 8, "Risk Management" p. 223. Interstate Publishers, Inc. Danville, Ill.

Gerik, Tom and Wyatte Harman, User's Guide for CroPMan (Crop Production and Management Model), Version 4.0, Blackland Research and Extension Center , Texas Agricultural Experiment Station, Temple, Texas, 2006.

Gerik, Tom, Wyatte Harman and Jimmy Williams, Researcher's Guide for WinEPIC, Version 3, BRC Report No. 05-01 (revised), Blackland Research and Extension Center , Texas Agricultural Experiment Station, Temple, Texas, 2006.

Lust, David G. 2008. An Optimization Model for evaluation of Dryland Forage-Livestock Systems Under Declining Irrigation Availability From the Ogallala Aquifer in the Texas Panhandle. Ph.D. Dissertation. West Texas A&M University, Canyon, Texas.

McCuistion, Kimberly C. 2006. Forage Sorghum and Sorghum x Sudangrass Hybrids in Ruminant Diets. Ph.D. Dissertation. West Texas A&M University, Canyon, TX.

National Weather Service. Amarillo Weather Forecast Office, Amarillo, TX. Archived data accessed at: http://www.srh.noaa.gov/ama/climate/yearly_precip.htm, accessed August 5, 2008.

National Research Council. 1996. Nutrient requirements of domestic animals: Nutrient requirements of beef cattle (Update 2000). Nat. Acad. Sci.- Nat. Res. Counc., Washington, D.C.

Texas AgriLife Extension Service, 2008. Extension Agricultural Economics. 2008 Texas Crop and Livestock Budgets. District 1. http://agecoext.tamu.edu/resources/crop-livestock-budgets/by-district/district-1/2008.html, accessed August 12, 2008.

Texas Agricultural Statistics Service, Texas Agricultural Statistics, 1984, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, and 2005.

Table 1. Estimated Costs and Returns Per Acre for Dryland Wheat (WH) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Wheat, grain	bu	6.33	19.0000	120.27
Total Income				120.27
Direct Expenses				
Seed, wheat	bu	12.30	1.0000	12.30
Fertilizer, nitrogen (ANH_3)	lb	0.28	30.0000	8.40
Custom labor				
Fertilizer application	ac	9.00	1.0000	9.00
Pesticide with application	ac	11.00	0.5000	5.50
Custom harvest - grain	ac	12.60	1.0000	12.60
Custom haul - grain	bu	0.14	18.0000	2.52
Fuel, diesel and gasoline	gal	2.78	4.2158	11.72
Repair and maintenance				
Implements	ac	3.80	1.0000	3.80
Tractors	ac	4.46	1.0000	4.46
Pickup	ac	0.16	1.0000	0.16
Interest on operating capital	ac	4.89	1.0000	4.89
Total direct expenses				75.35
Fixed expenses				
Implements	ac	6.74	1.0000	6.74
Tractors	ac	7.22	1.0000	7.22
Pickup	ac	0.28	1.0000	0.28
Total fixed expenses				14.24
Total specified expenses				89.59
Net Return to Land, Labor, and Management				30.68

Table 2. Estimated Costs and Returns Per Acre for Dryland Wheat with Grazing (WHGRZ) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Wheat, grazing	lb	0.43	68.0000	29.24
Wheat, grain	bu	6.33	19.0000	120.27
Total Income				149.51
Direct Expenses				
Seed, wheat	bu	12.30	1.0000	12.30
Nitrogen (ANH3)	lb	0.28	30.0000	8.40
Custom Labor				
Fertilizer Application	ac	9.00	1.0000	9.00
Pesticide with application	ac	11.00	0.5000	5.50
Custom harvest - grain	ac	12.60	1.0000	12.60
Custom haul - grain	bu	0.14	18.0000	2.52
Fuel, diesel and gasoline	gal	2.78	4.2158	11.72
Repair and Maintenance				
Implements	ac	3.80	1.0000	3.80
Tractors	ac	4.46	1.0000	4.46
Pickup	ac	0.16	1.0000	0.16
Interest on Operating Capital	ac	4.89	1.0000	4.89
Total Direct Expenses				75.35
Fixed Expenses				
Implements	ac	6.74	1.0000	6.74
Tractors	ac	7.22	1.0000	7.22
Pickup	ac	0.28	1.0000	0.28
Total Fixed Expenses				14.24
Total Specified Expenses				89.59
Net Return to Land, Labor, and Management				59.92

Table 3. Estimated Costs and Returns Per Acre for Dryland Wheat Grazing (WHGO) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Grazing, winter	lb	0.43	68.0000	29.24
Grazing, March 1 through grazeout	lb	0.43	207.0000	89.01
Total Income				118.25
Direct Expenses				
Seed, wheat	bu	12.30	1.0000	12.30
Fertilizer, nitrogen (ANH_3)	lb	0.28	30.0000	8.40
Custom Labor				
Fertilizer application	ac	9.00	1.0000	9.00
Herbicide with application	ac	11.00	0.5000	5.50
Fuel, diesel and gasoline	gal	2.78	4.3200	12.01
Repair and Maintenance				
Implements	ac	3.80	1.0000	3.80
Tractors	ac	4.46	1.0000	4.46
Pickup	ac	0.16	1.0000	0.16
Interest on Operating Capital	ac	4.89	1.0000	4.89
Total Direct Expenses				60.52
Fixed Expenses				
Implements	ac	6.74	1.0000	6.74
Tractors	ac	7.22	1.0000	7.22
Pickup	ac	0.28	1.0000	0.28
Total Fixed Expenses				14.24
Total Specified Expenses				74.76
Net Return to Land, Labor, and Management				43.49

Table 4. Estimated Costs and Returns Per Acre for Dryland Grain Sorghum (GS) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Sorghum, grain	cwt	6.43	21.0740	135.51
Total Income				135.51
Direct Expenses				
Sorghum seed	lb	1.35	2.2500	3.04
Fertilizer, nitrogen (ANH_3)	lb	0.28	40.0000	11.20
Custom Labor				
Fertilizer Application	ac	9.00	1.0000	9.00
Herbicide with application	ac	16.20	1.0000	16.20
Custom harvest - grain	ac	12.60	1.0000	12.60
Custom haul - grain	cwt	0.25	21.0740	5.27
Fuel, diesel and gasoline	gal	2.76	4.4637	12.32
Repair and maintenance				
Implements	ac	5.81	1.0000	5.81
Tractors	ac	5.02	1.0000	5.02
Pickup	ac	0.16	1.0000	0.16
Interest on Operating Capital	ac	2.90	1.0000	2.90
Total Direct Expenses				83.52
Fixed Expenses				
Implements	ac	9.44	1.0000	9.44
Tractors	ac	8.17	1.0000	8.17
Pickup	ac	0.28	1.0000	0.28
Total Fixed Expenses				17.89
Total Specified Expenses				101.41
Net Return to Land, Labor, and Management				34.10

Table 5. Estimated Costs and Returns Per Acre for Dryland Grain Sorghum with Residue Grazing (GSGRZ) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Sorghum, grain	cwt	6.43	21.0740	135.51
Grazing, sorghum residue	ac	37.50	1.0000	37.50
Total Income				173.01
Direct Expenses				
Seed, grain sorghum	lb	1.35	2.2500	3.04
Fertilizer, nitrogen (ANH_3)	lb	0.28	40.0000	11.20
Custom Labor				
Fertilizer Application	ac	9.00	1.0000	9.00
Herbicide with application	ac	16.20	1.0000	16.20
Custom harvest - grain	ac	12.60	1.0000	12.60
Custom haul - grain	cwt	0.25	21.0740	5.27
Fuel, diesel and gasoline	gal	2.76	4.4637	12.32
Repair and Maintenance				
Implements	ac	5.81	1.0000	5.81
Tractors	ac	5.02	1.0000	5.02
Pickup	ac	0.16	1.0000	0.16
Interest on Operating Capital	ac	2.90	1.0000	2.90
Total Direct Expenses				83.52
Fixed Expenses				
Implements	ac	9.44	1.0000	9.44
Tractors	ac	8.17	1.0000	8.17
Pickup	ac	0.28	1.0000	0.28
Total Fixed Expenses				17.89
Total Specified Expenses				101.41
Net Return to Land, Labor, and Management				71.60

Table 6. Estimated Costs and Returns Per Acre for Dryland Sorghum-Sudangrass Grazing (SS) in the Texas Panhandle (2008)

Item	Unit	Price ($)	Quantity	Amount ($)
Income				
Grazing, sorghum-sudan	lb	0.43	245.0000	105.35
Total Income				105.35
Direct Expenses				
Seed, sorghum-sudan	lb	0.36	15.0000	5.40
Fertilizer, nitrogen (ANH_3)	lb	0.28	50.0000	14.00
Fertilizer, custom application	ac	9.00	1.0000	9.00
Fuel, diesel and gasoline	gal	2.77	3.9666	10.99
Repair and Maintenance				
Implements	ac	3.72	1.0000	3.72
Tractors	ac	4.80	1.0000	4.80
Pickup	ac	0.16	1.0000	0.16
Interest on Operating Capital	ac	1.01	1.0000	1.01
Total Direct Expenses				49.08
Fixed Expenses				
Implements	ac	6.33	1.0000	6.33
Tractors	ac	7.82	1.0000	7.82
Pickup	ac	0.28	1.0000	0.28
Total Fixed Expenses				14.43
Total Specified Expenses				63.51
Net Return to Land, Labor, and Management				41.84

Table 7. System Rank for Net Return to Land, Labor and Management

Rank	System	Mean Net Return ($)	Standard Deviation
1	GSGRZ	71.60	89.56
2	WHGRZ-GSGRZ	65.76	75.01
3	WHGRZ	59.92	84.80
4	WHGO-GSGRZ	57.55	53.96
5	GSGRZ-SS	56.72	59.98
6	GS-GSGRZ	52.85	85.06
7	WHGRZ-WHGO	51.71	57.76
8	WH-GSGRZ	51.14	72.02
9	WHGRZ-SS	50.88	51.65
10	WHGRZ-GS	47.01	71.13
11	WH-WHGRZ	45.30	81.27
12	WHGO	43.49	31.90
13	WHGO-SS	42.67	27.16
14	SS	41.84	32.80
15	WHGO-GS	38.80	49.63
16	GS-SS	37.97	55.51
17	WH-WHGO	37.09	54.24
18	WH-SS	36.26	48.27
19	GS	34.10	80.56
20	WH-GS	32.39	68.09
21	WH	30.68	77.73

WH - wheat grown for grain

WHGRZ - wheat is grazed and then harvested for grain

WHGO - wheat grazeout, no grain harvested

GS - grain sorghum, grain production

GSGRZ - grain sorghum harvest for grain followed by residue grazing

SS - sorghum-sudan for grazing

paired systems are weighted equally

Table 8. System Rank by Increasing Coefficient of Variation for Net Return to Land, Labor and Management

Rank	System	Coefficient of Variation
1	WHGO-SS	0.6366
2	WHGO	0.7335
3	SS	0.7839
4	WHGO-GSGRZ	0.9376
5	WHGRZ-SS	1.0151
6	GSGRZ-SS	1.0575
7	WHGRZ-WHGO	1.1170
8	WHGRZ-GSGRZ	1.1406
9	GSGRZ	1.2509
10	WHGO-GS	1.2792
11	WH-SS	1.3313
12	WH-GSGRZ	1.4083
13	WHGRZ	1.4152
14	GS-SS	1.4620
15	WH-WHGO	1.4625
16	WHGRZ-GS	1.5131
17	GS-GSGRZ	1.6095
18	WH-WHGRZ	1.7939
19	WH-GS	2.1022
20	GS	2.3625
21	WH	2.5337

WH - wheat grown for grain production

WHGRZ - wheat is grazed and then harvested for grain

WHGO - wheat grazeout, no grain harvested

GS - grain sorghum -grain production

GSGRZ - grain sorghum harvest for grain followed by residue grazing

SS - sorghum-sudan for grazing

paired systems are weighted equally

Table 9. System Rank by Increasing Probability of Negative Net Returns to Land, Labor and Management

Rank	System	Probability of Negative NR
1	WHGO-SS	5.81%
2	WHGO	8.64%
3	SS	10.10%
4	WHGO-GSGRZ	14.31%
5	WHGRZ-SS	16.23%
6	GSGRZ-SS	17.22%
7	WHGRZ-WHGO	18.53%
8	WHGRZ-GSGRZ	19.03%
9	GSGRZ	21.20%
10	WHGO-GS	21.72%
11	WH-SS	22.63%
12	WH-GSGRZ	23.88%
13	WHGRZ	23.99%
14	GS-SS	24.70%
15	WH-WHGO	24.71%
16	WHGRZ-GS	25.43%
17	GS-GSGRZ	26.72%
18	WH-WHGRZ	28.86%
19	WH-GS	31.71%
20	GS	33.60%
21	WH	34.65%

WH - wheat grown for grain production

WHGRZ - wheat is grazed and then harvested for grain

WHGO - wheat grazeout, no grain

GS - grain sorghum -grain production

GSGRZ - grain sorghum harvest for grain followed by residue grazing

SS - sorghum-sudan for grazing

paired systems are weighted equally