Volume 20 2007

TEXAS JOURNAL OF AGRICULTURE AND NATURAL RESOURCES

A Publication of the Agriculture Consortium of Texas

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ISSN 0891-5466

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The Texas Journal of Agriculture and Natural Resource 20:1-9 (2007)

FEEDLOT PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDER LAMBS IMPLANTED AND RE-IMPLANTED WITH ZERANOL

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ABSTRACT

One hundred-twenty Rambouillet feeder lambs (Mean BW = 29.5 kg) were used to compare the effects of double and single implanting with Zeranol hormonal implants on lamb performance and carcass characteristics. Lambs were randomly assigned to three treatments: no implant (treatment 1), single implant (treatment 2), and double implant (treatment 3). On d 0, lambs in treatments 2 and 3 were implanted. Lambs in treatment 3 were re-implanted on d 56. Lambs were weighed every 28 d and slaughtered at 120 lb BW. Backfat thickness, leg circumference, hot carcass weight, USDA yield and quality grades were recorded, dressing percentage and calculated yield grade (CYG) were calculated. Treatments 2 and 3 had higher (P < 0.05) ADG than non-implanted lambs on d 28, 56, 84, and overall. Days on feed and feed to gain ratio were lower (P < 0.05) for implanted lambs than non-implanted lambs. Treatment 3 lambs had a lower (P < 0.05) dressing percentage and a lower (P < 0.05) percentage of choice grade carcasses and higher (P < 0.05) percentage of no grades. Treatment 2 and 3 wether lambs had a higher (P < 0.05) value and profit margin than implanted ewes and control lambs.

Key Words: Sheep, Feedlot, Zeranol, Carcass

INTRODUCTION

Texas Rambouillet feeder lambs have been known to produce carcasses of a low lean to fat ratio. This inefficiency puts the Texas Rambouillet sheep feeder at a disadvantage when competing with northern U.S. sheep producers. Low prices and lack of federal support for the fine Rambouillet wool further compounds this disadvantage.

Hormonal implants in the beef industry have been efficiently used for increasing lean deposition instead of fat deposition (Lemieux et al. 1990). Anabolic implants are widely used in the beef industry, but only 1.7% of sheep operations utilize growth promoting implants (USDA 1996). Zeranol is an anabolic agent that has been used in implants for growing-finishing cattle (Sharp and Dyer 1971). Zeranol, an estrogen-like compound, was found in corn mold *Giberella zeae* (Sharp and Dyer 1971).

Zeranol has been known to enhance ADG, feed efficiency, and lean tissue deposition. Both Hutcheson et al. (1992) and Jones et al. (1997) found that Zeranol improves ADG and feed efficiency of lambs. Hufstedler et al. (1996) found Zeranol implants will enhance profit related performance and exhibit the capacity for producing leaner, more acceptable carcasses.

A few negative attributes are associated with Zeranol implants. Estrogen-like compounds, like Zeranol, increase bone ossification, causing the closure of the distal metacarpal cartilage leading to a spool joint. However, Hufstedler et al. (1996) reported spool joint formation is usually observed when Zeranol's effects are prolonged by repeat implantation or extended feeding periods. Rectal prolapses are another concern when Zeranol implants are used. However, Jones et al. (1997) and Stultz (2000) both found no incidence of rectal prolapses in their trials.

In 2000, Stultz looked at feedlot performance and carcass characteristics of feeder lambs implanted with Zeranol implants. Average daily gain (ADG) and gain to feed ratio was higher for implanted lambs. The average rib eye area and carcass weights of the implanted lambs were larger compared to that of the non-implanted lambs.

Studies of Zeranol implantation in lambs have focused on the use of one implant, but little information is available on the effect of re-implanting lambs with Zeranol. The purpose of this study is to determine the effects of implanting and re-implanting Rambouillet feeder lambs with Zeranol implants on feedlot performance and carcass characteristics.

MATERIALS AND METHODS

This study was conducted at the Angelo State University Management, Instruction and Research Center, located in Tom Green County north of San Angelo, Texas. The lambs were slaughtered and carcasses evaluated at Ranchers' Lamb of Texas, Inc. located east of San Angelo.

One hundred-twenty Rambouillet feeder lambs with a mean BW of 29.5 kg were used. Lambs were randomly assigned to one of three treatments: control – no implant (treatment 1), one Zeranol implant (treatment 2), and one Zeranol implant plus re-implant at d 56 (treatment 3). The implant used was Ralgro-Zeranol (Schering-Plough Animal Health Corporation, Union, NJ). Each treatment was blocked by weight and sex and assigned to one of 30 pens measuring 10 ft. by 40 ft., with 4 lambs per pen, and 10 pens per treatment. Each lamb was vaccinated for Enterotoxemia (over-eating disease), dewormed and shorn before the trial. The first implants for treatment 2 and 3 were put in the left ear on d 0, and the second implant for treatment 3 was put into the right ear on d 56.

All lambs were fed a series of four rations (Table 1) *ad libitum*, with incremental increases in concentrate percentages, to a final finishing ration. Each ration was balanced to meet or exceed NRC requirements (NRC 1985). Lambs had *ad libitum* access to clean, fresh water and lambs were observed daily.

Lambs were weighed at the beginning of the trial and every 28 d afterwards during the 112 d trial, to determine their feedlot performance and weight gain for each treatment. Feed was weighed when it was put in the feeder and taken out and re-weighed at the end of each 28 d period to calculate each pen of four lamb's feed efficiency for all treatments.

During the trial, any lamb that reached market-end-weight (54.5 kg, best market weight for lambs slaughtered at Ranchers' Lamb of Texas, Inc.) on a weigh day was slaughtered. After slaughter, lambs were hung in a one-degree centigrade cooler overnight. The next morning, 12 to 14 hr postmortem, the carcasses were evaluated. At this time, carcass weight, backfat thickness, and leg score were measured and recorded. USDA Quality grades and USDA Yield grades were also recorded. Yield grades were calculated using backfat thickness and the standard formula.

STATISTICAL ANALYSIS

The General Linear Model procedure of SAS (1988) was used to determine the effect of Zeranol implants on lamb performance level and carcass characteristics. Pen of four lambs was considered the experimental unit. Means were considered significant at $P < 0.05$ and a Duncan's Multiple Range test was used to separate means.

Table 1. Dietary composition of lamb diets (as fed basis)

Ingredient	Ration #1	Ration #2	Ration #3	Ration #4
Corn, %	39.00	49.00	57.00	66.00
Peanut hull pellets, %	19.50	22.00	18.00	13.00
Cottonseed meal, %	29.00	16.00	8.00	8.00
Alfalfa pellets, %	7.00	7.50	11.50	7.00
Molasses, %	3.00	3.00	3.00	3.00
Sheep Mineral Premix, %	2.50	2.50	2.50	2.50

RESULTS AND DISCUSSION

A problem that has been associated with implanting lambs with Zeranol has been rectal prolapses. Prolapses usually range from 1% to 5% during the feeding period of Zeranol implanted lambs (Thornsberry 1993). During this trial, no rectal prolapses occured, but a total of 10 ewe lambs experienced vaginal prolapses. Five percent of treatment 2 and 20% of treatment 3 prolapsed vaginally (Table 2). Zeranol, an estrogen-like compound, causes uterine muscles to contract. Additionally, lambs deposit fat around the tail when finished in the feedlot on grain. The added fat plus the estrogen-like activity of the implant creates pressure in the vaginal area of the ewe lamb increasing the possibility of a vaginal prolapse.

Table 2. Prolapse and spool joint incidences on non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration.

	Treatment[a]		
	1	2	3
Number of prolapses	0	2	8
Percent prolapses	0	5	20
Number of spool joints	1	5	7
Percent spool joints	2.5	12.5	17.5

[a]Treatment 1 = control, 2 = single, 3 = double implant.

Another problem associated with implanting with Zeranol is the incidence of spool joints at slaughter. During this trial, a total of 13 lambs contained spool joints with treatments 1, 2 and 3 containing 1 (2.5%, $p < 0.05$), 5 (12.5%) and 7 (17.5%), respectively (Table 2). Field et al. (1990) and Hufstedler et al. (1990) also reported spool joints with the use of Zeranol implants. Implanting with Zeranol, an estrogen-like compound, causes increased levels of estrogen, which can cause greater calcium uptake leading to faster bone ossification. An increased number of lambs with spool joints in treatment three might be attributed to an increase in growth plate closure. Hufstedler et al. (1990) found three or five Zeranol implants resulted in 40 or 100% spool joints, respectively, when given at 30-d intervals.

Urinary calculi is another problem that has been recorded in previous implant studies using Zeranol. During this 112-d feeding period, the incidence of urinary calculi was not observed.

Performance data

Average daily gain was higher ($P < 0.05$) for both implanted treatments when compared to the control lambs on d 28, 56, 84, and overall; however, implanted treatments were similar for the whole trial (Table 3). This agrees with Stultz (2000), that zeranol implanted lambs were faster gaining than non-implanted lambs. Sluiter (1998), also found on d 56 implanted lambs were higher in ADG, but no differences on d 28. However, on d 112 no difference between implanted lamb treatments and the control treatment was found for ADG. Results of this project of implanted lambs on feed over 100 d were similar to Stultz (2000), where no differences were observed in ADG on d 105. Days on feed was less for both implanted treatments when compared to the control group ($P < 0.05$), but the two treatment groups were similar.

Lambs that were single and double implanted had an increased feed efficiency ($P < 0.05$) over the non-implanted lambs on d 56 (Table 4). On d 84, treatment 3 was more efficient ($P < 0.05$) than treatments 1 and 2. However, feed efficiency was similar among treatments on d 28 and 112. Treatments 2 and 3 also had an increased overall feed efficiency ($P < 0.05$) over treatment 1. These findings agree with Stultz (2000), Hufstedler et al. (1996), Jones et al. (1997), and Nold et al. (1992) that using Zeranol implants increases feed efficiency.

Table 3. Average daily gain (kg) and days on feed of non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration, 40 lambs/treatment.

	Treatment[a]			
Day	1	2	3	SE[b]
0-28	0.244[c]	0.290[d]	0.268[d]	0.013
28-56	0.255[c]	0.345[d]	0.327[d]	0.011
56-84	0.239[c]	0.275[d]	0.298[d]	0.014
84-112	0.212	0.174	0.184	0.018
Overall[e]	0.241[c]	0.293[d]	0.295[d]	0.008
DOF[f]	106.05[c]	96.05[d]	92.33[d]	2.029

[a]Treatment 1 = control, 2 = single implant, 3 = double implant.
[b]SE = most conservative standard error of the least square mean.
[cd]Means in the same row with different superscripts differ P < 0.05
[e]Mean overall ADG, d 0 thru slaughter date.
[f]Days on feed.

Table 4. Feed efficiency (kg feed/kg gain) of non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration per pen by treatment 40 lambs/treatment.

	Treatment[a]			
Efficiency by period	1	2	3	SE[b]
0-28	5.92	5.33	5.29	0.271
28-56	5.85[c]	4.83[d]	4.96[d]	0.160
56-84	7.00[c]	7.20[c]	5.73[d]	0.430
84-112	7.44	12.07	7.57	2.072
Overall[e]	6.40[c]	5.84[d]	5.52[d]	0.142

[a]Treatment 1 = control, 2 = single implant, 3 = double implant.
[b]SE = most conservative standard error of the least square mean.
[cd]Means in the same row with different superscripts differ P < 0.05.
[e]Mean feed efficiency d 0-112.

Carcass data

Carcasses were evaluated 12 – 14 hours postmortem. There were no differences among treatment groups for hot carcass weight, backfat, leg circumference, yield grade, or calculated yield grade (Table 5). These results are in contrast to Stultz (2000) and Jones et al. (1997) where they found that implanted lambs had heavier carcasses ($P < 0.05$), but in this trial, lambs were slaughtered at a common weight. Therefore, no differences in slaughter weight were expected and only small differences in dressing percent resulting in even less differences in carcass weight. However, treatment 3 had a lower dressing percentage ($P < 0.05$) than treatments 1 and 2, with treatments 1 and 2 being similar. Hufstedler et al. (1996) also found that implanted lambs had lower dressing percentages.

Table 5. Hot carcass weight, backfat, dressing percentage, leg circumference, yield grade, and calculated yield grade of non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration.

	Treatment[a]			
	1	2	3	SE[b]
Hot carcass weight, lbs	59.5	61.7	60.6	0.89
Backfat[c], in	0.261	0.267	0.247	0.009
Dressing percentage[d]	51.1[e]	51.2[e]	50.0[f]	0.30
Leg circumference, in	27.15	27.27	27.38	0.172
Yield Grade[g]	2.28	2.14	2.18	0.092
CYG[h]	3.01	3.06	2.87	0.095

[a]Treatment 1 = control, 2 = single implant, 3 = double implant.
[b]SE = most conservative standard error of the least square mean.
[c]Backfat measurement at the twelfth rib.
[d]Dressing percentage = (hot carcass weight / live weight) x 100.
[ef]Mean in the same row with different superscripts differ P < 0.05.
[g]Yield grade assigned by USDA grader.
[h]Calculated yield grade

No differences among treatment groups were observed for quality grade (Table 6). However, numerical differences were seen in total number of lambs from each treatment for the choice grade and no grade carcasses. Treatment 3 had 7 no grades, treatment 2 had 5 no grades, and treatment 1 had 1 carcass with no grade, representing 20.5, 12.8, and 2.5 percent, respectively for each treatment. No grade carcasses are carcasses that contained a spool joint and may not be graded as lamb carcasses. For treatments 1, 2, and 3, 38, 32, and 26 lamb carcasses graded choice, respectively.

Table 6. Quality grade by treatment of non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration.[a]

	Treatment[b]		
	1	2	3
N[c]	40	39	34
Prime[d]	1 (2.5)	2 (5.1)	1 (2.9)
Choice	38 (95.0)	32 (82.0)	26 (76.5)
Ng[e]	1 (2.5)	5 (12.8)	7 (20.5)

[a]Quality was analyzed using the categorical models of SAS utilizing Chi Square. A treatment by sex interaction was present, therefore, values in this table are only for main effect demonstration purposes.
[b]Treatment 1 = control, 2 = single implant, 3 = double implant.
[c]Representing only those lambs that were graded, taking out lambs that prolapsed before being graded.
[d]Percent of each treatment in ( ).
[e]NG = Carcasses that received no grade due to the presence of a spool joint.

Double implanted ewe lambs had a lower ($P < 0.05$) percentage of choice grade carcasses and a higher ($P < 0.05$) percentage of no grade carcasses than any other treatment (Table 7). Ewe lambs that were single implanted had a higher ($P < 0.05$) percentage of no grade carcasses than the control or single implanted wether lambs.

Economic calculations were based on actual lamb purchase price, feed cost and carcass value at the time of the current experiment. The average cost of the lambs was

$53.98/lamb with an implant cost of $0.50/implant (Table 8). The cost of gain (cost of ration/weight gain) for the lambs were $19.91, 19.78, and 18.08/lamb for treatments 1, 2, and 3, respectively. The carcass value for each treatment was $88.71, 89.03, and 89.94/lamb for treatments 1, 2, and 3, respectively. The carcass value per lamb for each treatment was calculated after prolapse and spool joint discounts were taken out. The average profit ((carcass value – (lamb cost + implant cost + cost of gain)) for treatment 1, 2, and 3 were $14.82, 14.77, and 9.88, respectively. Having more total no grades because of spool joints and prolapse discounts in treatment 2 and 3 caused the overall average profit/lamb to be lower than treatment 1.

Table 7. Quality grade by sex and treatment of non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration.[a]

	Treatment[b]					
	1		2		3	
	Ewe	Wether	Ewe	Wether	Ewe	Wether
N[c]	25	15	27	12	22	12
Prime[d]	1 (4)	0 (0)	1 (3.7)	1 (8.3)	1 (4.5)	0 (0)
Choice	24 (96)[e]	14 (93)[e]	22 (81.5)[e]	10 (83.3)[e]	14 (63.6)[f]	12 (100)[e]
Ng[h]	0 (0)[e]	1 (7)[e]	4 (14.8)[f]	1 (8.3)[e]	7 (31.8)[g]	0 (0)[e]

[a]Quality gade was analyzed using the categorical models of SAS utilizing Chi Square.
[b]Treatment 1 = control, 2 = single implant, 3 = double implant.
[c]Representing only those lambs that were graded, taking out lambs that prolapsed before being graded.
[d]Percent of each treatment in ( ).
[efg]Values in a row without common superscripts are different P < 0.05.
[h]NG = carcasses that received no grade due to the presence of a spool joint.

Table 8. Economic data on non-implanted, implanted, and double implanted Rambouillet feeder lambs fed a feedlot ration.

	Treatment[a]		
	1	2	3
Lamb cost[b]	$53.98	$53.98	$53.98
Implant cost	0.00	0.50	1.00
Cost of Gain[c]	19.91	19.78	18.08
Carcass value[d]	88.71	89.03	82.94
Average profit[e]	14.82	14.77	9.88

[a]Treatment 1 = control, 2 = single implant, 3 = double implant.
[b]Average value of all lambs on the experiment at initiation of project.
[c]Cost of ration/weight gain.
[d](Average sale value of carcass) – (Discounts)
[e]Profit = (carcass value) – (lamb cost + implant cost + cost of gain)

Economic data on no-implanted, implanted and double implanted Rambouillet wethers versus ewe feeder lambs fed a feedlot ration are presented in Table 9. No differences existed in cost of gain across all treatments. However, single and double implanted wether lamb carcasses had a higher (P < 0.05) value and profit margin than implanted ewe and control lambs. Double implanted ewe lambs had a lower ($P < 0.05$) carcass value and profit margin than all other treatments.

Table 9. Economic data on non-implanted, implanted, and double implanted Rambouillet wethers versus ewe feeder lambs fed a feedlot ration.

	Treatment[a]						
	1		2		3		
	Ewe	Wether	Ewe	Wether	Ewe	Wether	SE
Lamb cost[b]	53.98	53.98	53.98	53.98	53.98	53.98	0.00
Implant Cost	0.00	0.00	0.50	0.50	1.00	1.00	0.00
Cost of gain[c]	19.91	19.91	19.78	19.78	18.08	18.08	1.37
CarcassValue[d]	88.01[e]	89.88[e]	85.33[e]	97.66[f]	78.27[g]	93.00[e]	1.93
Profit[h]	14.12[e]	15.99[e]	11.07[e]	23.40[f]	5.21[g]	19.94[e]	1.68

[a]Treatment 1 = control, 2 = single implant, 3 = double implant.
[b]Average value of all lambs on the experiment at initiation of project.
[c]Cost of ration/weight gain.
[d](Average sale value of carcasses) – (discounts)
[efg]Means in the same row with different superscripts differ $P<0.05$.
[h]Profit = (carcass value) – (lamb cost + implant cost + cost of gain).

CONCLUSIONS

The data collected in this trial indicates that implanting Texas Ramboulliet feeder lambs with Zeranol will increase their ADG and feed efficiency. However, re-implanting the lambs did not improve performance to justify double implanting lambs. The ewe lambs that were implanted (once or twice) during the trial resulted in several discounts from spool joints and prolapses, however the wether lambs excelled on the implants. In conclusion, implanting Texas Rambouillet wether feeder lambs causes them to be more efficient, lowering the cost of gain, but implanting ewe lambs is cost prohibitive.

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Use of Expected Weather Information on Dryland Wheat Production in Texas High Plains

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ABSTRACT

Winter wheat (*Triticum aestivum L.*) is a commonly planted dryland crop in the Texas High Plains. The Texas High Plains is classified as a semiarid region with high degrees of variation in the amount of rainfall received in this area. Conditions of high climatic variability coupled with frequent droughts account for the low crop yields obtained in this region. Proper rainfall predictions before any production season provide valuable information to farmers to benefit from good years or reduce losses in bad years. A simulation study was conducted to evaluate the economic effects of management practices under below and above average rainfall scenarios. Stochastic dominance with respect to a function (SDRF) was used to introduce risk and take into account the inherent variability of dryland production systems. Expected net revenues above variable costs were compared across different management practices. Predicted benefits to producers by adjusting crop management practices to anticipated weather was found to be in the range of $18 to $32 million per year. The results indicate that expected seasonal rainfall information has a major effect on the profitability of dryland wheat producers.

KEYWORDS: Dryland Agriculture, Stochastic Dominance, Weather Information

INTRODUCTION

Climate is one of the most important uncontrolled factors affecting agriculture. The United States agriculture experiences vast changes in terms of droughts, storms, extreme heat and cold waves, in almost any given year. Over the past decade there have been increased efforts by researchers across the globe to demonstrate the utility of climate forecasts in climate sensitive areas like agriculture (Ritchie and Alagarswamy 2002, Jones et al. 2000, Riha et al. 1996). El Niño/ Southern Oscillation (ENSO) phenomenon is considered to be the main source of interannual climate variability in many parts of the world (Baethgen 1985). There is substantial literature which provides ample information on ENSO basics and decision theories applied to weather and climate forecasting cases (see Orlove and Tosteson 1999, Katz and Murphy 1997, Glantz 1996). According to the National Oceanic and Atmospheric Administration (NOAA), the 1998-99 La Niña event was responsible for agricultural losses of more than $2 billion in the United States when compared to $1.5 billion in agricultural damage from the 1997-98 El Niño cycle (NOAA 1999). Research at Texas A&M University suggested that 70% of monthly variances in Texas weather might be caused by outside effects, which implies that La Niña has a significant impact on Texas climate trends (TWRI 1996).

Seasonal climate forecasts assist farmers in managing cropping systems, either in short-term tactical decisions or long-term strategic decisions (Carberry et al. 2000). The effective applications of seasonal forecasts on crop productivity and the impact on farm level decision making is well documented in the scientific literature (Chen et al. 2002, Jochec et al. 2001, Mjelde and Penson 2000). International Research Institute for Climate Prediction (IRI) regularly offers updates and discussion on seasonal forecast information for various parts of the world. Forecast assessment by IRI can be accessed through Internet by using the web link http://iri.columbia.edu/climate/ forecast/ net_asmt. With increased awareness and availability of the current technologies to more accurately forecast weather related events, emphasis has been directed to how best utilize climatic information to reduce losses or to enhance profits for various sectors of the economy. The possibility of adjusting management practices in accordance with the expected weather conditions of the next season offers ample opportunities to dryland producers. Hence, the focus of this paper is on how to (i) select the appropriate winter wheat management practices (planting dates, plant population and fertilization practices) that can enhance the profitability/reduce losses under conditions of climate change and (ii) identify the economic benefits of adjusting winter wheat to seasonal rainfall expectations.

METHODS

Model Specifications and Simulating Climatic Variability

As actual field experimentation is time consuming and the choices available to researcher are limited, the best approach is to use a crop simulation model in conjunction with climatic data to simulate crop yields. Simulation models in combination with crop inputs can determine the uncertainty associated with various management practices (Thronton and Wilkens 1998, Lansigan et al. 1997). CroPMan version 3.1 (Crop Production and Management Model), as developed at the Blackland Research and

Extension Center, Temple, Texas was used in the present study to simulate crop yields. CroPMan is a computer framework designed to simulate the production and resource consequences to crop management. Management practices that can be simulated using CroPMan include, but are not limited to, planting date, crop maturity, plant population, crop type and rotation sequence. CroPMan uses actual daily weather data from established weather stations and statistically simulates random weather patterns for future season crop yields.

Cropping practices that might be used to take advantage of seasonal rainfall conditions would include crop choice, planting density, planting date and fertilization rates. The suitable planting and harvesting dates for the High Plains were identified using the Texas commodity calendar published by the Texas A&M University. Effects of planting dates were tested in weekly intervals from September 1 to October 28, and planting densities were tested in 10,000 plants/acre increments from 300,694 plants/ac to 450,694 plants/ac. Impacts of elemental nitrogen and fertilizer blends of 22-08-02, and 18-08-04 on winter wheat profitability were also studied. The fertilizer blends were increased at an interval 25 lbs/ac from 75 to 300 lbs/ac whereas elemental N was increased at 10 lbs interval to 60 lbs/ac. The prices for fertilizer blends were calculated manually based on nutrient grade.

A combined effort was made in simulating the effects of variable climatic conditions on dryland winter wheat production in the Texas High Plains, in which the actual meteorological data was integrated with the CroPMan software. The weather input file (*.dly) in CroPMan utilizes the daily weather values from 1956 to 2003. These data include daily values for precipitation (mm), maximum and minimum temperatures (ºC), solar radiation (MJ/m^2), relative humidity (%), and wind speed (m/s). The Perryton, Spearman, and Hereford weather station databases of the National Weather Service represented the baseline scenario. Actual precipitation data for these weather stations from 1991 to 2003 winter wheat growing season was collected, and the maximum and minimum amounts were identified. CroPMan weather input values were changed proportionately to the observed maximum and minimum rainfall levels to reflect the effects of climate change. The assumption made for this scenario was, the minimum rainfall level represents the driest climate (below normal) and the maximum rainfall represents the wettest climate (above normal). Under these changed weather scenarios, CroPMan simulations were ran for different management practices (planting date, plant population, fertilization, etc.,) to obtain the simulated yield.

Decision Making Under Uncertainty

Understanding risk in dryland farming is important in identifying sources of uncertainty and helps farmers in developing strategies for mitigating risk. The basic linkages between crop production due to climatic variability and its associated output are presented in Figure 1. Because of the changing climatic conditions, the VMP_x curve shifts. (It would shift outward in the case of good rainfall and would shift inwards in the case of drought.) Panel (d) in Figure 1 represents a drought condition scenario. Accordingly, the profit function also shifts and it is represented in panel (c) of Figure 1. This study used stochastic dominance with respect to a function (SDRF) to select the best combination of crop management strategies for producers with different risk preferences. SDRF is an evaluative criterion which orders uncertain action choices for classes of

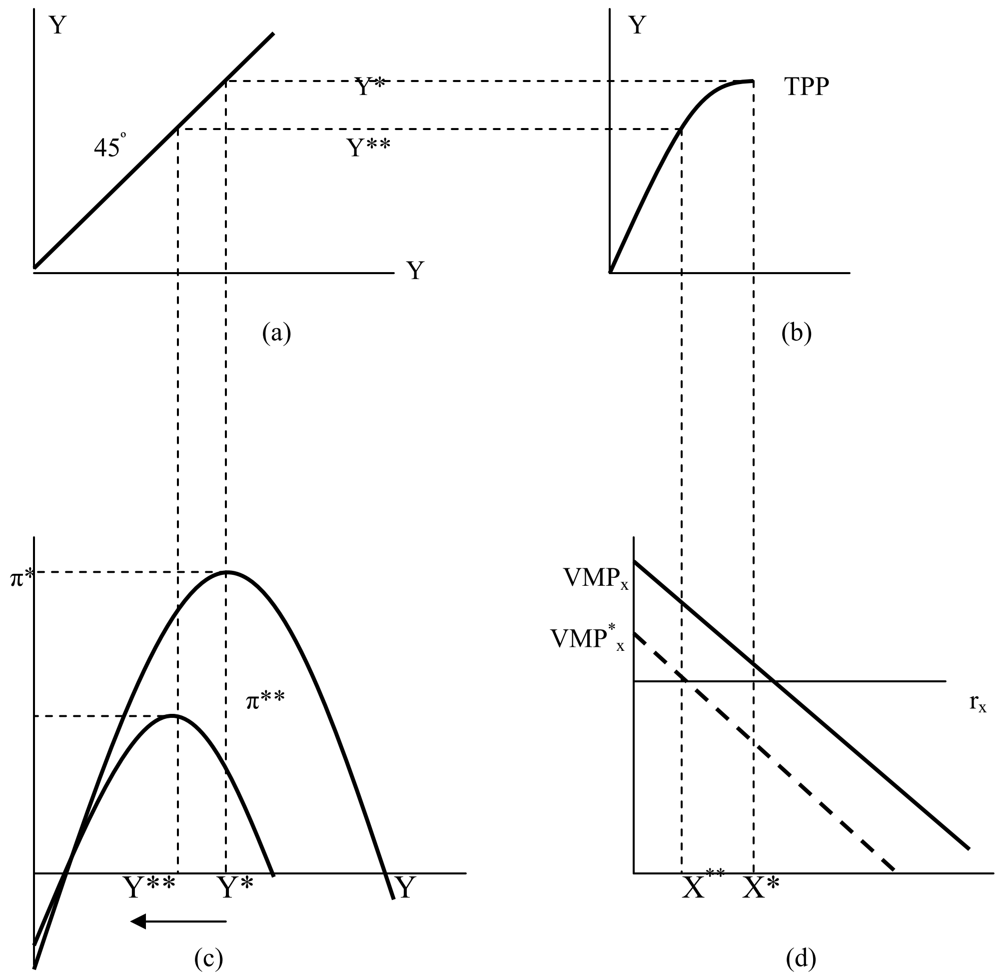

Fig 1. Linkages between production function and output relationship under changing weather conditions

decision makers defined by lower and upper bounds on the absolute risk aversion function (King and Robinson 1981). If a decision maker must decide between two risky alternatives, say M_1 and M_2 with CDF's given by α(φ) and β(φ) respectively, and if the expected utility of β(φ) is greater than the expected utility of α(φ), then M_2 is preferred over M_1 by the decision maker.

Mathematically, the absolute risk aversion coefficient can be defined as:
$r(\varphi) = -\mu''(\varphi) / \mu'(\varphi)$, where μ represents the decision maker's utility function and φ is income or wealth and $\mu''(\varphi)$ and $\mu'(\varphi)$ are the first and second derivatives of a utility function μ (φ). According to Meyer (1977), the solution requires the identification of a utility function μ (φ), which minimizes

$$\int_0^1 \{\alpha(\varphi) - \beta(\varphi)\}\mu'(\varphi)d(\varphi) \text{ subject to the constraint}$$

$$r_L(\varphi) \leq -\mu''(\varphi)/\mu'(\varphi) \leq r_U(\varphi) \text{ for all } \varphi \text{, and } \mu'(\varphi) > 0 \text{ for all } \varphi$$

Where r_L (φ) and r_U (φ) represents the lower and upper bounds of r (φ)

Stochastic dominance with respect to a function analysis was conducted using SIMETAR (Simulation for Applied Risk Management). For practical purposes, three alternative risk intervals for the dryland cropping systems of the Texas High Plains in the range –0.0003 to 0.0006 (risk neutral -0.0003 to 0.001; slightly risk averse 0.00 to 0.0003; strongly risk averse 0.0003 to 0.0006), similar to those used by Segarra et al. (1991) were used in the present study. Average variable costs for dryland winter wheat were based on District 1 and 2 of Texas Cooperative Extension budgets. By multiplying the simulated yields by the appropriate price ($3.00 per bushel), the expected gross revenues were derived. Net returns per acre were obtained by subtracting the variable costs from gross revenues. The simulated data was used to investigate different management strategies in order to derive stochastically efficient management practices.

RESULTS AND DISCUSSION

A total of 130 management practices were simulated under alternative production practices for winter wheat (based on all combinations of 16 planting densities, ten planting dates, four fertilizer rates, three fertilizer types, two rainfall scenarios, and 27 best management practices). It is important to point out that the results presented in this paper are not based on a whole farm approach but rather per acre.

Winter wheat yield levels at Ochiltree County as influenced by planting density ranged from 17.71 bu/ac to 29.86 bu/ac across all weather conditions. This study's findings showed that rainfall changes would be expected to have a strong influence on winter wheat yields at Ochiltree County. Population densities of 450,694 plants/ac (Tables 1 and 2) resulted in higher returns for both below and above normal rainfall conditions. However, comparing the "SDRF ranking" of plant densities to those obtained under "the average net return ranking" approach, it is evident that the rankings were different. Under SDRF approach, planting density of 430,694 plants/ac is the preferred choice for Ochiltree County under below rainfall conditions. Winter wheat producers are not only concerned with the "average" performance of their practices, but also take into consideration of the inherent variability of dryland production systems. For this reason, SDRF ranking was considered superior to average net return ranking approach.

Among the different factors that can be controlled by producer, date of planting is probably the most important for winter wheat (Campbell et al. 1991). Winter wheat is commonly planted over a wide range of dates in the Texas High Plains. The majority of planting occurs in the months of September and October. Summers in this region are usually dry and the timing of rains in early fall and winter play an important role in determining the planting date of wheat. Under conditions of below normal rainfall, the response of winter wheat yields to planting dates ranged from 20.24 bu/ac to 23.79 bu/ac. For Ochiltree County, planting dates had an inconsistent effect on the yields of dryland winter wheat at below normal rainfall conditions. Both early and late plantings were

Table 1. Effects of Plant Population under Below Normal Rainfall Scenario, Ochiltree County

Population (plants/ac)	Yield (bu)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
300,694	17.71	53.21	48.99	4.22	16	16
310,694	18.05	54.24	49.04	5.20	15	15
320,694	18.39	55.26	49.09	6.17	14	14
330,694	18.73	56.28	49.14	7.14	13	13
340,694	19.06	57.27	49.19	8.08	12	11
350,694	19.40	58.29	49.24	9.05	11	10
360,694	19.57	58.80	49.29	9.51	10	12
370,694	19.91	59.82	49.34	10.48	9	8
380,694	20.08	60.34	49.39	10.95	8	9
390,694	20.24	60.82	49.44	11.38	7	7
400,694	20.41	61.33	49.49	11.84	6	6
410,694	20.58	61.84	49.54	12.30	5	5
420,694	20.75	62.35	49.59	12.76	4	4
430,694	20.92	62.86	49.64	13.22	3	1
440,694	21.09	63.37	49.69	13.68	2	2
450,694	21.26	63.88	49.74	14.14	1	3

Table 2. Effects of Plant Population under Above Normal Rainfall Scenario, Ochiltree County

Population (plants/ac)	Yield (bu)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
300,694	25.47	76.53	48.99	27.54	16	14
310,694	25.98	78.06	49.04	29.02	15	15
320,694	26.32	79.09	49.09	30.00	14	16
330,694	26.82	80.59	49.14	31.45	13	13
340,694	27.16	81.61	49.19	32.42	12	12
350,694	27.50	82.63	49.24	33.39	11	10
360,694	27.84	83.65	49.29	34.36	10	11
370,694	28.17	84.65	49.34	35.31	9	9
380,694	28.51	85.67	49.39	36.28	8	7
390,694	28.68	86.18	49.44	36.74	7	8
400,694	28.85	86.69	49.49	37.20	6	6
410,694	29.19	87.71	49.54	38.17	5	4
420,694	29.35	88.19	49.59	38.60	4	5
430,694	29.52	88.70	49.64	39.06	3	3
440,694	29.69	89.21	49.69	39.52	2	2
450,694	29.86	89.72	49.74	39.98	1	1

found to be favorable for higher returns (Table 3). In case of high rainfall conditions, only early plantings had a clear advantage over other planting dates (Table 4).

Wheat responded positively to rainfall with yields in good rainfall situations ranging from 28.51 to 33.40 bu/ac. The present analysis showed that early planting is advisable, if the rainfall forecast for the next season is considered to be above normal. Early planting with enough precipitation helps seeds to germinate and plants to grow properly, resulting in higher economic returns. If sowing is delayed under good rainfall conditions, yields would be reduced significantly, by up to 29% in Ochiltree County. The delayed sowing exposes the wheat plant to water stress in the grain filling period, causing a reduction in yields. The other possible cause for the reduction in yields could be due to delayed sowing which enhances the susceptibility of the wheat to possible attack by rust and other diseases due to water limiting conditions.

Table 3. Planting Date Influences under Below Normal Rainfall Scenario, Ochiltree County

Planting date (dd/mm)	Yield (bu)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
01/09	23.79	71.48	49.49	21.99	1	1
07/09	21.26	63.88	49.49	14.39	3	2
14/09	20.75	62.35	49.49	12.86	5	5
21/09	20.75	62.35	49.49	12.86	5	8
26/09	20.58	61.84	49.49	12.35	6	9
01/10	20.24	60.82	49.49	11.33	7	10
07/10	20.92	62.86	49.49	13.37	4	7
14/10	21.26	63.88	49.49	14.39	3	6
21/10	21.42	64.36	49.49	14.87	2	3
28/10	21.42	64.36	49.49	14.87	2	4

Table 4. Planting Date Influences under Above Normal Rainfall Scenario, Ochiltree County

Planting date (dd/mm)	Yield (bu)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
01/09	33.40	100.36	49.49	50.87	1	1
07/09	29.86	89.72	49.49	40.23	2	2
14/09	29.19	87.71	49.49	38.22	3	3
21/09	29.02	87.20	49.49	37.71	4	5
26/09	29.02	87.20	49.49	37.71	4	4
01/10	28.85	86.69	49.49	37.20	5	6
07/10	28.85	86.69	49.49	37.20	5	7
14/10	28.85	86.69	49.49	37.20	5	8
21/10	28.51	85.67	49.49	36.18	6	10
28/10	28.51	85.67	49.49	36.18	6	9

This study found that fertility effects had a substantial influence on the yields of winter wheat. Twenty pounds of elemental N or 100 lb of 22-08-02 blend or 125 lbs of 18-08-04 fertilizer resulted in higher returns for Ochiltree County under below normal rainfall conditions (Table 5) whereas SDRF results indicated that the dominant practice would be 125 lbs of 18-08-04. Higher fertilizer rates were found to be necessary for higher returns under above normal rainfall conditions. Thus, 40 lbs of elemental N or 200 lbs of 22-08-02 or 250 lbs of 18-08-04 fertilizer would be required for a nutrient stress free plant growth (Table 6).

Best Combination of Management Practices

The top three risk efficient management practices with respect to planting density, planting date and fertilization were combined with other practices and the yield levels were simulated using CroPMan to evaluate the economic benefits of seasonal rainfall information. Winter wheat best management practices for Ochiltree County under below normal rainfall conditions are presented in Table 7. The results indicate that initiating planting on 1st September with a population density of 450,694 plants/ac and using 100 lbs of 22-08-02 fertilizer resulted in highest profits of $26.72 with an estimated yield of 24.12 bu/ac. If planting is further delayed by a week due to unanticipated weather conditions, then the next recommended planting strategy would be planting 7th September with a plant population of 450,694 plants/ac and using 100 lbs of 22-08-02. Under below normal rainfall conditions, results from the best combination of management practices reveal that Ochiltree County's dryland winter wheat producers would increase their profits up to $14.47/ac, as against no modification of management practices.

If above normal rainfall conditions prevail in the coming season at Ochiltree County, it would be advisable for dryland farmers to initiate planting on 1st September with a planting density of 450,694 plants/ac and using 250 lbs of 18-08-04 fertilizer (Table 8). The expected profits from the above combination practices were found to be $48.20/ac. The profits for Ochiltree winter wheat production showed that modifying management practices based on seasonal rainfall expectation would increase the revenues up to $10.63/ac.

Approximately about 1.6 million acres of dryland winter wheat was planted in the Texas High Plains in 2003. The potential value of seasonal climate information for changing winter wheat management practices (planting date, fertilizer amount, and planting density) is found to be from $18 to $32 million per year for Texas High Plains region. Thus, results from winter wheat reveal that tailoring management practices based on seasonal rainfall expectations is a viable option for managing climate risk and increasing mean income for High Plains dryland farmers.

CONCLUSIONS

Any research which directed towards decreasing the variability in returns in dryland production due to climatic uncertainty would benefit the producers. This analysis has quantified the effects of planting dates, planting densities and fertilization amounts on winter wheat yield under below and above normal rainfall scenarios in the Texas High Plains. Simulated results showed potential benefits of $18 to $32 million per year if management decisions were based on expected seasonal rainfall information. As like in any other study, some limiting assumptions were made in order to achieve the objectives of this study. Results presented in this investigation are by no means the definitive answers, but provide useful guidelines for farmers about the value of climate information and the necessity to adjust management practices based on such information.

Table 5. Impacts of Fertilization under Below Normal Rainfall Scenario, Ochiltree County

Fertilizer (lb/ac)	Yield (bu)	N stress (days)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
Elemental N							
20	20.08	1.4	60.34	47.15	13.19	7	7
30	20.58	0	61.84	49.49	12.35	8	8
40	20.58	0	61.84	51.83	10.01	9	9
22-08-02							
75	19.06	4.4	57.27	44.04	13.22	6	6
100	20.41	0.6	61.33	45.39	15.93	1	2
125	20.58	0	61.84	46.74	15.10	3	4
18-08-04							
100	19.57	3	58.80	44.50	14.30	5	5
125	20.41	0.5	61.33	45.62	15.70	2	1
150	20.58	0	61.84	46.75	15.08	4	3

Table 6. Impacts of Fertilization under Above Normal Rainfall Scenario, Ochiltree County

Fertilizer (lb/ac)	Yield (bu)	N stress (days)	Gross returns ($/ac)	Variable cost ($/ac)	Profits ($/ac)	Avg. Net Return ranking	SDRF ranking
Elemental N							
30	25.14	8.2	75.54	49.49	26.05	9	9
40	28.51	1.2	85.67	51.83	33.84	6	7
50	29.02	0	87.20	54.17	33.03	8	8
22-08-02							
175	28.17	1.7	84.65	49.43	35.21	4	5
200	28.85	0.3	86.69	50.78	35.91	2	2
225	29.02	0	87.20	52.12	35.07	5	4
18-08-04							
200	27.50	3.3	82.63	49.00	33.63	7	6
225	28.51	1.0	85.67	50.12	35.54	3	3
250	29.02	0.2	87.20	51.24	35.95	1	1

Table 7. Economic Benefits of Best Management Practices under Below Normal Rainfall Conditions, Ochiltree County

Population (Plants/ac)	Planting Date	Fertilization (lbs/ac)	Yield (bu/ac)	Gross Returns ($/ac)	Variable Cost ($/ac)	Profit ($/ac)
430,694	09/01	125+	23.96	71.88	45.77	26.11
430,694	09/07	125+	21.59	64.77	45.77	19.00
430,694	10/21	125+	21.42	64.26	45.77	18.49
430,694	09/01	150+	23.96	71.88	46.90	24.98
430,694	09/07	150+	21.59	64.77	46.90	17.87
430,694	10/21	150+	21.42	64.26	46.90	17.36
430,694	09/01	100*	23.96	71.88	45.54	26.34
430,694	09/07	100*	21.59	64.77	45.54	19.23
430,694	10/21	100*	21.42	64.26	45.54	18.72
440,694	09/01	125+	23.96	71.88	45.82	26.06
440,694	09/07	125+	21.59	64.77	45.82	18.95
440,694	10/21	125+	21.59	64.77	45.82	18.95
440,694	09/01	150+	23.96	71.88	46.85	25.03
440,694	09/07	150+	21.59	64.77	46.85	17.92
440,694	10/21	150+	21.59	64.77	46.85	17.92
440,694	09/01	100*	23.96	71.88	45.59	26.29
440,694	09/07	100*	21.59	64.77	45.59	19.18
440,694	10/21	100*	21.59	64.77	45.59	19.18
450,694	09/01	125+	24.12	72.36	45.87	26.49
450,694	09/07	125+	21.76	65.28	45.87	19.41
450,694	10/21	125+	21.76	65.28	45.87	19.41
450,694	09/01	150+	24.12	72.36	47.00	25.36
450,694	09/07	150+	21.76	65.28	47.00	18.28
450,694	10/21	150+	21.76	65.28	47.00	18.28
450,694	09/01	100*	24.12	72.36	45.64	26.72
450,694	09/07	100*	21.76	65.28	45.64	19.64
450,694	10/21	100*	21.76	65.28	45.64	19.64

Note: + indicate 18-08-04 fertilizer combination, * represent 22-08-02 fertilizer combination

Table 8. Economic Benefits of Best Management Practices under Above Normal Rainfall Conditions, Ochiltree County

Population (Plants/ac)	Planting Date	Fertilization (lbs/ac)	Yield (bu/ac)	Gross Returns ($/ac)	Variable Cost ($/ac)	Profit ($/ac)
430,694	09/01	225+	31.72	95.16	50.27	44.89
430,694	09/07	225+	29.35	88.05	50.27	37.78
430,694	09/14	225+	28.68	86.04	50.27	35.77
430,694	09/01	250+	33.07	99.21	51.39	47.82
430,694	09/07	250+	30.03	90.09	51.39	38.70
430,694	09/14	250+	29.52	88.56	51.39	37.17
430,694	09/01	200*	32.73	98.19	50.93	47.26
430,694	09/07	200*	30.03	90.09	50.93	39.16
430,694	09/14	200*	29.35	88.05	50.93	37.12
440,694	09/01	225+	31.72	95.16	50.32	44.84
440,694	09/07	225+	29.35	88.05	50.32	37.73
440,694	09/14	225+	28.68	86.04	50.32	35.72
440,694	09/01	250+	33.07	99.21	51.44	47.77
440,694	09/07	250+	30.20	90.60	51.44	39.16
440,694	09/14	250+	29.52	88.56	51.44	37.12
440,694	09/01	200*	32.90	98.70	50.98	47.72
440,694	09/07	200*	30.03	90.09	50.98	39.11
440,694	09/14	200*	29.35	88.05	50.98	37.07
450,694	09/01	225+	31.72	95.16	50.37	44.79
450,694	09/07	225+	29.52	88.56	50.37	38.19
450,694	09/14	225+	28.51	85.53	50.37	35.16
450,694	09/01	250+	33.23	99.69	51.49	48.20
450,694	09/07	250+	30.37	91.11	51.49	39.62
450,694	09/14	250+	29.69	89.07	51.49	37.58
450,694	09/01	200*	32.90	98.70	51.03	47.67
450,694	09/07	200*	30.20	90.60	51.03	39.57
450,694	09/14	200*	29.52	88.56	51.03	37.53

Note: + indicate 18-08-04 fertilizer combination, * represent 22-08-02 fertilizer combination

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Feedlot Performance and Carcass Traits of Texas Rambouillet Feeder Lambs Implanted With Growth Implants

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ABSTRACT

Three hundred cross-bred lambs with an average initial weight of 33.5 kg were used to compare the effects of three different hormone implants versus a control on lamb performance (ADG) and carcass characteristics. Lambs were divided into four groups and assigned implant treatments as follows: no implant (CON), Synovex[1] (SYN), Ralgro[2] (RAL), or Component C[3] (COM). On d 0, lambs were weighed, ear tagged and implanted according to treatment. Lambs were fed by a self-feeder. Weights were recorded on subsequent d 28, 56, 84, 97, and 108 and as end-weights were reached, lambs were slaughtered. Backfat thickness, cross-sectional ribeye area, USDA yield and quality grade measurements were recorded. Analysis showed significantly higher ADG *($P < 0.05$)* in COM and SYN lambs compared to CON d 28 through d 108. On d 56, RAL lambs also exhibited higher *($P < 0.05$)* ADG than CON lambs. Carcass evaluations yielded no conclusive evidence of improved quality of implanted vs. CON carcasses. A majority (95%) of carcasses received "choice" quality grades and yield grades of 3 to 5 thereby implying improved ADG with hormone implant use, with no simultaneous improvements in carcass quality.

Keywords: Sheep, Feedlot, Implants, Carcass

INTRODUCTION

With the loss of the wool support payments in 1995, there have been major strides made and increasing interest in the raising of lambs for profit in Texas. The early weaning of lambs and feeding of high-concentrate diets have led to favorable high market weights of these lambs (Shelton et al. 1969). Unfortunately, however, Texas lamb carcass quality has diminished and is in need of improvement (personal communication, Ken Emerick). On the USDA yield grade scale of 1 to 5, a majority of the Texas Rambouillet slaughter lambs have received a yield grade 3 or higher. Texas lambs continue to fall short of the industry's preferred leaner standard of yield grades 1 or 2. Methods of increasing the lean to fat ratio in these Texas Rambouillet slaughter lambs would prove to be an extremely profitable finding to the producer. Hormonal implants in the beef industry have been efficiently used for increasing lean deposition (Lemieux et al. 1990). Anabolic implants are widely used in the beef industry, but only 1.7% of sheep operations utilize growth promoting implants (USDA, 1996).

A wide variety of hormonal implants have been studied and used as an effective means of accomplishing such a desired shift or partitioning of nutrients away from the energy-expensive deposition of fat and towards the deposition of lean tissue. This metabolic shift consequently causes an increase in the animals' average daily gains due to a higher proportion of heavier lean tissue to lighter fat tissue, and this increase is accompanied by an associated increased feed efficiency, (Lemieux, et al. 1990).

Some side-effects associated with the use of such hormonal implants have been found. An increase in the frequency of rectal prolapses and decrease in the desired marbling trait of the carcasses have been observed. Problems with ear abscesses, or infection at the implantation site have also been noted Hufstedler, et al. (1996).

The purpose of this study was to determine the effect of implanting Texas Rambouillet feeder lambs with three different hormonal implants, in an effort to determine their effects on feedlot performance and carcass characteristics.

METHODS AND MATERIALS

This study was conducted at Denis Ranch feedlot located 25 miles east of San Angelo, TX. Three hundred Texas Rambouillet feeder lambs were randomly assigned to one of four groups to determine the effects of three different hormonal implant treatments, as compared to the control treatment, in affecting animal performance and carcass characteristics. The four implant treatments were: no implant (CON), Synovex[1] (SYN), Ralgro[2] (RAL) and Component C[3] (COM).

All lambs were fed a series of five rations (Table 1) *ad libitum*, for approximately 3 to 4 days each with increases in energy density, to a final finishing ration for the remainder of the trial. The beginning weight of the lambs was 35.5 kg. equalized across treatments. All lambs were fed in the same pen of 3.048 m by 9.14 m. Feed was dispensed by a self-feeder, and feed formulation met or exceeded NRC (1985) nutrient

[1]Synovex C- A product of Syntex, Inc., Palo Alto, CA. Dosage rate: estradiol benzoate, 10 mg and progesterone 100 mg per implant. One implant under skin of left ear. [2]Ralgro-Zeranol – A product of Schering-Plough Animal Health Corporation, Union, NJ. Dosage rate: Zeranol, 12 mg. One implant under skin of left ear.

[3]Componenet E-C – A product of Ivy Laboratories, Overland Park, KS. Dosage rate: One implant containing Estradiol benzoate, 10 mg and Progesterone, 100 mg. One implant under skin of left ear.

requirements for growing and finishing lambs. All lambs had access to clean, fresh water.

Throughout the course of the study, a total of 6 lambs experienced illness or death, and data pertaining to these lambs was excluded from statistical analysis.

Table 1. Dietary composition and nutritive values of diets fed to lambs (as fed basis).

Ingredient, %	Ration #1	Ration #2	Ration #3	Ration #4	Ration #5
Milo	30.0	36.0	48.7	63.2	73.7
Alfalfa	30.0	30.0	30.5	21.0	12.5
Cottonseed hulls	26.0	25.0	15.0	10.0	8.0
Urea	4.0	4.0	4.5	4.5	4.5
Cottonseed meal	7.5	2.5	0.0	0.0	0.0
Molasses	2.5	2.5	1.3	1.3	1.3
Aureomycin	0.05	0.05	0.05	0.05	0.05
Bovatec	0.02	0.02	0.02	0.02	0.02
Nutritional Value					
TDN, %	58.83	59.79	64.46	67.83	70.87
DE, Mcal/KG	2.69	2.73	2.84	2.99	3.12
Crude Protein, %	13.31	11.82	11.95	11.83	11.57

Animals were slaughtered as they reached approximately 56.7 kg as an end-weight. Lamb weights were recorded on d 0, 28, 56, 84, 97, and 108. Any lamb which had reached approximate market end-weight (56.7 kg) was slaughtered according to humane slaughter practices (Consortium, 1988) the following morning. No animals had reached slaughter end-weight by day 28 of the study, but animals were slaughtered on the day following all subsequent weigh dates. All lambs were slaughtered by d 108.

Post-slaughter, lamb carcasses were hung in a 34 degree cooler over-night and evaluated for carcass characteristics approximately 12 to 14 hours postmortem. Rib-eye areas and fat thickness were recorded on each carcass between the 12^{th} and 13^{th} rib. Yield grades were calculated by the equation: Yield Grade = 0.4 + (10 X Adjusted fat thickness, inches; USDA, 1992).

For both the performance test and carcass characteristic evaluations, the animal data were analyzed using repeated measures analysis of variance with day as the repeat measure; lambs (replications) were nested within treatments (Hicks, 1993). Differences among means were assessed by least significant difference when $P < .05$ (Gomez and Gomez, 1984). Data were analyzed with the statistical package JMP (SAS, 1994).

RESULTS AND DISCUSSION

A total of 294 lambs of the original 300 successfully completed the study and were included in the data analysis. The summer temperatures, including the 108 d of this study, were unusually hot. Calhoun et al. (1972) found decreased responses with hormone implant use in lambs in the heat of a Texas summer. They stated that lambs implanted with diethylstilbestrol and RAL gained 44.4 and 33.6 percent less, respectively, in the summer as compared to the winter months. Therefore, the unusually hot weather in west Texas may have been detrimental to the implants' potential effectiveness and in our obtaining more significant measures of difference between the implanted and CON.

Two problems encountered in previous implant studies have been increased incidence of rectal prolapses and abscesses at the ear implantation site. A total of 5 prolapses were observed in this study. COM, SYN, RAL, and CON treatment groups had 0, 2, 2, and 1 lamb(s), respectively, experienced rectal prolapse problems. Throughout the 108 d study, no ear abscesses were observed.

Performance data

In Table 2, average daily gains were significantly higher in the SYN implanted group, as compared to the CON group ($P < .05$), throughout the trial. Average daily gains were higher in the COM implanted group, as compared to the CON group ($P < .05$) on d 28, 56, and 84. There were no differences between the RAL and CON groups throughout the trial.

On d 28, the average daily gains of lambs implanted with SYN and COM were not different from each other, gaining .51 and .53 lb/d respectively, but greater ($P <.05$) than the ADG of RAL (.40 lb/d) and CON (.35 lb/d) lambs. At d 56, COM and SYN implanted lambs were higher ($P < .05$) in ADG than CON. Results of d 84 were similar to those at d 28, with SYN and COM implanted lambs not different from each other, but greater ($P < .05$) than the ADG of RAL and CON lambs. Average daily gain on d 97 showed SYN lambs to be greater ($P < .05$) than both CON and RAL with no difference between SYN and COM implants' effectiveness. Day 108 ADG showed SYN lambs to be greater ($P < 0.05$) than both CON and RAL lambs with no difference between SYN and COM implants' performance.

Table 2. The effect of hormone implant treatments on Texas Rambouillet feeder lambs average daily gain fed high concentrate diets

	Day				
Treatment	28	56	84	97	108
COM	$.53^{a} \pm .02$	$.92^{a} \pm .08$	$.59^{a} \pm .02$	$.55^{a,b} \pm .02$	$.48^{a,b} \pm .02$
SYN	$.51^{a} \pm .02$	$.92^{a} \pm .08$	$.62^{a} \pm .02$	$.60^{a} \pm .02$	$.55^{a} \pm .02$
RAL	$.40^{b} \pm .02$	$.75^{a,b} \pm .08$	$.53^{b} \pm .02$	$.48^{b} \pm .02$	$.44^{b} \pm .02$
CON	$.35^{b} \pm .04$	$.57^{b} \pm .06$	$.48^{b} \pm .02$	$.48^{b} \pm .02$	$.42^{b} \pm .02$

[a,b]Means with different superscripts in the same column differ ($P < 0.05$).

These data agree with Nold et al. (1992) that RAL had no significant effect on average daily gain. However, Hutcheson et al. (1992), found that RAL did increase ADG over non-implanted lambs.

Overall, there were no observed differences in carcass quality between implanted (COM, SYN, and RAL) and CON lambs as compared using ribeye area, subcutaneous backfat thickness, calculated and observed USDA yield grades and quality grades as indices of overall quality measures (Table 3). There were no differences among any of the implanted groups or CON, relative to calculated or observed (USDA) yield grade. Over 95% of the carcasses, across all treatment groups, received a quality grade of "choice", with the remainder grading "prime". No significant differences were observed in backfat thickness or ribeye area measurements among treatment groups.

Table 3. The effect of hormone implants on Rambouillet lamb carcass characteristics.

Item	Treatment			
USDA Grader YG, %	COM	SYN	RAL	CON
1	2.6	0.0	0.0	0.0
2	36.1	19.7	25.0	26.7
3	48.0	69.8	62.5	62.0
4	0.0	2.0	2.8	2.8
Calculated YG, %				
1.0 – 1.5	12.0	10.8	5.5	13.5
1.6 – 2.5	26.7	27.0	28.8	20.2
2.6 – 3.5	37.3	37.9	32.9	36.5
3.6 – 4.5	13.3	13.5	17.8	20.3
≥ 4.6	10.7	10.8	15.0	9.5
Quality grade, %				
Choice	98.6	95.8	96.8	98.6
Prime	1.3	1.4	4.1	0.0
Backfat thickness, mm	7.2	7.3	7.9	7.5
Ribeye area, cm^2	14.5	15.6	15.3	15.3

Therefore, these results indicate that hormonal implants, while having an effect on feedlot performance of Texas Rambouillet feeder lambs, did not have a subsequent effect on carcass characteristics of these same lambs at slaughter. The data agree with Nold et al. (1992) that implanted lambs with RAL did not affect carcass characteristics. However, Hutcheson et al. (1992) did find that RAL implanted lambs had a lower yield grade and lower kidney, pelvic and heart fat.

CONCLUSIONS

These data indicate that implanting with RAL which contains the active ingredient Zeranol did not increase ADG for the whole trial; however, SYN and COM which contain estradiol benzoate and progesterone were successful in increasing feedlot performance of Texas Rambouillet feeder lambs. However, both of these compounds are not approved for lambs to date. In addition, the desired affect of decreasing the yield grade of Texas Rambouillet slaughter lambs was also not obtained by using these implants. Therefore, more research in a more aggressive implant program is warranted incorporating re-implanting during the feedlot phase and perhaps using new compounds as well.

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FOOD HABITS OF THE AMERICAN BADGER (*Taxidea taxus*) IN SOUTHERN TEXAS: AN OBSERVATION

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ABSTRACT

Limited information exists on American badgers (*Taxidea taxus*) within their southern distribution. Our goal was to gather information on diet of badgers in southern Texas. We collected 6 badgers from private ranches and road sides in 2 counties (Dimmitt and Duval). Percent content of food items was calculated for each sample. Prickly pear (*Opuntia* spp.), mesquite (*Prosopis glandulosa*) bean pods, and rodent remains were found in 4 of the 6 samples collected. Although sample size was small we feel this information provides a good foundation for future research done on this cryptic mammal.

KEY WORDS: American badger, *Taxidea taxus*, southern Texas, food habits

INTRODUCTION

American badgers (*Taxidea taxus*) are solitary carnivores that occur throughout the Great Plains of North America from central Mexico to northwestern Canada (Long 1973). The diet of American badgers has been described from northern states of the U.S. including Michigan (Dearborn 1932), Iowa (Errington 1937), South Dakota (Jense 1968), Utah (Lindzey 1982), Minnesota (Lampe 1982), Idaho (Snead & Hendrickson 1942, Messick & Hornocker 1981), and Colorado (Armitage 2004). In general, diets in the northern U.S. consist of small fossorial rodents (*Rodentia*) supplemented with rabbits

We would like to thank the Sul Ross State University-Research Enhancement Program for their support throughout the project and the Texas Parks and Wildlife Department for use of their facilities. We would especially like to thank the entire staff at the Chaparral Wildlife Management Area for their help on the project.

(*Sylvilagus* spp.), reptiles, and invertebrates. However, no studies have reported badger food habits in their southern range specifically southern Texas. Our objectives were to collect basic information on diet of American badgers in southern Texas.

Study Area

The study area fell within Dimmit, and Duval counties located in the western South Texas Plains and the northern portion of the Tamaulipan Biotic Province (Blair 1950) around the Chaparral Wildlife Management Area (CWMA) (28° 20' N, 99° 25' W) (Correl & Johnston 1979; Hatch et al. 1990). Hot summers and mild winters characterize the climate. The average daily maximum summer (July) temperature and average daily minimum winter (January) temperature are 37°C and 5°C respectively. Average annual precipitation (1951-1978) of 55 cm (Stevens & Arriaga 1985) allows for a growing season of 249-365 days. The pattern of precipitation is bimodal with peaks occurring in late spring (May to June) and early fall (September to October). Elevation ranges between 177 and 186 m with the topography nearly level to gently sloping. A two-phase pattern of shrub clusters scattered throughout a grassland/savanna characterizes the vegetation (Whittaker et al. 1979, Archer et al. 1988). Mesquite (*Prosopis glandulosa*) – Granjeno (*Celtis pallida*) association characterizes the plant communities with subdominant woody species including twisted acacia (Acacia shafferi), brasil (Condalia hookeri), and hog-plum (Columbria texana).

MATERIAL AND METHODS

Badger gastrointestinal tracts were obtained through donated badger carcasses snared on private ranches located in Duval County and salvageable road-killed badgers in Dimmit County from March - November 2002. All donated badgers were expired upon retrieval by authorized personnel. Gastrointestinal tracts were removed and placed in bags, marked with location, sex, and date, and frozen to insure the integrity of the sample. Tracts were thawed, opened, and contents were separated into 4 categories: vegetation, invertebrate, mammal, and reptile. We measured dry mass (g) and percent content of each item for individual gastrointestinal tracts.

RESULTS AND DISCUSSION

Six gastrointestinal tracts (4 males and 2 females) were collected. Specimens were obtained during the summer months (May – August) from private ranches (4 snare caught) in Duval County and along FM 133 in Dimmit County (2 salvageable road kill). Vegetative material, bones, and hair were found in 4 tracts while 2 tracts were empty. Of the 4 tracts containing food, 2 contained prickly pear (*Opuntia engelmannii*) fruit remains and a trace of mesquite bean pods while the remaining 2 contained rodent remains, identified by the presence of rodent incisors and hair. A private ranch sample contained 19.4g of prickly pear, while another private ranch sample contained 19.8g of prickly pear and 1.7 of mesquite bean pod. The remaining two samples, one from a private ranch and a road side collection, contained 10.6g and 8.4g of rodent remains respectively (Table 1).

Table 1. Intestinal tract food items found in American badgers collected through snares and salvageable road kill from Duval and Dimmit Counties, Texas 2002.

					Prickly Pear		Mesquite		Rodent	
Badger	County	Collection	Sex	Total Mass (g)	Mass (g)	%	Mass (g)	%	Mass (g)	%
1	Duval	Snare	Male	19.4	19.4	100	0	0	0	0
2	Duval	Snare	Female	0	0	0	0	0	0	0
3	Duval	Snare	Male	8.4	0	0	0	0	8.4	100
4	Duval	Snare	Male	21.5	19.8	92.1	1.7	0.79	0	0
5	Dimmitt	Road kill	Male	0	0	0	0	0	0	0
6	Dimmitt	Road kill	Female	10.6	0	0	0	0	10.6	100

Previous studies on badgers have demonstrated their ability to forage on a variety of food items (Messick and Hornocker 1981). Aside from a few studies adjacent to agricultural lands (Jense 1968), no studies have documented the use of plant materials as a staple in the diet of badgers. In fact, most studies consider badgers strict carnivores (e.g., Lindzey 1982, Warner and Ver Steeg 1995) and consider vegetative material ingested by badgers as incidental.

A variety of food items are available to badgers in southern Texas. Ground squirrels *(Spermophilus* spp*.)*, pocket mice (*Perognathus* spp. and *Chaetodipus* spp), Ord's kangaroo rat (*Dipodomys ordii*), Southern Plains wood rat (*Neotoma micropus*), hispid cotton rat (*Sigmodon hispidus*), other rodents , and rabbits (*Lepus califonicus* and *Sylvilagus floridana*) are abundant throughout much of South Texas (Davis and Schmidly 1994) and were observed on the study area. Additionally, a variety of reptiles also occur regionally including the Texas horned lizard (*Phrynosoma cornutum*), Western diamondback (*Crotalus atrox*), and Texas indigo snake (*Drymarchon corais*) (Kazmier and Ruthven 1999). A larger sample number of gastrointestinal tracts possibly would have resulted in a wider variety of food items. South Texas was in a minor drought for 8 months (December 2001 to July 2002) prior to specimen collection, which could have resulted in a decline in rodent populations. Both honey mesquite and prickly pear are drought resistant and thrive in dry climates and may have been the most available foods for badgers. In fact, Andelt et al. (1987) noted coyotes (*Canis latrans*) changed their diet to fruit consumption such as Texas persimmon (*Diospyros texana*) and agarito berry (*Mahonia trifoliata*) in response to changing seasons, and relative in availability and vulnerability of prey. Additionally, prickly pear fruits and mesquite bean pods are high in crude protein during spring and summer months (Taylor et al. 1997) and provide some nutritional benefits.

This study suggests that badgers in these particular areas may be opportunistic foragers, and are omnivorous, foraging on small mammals, cacti fruit, and legume mast. However, sample sizes in this study were small and further investigation into seasonal diet and relationships between diet and food resource abundance are needed to fully assess badger diets on a regional scale throughout South Texas. Also, further investigation could show that badgers in southern Texas are more omnivorous than northern populations with possible explanations being a decline in small mammal abundance or an abundance of suitable and palatable vegetation such as prickly pear tunas and mesquite mast.

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Tolerance of Three Wheatgrass Cultivars to Sulfosulfuron Herbicide

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ABSTRACT

Crested, tall, and pubescent wheatgrasses are cool-season, drought-resistant perennial forages that grow well in semiarid environments and could complement wheat pasture grazing systems of the Texas Rolling Plains. However, wheatgrass stand establishment is difficult due to competing winter grasses. This study evaluated wheatgrass cultivars for tolerance to a sulfonylurea herbicide that may control competing annual grass weeds in wheatgrass stand establishment. Utilizing greenhouse facilities, three rates of sulfosulfuron were applied preemergence, 2 weeks after emergence (2 WAE) at the 2-leaf stage, or 4 WAE at the 3- to 4-leaf stage to individual plants of 'CD II' (crested), 'Jose' (tall), and 'Manska' (pubescent) wheatgrasses. Sensitivity to sulfosulfuron was least for CD II and greatest for Manska. Considering all treatments and timings, Manska and Jose had greater declines in above-ground and below-ground biomass and fewer surviving seedlings than CD II. Wheatgrass cultivars were most sensitive to sulfosulfuron when treated 2 WAE. Plant survival increased when sulfosulfuron application was delayed to 4 WAE, except for Manska where nearly 100% of the plants died regardless of herbicide rate. A rigorous selection program with CD II could possibly lead to the development of a non-genetically engineered, sulfosulfuron-tolerant crested wheatgrass.

KEY WORDS: Cool-Season grasses, Texas Rolling Plains, Winter forages

INTRODUCTION

Wheatgrasses like CD II [crested, *Agropyron cristatum* (L.) Gaertn. x *A. desertorum* (Fisch. ex Link) J. A. Schultes]), Jose [tall, *Thinopyrum ponticum* (Podp.) Barkworth & D. R. Devey], and Manska [pubescent, *T. intermedium* ssp. *barbulatum* (Shur) Barkworth & D. R. Devey] are cool-season, drought-resistant perennial grasses that provide excellent, high-quality forage for cattle and grow well in the semiarid environments of the southern Great Plains in addition to prairies of the western United States and Canada (Asay, 1995). Crested wheatgrass is seeded on approximately 12 million acres (Rogler and Lorenz, 1983). Wheatgrasses complement wheat pastures and bridge the gap in forage availability between initiation of grazing on native rangeland and improved warm-season grass pastures (Redmon and Bidwell, 1997; Reuter et al., 1999).

Crested, tall, and pubescent wheatgrasses are cross-pollinating polyploids (Asay, 1995). CD II is a 10-clone synthetic cultivar (Asay et al., 1997), while Manska is a 116-clone synthetic cultivar (Berdahl et al., 1993). Synthetic cultivars are defined as an advanced generation of a seed mixture of strains, clones, inbreds, or hybrids among them, propagated for a limited number of generations by open-pollination (Poehlman and Sleper, 1995). Therefore, synthetic cultivars can express more variation than standard cultivars to applied stresses because of more heterogeneity within the gene pool. Jose was developed as a non-synthetic cultivar (Anon., 1966).

Wheatgrass is usually planted from mid-September to October to take advantage of fall rains and cooler air temperatures during this period in the southern Great Plains. Establishing a uniform stand of wheatgrass can be difficult due to competition from annual winter grass weeds. Broadleaf weeds can be controlled in established cool-season grasses with 2,4-D (2,4-dichlorophenoxyacetic acid) or picloram (4-amino-3,5,6-trichloropicolinic acid) (Regehr et al., 2001). Control of some winter annual grasses also can be achieved. Whitson et al. (1997) reported at least 95% control of downy brome (*Bromus tectorum* L.) when applying either 1.0 lb ai ac^{-1} oxyfluorfen [2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluro-methylbenzene)] plus 0.25 lb ai ac^{-1} metribuzin (4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4H)-one) or 0.35 lb ai ac^{-1} metribuzin in the fall to established western (*Pascopyrum smithii* Rydb.), slender [*Elymus trachycaulus* (Link) Gould ex Shinners], or thickspike (*Elymus lanceolatus* Scribn. and Smith) wheatgrasses. Atrazine (6-chloro-N^2-ethyl-N^4-isopropyl-1,3,5-triazine-2,4-diamine) and diuron [N'-(3,4-dichlorophenyl)-N,N-dimethylurea] also exhibited high levels of downy brome control in established stands of crested wheatgrass (Wicks et al., 1965).

Fewer options are available for controlling annual grass weeds in seedling wheatgrass. Weed competition can be decreased by using an integrated weed management approach of a preplant burndown application of paraquat (1,1'-dimethyl-4,4' bipyridinium dichloride) or glyphosate [isopropylamine salt of N-(phosphono-methyl glycine)] prior to seeding wheatgrass in a stale seedbed. However, subsequent weed populations from later emerging weeds can occur while the wheatgrass is establishing, resulting in stand reductions. Peters et al. (1989) reported at least 90% control of a number of summer annual grasses with fenoxaprop {(+)-ethyl 2-[4-[(6-chloro-2-benzoxazolyl)oxy]phenoxy] propanoate)} at 0.2 lb ai ac^{-1} in seedling intermediate wheatgrass. However, control of winter annual grass weeds is more difficult because of similar emergence and development with fall-seeded wheatgrass. Winter annual grass weeds have been documented to be vigorous competitors for water and nutrients with wheatgrass and other cool-season perennial grasses during seedling establishment, thus decreasing the number of surviving plants (Skipper et al., 1996). In the southern Great Plains, winter annual grass competition is primarily comprised of the *Bromus* weed species complex [downy brome, cheat (*Bromus tectorum* L.), Japanese brome (*Bromus japonicus* Thunb.), and rescuegrass [*Bromus unioloides* (Willd.) Kunth] along with wild oat (*Avena fatua* L.) and jointed goatgrass (*Aegilops cylindrica* Host.). Malik (1991) reported >95% control of wild oat with 0.16 lb ai ac^{-1} of fenoxaprop with minimal injury to seedling crested wheatgrass. Generally, tolerance studies that evaluate seedling wheatgrass response to herbicide application rate and timing are limited. Additional control methods or weed control systems that offer a means to reduce winter annual weed competition during seedling wheatgrass establishment should be evaluated.

Sulfosulfuron is a sulfonylurea herbicide that controls winter annual grass weeds such as downy brome and cheat (Olson et al., 2000a) and Japanese brome (Geier and Stahlman, 1996). Moderate control of rescuegrass has been observed (Baughman, 1998) and suppression of wild oat with sulfosulfuron has been reported (Olson et al., 2000b). Sulfosulfuron also controls or suppresses certain members of the mustard family: field pennycress (*Thlaspi arvense* L.), flixweed [*Descurainia sophia* (L.) Webb ex Prand], and shepherd's purse [*Capsella bursa-pastoris* (L.) Medic.] (Anon., 2000). Sulfosulfuron is currently used in winter and spring wheat (*Triticum aestivum* L.) production with excellent crop safety. However, research to evaluate wheatgrass response to sulfosulfuron is lacking.

The objective of this research was to evaluate three wheatgrass cultivars, CD II, Jose, and Manska, for tolerance to sulfosulfuron at three herbicide rates and three application timings.

MATERIALS AND METHODS

Two greenhouse studies (Trials 1 and 2) were conducted at the Texas Agricultural Research and Extension Center, Vernon, TX, and each Trial was repeated (A and B). Trial 1 was a preliminary assessment of potential herbicide sensitivity among cultivars, followed by Trial 2 with a higher number of plants to verify results from Trial 1. Sulfosulfuron application rates of 0.01, 0.02, and 0.04 lb ai ac^{-1} were used to evaluate the chemical's effect on three wheatgrass cultivars: CD II, Jose, and Manska. The labeled use rate for wheat is 0.03 lb ai ac^{-1}. Treatments were applied at preemergence (PRE), 2 weeks after emergence (2 WAE) at the 2-leaf stage, or 4 WAE at the 3- to 4-leaf stage using a four-nozzle CO_2 backpack sprayer equipped with XR110015 tips and calibrated to deliver 15 gal ac^{-1} at 40 psi. Plants were placed in the greenhouse (85/60 $\pm$ 5°F day/night), watered daily, and fertilized with 2 x 10^{-4} lb of 15-30-15 (N-P_2O_5-K_2O) per pot. Following harvest, plant material was dried at 150°F for 48 hrs before determining plant dry weights. Each treatment in each trial had its own set of controls. The percentage reduction in dry weight following a sulfosulfuron application was determined for each trial by comparing that treatment with the untreated control of that cultivar at each application time.

Run A of Trial 1 was initiated on 21 February 2001 and Run B about 4 wk later. Plastic 6-in-diam. pots were filled with 3.1 lb of Miles fine sandy loam (fine-loamy, mixed, thermic family of Udic Paleustalf, 7.1 pH and 0.1% organic matter), seeded, and placed in a greenhouse. Pots were thinned to two plants after emergence. Treatments were replicated six times with two plants per replication or a total of 12 plants per treatment per Run. Four weeks following the 4-WAE treatment, above-ground viable biomass was determined.

Run A of Trial 2 was initiated on 18 February 2002, and Run B about 6 wk later using seed from the same seed lot used in Trial 1. Seed were kept in cold storage and germination and viability remained good between Trial 1 and Trial 2. The three cultivars were planted in 1.5-in-diameter cone pots filled with 0.45 lb of the soil type used in Trial

1 and thinned to two seedlings per cone following emergence (seven cones per treatment). Eight weeks following each herbicide application, above-ground viable biomass was harvested (Harvest 1), leaving about 0.4 in of plant height for regrowth. Four weeks after the initial harvest, all above-ground viable biomass was collected (Harvest 2). The number of live plants following the second harvest was recorded. Following Harvest 2, soil was rinsed from plant roots and root biomass determined. The treatments were replicated four times in each Run for a total of 56 plants per treatment per run.

The experiment was arranged as a randomized complete block with factorial arrangement of cultivar by application time by application rate. Data were analyzed using Proc Mixed in SAS (SAS Inst. 1996). Runs A and B within each Trial were considered random variables.

RESULTS

The preliminary data of Trial 1 indicated there was cultivar sensitivity to sulfosulfuron herbicide (Table 1).

Table 1. Analysis of variance of plant counts and harvest weights using SAS PROC MIXED.

	-Trial 1-	------------------------Trial 2----------------------			
	Harvest Wt.	Harvest 1 Wt.	Harvest 2 Wt.	Harvest 2 Plant #	Harvest 3 Root Wt.
Cultivar (C)	***	***	***	***	***
Time (Tm)	*	***	ns†	***	**
Tm x C	*	ns	ns	ns	ns
Treatment (Trt)	***	***	***	***	***
C x Trt	***	***	***	***	ns
Tm x Trt	ns	**	ns	ns	ns
Tm x C x Trt	ns	ns	ns	ns	ns

* Significant at $P < 0.05$, ** Significant at $P < 0.01$, *** Significant at $P < 0.001$,
† Not significant at $P < 0.05$

At first harvest, above-ground biomass averaged over treatment times was significantly higher for CD II than either Jose or Manska (Fig. 1) and when averaged over treatment rates at 2 and 4 WAE (Fig. 2).

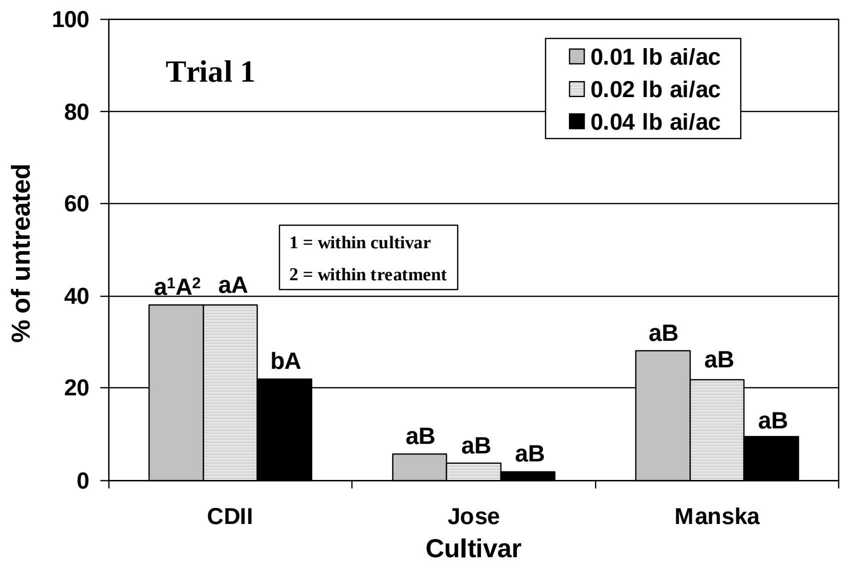

Figure 1. Above-ground biomass from first harvest averaged over treatment times.

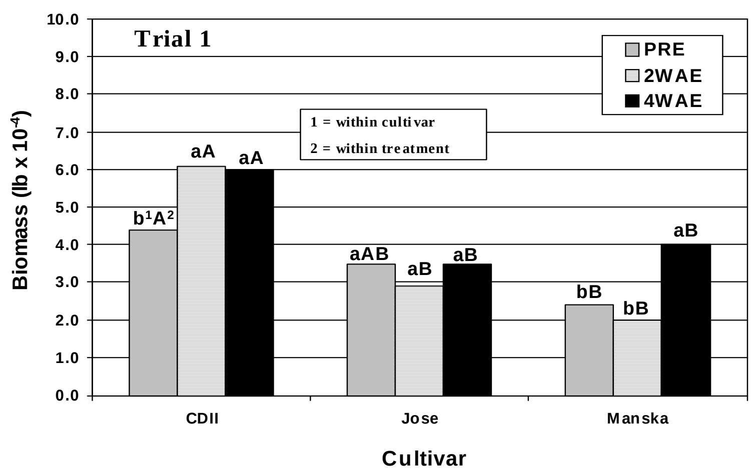

Figure 2. Above-ground biomass from first harvest averaged over treatment rates.

CD II generally showed greater tolerance to the herbicide than either Jose or Manska. Based on the results from this preliminary study, Trial 2 was initiated with a greater number of seedlings and further refined as to harvest timing.

In Trial 2, cultivar, time of treatment (except Harvest 2), and herbicide treatment were significant for above-ground biomass, number of surviving seedlings, and final root weights (Table 1). There were no interactions for root weight. Figure 3 shows the effects of increasing rates of sulfosulfuron, averaged across treatment times, on above-ground biomass for each wheatgrass cultivar at the first harvest date.

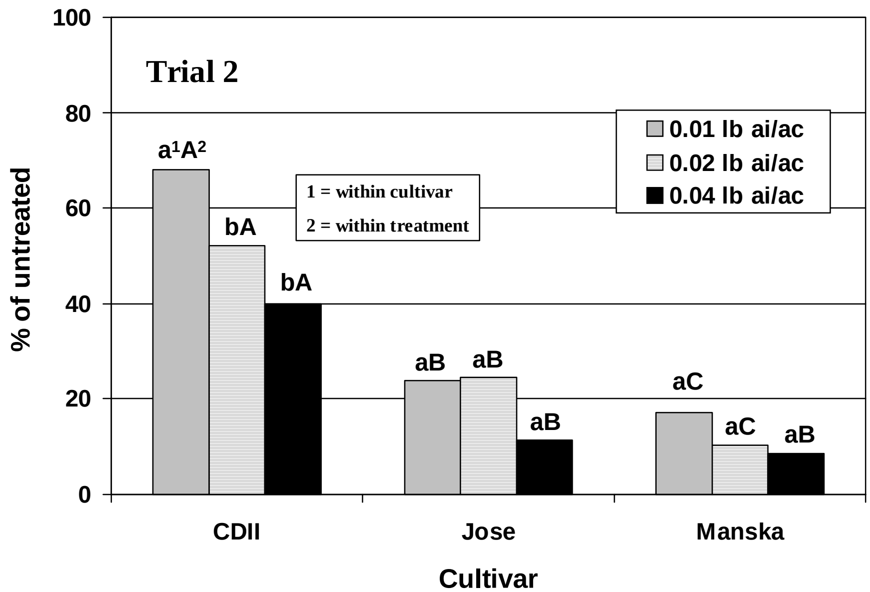

Figure 3. Above-ground biomass from first harvest averaged over treatment times.

It was quite evident that CD II was the most tolerant of the wheatgrasses at all herbicide rates and Manska was the most susceptible. Figure 4 shows the effect of treatment times and herbicide rate (averaged across wheatgrass cultivars) on loss of above-ground biomass at the first harvest date.

For post emergent applications, wheatgrasses were more susceptible when treated 2 WAE compared with 4 WAE. Across all treatments, the above-ground biomass from the second harvest was reduced more for Jose and Manska than CD II when compared with above-ground biomass from the first harvest (Figs. 3 and 5).

For post emergent applications, wheatgrasses were more susceptible when treated 2 WAE compared with 4 WAE. Across all treatments, the above-ground biomass from the second harvest was reduced more for Jose and Manska than CD II when compared with above-ground biomass from the first harvest (Figs. 3 and 5).

Manska was quite susceptible to all herbicide rates, with the higher rates resulting in nearly 100% loss of seedlings. CD II had the greatest number of surviving plants across all herbicide rates and timings.

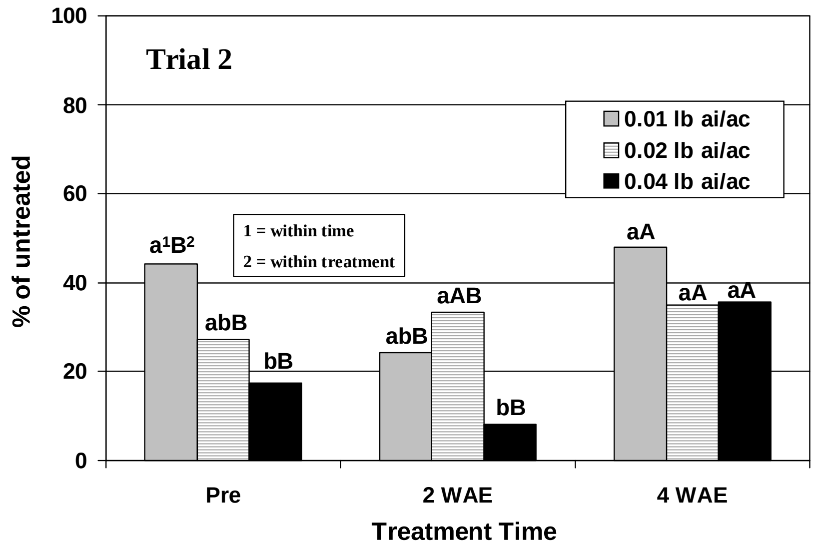

Figure 4. Above-ground biomass from first harvest averaged over cultivars.

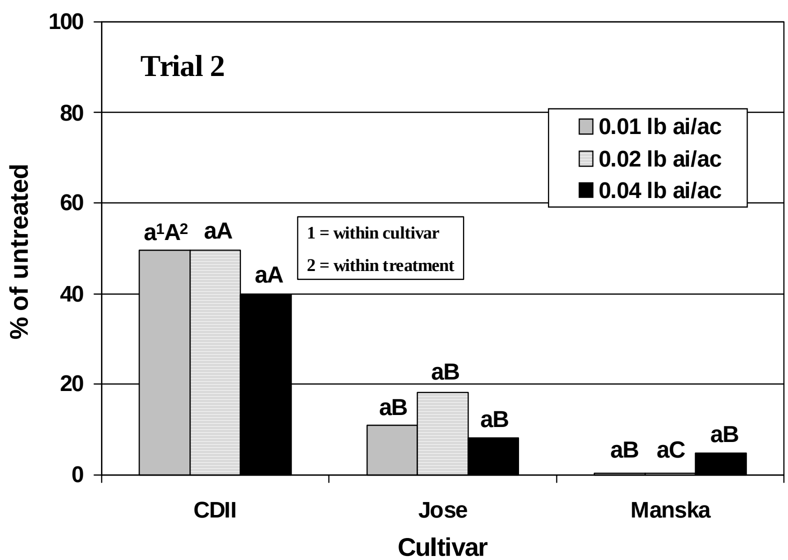

Figure 5. Above-ground biomass from second harvest averaged over treatment times

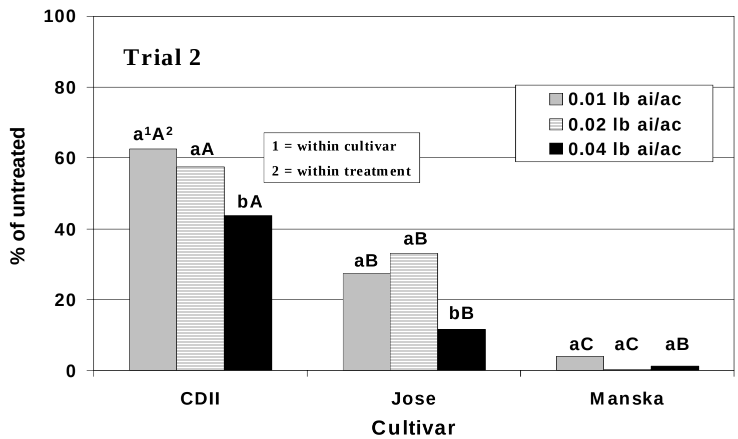

Figure 6. Number of live plants following second harvest averaged over treatment times.

Root mass showed a linear decrease with increasing herbicide rate and reflects the weakened condition of plants due to earlier leaf removal and the full effect of the herbicide treatment (Fig 7). Across all treatments and rates, CD II had the highest root mass, followed by Jose and Manska (data not shown).

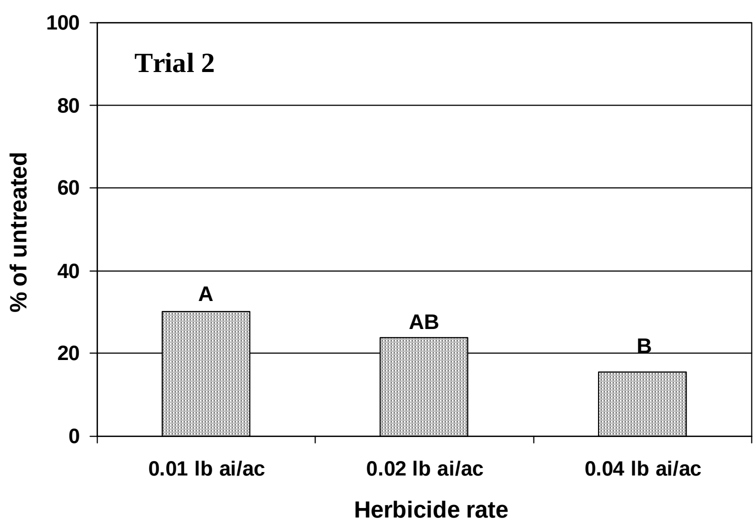

Figure 7. Root mass following second harvest averaged over treatment times and cultivars.

DISCUSSION

Differences in response to sulfosulfuron treatments for CD II compared with the other wheatgrasses may be partially explained by heterogeneity existing among plants due to its development from crossing two different wheatgrass species (Asay et al., 1997). *Agropyron cristatum*, a chemically induced tetraploid, was crossed with the naturally occurring tetraploid, *A. desertorum*, to form the hybrid, "Hycrest". A breeding program was initiated in 1985 to improve the Hycrest breeding population. Ten phenotypically similar clones were chosen out of the final breeding cycle and bulked to form CD-II breeder seed (Asay, et al., 1997). Apparently, one of the original parent species or a combination of the genetic material from the two crossed species in the 10 selected clonal lines provided some tolerance to sulfosulfuron.

Sulfosulfuron resistant downy brome has already been selected. Primisulfuron was applied to a downy brome population over a number of years, and resistance to primisulfuron developed. The primisulfuron-resistant downy brome was then screened for its response to sulfosulfuron, and cross-resistance to sulfosulfuron was identified (Mallory-Smith et al., 1999). Over a number of generations, selection pressure from repeated primisulfuron applications resulted in sulfosulfuron-resistant downy brome. Using similar procedures, it may be possible to select a CD II crested wheatgrass that is highly tolerant to sulfosulfuron.

Manska and Jose trace back to single plant introductions and may therefore constitute a small subset of the genetic variability within a population (Berdahl et. al, 1993; Anon., 1966). The narrow genetic base could contribute to Manska's and Jose's sensitivity to sulfosulfuron.

Greenhouse studies need to be followed by field evaluations, treating larger plant populations of CD II with sulfosulfuron, and selecting tolerant but fertile plants. Our data indicated that seedlings were generally most sensitive to herbicide treatment 2 WAE. This knowledge can be used to provide maximum selection pressure on seedlings in a large population of CD II. Over a number of generations it may be possible to develop a non-genetically engineered crested wheatgrass cultivar with high tolerance to sulfosulfuron. A highly tolerant sulfosulfuron crested wheatgrass would have significant implications in eliminating competing winter annual grass and broadleaf weeds during wheatgrass stand establishment. Furthermore, the possibility of developing tolerant, competing brome grass species is less likely with the establishment of a perennial forage like CD II than with an annual forage crop that would over time potentially receive multiple applications of the same herbicide.

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Profitability Analysis of a Beef Production on WW-B. Dahl (*Bothriochloa bladhii)* Pasture under Different Combinations of Irrigation and Supplement Feeding

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ABSTRACT

A benefit-cost analysis was performed on a stocker cattle operation on WW-B. Dahl [*Bothriochloa bladhii* (Retz) S.T. Blake] pastures under six combinations of irrigation and supplement. Beef production cost and net revenue in LI-S (low irrigation-supplement feeding), LI-NS (low irrigation-no supplement), HI-S (high irrigation-supplement feeding), HI-NS (high irrigation-no supplement), NI-S (no irrigation-supplement feeding), and NI-NS (no irrigation-no supplement) production scenarios were estimated. In the summers of 2003 and 2004 the cost of production considered in this research included expenditures on electricity, fertilizer, irrigation equipment maintenance, labor, feed, interest on steer investment, veterinary supplies, and minerals. Steer buying and selling prices used to estimate revenues were the average U.S. weekly steer prices reported for the Texas Panhandle region. Beef production cost was lower in the NI-NS scenario in both years and net revenue over operating cost was higher in the NI-NS scenario in 2003 ($124/acre) and the NI-S scenario in 2004 ($90/acre). These data suggest that incorporation of WW-B. Dahl into the forage/beef production systems of the Texas High Plains may provide a feasible economic option under non-irrigated conditions.

KEYWORDS: Old World bluestem, B*othriochloa bladhii*, irrigation, whole cottonseed, cattle, cost, revenue.

INTRODUCTION

Agriculture in the Texas High Plains depends on underground water from the Ogallala aquifer. Depletion of the aquifer is shifting land use from irrigated cropping systems to non-irrigated systems. This change affects agricultural producers and the regional economy (Johnson et al., 2004). Past research has focused on agricultural practices that will extend the economic life of the aquifer and protect the regional economy. Proposed solutions have included planting crops that use less water (Terrell and Johnson, 1999; Johnson et al., 2004) to implementing new forage/beef production systems (Philipp, 2004; Allen et al., 2005).

Ethridge et al. (1987; 1990) and Almas (1999) used linear programming models to analyze stocker enterprises in Old World bluestem and other pastures in the Texas High Plains. Computer software has been developed to economically evaluate stocker livestock enterprises in improved pastures (Williams et al., 1988; Kreuter et al., 1996). Economic analysis of net return per head and per area in Old World bluestem pasture under different stocking rates was performed by Phillips and Coleman (1995). Brorsen et al. (1983) developed a simulation model to estimate growth pattern and economic outcomes in stocker operations. Bransby (1989) analyzed profitability of bermudagrass pasture subjected to variable stocking rates with stockers. However, no studies have evaluated the profitability of producing beef specifically in WW-B. Dahl pastures under diverse irrigation conditions in the Texas High Plains. The objective of this study was to perform an economic analysis of a stocker operation in a WW-B. Dahl pasture.

MATERIAL AND METHODS

This analysis was conducted during two consecutive summers, 2003 and 2004, in Old World bluestem WW-B. Dahl [*Bothriochloa bladhii* (Retz) S.T. Blake] pastures located at the Craig Farm in Lubbock County, Texas. The study area has an elevation of 3,260 feet above sea level. Soils are mainly Estacado clay loam, Lofton clay loam, Portales loam, Randall clay, and Zita loam, with slopes from 0 to 1% (USDA, 1979). Climate is semiarid with mild winters and average annual temperatures of 57 °F. The minimum and maximum temperatures are 25 °F in January and 92 °F in July. Most precipitation occurs from April to October with an annual mean of 17 inches. Growing season is 208 days (National Weather Service, 2005). A 134 acre WW-B. Dahl pasture which was seeded in June of 1999 was used in these experiments. Prior to the experiment, pasture was fertilized each spring with ammonia sulfate at a rate of 120 lb/acre.

Six beef production scenarios were developed for alternative combinations of irrigation and feed supplement levels. These six combinations were as follow: High irrigation-Supplement (HI-S), High irrigation-No supplement (HI-NS), Low irrigation-Supplement (LI-S), Low irrigation-No supplement (LI-NS), No irrigation-Supplement (NI-S), and No irrigation-No supplement (NI-NS). Size of the beef production scenarios ranged from 20 to 23 acres. The amount of irrigation water applied to each treatment was HI at 1.0 inch every 10 days, LI at 1.0 inch every 20 days, and NI with zero water application. The feed supplement treatments consisted of 1.0 lb/head/day of whole cottonseed fed three times each week. Experimental animals used for the grazing trial during this study were 142 steers, with an average initial weight of 398 lbs (SD ± 67.5 lbs) in 2003 and 108 steers, with an average initial weight 473 lbs (SD ± 57.6 lbs) in 2004. Grazing trial duration was 88 and 84 days in 2003 and 2004, respectively. The average stocking rate was 425 and 399 lb/acre of liveweight in 2003 and 2004, respectively. Forage production cost and cattle purchases and the revenues from cattle sales were calculated in \$/acre. The following procedure was applied to estimate beef production cost and net revenue over operating cost in each production scenario. Net revenue per acre (P) was determined by subtracting expenditure per acre (E) from revenue per acre (R) [P = R – E]. Revenue per acre was calculated as final steer liveweight in lb/acre (W) times selling price in $/lb (K) [R = K * W], and expenditure per acre consisted of adding all operating costs per acre.

All information regarding production costs was collected from farm accounting records for both years. Collected information consisted of monthly electricity consumption, maintenance cost for the central pivot irrigation system, fertilizer cost, and labor cost. Labor cost was estimated from the average farm wage rate paid in the Oklahoma-Texas Panhandle during each year of study (USDA, 2004) times the amount (hours) of labor actually applied in handling the steers in the experiment. Electricity cost and labor cost were prorated according to the frequency and amount of irrigation in each production scenario. Maintenance cost and fertilizer cost were prorated from a whole farm basis to the area under study.

Steers used in the study were provided by a local stocker grower, but were valued at price market at the beginning of each grazing trial during the summer. Steer cost was estimated as the average weekly steer price reported for the Texas Panhandle region at the beginning of each summer trial (Cattle Fax, 2005) that most closely matched the initiation of the grazing trial times average initial weight. The 2003 grazing trial began July 7. Therefore, the price reported in the first week of July 2003 ($1.08/lb) for steers with average weight of 450 lbs was used. In 2004, the grazing trial began June 5 and the price reported in the first week of June 2004 ($1.30/lb) for steers with average weight of 450 lbs was used. Other expenses considered in this research included interest on steer purchases; feed cost applied to those scenarios in which whole cottonseed was fed, vet and medicine cost, and mineral cost. The interest cost on cattle was estimated from the average fixed interest rates on farm loans from the Agricultural Finance Databook (Federal Reserve Bank of Dallas, 2004) for feeder cattle loans for the 2 years respectively. In 2003 a 7.4% annual interest rate for a length of 88 days was applied to the steer purchase cost, while a 7.2% annual interest rate was applied for a length of 84 days in 2004. Whole cottonseed and vet supplies costs were prorated from the whole farm to the area of study.

To estimate revenue from cattle sales, similar procedures as used in steer buying were followed. It was assumed that steers were sold at the end of each grazing trial after 88 days (2003) and 84 days (2004) of summer grazing. A steer price reported for sales was the market price for the week of assumed sale. In 2003, the trial ended on October 4 and the steer price reported by the US weekly report in the first week of October 2003 ($1.07/lb) was used for steers with an average weight of 550 lbs. The second year the grazing trial ended August 28. The price reported in the last week of August for that year and for steers weighting an average of 650 lbs ($1.23/lb) was used as the selling price. Estimated revenues for the selected years were also used to analyze the effect on net revenue over operating costs at several price differential levels.

RESULTS AND DISCUSSION

Summer 2003 had relatively low rainfall while 2004 was one of the wettest years. In summer 2003, total water availability (rainfall plus irrigation) was 7.5 inches, 4.5 inches, and 0.5 inches for HI, LI and NI scenarios respectively. In summer 2004, total water availability was 15.5, 12.5, and 8.5 inches for HI, LI, and NI scenarios, respectively.

Beef production cost varied across production scenarios in 2003 (Figure 1). The lowest beef production cost was $0.28/lb in the NI-NS scenario. Non-irrigated production cost per lb of beef without supplement was $0.14 lower than NI-S scenario. Additionally, NI-NS beef production cost was $0.54 lower than the average production cost in the four irrigation scenarios. Higher revenue over operating cost per acre corresponded to the lower beef production costs (Figure 2 and Table 1). Higher revenue over operating cost per acre also occurred in the NI-NS scenario, which was 17% higher than in the NI-S scenario. Compared to the average net revenue in irrigation scenarios, it was $51.8/acre higher in 2003. Several factors may account for this outcome during 2003. First, operating costs in the irrigated and supplemented scenarios were high because of energy and supplement use (Table 1); in the LI-S and HI-S scenarios, energy plus supplement costs were $37.34 and $48.52 of the total operating costs, representing 46 and 53% of costs, respectively. In addition, in LI-NS and HI-NS, energy cost accounted for $22.11 and $36.58 representing 34 and 46%, of total costs respectively.

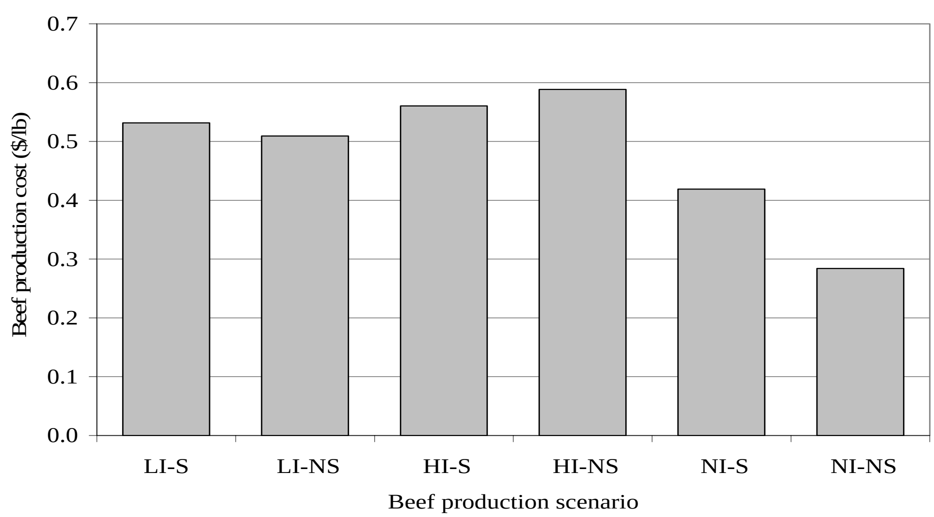

Figure 1. Beef production cost ($/lb) in six combinations of irrigation-supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture under summer grazing in 2003. LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

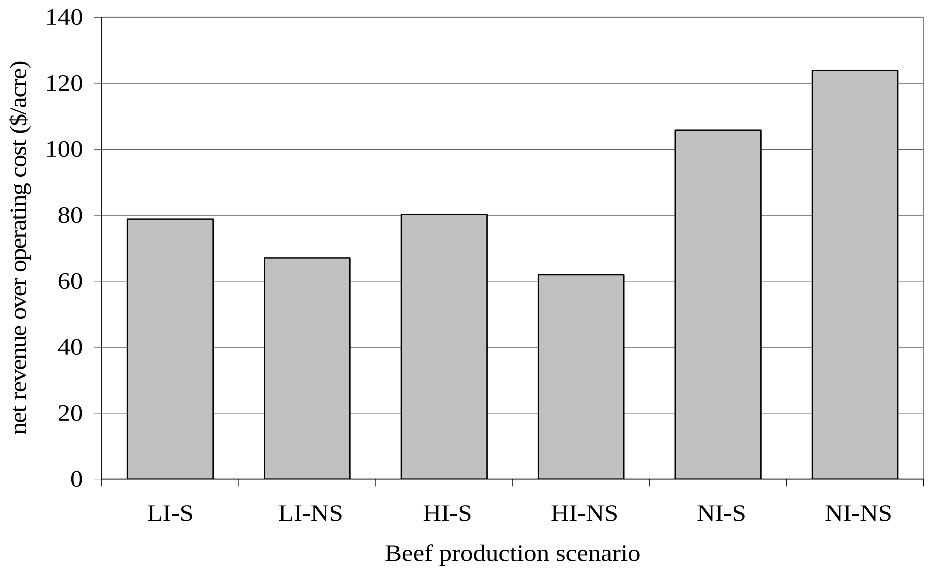

Figure 2. Net revenue per acre ($/acre) in six combinations of irrigation-supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture grazed by steers in summer 2003. LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

In the 2004 experiment, beef production costs are shown in Figure 3. Beef production cost in the NI-NS scenario was the lowest; it was $0.06/lb lower than the NI-S scenario and on average $0.16/lb lower than the HI-S, HI-NS, LI-S and LI-NS scenarios.

Table 1. Beef production costs and revenue in 2003 in six combinations of irrigation-supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture grazed by steers in summer.

Item	Beef production scenario					
	LI-S	LI-NS	HI-S	HI-NS	NI-S	NI-NS
	---$/acre---					
Energy	21.77	22.11	35.75	36.58	7.60	6.74
Fertilizer	15.37	15.37	15.37	15.37	15.37	6.22
Whole cottonseed	15.57	0.00	12.77	0.00	18.10	0.00
Interest in steer cost	8.43	8.29	7.26	7.84	9.90	8.33
Maintenance	6.28	6.28	6.28	6.28	6.28	6.28
Vet and medicine	6.47	6.05	5.53	5.94	7.83	6.44
Labor	6.28	5.10	7.69	6.84	4.57	1.87
Minerals	0.79	0.89	0.81	0.87	1.15	0.94
Total operating cost	80.96	64.09	91.46	79.72	63.20	36.82
Net revenue	78.81	67.06	80.21	61.93	105.82	123.87

LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

In 2004, the higher rainfall year, net revenue per acre had less variation across scenarios than in 2003, especially for the irrigated situations (Figure 4). In contrast, net revenue per acre in the non-irrigated beef production scenario with supplement was higher than other scenarios. Similar to the previous year, the cost of energy in 2004 represented the highest operating cost in all irrigation scenarios (Table 2). Fertilizer cost was the second highest cost.

Other operating costs involved in the beef production such as maintenance, interests on steer investment, vet and medicine, labor, and minerals cost showed no great variation among production scenarios. These costs did not have important effect on net revenue over operation costs per acre in either year.

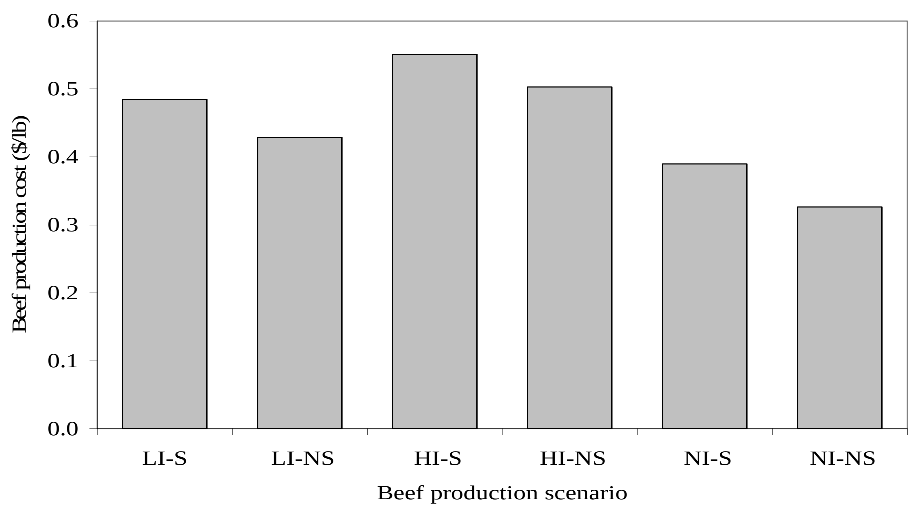

Figure 3. Beef production cost ($/lb) in six combinations of irrigation-supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture under summer grazing in 2004. LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

Net revenue per acre under 2003 and 2004 operating conditions was analyzed using different cattle purchasing and selling prices (Tables 3 and 4). It was assumed that steers were sold at the end of each grazing trial after 88 days (2003) and 84 days (2004) of summer grazing. A steer price reported for sales was the market price for the week of assumed sale. When the differential between buying/selling prices increased in absolute dollar value, net revenue per acre decreased. Moreover, as price differential approached 17%, revenue/acre dramatically decreased and began showing negative values. In both years of this study, the price differential was negligible; therefore, net revenue per acre was positive in all production scenarios.

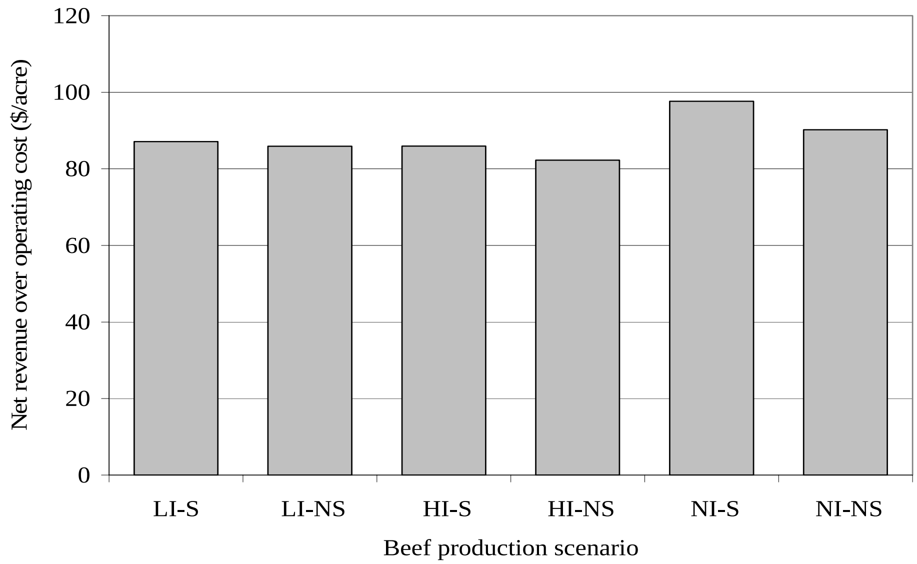

Figure 4. Net revenue per acre ($/acre) in six combinations of irrigation- supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture grazed by steers in summer 2004. LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

Table 2. Beef production costs and revenue in 2004 in six combinations of irrigation-supplement scenarios in a WW-B. Dahl (*Bothriochloa bladhii*) pasture. pasture. grazed by steers in summer.

	Beef production scenario					
Item	LI-S	LI-NS	HI-L	HI-NS	NI-S	NI-NS
	------------------------------$/acre--------------------------------					
Energy	17.17	17.44	30.87	31.70	3.70	3.28
Fertilizer	16.71	16.71	16.71	16.71	16.71	16.71
Whole cottonseed	12.04	0.00	14.97	0.00	11.79	0.00
Interest in steer cost	7.49	8.07	9.43	11.03	7.56	7.40
Maintenance	6.28	6.28	6.28	6.28	6.28	6.28
Vet and medicine	4.41	4.47	5.53	6.22	4.35	4.38
Labor	2.64	5.31	8.01	7.13	4.75	1.95
Minerals	0.20	0.63	0.77	0.87	0.61	0.61
Total operating costs	66.94	58.91	92.57	79.94	55.75	40.61
Net revenue	87.11	85.90	85.97	82.25	97.67	90.24

LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement).

These results agree with Peel (2000) cited by Phillips et al. (2003) and Bransby (1989), which concluded that income comes from initial steer weight and weight gained during the grazing period. In addition, during summer 2003 and 2004, buying and selling prices registered in the Texas Panhandle region were considered high. Ethridge et al. (1987) recommended that, under high buying and high selling price, the most profitable alternative is to stock steers with average initial weight of 450 lbs from June to August in Old World bluestem pasture. In this study all of these conditions coincided and results strongly supported by the Ethridge et al. (1987) findings.

Table 3. Net revenue over operation costs per acre ($/acre) in selected buying and selling prices in six combinations of irrigation-supplement scenarios in operation conditions in 2003 in a WW-B. Dahl (*Bothriochloa bladhii*) pasture grazed by steers in summer.

			Beef production scenario					
Steer price ($/lb)			LI-S	LI-NS	HI-S	HI-NS	NI-S	NI-NS
Buy	Sell	Diff	------------------------------Net revenue ($/acre)---------------------					
0.99	0.84	0.19	-14.64	-19.12	-7.52	-23.41	-1.48	32.59
1.08	1.07	0.01	78.78	67.03	80.18	61.9	105.77	123.82
1.09	0.97	0.12	18.43	10.16	25.1	6.45	35.95	70.87
1.13	0.93	0.20	-23.38	-29.92	-12.16	-32.15	-12.71	23.95

LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement). Buying price is based on 450 lbs steer liveweight. Selling price is based on 550 lbs steer liveweight. LI-S low irrigation–supplement

Table 4. Net revenue over operation cost per acre ($/acre) in selected steer buying and selling prices in six combinations of irrigation-supplement scenarios in operation conditions in 2004 in a WW-B. Dahl (*Bothriochloa bladhii*) pasture grazed by steers in summer.

			Beef production scenario					
Steer price ($/lb)			LI-S	LI-NS	HI-S	HI-NS	NI-S	NI-NS
Buy	Sell	Diff	------------------------------Net revenue ($/acre)---------------------					
1.00	0.81	0.15	-16.98	-17.43	-40.12	-49.52	-3.83	-2.36
1.04	0.91	0.13	21.84	22.10	15.24	6.92	34.80	33.71
1.07	0.99	0.01	51.76	52.56	43.16	40.37	64.57	61.50
1.12	0.94	0.20	7.40	5.78	-11.86	-22.06	20.03	18.70
1.30	1.23	0.07	97.68	96.33	96.40	92.23	109.52	101.19

LI-S = (low irrigation–supplement), LI-NS = (low irrigation–no supplement), HI-S = (high irrigation-supplement), HI-NS = (high irrigation-no supplement), NI-S = (no irrigation-supplement), and NI-NS = (no irrigation-no supplement). Buying price is based on 450 lbs steer liveweight. Selling price is based on 650 lb steer liveweight.

Overall, these results show that stocker steers grazing on non-irrigated WW-B. Dahl provided higher net returns than irrigated in this experiment, during both 2003, a dry year, and 2004, a wet year. Further, comparing the net returns (NI-NS) from this experiment ($124/acre and $90/acre) to competing crop enterprises for land and water, Allen et al (2005) reported net revenues from irrigated cotton in the region of $125/acre for the 1997-2002 period and Sides et al (2005) reported net revenue above operating costs of $96.09/acre without government program payment and $127.27/acre with government payments for non-irrigated cotton. Additionally, NI-NS system conserves groundwater and is less management and labor intensive than some competing alternatives.

CONCLUSIONS

Results from the economic analysis suggest that under current energy prices, the summer grazing of yearling steers on irrigated WW-B. Dahl pasture with the irrigation levels used is not profitable. In both wet and dry years irrigation provides insufficient additional beef gain revenue to cover the additional cost of irrigation. Moreover, under the current revenue and cost structure confronting cattle producers, irrigating WW-B. Dahl pasture will become increasingly unprofitable if the groundwater table continues to drop in the Texas High Plains. However, summer grazing on dryland WW-B. Dahl pasture is becoming very competitive with irrigated and dryland cotton production. The assessment of supplemental feeding whole cottonseed as an energy supplement to enhance beef production is not definitive from the results of this experiment since the supplement resulted in higher net revenue in one (the wet) year and less in the other (dry) year. The economic efficacy of the research recommendations are not impacted by variations in steer purchase and selling price under normal variation in their price spread.

WW-B. Dahl non-irrigated pasture combined with stocker enterprises appears to be generally competitive with non-irrigated cotton, the dominant field crop in the region. This would be particularly true if the government price support level for cotton is decreased in the future. The NI-NS beef enterprise offers a viable alternative; as lower-value cropping systems move more to a non-irrigated status, releasing limited groundwater for higher-value enterprises. Additional research on beef enterprise grazing within a production systems framework is required to further define these opportunities.

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EFFECTS OF PROTEIN AND ENERGY FEEDING ON OVINE OOCYTE PRODUCTION AND DEVELOPMENTAL CAPACITY

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ABSTRACT

A study was conducted to determine the effects of protein and energy on oocyte production in ewes. Eighty-one multiparous whiteface ewes were randomly divided into three feeding treatments, and penned in groups of three, which served as the experimental unit. Ewes were placed on one of three feeding treatments, wheat hay (maintenance), mixed grain with added protein, or mixed grain with added energy. Ewes were fed for 35 d then ovaries were removed, trimmed, weighed, lacerated, and rinsed with TL Hepes. Recovered oocytes were graded and matured in the incubator for 24 h in 5% CO_2 at 38.5°C. Following incubation, oocytes were removed, rinsed and activated to begin development. Oocytes were incubated in a blood gas mixture for 7 d and evaluated at d 4 and d 7 for cleavage rates and morula formation. Results yielded no difference (*P* > 0.05) among feeding treatments with respect to ovarian weights, oocyte numbers, quality scores, or developmental rates.

Key Words: Sheep, Oocytes, Ovaries, Protein, Energy

INTRODUCTION

Reproductive capabilities of livestock have long been associated with their nutritional state. The methods in which nutrition, genetics, health, and reproduction correlate together are not well understood (Ayalon, 1978). Animals are placed into a negative nutritinal balance when they do not receive enough energy or protein in their diet to meet the demands of energy expenditure for locomotion, milk production, reproduction, and maintenance (Dunn and Moss, 1992). Once an animal cannot meet its maintenance needs, it begins to falter in other areas such as reproduction in order to maintain its body functions to survive.

Angora nannies that were flushed for five weeks with additional energy in their diet just prior to mating showed improved conception rates over the nannies that were not flushed. Even nannies that were not flushed but simply put on a higher level of feed were able to improve their body condition enough within five weeks of breeding to conceive (Taylor et al., 1988a). Taylor et al. (1988b) conducted another study that involved

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subjecting angora nannies to nutritional stress for a period of three days, then placing them back on free feeding. They believed that this fast-then-feed method raised glucose levels to stimulate ovulation. What role the physiological aspects might have played in the increased ovulation or conceptions of the studies is unclear; however it is apparent that nutrition is a key component to reproduction. Hunt et al. (1988) produced results that concur with Taylor et al. (1988) and showed non-significant trends in ovulation increases when ewes were flushed.

Research has shown increased amounts of protein in the diet of dairy cows can have a detrimental effect on their reproductive success (Jordan and Swanson, 1979). Elrod and Butler (1993) found a decrease in the rate of pregnancy from 82% in the normal feeding group to 61% in the group of heifers fed high levels of protein. Protein excesses have continually shown a deleterious effect towards reproductive performance. Energy feeding has also been shown to affect reproductive traits in cattle. Butler and Smith (1989) state that energy can be a limiting factor on reproductive performance in postpartum cows. Wiltbank et al. (1965) stated energy limitations could adversely affect reproductive success of beef cattle more than protein. However, an increase in dietary energy seems to enhance reproduction while protein inhibits reproductive ability. Studies by Gwazdauskas et al. (1999) and Kendrick et al. (1999) both showed that cows fed high-energy diets produced more overall good oocytes than cows fed low energy diets. Contrary to these findings, Nolan et al. (1998) and Callaghan et al. (2000) found nutrition had no effect on the morphological grading of oocytes.

It is essential that the nutritional affects on the ovary and the substrates of the diets be further evaluated to try and close the gap in information. Not only is it important that we study the effects on the embryos of nutritional stress and dietary changes, but the levels before embryo development must also be further evaluated. Therefore, this study was designed to evaluate the effects of protein and energy on oocyte production, quality and developmental capacity in white-face ewes.

MATERIALS AND METHODS

Animals and Dietary Treatments

Eighty-one multiparous whiteface ewes were randomly divided into three groups of 27. Ewes were fed in groups of three and each group of three ewes formed an experimental unit. Treatments consisted of: a mixed grain diet containing more available energy (Treatment 1), a mixed grain diet containing more protein (Treatment 2), or a maintenance diet of wheat hay (Treatment 3) intended to meet only maintenance needs (Table 1). Ewes were fed at a rate of 2.5% of body weight to meet the NRC recommended amount of total digestible nutrients for maintenance. One ewe died and the feeding ratio was adjusted accordingly for that pen. Treatment 1 consisted of a higher amount of corn (19.6% vs. 9.7%) to add energy to the diet, than the protein diet, which had a higher level of cottonseed meal (11.8% vs. 3.1%), to add protein to the diet.

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Table 1. Ingredients and nutritional analysis, DM basis, of dietary treatments fed to ewes at 2.5% of body weight per day.[a]

	Treatment[b]		
Ingredients, %	1	2	3
Corn Grain	19.6	9.7	0.0
Soybean Hulls	30.4	30.2	0.0
Sheep Premix	2.7	2.7	0.0
Cane Molasses	4.2	4.2	0.0
Cotton Hulls	40.0	41.3	0.0
Cotton Seed Meal	3.1	11.8	0.0
Wheat Hay	0.0	0.0	100.0
Nutrients, %			
Crude Protein	12.1	15.9	19.6
Total Digestible Nutrients	71.0	72.0	59.0
Acid Detergent Fiber	42.4	43.1	29.7
Neutral Detergent Fiber	51.8	48.6	51.6

[a] Randomized complete block design with pen of three ewes serving as the experimental unit
[b] Treatments consisted of 1, energy diet; 2, protein diet; 3, wheat hay.

Before the ewes were assigned to their dietary trial, they were fed a diet of strictly wheat hay that meets the NRC requirements for maintenance to allow them to adjust to the environment (adjustment). For purposes of time management, the three groups of ewes were staggered one week apart when placed on their respective diets. Three subgroups, consisting of three ewes each from each feeding treatment, were placed on their dietary rations. Due to the amount of time involved in the harvesting of the ewes and the collection and processing of their ovaries, it was necessary to divide the overall feeding, collection, and processing into thirds. Therefore, the first subgroup was on the adjustment diet for two weeks, the second group for three weeks, and the third group for four weeks. Once assigned to their feed trial period, all ewes stayed on their designated feed for five weeks.

Ovary Retrieval

Upon the conclusion of the five-week feeding trial, each set of ewes was taken to Ranchers' Lamb of Texas Inc. (San Angelo, Texas) for harvest. Ovaries from each ewe were removed by manually pinching them off the reproductive tract. They were immediately placed in phosphate buffered saline for transportation to the laboratory for processing. The ovaries were trimmed of excess tissue and a weight was taken on a per pen basis.

Cumulus Oocyte Complexes Retrieval

Protocols used for cumulus oocyte complexes (COC) retrieval, oocyte maturation, storage and culture, were provided by Ovagenix Laboratories (East 37th Street San Angelo, Texas 76903). Ovaries were sliced with a scalpel blade and rinsed with TL

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Hepes, modified Tyrode's medium with 0.03% bovine serum albumin fraction V (BSA), commonly used for most embryo and oocyte holding and culture media. The ovaries were then chopped and placed in a 50 ml conical tube (Fisher Scientific, Houston, TX) with 10 mls of TL Hepes, shaken, then drained and rinsed into another 100 ml petri dish. The COC's were removed from the original dishes and placed in a clean dish of TL Hepes for rinsing and sorting. Cumulus oocyte complexes were counted into a third dish for a third wash and grouped according to quality.

Oocyte Grading

Quality scores were based on those of Deloose et al. (1989) and Tripp et al. (1999). Scores ranged from A (excellent) to D (poor) based on cumulus orientation and ooplasm regularity. Category A consisted of oocytes that are surrounded by at least 3 layers of compact cumulus cells and contained a normal cytoplasm. Cumulus oocyte complexes scoring a B were surrounded by 2 layers of compact cumulus cells and held a normal cytoplasm. Category C contained oocytes surrounded by 1 layer of compact cumulus cells and contained a normal cytoplasm. Category D included COC's with less than 1 layer of cumulus cells or an unstable layer of cells with an abnormal cytoplasm. Normal cytoplasms appeared smooth and complete in structure without defects. Abnormal cytoplasms had color blotches and voided areas. The COC's scoring A and B were grouped together for maturation, culture, and overall assessment. The COC's scoring C were kept alone, and the D scoring groups were disposed of, as it was highly unlikely that the D groups would be capable of maturation (Deloose et al. 1989).

Oocyte Maturation

The COC's were placed in a maturation medium containing 88% M199 with Earle's salts (Gibco), 0.5% luteinizing hormone (LH), 0.5% recombinant bovine follicle stimulating hormone (bFSH), 10% fetal bovine serum (FBS), and 1% penicillin/streptomycin and placed in incubation with 5% CO_2 at 38.5˚C for 24 h. The M199 is a complex cell culture medium used as the base medium for oocyte maturation and embryo culture, and Earle's salts is bicarbonate buffered and must be used in an atmosphere of 5% CO_2 to maintain proper pH (Ovagenix Laboratories). Luteinizing hormone, bFSH, and FBS were used in oocyte maturation. This procedure was done to mature the COC's relatively close to the same developmental stages and equilibrate them into the new environment outside of the follicle (Ovagenix Laboratories).

Oocyte Rinsing and Storage

After 24 h of incubation, the matured oocytes were removed and placed in 1 ml of TL Hepes in a 15 ml conical tube. The oocytes were vortexed at high speed for 2 min 15 s to remove cumulus cells and reveal the actual oocyte. The oocytes were rinsed from the conical tube into a 60 mm petri dish with TL Hepes. The oocytes were rinsed using a multiple step activation protocol. First, they were rinsed in a combination of 5% ionomycin in TL Hepes for four min to disinfect them from any outside contaminants. The lights were turned down to a minimum and the ionomycin was kept covered at all possible times since it is light sensitive. Second, the oocytes were rinsed in a wash of TL Hepes for four min to remove ionomycin debris. Third, they were rinsed in a wash of M199 with 10% FBS and 10% 200 mM dimethlyaminopurine (DMAP; Genetic Savings and Clone, Bryan, TX) to remove all other liquid associates. Finally, they were stored in

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a fresh mixture of M199 with 10% FBS and 10% 200 mM DMAP for 5 h at 38.5°C with a 5% CO_2 atmosphere. DMAP was added to the medium to maintain oocytes in a state of meiotic arrest once they have been removed from the follicle. The addition of DMAP allowed the oocytes to be incubated at a fixed point in development without advancement beyond the stage of initiation. This allowed time for the oocytes to re-equilibrate with the holding environment before they were activated for culture.

Oocyte Culture

At the completion of 5 h, the oocytes were removed from the incubator, then rinsed and stored in a solution called Barc's (Genetic Savings and Clone, Bryan, TX) designed to cause the oocytes to undergo cleavage and divide as if they had been fertilized and become embryos. The oocytes were cultured for 7 d at 38.5°C in a medical grade, blood gas mixture containing 90% nitrogen, 5% carbon dioxide, and 5% oxygen (Airgas, San Angelo, TX) to enhance tissue development and growth. After 4 d of culture, the oocytes were removed and evaluated for cleavage rates. After the oocytes were evaluated and the findings recorded, they were placed back into the gas mixture and cultured for the remaining 3 d. Once the oocyte completed the full 7 d culture period, they were removed and assessed for morula formations, and blastocyst development. Oocytes evolving to blastocyst were considered fully developed because that is as far as an oocyte can transform without the assistance of DNA from sperm.

Data Collection and Procedures

Collection and handling procedures of ovaries and oocytes were similar to the methods of Rho et al. (2001) and Khurana and Niemann (2000). Body weights were taken prior to the initiation of each groups' feeding trial and after the completion of each trial before harvest. Means were calculated and recorded according to experimental units and feed groups. Totals were recorded for ovarian mass, oocyte production, oocyte grades, and oocyte development for each of the treatment groups.

Statistical Analysis

Pen of three ewes was considered the experimental unit. Day of harvest was included in the model to account for any differences in day associated with the ewes completing the experiment on different weeks. Body weight, ovarian weight, oocyte numbers (total and per classification), percent cleavage rates and development rates (morula and blastocyst) were analyzed using the General Linear Models of SAS (SAS Inst., Inc., Cary, NC.). Duncan's Least Significant Difference procedure was performed to separate mean differences. Treatment differences were considered different at $P < 0$ .05.

RESULTS AND DISCUSSION

Animal Performance

There were no difference ($P > 0.05$) in weight gain or loss among the different treatment groups in relation to oocyte production. Neither ovarian weights, oocyte production, oocyte grades, nor oocyte development were affected ($P > 0.05$) by weight gain or loss of the ewes.

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Dietary Treatments

Feed analysis were performed by Dairy One DHI Forage Testing Laboratory and the results were: treatment 1 contained 19.6% corn grain on a DM basis, where treatment 2 contained only 9.7% corn grain on a DM basis. Treatment 3's energy availability was derived from the nutritional value of the wheat hay with no supplementation (Table 1). After analysis, the quality of the hay was higher than anticipated. Thus, the maintenance diet was not present, but two diets had protein levels above those reported for maintenance. The differences were then forage versus mixed grain.

Ovarian Weights, Oocyte Totals, Grade Percentages, and Development

No differences ($P > 0.05$) in ovarian weights, oocyte totals, oocyte grades (Table 2), or blastocyst development were seen among treatment groups (Table 3). No differences were found that would indicate nutritional levels: 1) affected the way the ovary grows due to follicular or tissue development, 2) caused the oocyte to produce more primary, secondary, or tertiary follicles, 3) resulted in a higher or lower abundance of retrievable oocytes, 4) produced varying amounts of A, B, C, or D quality oocytes, 5) influenced the developmental capacity of the oocytes to reach the blastocyst stage.

Table 2: Ovarian weights, oocyte totals, and oocyte grade percentages from ewes offered three dietary treatments.[a]

	Treatments[b]			
	1	2	3	Standard Error
Ovarian weight, g	10.76	9.72	10.42	0.476
Oocyte totals, g	39.78	47.11	55.00	6.968
Percent A/B	41.56	46.89	38.43	3.68
Percent C	19.27	20.15	21.51	1.73
Percent D	39.56	32.95	36.86	3.15

[a] Randomized complete block design with pen of three ewes serving as the experimental unit.
[b] Treatments consisted of 1, energy diet; 2, protein diet; 3, wheat hay.

Table 3. Percentages of oocyte cleavages, morulas, and blastocyst formations from ewes offered three dietary treatments.[a]

	Treatments[b]			
Item, %	1	2	3	Standard Error
A/B Cleavage	92.75	91.42	81.88	4.84
A/B Blastocysts	60.60	57.29	51.82	6.60
A/B Morulas	8.35	11.62	9.71	2.54
C Cleavage	72.09	80.69	73.21	7.58
C Blastocysts	41.54	37.00	21.62	8.05
C Morulas	10.41	19.85	10.27	6.26

[a] Randomized complete block design with pen of three ewes serving as the experimental unit
[b] Treatments consisted of 1, energy diet; 2, protein diet; 3, wheat hay.

One area of interest that was not approached in this study was the feeding of different quantities and the effect that it has on ovary production. Papadopoulos et al.

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(2000) conducted a study where they fed grass meal to sheep at either 2.0 times maintenance energy requirements (MER) or 0.5 times MER. They found that ewes on the 0.5 MER diet produced less overall follicles than the ewes on the 2.0 MER diet. Despite these findings, no difference in the rate of oocyte retrieval due to feeding amounts was observed. Animals on the 2.0 MER did have a lower cleavage rate than those on the 0.5 MER diet; however, no differences in blastocyst rate, blastocyst-hatching rate, or blastocysts cell number were seen when expressed as percentage of cleaved oocytes. The development of more follicles in their study could affect the weights of the ovaries whereas in our study, the weights were unaffected by the three feeding groups. The altering of the amount of the grain diets and forage diet could have shown a difference in the weights of ovaries retrieved due to follicle production. Similar to these results, our study did not show a difference in the total number of oocytes derived from the three treatment groups. This evidence suggests that neither feeding amounts, nor the type of feed affects the total oocyte production of the ovary. Papadopolous et al. (2000) concurs with the current study that neither different feeding amounts, nor nutritional amounts or types affect the development of oocytes after cleavage occurs. Callaghan et al. (2000) also supports these findings. When crossbred ewes were assigned to one of three diets and fed levels of 0.5, 1.0, or 2.0 times maintenance energy requirements, no difference in oocyte morphology was found associated with the feeding trials. Another study corresponding to these was conducted by Nolan et al. (1998). Heifers were fed an *ad libitum* or restricted diet of grass silage/concentrate at a 10:1 ratio. These feeding treatments had no apparent effect on oocyte grades or oocyte development in an *in vitro* setting. Results appear to be conclusive that feeding amounts do not effect ($P > 0.05$) the quality and development of oocytes but do affect the ovulation rates as expressed by Henniawati and Fletcher (1986) in an experiment with Indonesian sheep and goats. Sheep and goats were placed on either a maintenance level or a supramaintenence level of nutrition containing elephant grass and a supplemental commercial concentrate. The supramaintenece diet showed a strong improvement of ovulation over the maintenance diet. Research has shown that ovulation rates and follicle formation can be affected by feeding amounts to allow for an area of improvement in reproduction.

Other research supports the evidence that differences in ewes offered half maintenance energy requirement diets vs. ewes offered double the maintenance energy requirements is insignificant in regards to oocyte morphology (Boland et al. 2001). However, other evidence suggests a relation between the *in vitro* development of oocytes from harvested heifers that were restricted from energy intake prior to slaughter (McEvoy et al., 1997). McEvoy et al. (1997) also found that the blastocyst yields from heifers on low energy intake rather than high-energy intake were enhanced by the nutritional diets. Nolan et al. (1998) also supports these results in their study with enhancement of oocytes collected trans-vaginally to blastocyst development *in vitro* from heifers restricted of dietary intake. These research studies further emphasize the role that nutrition plays on reproduction is very important. Enough evidence exists to suggest a relationship between nutrition and reproduction at the level of the oocyte.

Feeding different types of diets, forages or concentrates, may be capable of producing different outcomes in regards to oocyte production. An experiment was conducted on heifers that were fed either a diet of barley concentrate or a diet of a citrus/beet pulp mixture. Both feeds were designed to contain 14% crude protein. Heifers on the citrus/beet pulp diet produced more freezable and transferable embryos

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than heifers on the barley diet. However, the numbers of retrieved embryos with lower grades, and unfertilized ova were not affected by concentrate type (Yaakub et al., 1998). This study did not take into account different amounts of nutritional protein in the diet, or energy levels, nor did it evaluate the results of the diets used on the production and development of oocytes. The information provided does give an implication that a different effect was found on the production of embryos according to the feed types. This insinuates a possible impact on the ovaries or the oocytes before the time of conception. It is possible a greater number of quality oocytes were produced that led to a larger amount of quality grade embryos from the feeding of citrus/beet pulp as compared to the feeding of barley concentrate. This would give hope to the assumption that the production and development of oocytes can be affected by the influence of the type of feed and the nutritional components of the feed.

An abundance of data exists revealing connections with reproduction and nutrition at the level of the ovary and the oocyte. While some of the evidence is contradictory, it all shows a connection in one way or another. Whether it is the effect of nutrient deficiencies, feeding abundances, or different types of feeds involved, many of these studies show an effect on the production of the ovary and the oocyte. Some of the studies show increases in follicular production and enhanced oocyte developmental capacities, and others provide information contradicting these findings showing decreases in follicular production and oocyte developmental capacities. Several of the studies indicated decreases in the nutritional feeding of animals causes a positive outcome with ovarian production, and some insist that enhanced feeding is required to reach the same effects. A few of the studies even offer the explanation that energy is beneficial to reproductive success and protein is deleterious to reproductive success. It is apparent that the dynamics of nutritional effects on reproduction are still not fully understood. So many of the studies offer contradictory findings that a definite need for further investigation in the search for answers regarding nutritional effects on reproductive success exists.

CONCLUSIONS

The primary goal of this study was to determine if added protein or energy to a maintenance diet would increase oocyte production rates, oocyte quality or developmental capacity in mature ewes, therefore enhancing the reproductive rate and success of sheep. This study did not take into account physiological characteristics or digestibility factors of different types of feeds. It also did not address the issues of nutritional stress from limit feeding or the effects of over feeding. These are areas that should be further explored as a large amount of research exists that indicating these areas have an effect on reproduction in one way or another.

Based on the literature reviewed, we hypothesized an increase in protein would have detrimental affects on oocyte production through decreased numbers, quality, and survivability, but energy increases should have shown beneficial results in the respective fields of oocyte production. This hypothesis was not supported in this study. We did not see differences in any of the respective areas in association to the diets used.

Results of this study indicate that increased amounts of protein in a ewe's diet will not increase oocyte production or developmental capacity thus not having an effect

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on conception rate. Therefore, it may prove more economically efficient for producers to feed energy instead of protein to ewes during the breeding season since energy is more cost efficient than protein. Also, researchers in the field of oocytes may not need to account for differences in nutritional values of feeds when evaluating the developmental capacities of oocytes from ewes when maintenance requirements are met by the diet.

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Creating a Promotional DVD for an International Agricultural Research Center: A Delphi Study

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ABSTRACT

Research was conducted to determine what should be included on a promotional DVD for the International Center for Food Industry Excellence, or ICFIE, an animal and food science research center at Texas Tech University in Lubbock. The researcher utilized a three-round Delphi using online questionnaires. Faculty and industry board members and center staff agreed to participate on the panel of experts. The panel gave 97 items in Round 1 to be considered. In Round 2, panelists reached a 100% consensus on 14 items received 100% consensus and reached the minimum 80% consensus on a total of 65 items. For Round 3, panelists again rated items from Round 2 which not make consensus, and four of these items received at least an 80% consensus. The researcher proposed items receiving 100% consensus should be the focus of the promotional DVD, and items which received more than an 80% but less than 100% consensus should also be shown on the DVD, but should have less focus.

KEYWORDS: Promotion, marketing, agricultural communications, Delphi, DVD, electronic media, communications

INTRODUCTION

The purpose of this study was to evaluate what components should be included on a promotional DVD for ICFIE in order to effectively showcase the features, services, and capabilities potential clientele need or would utilize. The study narrowed down the large amount of components and services ICFIE offers by uncovering the most important features of the center. Experts, or those who serve on the board or work for ICFIE, have the best grasp of the needs of the center and the industry and must designate the most valuable features using their professional opinions.

The following objectives were developed in order to reveal the most important features of ICFIE to use in a promotional DVD and thus accomplish the purpose of the study:

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1. Determine what faculty and industry board members of and staff employed by ICFIE believe are the most important features to show on the DVD.
2. Determine what general and specific features of the center should be included.

The theoretical framework used for the study included the needs assessment and key informant models. According to Birkenholz (1999), needs assessment is used to "identify problems or situations that could be solved or improved through educational activities" (p. 71). A needs assessment locates a gap in adult education. Fulfilling the need bridges the gap between adults' current level of knowledge and the desired level of knowledge as demonstrated in Figure 1 (Birkenholz, 1999). The ICFIE promotional DVD aims to educate adults which have little to no knowledge of the center. Knowledge of ICFIE's basic information, services, and capabilities serves as the desired level of knowledge. Information from the DVD should bridge the gap.

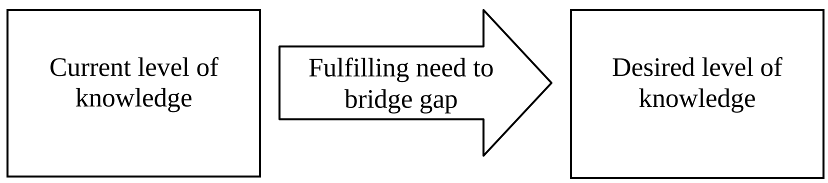

Figure 1: Needs assessment model Birkenholz, 1999).

The Key Informant Model builds on basic needs assessment. It states the informants must be knowledgeable of the target audience's needs and the informants should be stakeholders in the program. Additionally, the informants' perceived audience needs should coincide with what the target audience wants as shown in Figure 2 (Birkenholz, 1999). Thus, the effectiveness of educational material is dependent upon content, and using needs assessment in conjunction with the Key Informant Model identifies that content. Because the faculty board members and staff research and develop industry methods and industry board members work in the fields ICFIE targets, they fit in the requirements of the Key Informant Model.

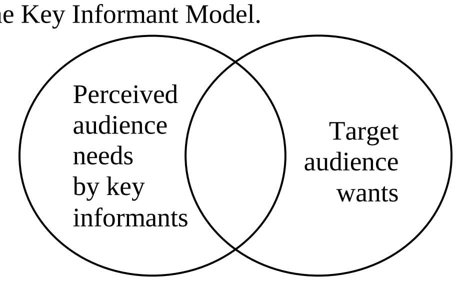

Figure 2: Overlapping of perceived audience needs and audience wants in the key informant model. A large overlapping area translates to effective key informants (Birkenholz, 1999).

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The study utilized the Delphi method for the research design. According Linstone and Turoff (1975) and a Web page owned and created by Dr. Marion Joppe of Ryerson University (2005), the Delphi method is a form of qualitative research using a panel of experts selected by the researchers for their knowledge and expertise in a certain area. Joppe also wrote, "The notion is that well-informed individuals, calling on their insights and experience, are better equipped to predict the future than theoretical approaches or extrapolation of trends" (2005).

Selected experts anonymously complete a series of separate questionnaires. Mullen (2003) wrote the questionnaires may be "structured or relatively unstructured" (p. 38), and responses are kept anonymous. The answers from the first questionnaire determine the content of the second; the answers from the second determine the third, and so on as needed. This reduces and narrows the range of responses to eventually find the "best" response or responses (Joppe, 2005). Typically, researchers use a total of three questionnaires (Fischer, 1978). See Figure 3 for a flow chart which illustrates the Delphi method.

The use of the Delphi method in agriculture has primarily been used for curriculum creation and reform (Bailey-Evans, 1994, Simon, 2003, and Stewart, Moore, & Flowers, 2003) and occasionally for expert opinion on forecasting scientific matters (Angus, Hodge, McNally, & Sutton, 2003).

Promotional and marketing content should directly focus on target audience and strive to create a long-term relationship with clients (Garber & Dotson, 2002, and McKee, 2005). Also, John Harlow, an executive for the advertising company, Naked, stated in an interview advertisements should not present a glossed-over, overreaching view of a company because consumers would be disappointed if the companies' products or services were anything less than perfect (Bloom, 2005). Instead, Harlow said companies should strive to present an accurate view of products and services in advertisements (Bloom, 2005). A 1999 article in *Advertising Age* titled Emotion Sells told how McDonald's advertising agency, Burrell Communications Group, believed creating emotional, sentimental advertisements would create an emotional bond between the company and its consumers, and the campaign proved successful (*Advertising* Age, 1999). Also, the University of Texas acknowledged the advantage of accessibility of their electronic magazine, *Vmag*, which allows subscribers an inside look of the Longhorns football program (Varughese, 2005). Because *Vmag* is distributed electronically, there are no geographical limitations or impositions (Varughese, 2005).

Tyson, Ross, Broderick, and Westa (2004) studied the viewing rates of direct-mail discs compared to direct-mail printed materials. Their study stated 90% of people who received the video watched it and were more likely to visit the subject company's Web site, and discs received a 600% higher response rate than printed materials (Tyson, Ross, Broderick, & Westa, 2004).

METHODOLOGY

The study used a three-round Delphi method, designed by the authors, to achieve a consensus from a panel of experts based on multiple responses. The researcher emailed three separate surveys. The first survey gained information from the population six categories. The second and third surveys narrowed the responses using an 80% consensus. A group of researchers consisting of the authors developed the questions

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asked in the surveys by using ICFIE's strategic plan. By asking participants to list items the DVD should highlight of six different areas of ICFIE as well as a seventh "other" category to identify areas which might not fit into the

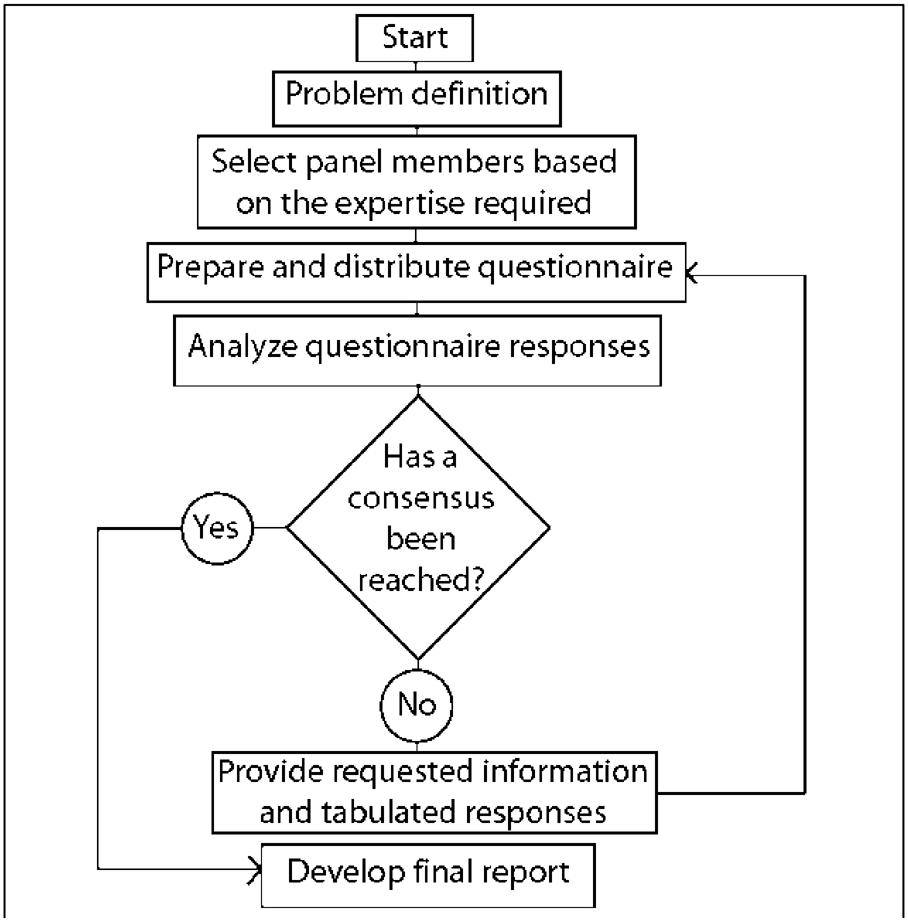

Figure 3: Flowchart for the Delphi method (Joppe, 2005).

The population of this study consisted of 6 of 12 faculty board members, 10 of 13 industry board members, and 8 staff members of ICFIE. The faculty board members either helped create or develop ICFIE or existing members selected them to join. The faculty board members selected the industry board members to serve. The faculty board members also employed the staff members and student assistants. All 24 members of the population share a common tie by serving as ICFIE board members or working for ICFIE. Each person selected demonstrated a sufficient knowledge of ICFIE, its purposes, and its goals. Additionally, no turnover of board members, staff members, or student assistants occurred during the study.

Initial contact was made March 29, 2006, when the researcher sent a participation letter to all 33 potential participants. Six of the 12 faculty board members (3 males and 3 females) and 10 of the 13 industry board members (9 males and 1 female)

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agreed to participate. Additionally, ICFIE faculty board members asked their staff members and student assistants to participate. The eight staff members and student assistants joined the study by this method. Thus, 26 of 33 population members agreed to participate, creating the sample. Respondents were not made aware of who else was completing the questionnaires.

The authors administered the three rounds of questionnaires electronically. Each participant was informed his or her answers were confidential. The population was sent an email containing a Web site created by the authors for each round of the Delphi. For Round 1, the Web site consisted of the six areas of ICFIE along with the "other" category with a text box underneath each where respondents listed items within each area they believed should be included on the promotional DVD. For Round 2, items gained in the Round 1 questionnaire were listed in their respective categories, and panelists used a four-point Likert scale to rate if they agreed or disagreed with the importance of placing each item on the DVD. Items which received an 80% consensus, or agreement percentage, of "agree" or "strongly agree" were recommended to be placed on the DVD. Round 3 consisted of items on the Round 2 questionnaire which did not reach 80% consensus. Panelists again used the same four-point Likert scale to rate importance. Items which achieved the consensus in Round 3 were also recommended for inclusion on the DVD.

Because the study utilized online questionnaires, once population members submitted their answers electronically, authors obtained the responses and response percentages. Additionally, the primary author calculated all responses aside from the electronic statistics to verify the accuracy of percentages.

RESULTS

Round 1 of the Delphi yielded 97 items within the seven areas of ICFIE from 19 respondents, creating a response rate of 79.17%. In Round 2, 16 respondents (66.67% response rate) came to a consensus of at least 80% on 65 of the 97 items. Round 3 produced at least an 80% consensus on 4 of 32 items which did not reach consensus in Round 2.

A total of 16 items in the animal and food science area which reached at least an 80% consensus in Round 2 are shown in Table 1. Table 2 contains the nine items in the human sciences area which reached at least an 80% consensus in Round 2 of the Delphi, including three which received 100.00% consensus. The six items in the agricultural education and communications area which had at least an 80% consensus in Round 2 are displayed in Table 3. "Short course and training session capabilities" reached 100.00% agreement. The ICFIE services area had the greatest number of items which reached at least 80% consensus in Round 2. Table 4 contains these 18 items, and within those are four items with 100.00% agreement. Table 5 holds the 12 items in the area of ICFIE accomplishments which made the consensus in Round 2. "Total grant dollars earned and money generated for research by ICFIE" made 100.00% consensus.

The Texas Tech University section contained two items which reached the 80% consensus in Round 2 as shown in Table 6. The other areas or items section in Table 7 also contained two items which made consensus in Round 2. Although no items within the animal and food science area achieved at least an 80% consensus in Round 3, two items in the human science area achieved consensus in the final round. As shown in

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Table 8, the items "training and preparation for industry employment" (86.67%, *n* = 13) and "industry connections" (80.00%, *n* = 12) were recommended for inclusion on the promotional DVD.

No items from the agricultural education and communications area achieved at least an 80% consensus in Round 3. However, in the area of ICFIE services, two items received a Round 3 consensus of 80.00% (*n* = 12): "lab and sensory lab services" and "contract research." The two previous items can be found in Table 9.

Table 1. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence components in the area of animal and food science which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
Animal and food science				
– Animal and food science building	31.25	43.75	25.00	100.00
– Capability to install pilot plants	31.25	43.75	25.00	100.00
– Food safety research	31.25	43.75	25.00	100.00
– Laboratories and sensory labs	31.25	43.75	25.00	100.00
– Product development and testing capabilities	31.25	43.75	25.00	100.00
– Global ICFIE activities	31.25	37.50	25.00	93.75
– Gordon W. Davis Meat Science Laboratory	25.00	43.75	25.00	93.75
– Nutrition research	25.00	43.75	25.00	93.75
– Research capabilities	31.25	37.50	25.00	93.75
– AFS building tour	25.00	43.75	18.75	87.50
– Animal health research	18.75	43.75	25.00	87.50
– Food safety laboratories	25.00	7.50	25.00	87.50
– Interviews with researchers	31.25	37.50	18.75	87.50
– Researchers' range of expertise	31.25	37.50	18.75	87.50
– Food Technology building, equipment, and laboratories	31.25	25.00	25.00	81.25
– Proximity to commercial beef feeding and processing	25.00	31.25	25.00	81.25

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

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Table 2. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence components in the area of human sciences which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
Human sciences				
– Human sciences laboratories	31.25	43.75	25.00	100.00
– Sensory laboratories	31.25	43.75	25.00	100.00
– What differentiates TTU human sciences from other universities' programs	31.25	43.75	25.00	100.00
– Nutrition and health research	25.00	43.75	18.75	87.50
– Published and recognized research, projects, and programs	31.25	37.50	18.75	87.50
– Test/research kitchens	31.25	37.50	18.75	87.50
– Food preparation and marketing	25.00	43.75	12.50	81.25
– Interview human science researchers	31.25	31.25	18.75	81.25
– Media coverage	31.25	31.25	18.75	81.25

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

Table 3. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence components in the area of agricultural education and communications which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
Agricultural education and communications				
– Short course and training session capabilities	31.25	43.75	25.00	100.00
– ICFIE Web site	31.25	37.50	25.00	93.75
– Communication connections within the food industry	25.00	37.50	25.00	87.50
– Distance education capabilities and facilities	25.00	31.25	25.00	81.25
– Multimedia services	31.25	25.00	25.00	81.25
– Telecommunications abilities	25.00	37.50	25.00	81.25

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

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Table 4. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence (ICFIE) components in the area of ICFIE services which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
ICFIE services				
– Ability to use pilot plant as tool for industry partners	31.25	43.75	25.00	100.00
– HACCP training	31.25	43.75	25.00	100.00
– Microbiological analysis	31.25	43.75	25.00	100.00
– Pre-harvest and post-harvest food safety	31.25	43.75	25.00	100.00
– Ability to scientifically research product packing and promotion	31.25	37.50	25.00	93.75
– Food quality and safety research and accomplishments	25.00	43.75	25.00	93.75
– Technology transfer	31.25	43.75	18.75	93.75
– Distance education courses	25.00	37.50	25.00	87.50
– Educational workshops	25.00	37.50	25.00	87.50
– Sensory analysis	31.25	37.50	18.75	87.50
– Services available to the business community	25.00	43.75	18.75	87.50
– Short courses	25.00	3.75	18.75	87.50
– Consumer sensory studies	25.00	43.75	12.50	81.25
– Genomic capabilities	25.00	37.50	18.75	81.25
– New meat processing facility	25.00	43.75	12.50	81.25
– Retail case life and display	31.25	25.00	25.00	81.25
– Show equipment and list general services available	31.25	37.50	12.50	81.25
– Third-party endorsements from industry partners	25.00	37.50	18.75	81.25

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

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Table 5. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence (ICFIE) components in the area of ICFIE accomplishments which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
ICFIE accomplishments				
– Total grant dollars earned and money generated for research by ICFIE	31.25	43.75	25.00	100.00
– Adoption of research technologies for commercial industries	31.25	37.50	25.00	93.75
– 2 endowed chair positions in meat science	18.75	43.75	25.00	87.50
– Internationally known researchers who validated work through ICFIE	25.00	37.50	25.00	87.50
– Nationally recognized faculty awards	25.00	37.50	25.00	87.50
– Research projects received	25.00	37.50	25.00	87.50
– $4 million in endowments to support meat science	12.50	43.75	25.00	81.25
– Corporate sponsors	18.75	43.75	18.75	81.25
– Food safety accomplishments	25.00	37.50	18.75	81.25
– Grants	31.25	31.25	18.75	81.25
– Patents	18.75	43.75	18.75	81.25
– Web site and dissemination of information	25.00	31.25	25.00	81.25

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

Table 6. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence components in the area of Texas Tech University which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
Texas Tech University				
– Unique opportunity of being near prominent West Texas agricultural industries	31.25	37.50	25.00	93.75
– University contains academic campus, law school, and medical school	25.00	37.50	25.00	87.50

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

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Table 7. Agreement levels of Round 2 questionnaire International Center for Food Industry Excellence components in the other areas or items section which received 80% consensus (n = 16).

Features	Faculty	Industry	Staff	Agreement %*
Other areas or items				
– Pathogen processing laboratory	31.25	37.50	25.00	93.75
– International work	25.00	37.50	25.00	87.50

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

Table 8. Agreement levels of Round 3 questionnaire International Center for Food Industry Excellence components in the area of human sciences which received 80% consensus (n = 15).

Features	Faculty	Industry	Staff	Agreement %*
Human sciences				
– Training and preparation for industry employment	20.00	40.00	26.67	86.67
– Industry connections	20.00	40.00	20.00	80.00

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

Table 9. Agreement levels of Round 3 questionnaire International Center for Food Industry Excellence (ICIFE) components in the area of ICFIE services which received 80% consensus (n = 15).

Features	Faculty	Industry	Staff	Agreement %*
ICFIE services				
– Lab and sensory lab services	20.00	40.00	20.00	80.00
– Contract research	20.00	33.33	26.67	80.00

* Percentage of respondents who answered with either 3 (Agree) or 4 (Strongly Agree) combined.

DISCUSSION

The data indicated the panelists desired the DVD to provide an all-around view of ICFIE with basic information, specialties and research concentrations, and items which made ICFIE unique. Complete information about features which should be included in the promotional DVD is found in the previous section. The experts came to a consensus on 69 items which give a well-rounded view of the center and region to potential clientele. They targeted some basic features of ICFIE, showed items unique to the center, and focused on highlighting the biggest strengths of the center and its researchers. The Delphi method proved successful in sorting through a high number of items in a very specialized field.

ICFIE industry board and faculty board members as well as staff responded positively to areas which gave general impressions and very basic information about the

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center and its facilities, such as the different types of laboratories. They also reacted well to items which conveyed an individual, unique feel to the center, such as "global ICFIE activities," "nationally recognized faculty awards," and "what differentiates TTU human sciences from other universities' programs." Additionally, the panelists focused on the center as a whole rather than spotlighting very specific areas by eliminating several items dealing only with the meat science program's individual success unrelated to ICFIE.

The DVD should focus more on items which received a high agreement percentage than those with a lower agreement percentage. The 14 items which achieved a 100.00% consensus in Round 2 ($n = 16$) from the respondents should be the primary focus of the DVD. Those which received at least an 80% consensus but less than a 100.00% consensus should also be featured on the DVD but receive less attention and time than those with 100.00% agreement.

Some discrepancies arose among items. "Unique opportunity of being near prominent West Texas agricultural industries" and "proximity to commercial beef feeding and processing" achieved consensus while "university close to many large feedlots and packing plants" did not. "Global ICFIE activities will be included in the DVD, and "international travel" will not. These discrepancies should not make a significant difference to the finished DVD in the eyes of potential clients or those involved with ICFIE. Most are overlapping areas, so they will be covered in some form in the DVD. To avoid discrepancies in future research or other Delphi studies, a researcher could utilize a focus group independent of the panel of experts to streamline answers to open-ended questions to develop more uniform items for further Delphi rounds to avoid confusion for respondents.

Gaining consistent participation from panel members was also a challenge. Despite giving consent to participate in the study knowing its time requirements and the use of follow-up emails and phone calls, response rates came to 79.17% in Round 1, 66.67% in Round 2, and 62.50% in Round 3 – all below the desired response rate of 100.00%. To increase response rate in the future for this type of Delphi, researchers may benefit from keeping the time frame of the study quick and concise from beginning to completion, not conducting the questionnaires during the summer to avoid absences from faculty and staff due to research conferences, and maintaining personal contact through all rounds with panelists, especially those reluctant or late to respond.

Overall, the Delphi method was an efficient, effective method for determining the content of a promotional DVD. The use of the Internet surveys with a Delphi was cost-effective for the researcher and time-effective for both the researcher and panel of experts. It allowed the researcher to keep track of respondents and their responses and gave 24-hour access from any Internet-capable location to the questionnaire to the panel members. The researcher recommends others look beyond the use of the Delphi method for curriculum development and utilize the method for developing promotional material for businesses.

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The Effect of Protein Level On Feedlot Performance And Carcass Characteristics Of Texas Rambouillet Ewes

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ABSTRACT

Aged Rambouillet ewes, 5 to 7 years old, are usually culled in Texas. Some producers have chosen to feed their aged ewes high energy diets, a feedlot practice, before they send them to harvest. This practice may prove to be profitable as the ewes will gain extra weight and bring more money at sale time. Research on the feedlot performance of aged ewes is very limited. The purpose of this research is to compare different protein level on feedlot performance (rate and efficiency of gain) and carcass composition in aged Rambouillet ewes. A total of 28 ewes were blocked by weight and BCS and randomly assigned to a pen. The pens measured 3.048 m by 9.144 m. The trial consisted of 28 ewes placed in one of 14 pens with two ewes per pen. Pens were allocated to one of three different treatments consisting of four pens on WH (wheat hay), five pens on SBH (soybean hulls), and five pens on GR (grain ration). These treatments resulted in varying amounts of protein. Ewes were weighed every 28 days and kept on trial for 84 days. Carcass characteristics were measured after carcasses were chilled for 24 hours. Performance was greater (*P*<0.05) for ewes on GR for total gain, ADG as well as BCS and BCS change. Feed efficiency was also better (*P*<0.05) for GR as compared to WH and SBH. Ewes on GR had greater (*P*<0.05) fat depth at the twelfth rib than SBH or WH and SBH ewes were fatter than WH with no differences (*P*>0.05) across treatments in carcass weights or dressing percents. Upon evaluation of the economic data, the feeding of aged ewes in a down market appears to be unprofitable and actually resulted in a loss. However, if the market remained steady, profit could be gained by feeding aged ewes. This research only shows that further focus of commercial operations is needed to determine the actual profitability of feeding aged ewes.

KEYWORDS: Sheep, Protein, Carcass

INTRODUCTION

Sheep production in West Central Texas is a large constituent of the agricultural economy of the area. The West Texas region is considered the top sheep producing region in the nation (USDA-AMS, 1997). According to the United States Department of Agriculture – National Agriculture Statistics Service (USDA-NASS), the West Central region of Texas had an inventory of 857,000 head of sheep in 2003. This comprises 76 percent of all sheep in Texas (USDA-NASS, 2003). In 1997 sheep, lamb, and wool sales totaled 97 million dollars in Texas. Most of this was from the sale of red meat, especially that of lambs. Yet, a part of this red meat also comes from the sale of older ewes.

The termination of wool subsidies made sheep producers turn their focus from wool production to red meat production. Sheep operations in West Central Texas make most of their money from the sale of feeder lambs to feedlots (Personal communication, A.H. Denis, Denis Ranch, Vancourt, TX). On a per farm basis, there is a thin margin between profit and loss on sheep operations. Therefore, any extra from any venue, such as sales of cull ewes fed to a higher weight, can be the difference between profit and loss.

Aged ewes, 5 to 7 years old, are usually ewes that the producer has decided not to breed anymore. The ewes are usually sent to harvest facilities after their last lamb is weaned, as an effort to minimize the cost of maintenance for the operation. Some producers have chosen to feed their aged ewes high energy diets, a feedlot practice, before they send them to harvest. This practice may prove to be profitable as the ewes will gain extra weight and bring more money at sale time.

Research on the feedlot performance of aged ewes is very limited. Therefore, little is known about how aged ewes perform in feedlot situations. The purpose of this research is to compare protein level on feedlot performance (rate and efficiency of gain) and carcass composition in aged Rambouillet ewes.

MATERIALS AND METHODS

Animals and Feeding

This study was conducted at the Angelo State University Management, Instruction, and Research Center (MIR Center), located in Tom Green County north of San Angelo, Texas. A total of 28 Rambouillet ewes greater than 4 years of age averaging 53 kg were used for this trial. The ewes were blocked by weight and BCS and assigned to 14 pens of two ewes per pen. Pens were allocated to one of the three different treatments consisting of four pens on WH, five pens on SBH, and five pens on GR, which was prepared at the MIR Center, (Table 1) containing varying levels of protein. All treatments met or exceeded NRC requirement for maintenance in ewes (NRC, 1985a). Ewes had *ad libitum* access to feed and fresh water for the 84d trial. Feed refusals were removed and weighed each time a new batch of feed was placed in the feeders so that feed efficiency could be calculated, including ADG, gain:feed ratio, cost of gain, and profit. Feed efficiency was calculated by dividing the kg of gain by kg of feed. Percent of maintenance CP and percent of maintenance TDN were calculated for each diet. Ewes were kept in pens measuring 3.048 m by 9.144 m. Upon arrival ewes were tagged and weighed and treated with an anthelmintic.

Data Collection

Ewes were individually weighed on day zero, 28, 56, and 84 to determine feedlot performance for each treatment. At initial and final weigh days, ewes were evaluated and given a BCS on a scale of zero to five, zero being extremely emaciated and five being excessively obese. Evaluation was done by palpation method as described in the Sheep Production Handbook (American Sheep Industry Association, 1996). At d 84 of the trial, ewes were harvested following normal commercial conditions at Rancher's

Lamb of Texas Inc., and carcasses were spray chilled at 2°C for 20 to 24 hours. Carcasses were then evaluated for backfat thickness at the twelfth rib. Dressing percent was also calculated by taking the hot carcass weight (HCW) and dividing it by the live weight and multiplying it by 100.

Table 1. Ingredients and nutrient density for WH, SBH, and GR fed *ad libitum* for 84 d.

	Treatment[a]		
Item	WH	SBH	GR
	--------------------------------% as fed----------------------		
Ingredients			
Sorghum grain	-	-	45
Soybean hulls	-	100	22.5
Alfalfa pellets	-	-	17
Cottonseed meal	-	-	10
Cane molasses	-	-	3
Mineral premix	-	-	2.5
Wheat hay	100	-	-
	---------------------------------DM--------------------------		
Nutrient Density			
Crude Protein(CP), %	15.4	14.3	17
NE_g, Mcal/kg	0.6	0.7	1.2
Neutral Detergent Fiber, %	51.4	59.8	34.3
Acid Detergent Fiber, %	28.7	40.2	25.7
TDN, %	59	63	76

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration

Statistical Analysis

The trial was a completely randomized block design with a pen of two ewes being the experimental unit. The General Linear Model procedure (SAS Inst. Inc., Cary, NC) was used to determine the effect of protein level on feedlot performance and carcass characteristics. Analysis of variance and Fisher's protected LSD test was used to determine statistical significance at a predetermined $\alpha = 0.05$.

RESULTS AND DISCUSSION

Feed Analysis

Chemical analysis of all three feed treatments was conducted by Dairy One Inc., Ithaca, NY. Although the CP levels in SBH were lower than WH, TDN values were lowest in WH followed by SBH and then GR. Table 2 shows the percent of maintenance CP and TDN which the ewes ingested for each treatment. Maintenance CP and TDN levels were obtained from the NRC (1985a).

Performance Data

Ewes were blocked by weight and initial BCS. No differences ($P>0.05$) were found for weight and initial BCS (Table 3). The total number of ewes on trial was 28 in 14 different pens. The 14 pens were four pens on WH, five pens on SBH, and five pens on GR. Table 3 shows the least square means of final body weight (BW), gain, ADG, final BCS, and BCS change. No differences (*P*>0.05) were observed for the mean final weights. Although the ewes on GR gained more than the other treatments, they averaged a lighter initial weight numerically, therefore, the final weights tended to average to the same weight. Both total gain and ADG were significantly higher (*P*<0.05) for GR when compared to WH and SBH. Ewes on GR increased an average of 19.7 kg, which was 15 kg and 10.6 kg more than WH and SBH, respectively. This result agrees with Fluharty and McClure (1997), Hinds et al. (1965), and Hudson et al. (1967) who found increases in ADG and final weight in growing lambs when they increased the recommended NRC protein requirement. The final BCS and BCS change were also different (*P*<0.05) for SBH and GR from WH.

Table 2. Percent of maintenance crude protein and total digestible nutrients which pens of Texas Rambouillet ewes were ingesting per treatment.

	Treatment[a]		
Item	WH	SBH	GR
N	4	5	5
% of maintenance CP	166	258	405
% of maintenance TDN	109	195	311

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration

Table 3. Least square means of initial weight and BCS, and the effect of protein level on feedlot performance of pens (two ewes/pen) of Texas Rambouillet ewes.

	Treatment[a]			
Item	WH	SBH	GR	SE[b]
N	4	5	5	
Initial wt (kg)	113	108	100.2	6.8
Initial BCS(avg/animal)	2.25	1.97	1.96	0.17
Final BW, kg	122.4	126.2	139.8	8.5
Total Gain, kg	9.4[c]	18.22[c]	39.4[d]	4.5
ADG. kg/d	0.1[c]	0.22[c]	0.46[d]	0.06
Final BCS(avg/animal)	1.72[c]	2.83[d]	3.28[d]	0.18
BCS change(avg/animal)	0.53[c]	0.85[d]	1.31[d]	0.21

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration.
[b]Standard error of estimate.
[c,d]Means in the same row with uncommon superscripts differ $P < 0.05$.

Table 4 displays the intake and feed efficiency least square means for the three treatments. All three treatments significantly differed (*P*<0.05) from each other in intake. A difference in intake greatly differed between WH and GR from 199.6 to 393.2 kg per pen, respectively, a difference of 193.6 kg. A significant difference (*P*<0.05) was seen in efficiency when GR was compared to WH and SBH. GR ewes gained 0.10 kg per kg of feed consumed, while WH and SBH ewes only gained 0.03 kg and 0.06 kg, respectively, per kg of feed consumed. Fluharty and McClure (1997) also found an increase (*P*<0.01) in dry matter intake, but observed no difference in feed efficiency when protein level was increased in lamb rations. In another study, done by Braman et al. (1973), lambs and steers fed protein supplements had significantly higher feed efficiencies. Lana et al. (1997) observed no improvement in ADG or feed efficiency. The effects of protein increases in a ration are greater when a ration is low in protein than a ration high in protein where energy is readily available (Zinn and Owens, 1993).

Table 4. Least square means of intake, feed efficiency, and the effect of protein level on carcass characteristics of pens (two ewes/pen) of Texas Rambouillet ewes.

	Treatment[a]			
Item	WH	SBH	GR	SE[b]
N	4	5	5	
Intake, kg	199.6[e]	308[f]	393.2[g]	31.6
Efficiency, kg gain/kg feed	0.03[e]	0.06[e]	0.10[f]	0.015
Fat depth[c]. cm	0.45[e]	0.57[e]	1.07[f]	0.05
Hot carcass weight, kg	52.2	55.5	61.9	4.3
Dressing percent[d]	42.8	44.9	48.0	2.21

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration.
[b]Standard error of estimate.
[c]Fat depth measurement at the twelfth rib (avg/animal).
[d]Dressing percent = hot carcass weight/live weight.
[e,f,g]Means in the same row with uncommon superscripts differ $P < 0.05$.

Carcass Data

In this study fat depth, at the twelfth rib, hot carcass weight, and dressing percent were observed (Table 5). The fat depth of GR ewes was significantly different ($P<0.05$) from that of SBH and WH. WH and SBH fat depth measurements were not significantly different ($P>0.05$), but tended to increase as protein level increased. No differences ($P>0.05$) were found in hot carcass weight and dressing percent measurements. There was a tendency for weight to increase as protein level increased. Overall protein had only a slight effect on carcass composition other than fat depth. This agrees with the findings of Braman et al. (1973) on steers and lambs and Prior et al. (1977) with cattle.

Economic Data

Table 5 shows the cost of the WH, SBH, and GR feeds. The average price of WH was $70 per 909.1 kg (USDA-NASS, 2003) which equated to $0.08 per kg. The prices for SBH and GR were obtained from the financial records of the MIR Center and calculated to $0.12 and $0.14 per kg, respectively. The highest protein, GR, was $61.94 per 909.1 kg more than lowest protein WH.

Table 5. Analysis of treatment cost.

	Treatment[a]		
Item	WH	SBH	GR
Price per 909.1 kg	$70.00	$106.00	$131.94
Price per kg	$ 0.08	$ 0.12	$ 0.14

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration

Table 6 shows the least square means of the economic data for this trial. Ewes were sold at the harvest facility for $0.55/kg of carcass weight. No differences ($P>0.05$) were found between any of the treatments for carcass value. Total feed cost, cost of gain, and profit were not statistically tested, only calculated on averages. Table 6 shows that all treatments were at a loss. Yet, since the smallest cost of gain is $1.70/kg, and the ewes only bring $0.55/kg, this seems to imply that feeding out aged ewes is non-profitable. However, at the time these ewes were bought the price of slaughter ewes was high because supply was low, and when ewes were sold prices were low. If the market had remained steady from purchase to sale the profit margin would have been positive.

Table 6. Least square means of economic data (U.S. dollars) for pens (two ewes/pen) of Texas Rambouillet ewes.

	Treatment[a]			
Item	WH	SBH	GR	SE[b]
n	4	5	5	
Purchase price[c], $	107.66	107.66	107.66	
Carcass value[d], $	66.83	68.93	76.37	5.27
Total feed cost[e], $	15.06	37.57	55.49	
Cost of gain kg[f], $	2.19	2.63	1.70	
Profit[g], $	-55.89	-76.30	-86.78	

[a]WH = wheat hay, SBH = soybean hulls, GR = grain ration.
[b]Standard error of estimate.
[c]Average price of ewes at beginning of trial.
[d]Average value ewes were sold for.
[e]Average cost of ration per ewe.
[f]Cost of ration per weight gain in kg.
[g]Profit = (carcass value) – (purchase rice + tot feed cost).

CONCLUSIONS

Results from this trial show increased gain rates and more weight in aged ewes on the higher protein treatment. In addition, the fat depth at the twelfth rib increases with increasing protein level. Overall, this trial showed a loss of money occurs when feeding out aged ewes; however, if market conditions remain steady the cost of gain should be profitable. Further research is needed to determine the actual profitability of feeding aged ewes on an actual operation situation where the operator does not have to purchase the ewes.

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EFFECTS OF VARYING FORAGE SOURCE IN A CONCENTRATE DIET ON THE METABOLISM AND APPARENT RETENTION OF CRUDE PROTEIN BY LAMBS

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ABSTRACT

Twenty-one Rambouillet wether lambs (average initial body weight (BW) = 41 kg) were used in a metabolism trial to evaluate the digestibility of three different concentrate diets each containing one of the following: alfalfa pellets (*Medicago sativa* L.), bermudagrass-clipping (*Cynodon dactylon* L.) pellets, or Coastal bermudagrass hay (*Cynodon dactylon* L.) pellets. Treatments were arranged in a completely randomized design for dry matter intake (DMI), fecal excretion, and dry matter digestibility (DMD) using analysis of variance. Analysis of covariance was used for N intake, (g/d), fecal N, (g/d), fecal N, (% of intake), urinary N, (g/d), urinary N, (% of intake), N absorbed, (g/d), % N absorbed, N retained, (g/d), and N retained, (% of intake). Prior to the study, lambs were housed in pens and fed the control diet containing alfalfa pellets. A five day adaptation period was followed by a seven day collection period. Intake by lambs was limited to 2.5% of BW. Dry matter intake and dry matter digestibility were not different (P > .05) among treatment groups. Nitrogen intake, apparent absorption, and apparent retention expressed as percent of intake and g/d did not differ among lambs fed their diets. Initial weight was used as a covariate in the N data to account for any unwanted variation within treatment groups. Based on the absorption and retention data, bermudagrass-clipping pellets are an adequate forage source at 10% of the diet for lambs on a concentrate diet.

KEYWORDS: bermudagrass, metabolism, digestibility, lamb

INTRODUCTION

Proper amounts of forage are necessary for the development of lambs consuming a concentrate diet. It is suggested by the NRC (1985) that lambs between the ages of 4 and 7 months of age weighing approximately 30 kg should receive a diet consisting of 60% concentrate and 40% forage. Alfalfa is often the forage used in these concentrate diets because of the high nutritive qualities that it can provide to the animal. Crude protein in high quality alfalfa commonly exceeds 18% (Weder, 1999). Alfalfa also is high in calcium and phosphorus as well as vitamin A. These are minerals and vitamins that are necessary for proper development of growing lambs (NRC 1985). All of these qualities make alfalfa an excellent forage source to use in the diets of livestock.

Bermudagrass grown in domestic lawns is maintained under near optimal conditions to provide a high aesthetic value to homes. This aesthetic value increases the value of the home, but generally provides no other value. After these lawns are cut, the grass-clippings are disposed. Laboratory analysis has determined that grass clippings from these highly maintained lawns can provide some of the same nutritive characteristics as alfalfa. Crude protein levels of samples taken from these lawns have reached as high as 24% (Starbuck, 2003). Calcium and P levels also have shown to be similar to alfalfa through laboratory analysis.

While alfalfa is an excellent forage source for livestock; planting, growing, fertilizing, harvesting, baling, and transporting can become costly. Bermudagrass grown in domestic lawns on the other hand is grown for reasons other than providing forage to livestock. Therefore, research was conducted to determine if bermudagrass-clippings can provide an alternative forage source to alfalfa. The objective of this study was to evaluate the apparent absorption and retention of CP by lambs fed a concentrate diet containing alfalfa pellets, bermudagrass-clipping pellets, or Coastal bermudagrass hay pellets at 10% of the diet.

MATERIALS AND METHODS

Animals, Diets, and Management: Twenty-one Rambouillet wether lambs (average initial BW=41 kg) were used to evaluate the effect of forage source in a concentrate diet on the metabolism and retention of CP by lambs. Prior to the study, lambs were vaccinated, drenched, and placed in a feedlot style pen where they had free access to water and began to receive the control diet (Table 1) at 1.36 kilograms per head. Lambs were fed in the feedlot pen for 2-week period for adjustment to the diet. Lambs were then randomly assigned to treatment groups (seven lambs per treatment) in a completely randomized design and placed in metabolism crates. Metabolism crates were designed to allow a full collection of unconsumed feed, urine, and fecal material. The crates included an individual water source, removable feed bunk, fecal tray and collection bin, and a urine pan that funneled urine into a storage container. Diets consisted of: alfalfa pellets, Coastal bermudagrass hay pellets, or bermudagrass-clipping pellets at 10% of the total ration. Alfalfa pellets and bermudagrass hay were obtained from a local feed company. Bermudagrass-clipping pellets were obtained through a local landscape company. All clippings were obtained from one sight. Tables 2 and 3 list the ingredient composition of the treatment diets. Chemical composition of experimental diets fed to lambs is listed in Table 2. Lambs remained in metabolism crates for 12 d. Day 1 through 5 was considered an adaptation period and day 6 through 12 was the collection period. Table 3 shows the collection schedule of samples taken and the days of the collection period when samples were taken. Initial weights were used to calculate the daily quantity of feed (2.5% of BW) to be offered to the lambs for the duration of the 12 d period. After lambs were placed in metabolism crates, they were offered half of their daily allotment of feed. Lambs were fed twice daily at approximately 0800 and 1700 daily. A feed sample from each diet was On day 5 through 11, unconsumed feed was transferred to numbered buckets, weighed, and stored for later laboratory analysis.

Table 1. Ingredient Composition of Diets (% of diet, DM basis)

Item	Alfalfa Diet	Coastal Hay Diet	Grass Diet
Ingredient			
Cracked Corn	64.70	64.37	64.87
Cottonseed Meal 41% CP	5.75	5.75	5.75
Soybean Meal 44% CP	2.05	2.05	2.05
Cottonseed Hulls	10.50	10.50	10.50
Pelleted Bermudagrass-Clippings	0.00	0.00	10.00
Coastal Bermudagrass Hay Pellets	0.00	10.00	0.00
Alfalfa Pellets	10.00	0.00	0.00
Calcium Carbonate	1.30	1.30	1.30
Ammonium Chloride	0.50	0.50	0.50
Cane Molasses	5.00	5.00	5.00
Urea	0.17	0.50	0.00
Premix[a]	0.03	0.03	0.03

[a]Premix included Vitamin A, Selenium, and Decox at levels recommended by NRC (1985)

Table 2. Chemical Compositions of Experimental Diets Fed to Lambs

Item	Alfalfa Diet	Coastal Hay Diet	Grass Diet
DM, %	86.6	87.25	87.8
Ash, %	7.61	8.27	8.45
CP, %	13.82	13.71	13.65
Ca, %	1.2	1.05	1.14
P, %	0.39	0.38	0.41

Table 3. Collection Schedule of Samples Obtained

	Samples Obtained[a]				
Day	Body Weight	Feed	Refusal	Fecal	Urine
0	+	x	x	x	x
1	x	x	x	x	x
2	x	x	x	x	x
3	x	x	x	x	x
4	x	+	x	x	x
5	x	+	+	x	x
6	x	+	+	+	+
7	x	+	+	+	+
8	x	+	+	+	+
9	x	+	+	+	+
10	x	+	+	+	+
11	x	x	+	+	+
12	x	x	x	+	+

[a] + = sample taken; x = no sample taken

After completion of the study, each sample was ground through a 2mm screen in a Wiley mill and dried overnight in a 100° C oven to determine dry matter. The quantity of the dry unconsumed feed was then subtracted from the quantity of dry feed offered from day 4 to 10 to determine the actual amount of dry feed consumed.

Urine samples were obtained from each lamb on day 6 through 12 of the collection period. Prior to the P.M. feeding, urine containers (one gallon plastic jugs) from each crate were removed. To ensure that no urine was lost, another container containing 100 mL of 20% (vol/vol) HCl immediately replaced the old container. HCl was added to each container to prevent loss of N to the atmosphere through volatilization (Salisbury et al., 2004). The quantity of urine excreted by each lamb was weighed daily and a 20% sub-sample was taken. The sub-samples were then transferred to a plastic container and stored in a refrigerator. At the end of the study, storage containers were frozen for later laboratory analysis. Upon analysis, a 3-mL sample was used to determine N content by Kjehldahl analysis (AOAC, 1990).

Fecal samples were obtained on d 6 through 12. At the conclusion of the trial, fecal samples were placed in a freezer for later laboratory analysis. Upon analysis, samples were dried overnight in a 100° C oven to determine dry matter. Samples were then ground through a 2mm screen in a Wiley mill and analyzed for N content via LECO analysis.

Statistical Analysis: Dry matter intake g/d, fecal excretion g/d, and percent dry matter digestibility were analyzed as a completely randomized design in the GLM procedure of SAS (1999). Animal was considered the experimental unit with seven replications per treatment group.

N intake g/d, fecal N g/d, fecal N percent of intake, urinary N g/d, urinary N percent of intake, N absorption g/d, percent N absorbed, N retained g/d, N retained percent of intake, and N retained percent of absorbed was analyzed as a completely randomized design using initial body weight as a covariate in the GLM procedure of SAS (1999). Initial body weight was used as a covariate to account for any unwanted variation within treatment group. Animal was again considered the experimental unit and there were seven replications per treatment group.

RESULTS

Dry matter intake, fecal excretion, and dry matter digestibility were not significantly different ($P > .05$) among the alfalfa diet, Coastal hay diet, and bermudagrass-clipping diet. Nitrogen intake, (g/d), fecal and urinary N excretion, and apparent absorption and retention (g/d or percent of intake) did not differ among diets ($P > .05$). Initial weight, expressed as a covariate, was not significant at the ($P < .05$) level for any N analyses, but began to approach significance ($P < .15$) for N intake, fecal N g/d, urinary N g/d, and N absorbed g/d. Therefore, initial weight expressed as a covariate was left in the model to account for the unwanted variation within treatment groups. Results from the metabolism trial are listed in Tables 4 and 5.

DISCUSSION

Lambs in this study were placed in metabolism crates to determine digestibility of diets as well as CP retention and absorption. Results indicate that each diet offered to the lambs within each treatment provided the same amount of digestibility as well as retention and absorption of protein. Previous research by Galloway et al., 1991; and Buxton et al., 1995 found that cool-season grasses usually contain higher concentrations of crude protein and lower concentrations of NDF than warm season-grasses. This can also be said for legumes such as alfalfa which is a cool season plant. Preliminary laboratory analysis of alfalfa pellets, bermudagrass-clipping pellets, and Coastal bermudagrass hay; (Table 6) shows that the alfalfa has higher crude protein values than that of the Coastal bermudagrass hay and the lowest percent neutral detergent fiber values. This would lead to believe that the alfalfa diet would be the most digestible. However, because the results reflect no differences ($P < .05$), we conclude that because the forage source only made up 10% of the diet, it was not substantial enough to effect digestibility, protein retention, or absorption.

Table 5. Treatment Effects On Nitrogen Metabolism By Lambs Consuming Three Different Forage Sources

	Treatment			
Item	Alfalfa Diet	Coastal Hay Diet	Grass Diet	SEM
Lambs per treatment	7	7	7	-
Nitrogen intake, g/d	18.09[a]	18.63[a]	19.99[a]	1.26
Fecal N, g/d	5.96[a]	5.57[a]	7.07[a]	0.60
Fecal N, % of intake	32.50[a]	30.24[a]	35.12[a]	2.09
Urinary N, g/d	10.49[a]	9.76[a]	9.31[a]	0.85
Urinary N, % of intake	60.77[a]	53.44[a]	47.05[a]	5.80
N absorption, g/d	12.13[a]	13.05[a]	12.91[a]	0.92
N absorption, %	67.49[a]	69.75[a]	64.87[a]	2.09

N retained, g/d	1.63[a]	3.29[a]	3.60[a]	1.15
N retained, % of intake	6.72[a]	16.30[a]	17.81[a]	6.33
N retained, % of absorbed	9.36[a]	22.93[a]	26.51[a]	9.16

[a] Means within the same row with different superscripts differ (P < .05)

While fecal N g/d is not different (P < .05) between the three diets, it approaches significance (P = .09) between the coastal and grass diet. The grass diet has the highest numerical value for fecal N g/d, but has the lowest numerical value for urinary N g/d. While the differences from the diets are not significant (P < .05) for fecal and urinary N, assumptions can be made that lambs on these diets may have been synthesizing microbial protein at a slightly higher rate. Antoniewicz et al., 1980; and Lindberg et al., 1989 supported this by stating that urinary N excretion is an indicator of microbial protein synthesis. However, N intake was also numerically higher for lambs on the grass diet. Nitrogen absorbed and nitrogen retained were also not significantly different (P < .05) between treatment diets.

Table 6. Chemical Composition of Alfalfa Pellets, Bermudagrass-Clipping Pellets, and Coastal Bermudagrass Hay Pellets[a]

	Alfalfa	Coastal Hay	Bermudagrass
DM, %	92.81	92.1	89.25
Ash, %[a]	12.3	6.08	15.35
CP, %[a]	18.81	10.65	24.23
Ca, %[a]	1.19	0.43	1.12
P, %[a]	0.22	0.15	0.3
NDF, %[a]	45.52	72.31	58.51

[a] DM Basis

IMPLICATIONS

Bermudagrass-clippings used in this study were a viable forage source in the diets of lambs when used at 10% of a concentrate diet. While there were no differences ($P < .05$) in digestibility, N retention, and apparent N absorption, further studies need to be conducted with higher percentages of forage sources to determine differences amongst treatments.

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The Texas Journal of Agriculture and Natural Resource 20:91-97 (2007)

Anhydrous Ammonia Injection Into Polyethylene Silage Bags to Enhance Forage Quality Attributes

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ABSTRACT

The injection of anhydrous ammonia (A-NH_3) into bagged silage would allow variable applications of N to improve crude protein content of feeds. Trials evaluated the effectiveness of A-NH_3 injection into silage for changes in nutrient characteristics and to evaluate animal preference. In Trial 1, A-NH_3 was injected into a 30 t polyethylene bag of sorghum silage at 1% DM. Injection was easily accomplished; the A-NH_3 moved some vertically and horizontally, but movement was limited, likely due to excessive moisture in the silage. In Trial II, polyethylene bags with 10 lb of forage were injected with 0, 1 or 2% A-NH_3 on a DM basis and injected either pre-ensiling with or without corn or post-ensiling. Silage quality was improved with higher levels of A-NH_3. Injection of A-NH_3 during pre-ensiling stage of fermentation improved ($P<.05$) crude protein (CP) and NDF characteristics. Injection of A-NH_3 during post-ensiling phase had no effect ($P>.05$) on characteristics, but A-NH_3 volatilization losses occurred during injection. Holstein heifers fed various treated silage combinations showed no refusals, indicating acceptable silages. Treating silages with A-NH_3 shows potential as a method of increasing CP of silages and improving diet digestibility, but issues of optimum moisture content in silages and timing should be addressed.

KEY WORDS: silage, anhydrous ammonia, quality characteristics

INTRODUCTION

Profitable livestock operations are dependent on providing inputs that efficiently generate outputs, usually with high levels of animal performance. Feed costs represent from 45 -75% of the total cost of livestock production, depending on the species, and average 50 -60% and 70% for dairy and finishing beef cattle operations, respectively (Damron, 2003). Protein supplements in livestock diets are usually one of the most costly feed ingredients. Because of their ability to utilize dietary N to fulfill their nutrient requirements for protein, ruminants can be fed NPN sources (Jewell et al., 1986). Anhydrous ammonia (A-NH_3) is generally the cheapest source of N, but it is a hazardous material and caution must be taken with this pressurized liquid that has a boiling point of -28^{0}F (Shutske, 2005). Pressurized liquid A-NH_3 becomes a gas when exposed to the atmosphere and quickly binds with water, so typically it has been used as a fertilizer for agronomic crops and injected into the soil where it turns into a gas, but quickly binds with soil moisture.

"Bagging silage" began in Germany in the 1970's and came to the U.S. later that decade. Bagged silage continues to gain popularity as an inexpensive way to store silage and bags can be placed almost anywhere. The silage polyethylene bags (portable silos) could potentially allow an easy method of applying A-NH_3 to silages, since a small hole can be made in the bag at specified intervals to inject the A-NH_3 to effectively deliver the desired amount of N to the silage. While adding A-NH_3 to conventional silos has been attempted, most methods occur in the field at the end of the chopper or at the end of a blower, exposing the A-NH_3 to air. Volatilization losses of A-NH_3 are typically between 10 and 30% when utilizing these conventional methods of applying A-NH_3 (Kung et al., 1989). The silage bag would seem to be a better alternative because of its airtight environment and the small holes made in the bag to inject A-NH_3 can be closed post-injection with tape. However, there is no available research regarding injecting A-NH_3 into silage and any potential problems.

The objectives of this study were to evaluate A-NH_3 injection into a large silage bag to determine the potential, and if successful, utilize small experimental silos to evaluate level (0, 1 or 2%) of A-NH_3 injection at either pre-ensiling with and without added corn or post-ensiling, and to offer treated silages to heifers to determine silage refusals.

MATERIALS AND METHODS

This project had three phases: 1) pilot study to determine feasibility of injecting A-NH_3 and "small" bag experimental silos, 2) rates and timing of A-NH_3 application and its effects on silage quality characteristics, and 3) animal preference trial. The pilot project was to determine feasibility of adding A-NH_3 to the silage mass since only references regarding adding A-NH_3 to dry hay were available (Woolford et.al., 1984 and Wyatt et.al., 1989).

Phase 1. The pilot project was performed beginning in the summer of 2004 by injecting 1% A-NH_3 (DM basis) into a small (30 t) polyethylene bag of sorghum silage. The purpose of the pilot project was threefold: 1) test the effectiveness of the application device, b) test movement of the A-NH_3 and c) determine the effectiveness of mini silos.
Approximately 30 t of high moisture sorghum silage was bagged using a 10 ft diameter bagging machine manufactured by Ag Bag International. Injection of A-NH_3 was accomplished using a 1 in pipe 6 ft long and injected into the silage every 15 ft. The 1 in pipe was welded closed on one end and sharpened to a point and then re-opened by drilling a .5 in hole immediately behind the point. The other end of the pipe was attached to a flow meter, which was attached to a hose and fed directly from an A-NH_3 transport

trailer. After 4 wk post-injection, the silage bag was opened and visually inspected along with samples taken from four areas around the injection site (Figure 1).
The mini-silo feasibility project was performed using the sorghum silage to visually observe various A-NH_3 treatments. This study placed 10 lb of silage in 12 different 20 qt containers lined with heavy duty 120 qt trash bags. Each of the mini silos were labeled, twisted closed and rolled, and then duct-taped to properly seal the bags. Each mini-silo was injected with various amounts of A-NH_3, based on the number of seconds the valve on the regulator was opened.

Phase 2. In spring, 2005, 36 mini-silos were filled with approx. 10 lb each of mixed small grain (oat/ryegrass, *Avena sativa/Lolium multiflorum*) forage that was between 65% and 75% moisture. These mini-silos were created using a 3 ft diameter plastic tube filled with 10 lb of chopped forage and vacuum sealed. Bags were injected with A-NH_3 in three sites along each tube with a 60 ml syringe and 2 ½ in needle. The 36 mini-silos were divided into 4 replicates, each replicate having sub sets; 1): control silage, 2): A-NH_3 applied at the time of ensiling at 1% of DM , 3): A-NH_3 applied at the time of ensiling at 2% of DM, 4): control silage, 5): A-NH_3 applied post-ensiling, 1% A-NH_3, 6): A-NH_3 applied post-ensiling, 2% A-NH_3, 7): control + corn grain , 8): control +corn grain and 1% A-NH_3 at ensiling, and 9): control + corn grain and 2% A-NH_3 at ensiling. All mini-silos were allowed to ferment at least 4 wk to ensure ample fermentation time, with silos opened and sampled for nutrient characteristics, including % CP, NDF, ADF and IVDMD.

Phase 3. After completion of the ensiling period and collection of samples for chemical analysis, remaining silage was utilized in a silage preference trial using 340 kg Holstein heifers. Trials consisted of heifers in individual pens with access to three different treated silages in individual containers to determine if heifers refused to consume any of the silage treatments. The first set of studies evaluated preference of silages differing by timing of the application of the A-NH_3 (pre-ensiling with or without corn or post-ensiling). The second set of preference trials evaluated the effects of the level of A-NH_3 injected into the forage (0, 1% or 2% of DM). In preference trials, 4 heifers in individual pens were given choices in a cafeteria-style preference study with 5 lb of different types of silage: Day 1: 0% A-NH_3, control silage or silage + corn. Day 2: 1% DM of A-NH_3 injected pre-ensiling, post-ensiling, or pre-ensiling + corn. Day 3: 2% DM of A-NH_3 injected pre-ensiling, post-ensiling and pre-ensiling + corn. In the second portion of the trial where level of injection A-NH_3 was compared; Day 4: silages injected pre-ensiling plus corn with A-NH_3 at 0, 1%, and 2% DM basis. Day 5: silages injected post-ensiling with A-NH_3 at 0, 1%, and 2% DM basis. Day 6: silages injected pre-ensiling with A-NH_3 at 0, 1%, and 2% DM basis. The preference measurement period was 2 hr, with an intermediate weight of any remaining silage at 30 minutes. After each measurement period, heifers were allowed feed and water until 18:00 h, then only water until the following preference measurement period at 8:00 h.

Statistical Analysis.

The experimental design for the silage quality characteristics (CP %, NDF %, ADF %, hemicellulose %, IVDMD % and DM%) was a 3 x 3 factorial in a completely randomized design with 4 replications per treatment. Statistical analysis of each experiment was conducted using SAS PROC=GLM (SAS Institute, 2004, Cary, NC). Two separate analyses were used, one that recognized structure within the experiment and one that considered each treatment separately and therefore did not take the structure into account. The analysis that accounted for structure used the following sources of variation: A-NH_3 level, timing, timing × A-NH_3 level, carbohydrate (timing), and A-NH_3 level × carbohydrate (timing) which totaled 8 d.f. Sources of variation are considered significant at $P < .05$. For the second (unstructured) analysis, each treatment was allotted a unique dummy variable. These dummy variables were then used to facilitate construction of specific comparison (contrasts) that were not available from the structured analysis as well as for calculating a global LSD value applicable across treatments. The experimental design for the feeding preference portion of this project was a 3 x 3 factorial in a randomized block design (b = 4) and each heifer considered a block.

RESULTS AND DISCUSSION

Injecting A-NH_3 into the 30 t bag of silage (phase 1) increased CP content of the silage, but individual samples taken from four areas within the silage bag showed the increase in CP was inconsistent, indicating poor distribution of the A-NH_3 (Figure 1). However, this increase in CP % showed that it was feasible to use a probe to inject A-NH_3 into silage. The manufactured probe worked without problem, with no visual signs of volatilizing A-NH_3 during the injection process. The sorghum silage used in this study was over 80% moisture, which is higher than recommended, particularly when using A-NH_3 which is known to be highly attracted to water. The excessive moisture in the silage caused the formation of a Maillard reaction which allowed us to observe the pattern of diffusion of the A-NH_3 in the silage, seen as a dark area in the silage (Figure 1). Initially, the fresh silage was 9.5% CP, but increased to 10.2 to 20.5% in the four sampled areas approximately as shown below (Figure 1). The expected increase in CP was 4 % (Kung et al., 1989), with this study reporting increases of less than 1% to 10%.

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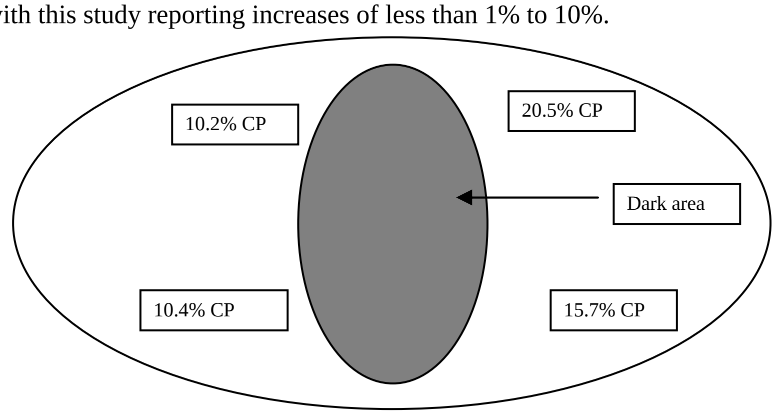

Figure 1. The 10 ft silage bag and the approximate areas sampled for CP content, and the visualappraisal of the area affected by the Maillard reaction

In the pilot study evaluating the "mini-silos," inspection of the treated silage revealed no NH_3 odor in any of the treatment bags. In treatments with 2% A-NH_3, spots of mold within the packed portion of the silage were observed, revealing complications with the fermentation process, possibly due to the effects of the NH_3 slowing the necessary drop in pH. All samples with 2% A-NH_3 injection felt "gooey" to the touch, possibly indicating the cell structure of the silage was broken down, similar to Grotheer et.al. (1986). This breakdown of the fiber would increase digestibility, but may negatively impact feed intake. One of the 1% A-NH_3 samples from the post-ensiled treatment had this same poor texture. Color of the silages was somewhat inconsistent. All control samples (0% A-NH_3) had a normal green color, while there was a yellowing of the forage in some of the 1% A-NH_3 –treated samples. The 2% A-NH_3 samples had a slightly darker appearance.

Forage analysis from silage in the mini silos (phase 2; Table 1) showed increases (P<.05) for CP for the silage injected with A-NH_3

Table 1. Effects of injecting different levels of A- NH_3 either post- or pre-ensiling with or without corn on the nutrient characteristics of oat-ryegrass silage

-----------NH_3------------			CP	NDF	ADF	Hemi-cellulos	IVDMD
Timing[1]	Level[2] (%)	Carb[3]	------------------------------%-------------------------------				
Pre	0	No	15.9 ^{h}	59.9 ^{d}	38.5 ^{d}	21.3 ^{d}	70.3 ^{g}
Pre	0	Yes	16.2 ^{gh}	58.4 ^{de}	37.7 ^{d}	20.7 ^{d}	72.4 ^{efg}
Post	0	No	16.3 ^{gh}	59.9 ^{d}	38.3 ^{d}	21.6 ^{d}	71.1 ^{fg}
Pre	1	No	18.9 ^{de}	54.4 ^{fg}	35.5 ^{de}	18.9 ^{de}	74.8 ^{de}
Pre	1	Yes	17.9 ^{ef}	55.6 ^{efg}	38.6 ^{d}	17.0 ^{ef}	71.7 ^{fg}
Pre	2	No	18.9 ^{de}	53.6 ^{g}	38.3 ^{d}	15.3 ^{f}	73.2 ^{def}
Pre	2	Yes	19.8 ^{d}	53.9 ^{fg}	37.2 ^{de}	16.6 ^{ef}	75.8 ^{d}
Post	1	No	16.9 ^{fgh}	57.4 ^{def}	38.6 ^{d}	18.8 ^{de}	72.3 ^{efg}
Post	2	No	17.3 ^{fg}	57.5 ^{def}	38.1 ^{d}	19.4 ^{de}	73.1 ^{ef}
LSD(0.05)			1.1	3.7	1.9	3.1	2.7

[1] Timing of A-NH_3 injection
[2] Percent of A-NH_3 injected per Mg of silage
[3] Corn added to silage prior to ensiling (5 lb/100 lb)
[4] Hemicellulose is a calculated value (NDF-ADF=Hemicellulose)
[a,b,c,d,e] Means in the same column with different superscript letters differ (P<.05).

pre-ensiled compared to controls, but silages injected with A-NH_3 post-ensiled showed no or only slight increases in CP. Adding A-NH_3 should increase N in the silages, unless volatilization losses occurred. Ambient temperatures were about 12 to 14^0F higher when A-NH_3 injection was attempted into mini silos post-ensiling, and the volatilization losses were quite obvious using the needle and syringe. Similar to the CP responses, IVDMD generally improved (P<.05) with A-NH_3 injection pre- but not post-ensiling, again indicating that volatilization losses occurred post-ensiling. Additionally, NDF levels were generally lower (P<.05) for A-NH_3 injected pre-ensiling as compared to either post-ensiling or control silages.

Table 2. *P* values for statistical analysis with structure for selected quality characteristics as influenced by anhydrous ammonia level and timing (pre-ensiled or post-ensiling) and the addition of a carbohydrate source.

		Quality characteristic					
Source	DF	CP	NDF	ADF	Hemi	IVDMD	DM
		Pr>F					
NH_3[a]	2	0.0001	0.0007	0.0221	0.0002	0.0006	0.1074
Timing[b]	1	0.0005	0.0160	0.1557	0.0430	0.2457	0.6224
Timing x NH_3	2	0.0056	0.4844	0.3026	0.5522	0.2813	0.6748
Carb(timing)[c]	1	0.7229	0.9911	0.4492	0.6447	0.4913	0.8614
NH_3 x Carb(timing)	2	0.0566	0.3895	0.2087	0.2062	0.1398	0.1806

[1] Level of NH[a] injected (0, 1, and 2 %)
[b] Pre-ensiled or post-ensiled
[c] Pre-ensiled + corn

Injection of A-NH_3 (0, 1 or 2%) affected (P<.05) all quality attributes analyzed except DM (Table 2). There was a timing of the injection effect (P < .05) on CP, NDF, and hemicellulose likely due to the A-NH_3 volatilization losses that occurred post-ensiling due to instrumentation. There was also a timing x A-NH_3 level interaction for CP (P < .05). In the heifer preference trial, all silages were acceptable and there were no refusals. While there appeared to be some textural problems with silages injected with 2% A-NH_3 on visual inspection, heifers readily consumed all silages.

CONCLUSION

In conclusion, with the ability to add A-NH_3 to silage already in polyethylene bags, timing and amount of A-NH_3 application become options. Due to the volatilization losses at post-ensiling in the present study with mini silos, further work with improved A-NH_3 injection equipment needs to be conducted to better evaluate the effects of time of application (pre- or post-ensiling) along with rate of application. Also, initial moisture content of the silage and the subsequent lack of movement of injected A-NH_3 through the silage mass should be conducted to determine optimum silage moisture content. Feeding trials need to be conducted to evaluate animal performance using various levels and timing of A-NH_3 injection into silages.

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Seed Quality of Windmillgrass Ecotypes in Two Locations of South Texas

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ABSTRACT

Hooded and shortspike windmillgrasses are native perennial grasses with potential for planting on highly erodible sites. However, both species display unfilled seed and seed dormancy resulting in poor seed quality. This study examines variations in filled seeds, viability, and germination response in windmillgrass ecotypes. Germination conditions were 12 hr dark, 68°F and 12 hr light, 86°F. Percent of seeds filled was superior (P<0.05) in Beeville with 21, 22, 24, and 29% compared to Kingsville with 5, 8, 12, and 15% for S-260, S-283, H-301, and H-313, respectively. No significant differences (P>0.05) in seed viability were found among production sites with values of 75, 64, 72, and 67% in Kingsville and 84, 70, 85, and 75% in Beeville for S-260, S-283, H-301, and H-313, respectively. The germination response was different (P<0.05) between production sites and species with germination in Beeville of 72 and 99% compared to Kingsville with 59 and 90% for shortspike and hooded windmillgrasses, respectively. Filled seed and germination in windmillgrass were better in Beeville than Kingsville. The seed viability of the filled seed of windmillgrass was not affected by production site.

KEY WORDS: Native grasses, percent seeds filled, seed viability, germination, *Chloris cucullata, Chloris subdolichostachya.*

At the time of the study, senior author was a Ph.D. student in Wildlife Program at Texas A&M University – Kingsville, Kingsville, Texas.

INTRODUCTION

The demand for native grass seed is increasing for use in revegetation, restoration, erosion control, landscaping, and other uses because of their low maintenance requirements and ecological adaptation (Stoner et al. 2004). Hooded windmillgrass (*Chloris cucullata* Bisch.) and shortspike windmillgrass (*C. subdolichostachya* Muell.) are warm-season, perennial grasses that are native throughout Texas, Oklahoma, New Mexico, and the Northeast portion of México (Hitchcock 1971; Hatch et al. 1999). Both grasses have potential for planting on highly erodible sites, especially for roadsides and on sites where introduced species have traditionally been planted for erosion control and other ground cover uses.

Hooded windmillgrass is a short, perennial bunchgrass with culms 6-24 inches tall that produces multiple seed crops allowing it to reseed itself and spread, whereas shortspike windmillgrass is a medium growth, strongly stoloniferous, perennial grass with culms 12-28 inches tall (Gould 1975; Correll and Johnston 1996). However, in Texas, availability and wide-scale use is limited by a number of factors including commercial seed availability and a lack of scientific information on seed production of these native species.

Furthermore, there are constraints for establishing these important native species from seed. The major challenges are that both species produce spikelets with unfilled seed and exhibit seed dormancy, resulting in very poor seed quality.

The primary biological purpose of seeds is to propagate the species by successfully completing germination and resuming plant growth (Baskin and Baskin 2000). Native species have innate mechanisms that regulate their potential for germination, often delaying or timing germination to coincide with optimal conditions for growth (USDA, NRCS 2004). Planting high quality seed is key to successful grass species establishment, but both biological and environmental factors can reduce seed quality (Boe 2003). Consequently, the site or perhaps more correctly the environmental characteristics of the site of seed production can be an important factor in the quality of seed produced.

The correct choice of location is a major requirement for the success of the seed production activity, mainly for specialized systems (Darris 2005). Harrison et al. (1996) stated that environmental and site conditions including geomorphology, slope, aspect, soil type, salinity, human impacts or management, seed sources, and existing vegetation determine how productive a plant species will be on a site. Coffin and Lauenroth (1992) found that differences in seed yield of blue grama (*Bouteloua gracilis* Lag. ex Steud) between range sites in north-central Colorado were greatly influenced by soil texture and animal grazing. For some grass species, temperature conditions during seed fill, oxygen conditions around the seed, and the location of seed production can promote the development of dormancy (Chapman 1996).

Kelly et al. (2000), mentioned that the dispersal unit in some grasses includes seed appendages integrated with the caryopsis (seed fill), and so the number of seeds filled by a grass plant can vary markedly according to species and site. Favorable temperature and/or precipitation levels in certain areas can promote greater photosynthate production resulting in above-average seed production in that year or in subsequent years (Veenendaal et al. 1996). Conversely, factors such as adverse temperature, humidity, or wind at the time of pollination or seed development can reduce flowering or seed fill and could negatively influence the seed quality (McKone 1990).

Chambers (1989) found that viable seed production of species such as Idaho fescue (*Festuca idahoensis* Elmer), tufted hairgrass (*Deschampsia cespitosa* [L.] Beauv.), and alpine reedgrass (*Calamagostris purpurascens* R. Br.) vary both temporally and spatially, and that production of viable seed and seed fill is dependent upon the production site and the growing conditions for the production season.

Objectives of this study were to determine variations in seed fill, seed viability, and germination response in windmillgrass ecotypes as related to differences in production site.

MATERIAL AND METHODS

Hooded and shortspike windmillgrass seeds were collected by hand in 2003 from field plots located at Texas Agricultural Experiment Station in Beeville, TX and at Kika de la Garza Plant Materials Center at Kingsville, TX.

The Experiment Station at Beeville (28°27' N, 97°42' W; 256 ft elevation) is located in south Texas in the Rio Grande plain physiographic region. In winter the average temperature is 54°F, whereas in summer it is 84°F. Total annual precipitation is approximately 30 inches of this,19 inches, or 63%, usually falls during April through September, which includes the growing season for most warm season perennial grasses. Average relative humidity in mid-afternoon is about 60 percent. Terrain is level to gently rolling slopes. Many of the soils under forage-livestock production in this region are shallow and calcareous. The soils at the research site are Weesatche sandy clay loam (Fine-loamy, mixed, hyperthermic, Typic Argiustolls). This series is characterized as deep, well-drained loamy soil, with medium surface runoff, moderate permeability, and low water holding capacity (USDA, SCS 1981).

The Kika de la Garza Plant Materials Center (PMC) (27° 33’ N, 97° 52’ W; 53 ft elevation) is located just outside of Kingsville, TX. In winter, the average temperature is 68°F, whereas in summer it is 84°F. Mean annual rainfall is 28 inches. Long term rainfall are well distributed in the growing season of warm season grasses. September is the wettest month with 6 inches, whereas March is the driest month with 0.9 inches. Humidity is high during most of the year because the prevailing southeasterly winds bring in moist air from the Gulf of Mexico with an average of 60% at 6 a. m., 56% at noon, and 60% at 6 p. m. Topography of the PMC is flat. Soils at the PMC are classified as fine, mixed, hyperthermic Vertic Calciustolls (Raymondville clay loam) and moderately crumbly, Calcareous Grumosols (Victoria clay). Raymondville clay loam soils are characterized as moderately well drained, slow surface runoff, low permeability, and the available water holding capacity is moderate (USDA, SCS 1982). Victoria clay soils are dark, calcareous, crumbly soils that are called blackland which crack when they dry, and when wet, they swell and take in water slowly (USDA, SCS 1992).

Studied windmillgrass ecotypes were: shortspike 9085260 (S-260), shortspike 9085283 (S-283), hooded 9085301(H-301), and hooded 9085313 (H-313). Three replications of 100 seeds of each ecotype were used for determining percent of seeds filled. Each seed was checked by hand to determine if it contained a well-developed caryopsis.

Viability of seeds from each ecotype of the different collection sites was evaluated using 1% aqueous solution of tetrazolium (2, 3, 5-triphenyl tetrazolium chloride). Three replications of 100 filled seeds were soaked in distilled water for 18 h, subsequently, the lemma and palea were removed and the caryopsis was bisected longitudinally with a razor blade to expose the main structures of the embryo. As per the Grabe methodology (Grabe 1970), half of each caryopsis was immersed in the tetrazolium solution. After 3 h of dark incubation at 86°F, caryopsis with completely stained embryos were scored as viable (AOSA, 1970).

The germination test was conducted on naked caryopsis. Naked caryopses were extracted by hand rubbing seed on a rubber-corrugated mat with a rubber block to remove the lemma and palea from whole seeds. Later, a South Dakota Seed Blower was used to separate the bare caryopsis from the chaff. Plastic boxes of 5 x 5 x 1.4 inches, with tight fitting lids were used to germinate the seeds. The substrate for each container was one sheet of K-24 Kimpack 14 ply cellulose paper and one of blue paper (both are from Anchor paper Co. St. Paul, Minn.). The kimpack blotter designed to be very absorbent and maintain moisture for the seeds. Blue paper improved the contrast with seeds to facilitate counting the seedlings resulting in more reliable counts (Schleicher & Schuel 2002). Seeds were moistened with distilled water. Each box, containing one hundred randomly selected caryopsis, and was considered as an experimental unit. Three replicates per ecotype from each production site were used in the study. Germination conditions were 12 hr dark 68°F and 12 hr light 86°F. Germination counts were made every day for 28 d. Seeds were considered germinated if both the radicle and coleoptile exceeded the seed in length and the seedling was normal according to the seedling evaluation criteria of the AOSA for comparable grasses (AOSA, 1992). Seedlings were removed as they were counted.

Data were analyzed using a randomized complete block design with a three-way factorial arrangement of treatments with three replicates (Snedecor and Cochran 1980). Factors evaluated were two sites, two species, and two ecotypes. Seed fill, viability and germination data were subjected to analysis of variance using the general linear model (GLM) procedure of the Statistical Analysis System (SAS Inst., Cary, NC, 2000). Percent germination values were adjusted for the percent of live seed in each ecotype. An arcsine transformation was used on percent germination data before analyses.

RESULTS

Temperatures were similar over the months of the experiment on both sites, except for a sudden drop in temperature in September and October at the Beeville site (Figure 1). Even though the amount of annual rainfall was similar, the distribution of rainfall differed markedly between sites (Figure 2). Total precipitation during the growing season (May-Sep) was 19.6 and 18.1 inches for the Kingsville and Beeville sites, respectively. The rainfall amount (6.8 inches) during July at Beeville produced an increase in plant growth, resulting in increased seed head emergence. At Kingsville, rainfall (10.5 inches) occurred after the growing season with no effect on plant growth. During most of the period of seed head formation and emergence the rainfall was only 3.7 inches and suppressed plant growth. Relative humidity during the growing season averaged 70% in Beeville compared to 60% registered in Kingsville. Average wind speed during the pollen dispersal period (May-Jul) was 16.6 miles/h at Beeville compared to 25.6 miles/h at Kingsville.

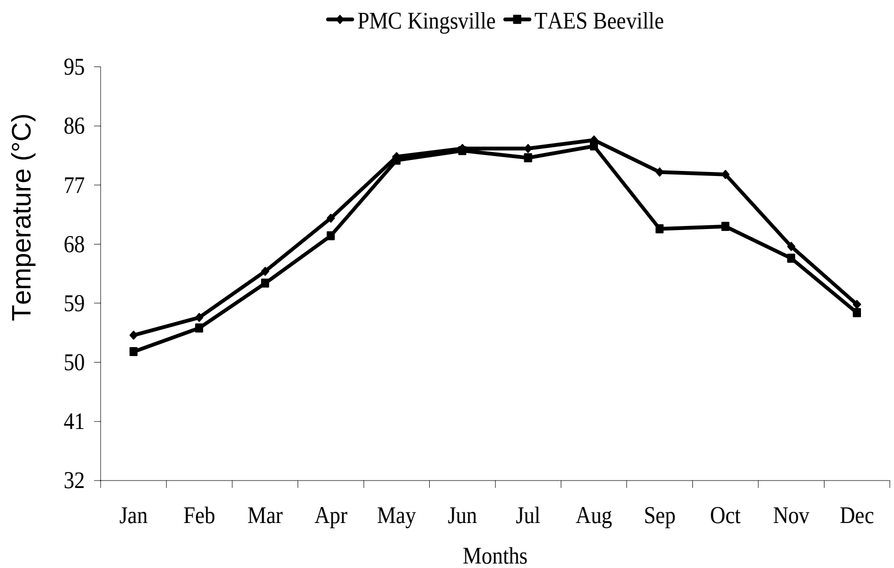

Figure 1. Mean monthly temperature comparison between PMC Kingsville versus TAES

No (P>0.05) interactions among treatments were found for fraction of seed fill. Production site, species, and ecotypes were different (P<0.05) in percent of seed fill. The Beeville location was higher (P<0.05) with 21, 22, 24, and 29% compared to Kingsville with 5, 8, 12, and 15% for S-260, S-283, H-301, and H-313, respectively (Figure 3).

No interaction (P>0.05) among production site X species X ecotypes was detected in seed viability with values of 79, 67, 78, and 71% for S-260, S-283, H-301, and H-313, respectively. No response (P>0.05) to main effects was found for seed viability.

No interaction (P>0.05) among production site X species X ecotypes was detected in seed viability with values of 79, 67, 78, and 71% for S-260, S-283, H-301, and H-313, respectively. No response (P>0.05) to main effects was found for seed viability.

No (P>0.05) interactions among treatments were found for seed germination. A location effect (P<0.05) was observed, where the two species performed consistently in the two locations with values in the Beeville location of 72 and 99% compared to the Kingsville location with 59 and 90% for shortspike and hooded windmillgrasses, respectively (Figure 4).

Table 1. Mean monthly temperature and total monthly rainfall for 2003 at PMC

	PMC Kingsville		TAES Beeville	
Month	Temperature °C	Rainfall (mm)	Temperature °C	Rainfall (mm)
Jan	12.3	25.50	10.9	58.3
Feb	13.8	33.50	12.9	76.0
Mar	17.7	32.25	16.7	57.0
Apr	22.2	3.00	20.7	5.5
May	27.4	0.25	27.1	1.0
Jun	28.1	81.25	27.9	82.5
Jul	28.1	107.00	27.3	173.8
Aug	28.8	41.25	28.3	12.5
Sep	26.1	268.30	21.3	190.3
Oct	25.9	89.50	21.5	92.7
Nov	19.8	21.50	18.8	33.3
Dec	14.9	14.25	14.2	12.3
Average	22.1		20.6	
Total		717.55		795.05

The influence of production site on percent of seeds filled observed in this study agreed with the findings of several studies where environmental factors such as soil types, temperature, precipitation, humidity, and wind at the time of seed development can impact seed fill in one area. McKone 1990 working with snow tussock-grass (*Chionochloa pallens* Zotov) found that seed fill was different in dark gray loamy sand soil compared to olive yellow gravelly sand soil with values of 76% and 21%, respectively. In another study, Coffin and Lauenroth (1992) demonstrated that soil texture had a significant effect on seed fill of blue grama (*Bouteloua gracilis* Lag. ex Steud), where coarse-textured soil produced the higher seed fill value with 82% compared to 52% obtained on fine-textured soil. Based on our results, soil type, wind, relative humidity and precipitation pattern were the main factors responsible for the differences in seed fill in windmillgrass ecotypes. Seed fill in windmillgrasses was higher in Beeville than Kingsville. This difference between production sites may suggest a greater stress was imposed by lower precipitation during seed development at the Kingsville site. In addition to dry spring weather in Kingsville, high drying winds may have further stressed the plants at Kingsville. Beeville received adequate precipitation, and experienced high relative humidity and low wind resulting in less stressful conditions for plant growth and seed production.

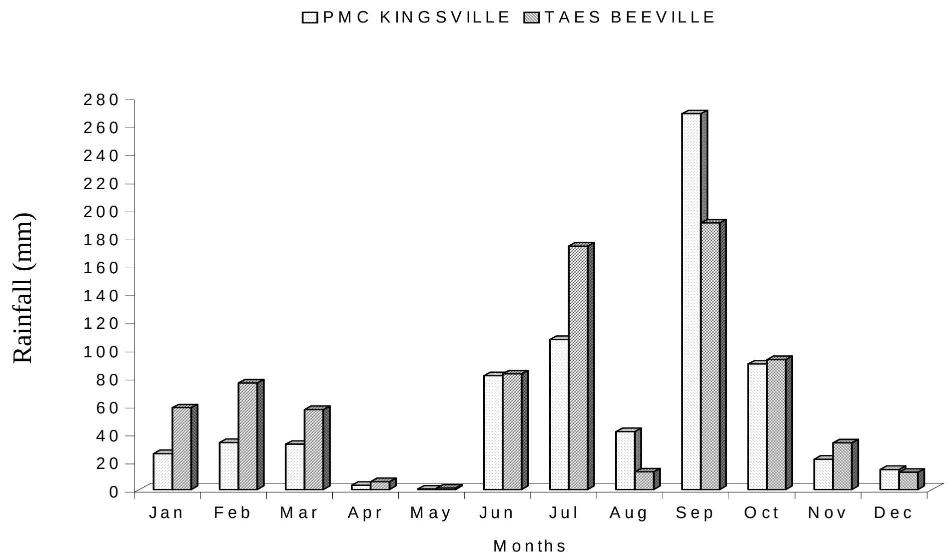

Figure 2. Rainfall comparison between PMC Kingsville versus TAES Beeville over the period of study (2003).

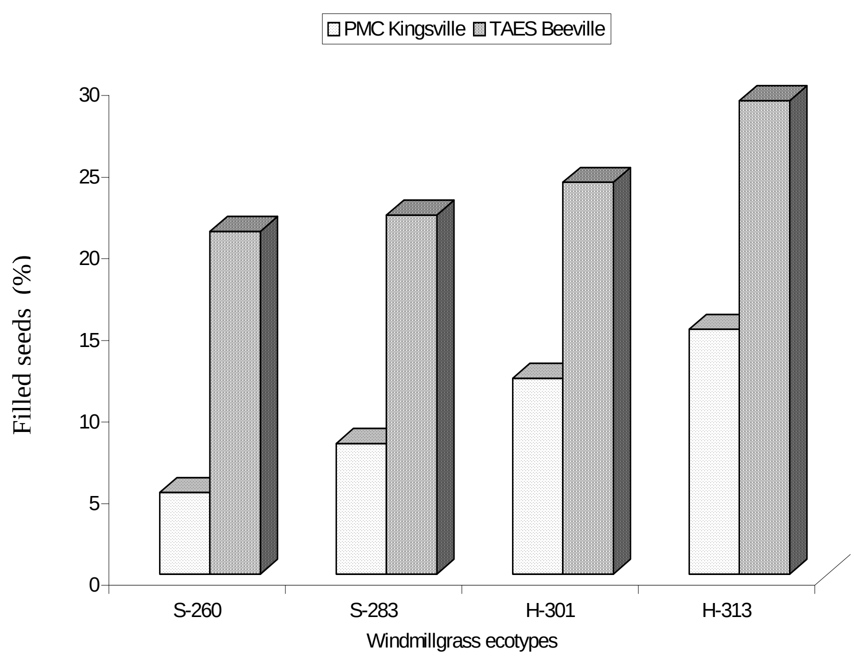

Figure 3. Production site effects on seed-fill of windmillgrass ecotypes

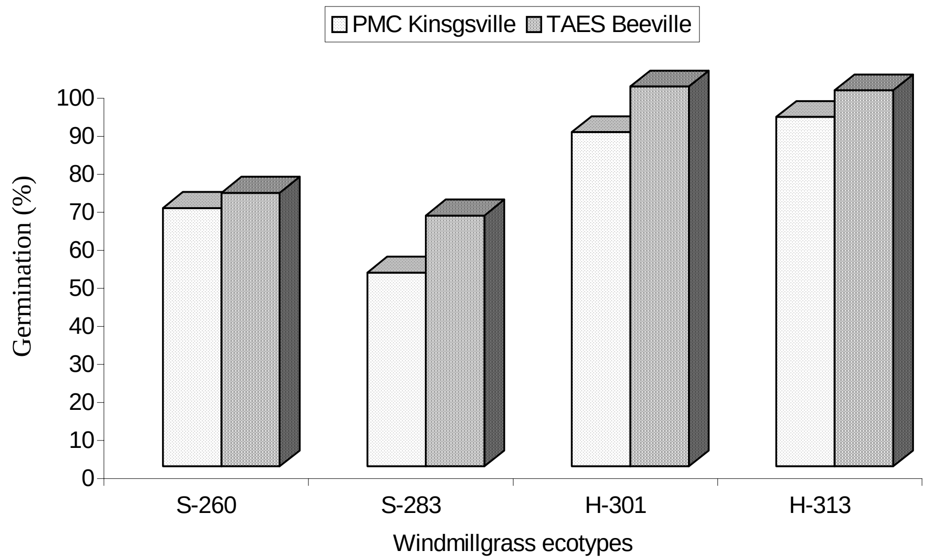

Figure 4. Production site effects on seed germination of windmillgrass ecotypes during 2003.

DISCUSSION

Based on our results, soil type, wind, relative humidity and precipitation pattern were the main factors responsible for the differences in seed fill in windmillgrass ecotypes. Seed fill in windmillgrasses was higher in Beeville than Kingsville. This difference between production sites may suggest a greater stress was imposed by lower precipitation during seed development at the Kingsville site. In addition to dry spring weather in Kingsville, high drying winds may have further stressed the plants at Kingsville. Beeville received adequate precipitation, and experienced high relative humidity and low wind resulting in less stressful conditions for plant growth and seed production.

Another important issue to consider about seed fill differences between production sites is that wind pollination, or anemophily, is considered a primary pollen dispersal mechanism in many grasses (Lyons et al. 1989) and a numbers of factors, including wind, humidity, and temperature can affect pollen viability (Luna et al. 2001).

Desiccation may have contributed to the loss of windmillgrass pollen viability in Kingsville due to high temperature and high wind-speed. Conditions for pollen survival at Beeville were better during this same time period than at Kingsville, which may have contributed to the higher seed fill at Beeville than at Kingsville.

In a study conducted by Chambers (1989) the percent of seed fill of Idaho fescue (*Festuca idahoensis* Elmer) and tufted hairgrass (*Deschampsia cespitosa* [L.] Beauv.)

varied greatly in response to the timing and the amount precipitation on central and southern Rocky Mountains sites in Colorado. Both species exhibited the same pattern of seed fill, indicating poor seeds fill in central sites with 20 and 18% compared to southern sites with 72 and 63% for Idaho fescue and tufted hairgrass, respectively. Observed variation in seed fill was largely attributed to more water from the winter snow, causing dry soils during the growing season. In addition, Coffin and Lauenroth (1992) found that differences in seed fill of blue grama (*Bouteloua gracilis* Lag. ex. Steud.) were greatly influenced by soil texture and animal grazing in north-central Colorado. On locations protected from grazing, soil texture had effect on seed fill; the greatest seed fill was produced on the coarse-textured soil and the fewest on the fine-textured soil.

Seed viability in windmillgrasses ecotypes was not affected by production site, whereas seed germination was strongly affected by production site. Similar results were found by Hacker and Ratcliff (1989) working on fifteen accessions of buffelgrass (*Cenchrus ciliaris* L.), eight of near-equatorial and six of near-tropical origin with high (1200-1400 mm), medium (700-800 mm), low (400-500 mm), and very low rainfall (25-220 mm) sites. Seed viability tended to be similar (85%) in the sites and under all rainfall patterns. Seed germination was higher for near-equatorial (88%) than from near-tropical accessions (62%) and from high (79%) rather than for low (63%) rainfall areas. They suggested that buffelgrass accessions maintain seed viability and differ in seed germination attributes that may be adaptive to their climate of origin.

Minnick and Coffin (1999) studied effects of climate variables on spatial patterns in germination of *Bouteloua gracilis* (H. B. K.) Lag Ex Steud and *Bouteloua eriopoda* Torr. along a gradient from northern Colorado (40° 49’ N; 104° 46’ W) to southern New Mexico (31° 50’ N; 107° 39’ W). For *B. gracilis* they found that germination decreased from north to south along the climate gradient with values of 98% at Trinidad, CO (37° 15’ N) to 89% at Bosque, NM (33° 46’ N). In contrast, the percentage of germination of *B. eriopoda* increased from north to south with values of 34% at Limon, CO (39° 16’ N) to 78.5% at New Mexico State University, NM (32° 17’ N).

Low seed fill for the grass species in Kingsville coincided with low seed germination, indicating poor seed development at that site. This may be attributed to slower species phenological development at Kingsville compared to those growing on the Beeville site. Seed properties, including seed fill, viability, and germination can greatly affect the success of seed grass industry efforts. Production of filled seeds and viable seed of windmillgrass is not only variable among species, but also among ecotypes within any given site.

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Grazing Intensity and Nitrogen Fertilization to Manage Invasive Kleberg Bluestem on Pangolagrass Pastures in Northern Mexico

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ABSTRACT

This study was conducted at the Aldama Experimental Station of the National Research Institute of Forestry, Crops, and Livestock in Aldama, Tamaulipas, Mexico. The objective was to determine the effect of grazing intensity (I) and nitrogen fertilization (F) on botanical composition and forage accumulation (FA) of a pangolagrass (*Digitaria decumbens* Stent.) (P) pasture with Kleberg bluestem (*Dichanthium annulatum* Forsk.) (D). Treatments evaluated resulted from the combinations of two levels of I (High= 80% and Medium= 50% utilization), and two levels of F (0 and 45 lb acre^{-1} of nitrogen). Response variables were seasonal and annual FA and percentage aerial canopy cover of D and P. Response variables were analyzed in complete randomized block design with a 2x2 factorial arrangement of treatments replicated twice. A selected set of orthogonal linear contrast comparisons was made to quantify differences attributable to grazing intensity and fertilization. Each single degree of freedom was tested for significance with the Student's t-test. Differences were considered significant at the 0.05 level. Percentage of D and P varied inversely, and statistical difference was found only for F, D decrease averaged 39% in treatments with F. Forage accumulation was similar during the dry season. A significant ($P<0.03$) interaction between I and F was found for FA in the rainy season. The best results were obtained in the treatment of moderate grazing intensity and fertilization with a forage accumulation of 7213 lb ac^{-1} year^{-1} with 30% D aerial canopy cover compared to the treatment of high grazing intensity without fertilization which had a FA of 4086 lb ac^{-1} year^{-1} with 55% D.

KEY WORDS: Grazing management, nitrogen fertilization, *Digitaria decumbens, Dichanthium annulatum*, pangolagrass, Kleberg bluestem, invasive species

INTRODUCTION

Overgrazing has been identified as one of the most overwhelming factors affecting productivity of cattle operations in Northern Mexico (Martinez et al. 1997). Cattle stocking rates higher than what grazinglands can safely sustain causes weakening and death of native and introduced desirable species creating optimum conditions for the invasion of less valuable plants. Invasive species have become a problem in many native and cultivated areas, reducing plant diversity and wildlife habitat in rangeland and efficiently competing with cultivated perennial grasses that are more valuable and productive for cattle. Even when many invasive species have been introduced to improve primary productivity of grazinglands for cattle, in several cases these have become a problem due to their aggressiveness and in many cases lower forage value and cattle preference which make these plants very efficient competitors with desirable species.

Cattle grazing in southern Tamaulipas in Mexico consists of grazing native and introduced perennial grasses. Some of the most common introduced grasses are African stargrass (*Cynodon nlemfuencis* Vanderyst), Guineagrass (*Panicum maximum* Jacq.), signalgrass (*Brachiaria decumbens* Stapf), and pangolagrass (*Digitaria decumbens* Stent.). Even when some of these grasses are invasive species for native rangelands, they are considered desirable introduced species for cattle in this region. However, other introduced species of lower forage value that are more aggressive in nature can invade pastures reducing the productivity of these grasses. The most typical example is the group of grasses identified as “Old World Bluestems” that include Plains bluestem, [*Bothriochloa ischaemum* (L.) Keng], Kleberg bluestem [*Dicanthium annulatum* (Forsk) Stapf], Caucasian bluestem (*Bothriochloa caucasica*), and Hurricanegrass [*Bothriochloa pertusa* (L.) Camus] among others. The most common invasive species in southern Tamaulipas are Kleberg bluestem and Hurricanegrass which are locally named “carreterograss” due to the fact that most of the roads sides are covered with these species. *Bothriochloa pertusa* was initially identified in the early 1970’s and it is believed it was introduced from south Europe to the Caribbean and from there it has invaded a large part of the Mexican Gulf Coast (De Alba and Gould 1977). However, most of the population currently invading native and introduced pastures in the area is Kleberg bluestem which is native to India, China, North Africa and Egypt. It grows in clumps and plants are erect and uniform with most of the leaves near the base. Numerous green slender stems 30" long become straw-colored at maturity, have white bearded nodes and seedheads with 2-10 purplish branches. It volunteers aggressively and has excellent drought tolerance and some salinity tolerance (Mutz and Drawe 1983). In general, Old World bluestems are very stemy and do not produce the quantity or quality of forage when grown in south Texas that they do when grown in areas north of this region (Ocumpaugh and Rodriguez 1999). The main dispersal mechanism of Kleberg bluestem is by seed that is moved along with animals, vehicles, air and water runoff. Old World bluestems overall are lower in quality than most native species, but because of their ability to persist under increased grazing pressure, higher temperatures and less water, they become very competitive for native and introduced desirable species.

Moderate grazing intensity is a key factor for persistence of desirable species and research has shown that primary productivity, cow herd productivity and net economic returns are maximized by moderate grazing (Falconer et al. 1999; Holocheck et al. 1999; Ortega and Gonzalez 1992). Responses to nitrogen fertilizer differ among grass species (Petersen and Moser 1985; Jacobsen et al. 1995). For example, the pangolagrass response to nitrogen fertilizer is stronger compared to Kleberg bluestem. Berg (1990, 1993) studied the response of *Bothriochloa ischaemum* to N fertilization and spring burning and found N fertilization to substantially increase forage production resulting in an average of 66 lb of forage being produced per kg N applied. Berg and Sims (1995) found that N applied at 38 lb N/ac resulted in steer gains ranging from 5 to 9.5 lb/yr. Pangolagrass is a high quality introduced species that very readily consumed by cattle. Ortega et al. (1985) indicated that an application of 90 kg of N per ha using ammonium sulfide as a N source increased forage production by 50%.

We tested the hypothesis that moderate grazing intensity and nitrogen fertilization would increase primary productivity of the grassland and decrease the percentage Kleberg bluestem in pastures. We predicted that pangolagrass would have a stronger response to N fertilizer and moderate grazing intensity would have a positive effect on the primary productivity of pangolagrass which would contribute to the dominance of this species over the invasive Kleberg bluestem.

MATERIAL AND METHODS

Study Area

The study was conducted at Aldama Experimental Station of the National Research Institute of Crops, Forestry and Livestock (INIFAP) in Aldama, Tamaulipas, Mexico, which is located 11 miles North of Manuel, Tamaulipas (23^{o} N, 98 ^{o} W). The experimental station is about 207 ft above the sea level with a slope gradient < 1%. Soil type is considered moderately well drained clays with pH of 7.4. Climate is characterized as subtropical with hot summers and mild winters. The average annual temperature was 23.7 ^{o}C. Average annual rainfall (1990 –2000) recorded at the station was 32.6 inches per year.

Experimental Design

A 9.9-acre pasture of pangolagrass with an average invasion of 49 % of Kleberg bluestem was used to allocate two separate blocks consisting of 4 1.24-acres pastures. Treatments evaluated resulted from the combination of two levels of N fertilizer (0 and 45 acre^{-1}) and two levels of grazing intensity (Moderate= utilization of 50% of the available aerial biomass and High= utilization of 80% of available aerial biomass). The four treatment combinations were randomly assigned to each block. Pastures with different levels of grazing intensity were grazed with the same number of animals varying the number of grazing days to achieve the desired percentage utilization. During the rainy season (June to November), pastures were grazed every 28 days and every 56 days during the dry season (December to May). Nitrogen fertilizer was applied at the beginning of the rainy season every year.

Response Variables

The amount of Kleberg bluestem and pangolagrass was estimated based on aerial cover in pastures. Aerial cover of the two species was estimated using the line intercept method (Pieper 1973). Two permanent 16-ft transects were used per pasture and percent aerial cover per species was determined in the middle of the rainy and dry seasons every year during the three years of the study.

Response variables evaluated were forage accumulation and botanical composition in terms of percentage of Kleberg bluestem and pangolagrass. In order to calculate forage accumulation, pastures were sampled before and after grazing every cycle to determine standing biomass in each pasture. Standing biomass before and after grazing was determined using a double sampling technique (Frame 1981). Five double samples (visual estimation of standing biomass followed by clipping all herbage to ground level in a 1.64 ft^2 sampling frame) were taken in each sampling date in each pasture at sites selected to cover the variability of the pasture. Then visual estimations of standing biomass were taken at 16 randomly selected sites in each pasture. Samples from the 1.64 ft^2 were dried at 60 ^oC to obtain the actual dry weight of standing biomass. From double-sampling sites, actual values for standing biomass were regressed on visual estimations. Each year separate simple regression equations were developed for pregraze and postgraze samples. The simple regression equations possessed r^2 values higher than 0.76 in all cases. Averages of the 16 visual estimations taken per pasture were corrected using regression equations to estimate pasture values for standing biomass to be used for evaluating the effect of grazing intensity and fertilization. Forage accumulation for a given grazing cycle was considered to be the difference between standing biomass after grazing of the previous grazing cycle and standing biomass before grazing of the current cycle. Forage accumulation for the first grazing cycle was pregraze standing biomass. Data were summed over cycles to provide seasonal and annual totals.

Data Analysis

Response variables were analyzed in complete randomized block design with a 2x2 factorial arrangement of treatments replicated twice. A selected set of orthogonal linear contrast comparisons was made to quantify differences attributable to grazing intensity and fertilization. Each single degree of freedom was tested for significance with the Student's t-test. Differences were considered significant at the 0.05 level (SAS Institute, Inc., 1989).

RESULTS

Botanical composition in terms of percentage aerial cover of Kleberg bluestem and pangolagrass was analyzed only for the last year of the study to because we considered that percentages of the two species involved reflected the long term cumulative effect of the treatments. Percentage cover of Kleberg bluestem and pangolagrass at the end of the study was different ($P<0.02$) only for fertilization level (Table 1). Pangolagrass and Kleberg bluestem varied inversely in the pastures with fertilization. Fertilized pastures had 34% Kleberg bluestem cover compared to 56% for the treatments with no fertilization. Percentage aerial cover of Kleberg bluestem in pastures with fertilization was 39% lower compared to pastures with no fertilization, independently of the grazing intensity. In pastures with fertilization, percentage cover of Kleberg bluestem decreased from beginning to end of the study while pangolagrass cover increased.

As we hypothesized, pangolagrass had a stronger response to nitrogen fertilizer which allowed it to effectively compete with Kleberg bluestem. As indicated by Mutz and Drawe (1983), Kleberg bluestem response to nitrogen fertilization can be considered poor compared to the response obtained with buffelgrass (*Cenchrus ciliaris* L.), bell rhodesgrass (*Chloris gayana* Kunth) and blue panicgrass (*Panicum antidotale* Retz.). Kleberg bluestem percent aerial cover in treatments of moderate and high grazing intensity without fertilization increased 22 and 17%, respectively, while treatments of moderate and high grazing intensity with fertilization caused Kleberg bluestem to decrease 34 and 18%, respectively.

Table 1. Effect of grazing intensity and nitrogen fertilization on botanical composition (Percent aerial cover) of a pangolagrass pasture invaded with Kleberg bluestem.

Treatment			
Grazing Intensity	**N Fertilization (lb acre^{-1})**	**Pangolagrass (%)**	**Kleberg bluestem (%)**
High	0	45 b*	55 a
High	56	63 a	37 b
Moderate	0	44 b	56 a
Moderate	56	70 a	30 b

* Different letters within a column indicate statistically different means (P=0.05).

Forage accumulation was analyzed by season of the year (dry and rainy) averaged over the three years of the study (Table 2). Results for the dry seasons did not differ (P>0.05) among treatment combinations with an average forage production of 1773 lb acre^{-1}.

Table 2. Effect of grazing intensity and nitrogen fertilization on annual and seasonal primary productivity of a pangolagrass pasture invaded with Kleberg bluestem .

Treatment		**Average Forage Accumulation (lb acre^{-1})**		
Grazing Intensity	**N Fertilization (lb acre^{-1})**	**Dry Season**	**Rainy Season**	**Annual**
High	0	1978 a*	2605 c	4581 b
High	56	2112 a	3710 b	5822 b
Moderate	0	2399 a	2615 c	5015 b
Moderate	56	2520 a	4694 a	7213 a

* Different letters within a column indicate statistically different means (P=0.05).

In this region, moisture availability as well as low temperatures during the months of December and January limit growth of grasses. Precipitation during February, March and April during the study was lower than 0.76 inches, and average minimum temperature from November to March was lower than 16^{o}C which likely limited forage production. Pangolagrass and Kleberg bluestem are C4 grasses that require higher temperature for optimum growth as indicated by Coyne et al. (1995).

Forage accumulation during the rainy season was different for grazing intensity (P<0.001), fertilization (P<0.003) and the interaction between the two factors (P<0.003) (Table 2). Forage accumulation was higher in pastures that received the treatment combination of moderate grazing intensity with fertilization with 4694 lb acre^{-1} compared to the treatments of high grazing intensity with fertilization and moderate and high grazing intensity without fertilization that produced 3710, 2615, and 2605 lb acre^{-1}, respectively. The results indicate that moderate levels of grazing intensity and nitrogen fertilization increased productivity of pangolagrass probably because enough leaf area remained in the plants after grazing for the plants to initiate regrowth, and nitrogen availability was sufficient to allow the plant to maximize growth potential. Increased production of forage occurs when moderate levels of defoliation by grazing animals are applied (Ortega et al. 1992). Canudas (1988) reported increased forage production of pangolagrass when residual dry matter after grazing was intermediate. Differential response of warm season grasses to nitrogen fertilizers have been documented by Mutz and Drawe (1983) and the results of this study agree with the positive effect of moderate levels of defoliation on primary productivity reported by Holocheck et al. (1999) and Ortega and Gonzalez (1992).

Annual forage accumulation (sum of dry and rainy season forage accumulation) (Table 2) differed only for fertilization ($P < 0.01$). Treatments with fertilization yielded 26% more forage than treatments without fertilization.

Considering that percentage cover of Kleberg bluestem was 39% lower in treatments with fertilization, 65% of the forage accumulation was produced during the rainy season, and the highest forage accumulation was obtained in pastures that received the treatment combination of moderate grazing intensity with nitrogen fertilization, we conclude that fertilization and moderate grazing intensity effectively limited the invasion of Kleberg bluestem in pangolagrass pastures and increased primary productivity of pastures. The significant interaction detected between fertilization and grazing intensity during the rainy season for forage accumulation and the decreasing trend of the percentage Kleberg bluestem from the beginning to the end of the study in treatments with fertilization indicate that moderate grazing intensity in combination with nitrogen fertilization during the rainy season could have potential to keep pangolagrass pastures from Kleberg bluestem invasion. The response of pangolagrass to grazing intensity and fertilization may become stronger, increasing forage accumulation, as Kleberg bluestem percentage in pastures decreases, allowing pangolagrass to become more productive and competitive.

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