Volume 19 2006

TEXAS **J**OURNAL OF **A**GRICULTURE AND **N**ATURAL **R**ESOURCES

A Publication of the Agriculture Consortium of Texas

The ***Texas Journal of Agriculture and Natural Resources*** is a refereed journal published electronically by the Agriculture Consortium of Texas (ACT). The ACT is composed of 13 Texas Universities offering degrees in agriculture or natural resources. These universities are Abilene Christian University, Angelo State University, Prairie View A&M University, Sam Houston State University, Southwest Texas State University, Stephen F. Austin State University, Sul Ross State University, Tarleton State University, Texas A&M University, Texas A&M University-Commerce, Texas A&M University-Kingsville, Texas Tech University, and West Texas A&M University.

CONTRIBUTIONS: Either descriptive or experimental research reports from the various disciplines of agriculture and natural resources are published in the Journal subject to critical review and approval of the Editorial Board. Articles submitted for publication should report on work completed in Texas within the last two years by university personnel and their associates. No paper is to be submitted for review if the paper is being considered for publication by another journal or magazine. Papers should be written in a format consistent with this volume (Volume 25) of the Journal and a style consistent with the CSE Style Manual (Council of Science Editors, 2006) using only English units of measure and the CSE name-year version of documentation. Papers should report high quality research with critical analysis, but should be easily understood by professional agriculturalists and resource managers. Questions regarding publication style should be addressed to a member of the Editorial Board. Manuscripts to be considered for publication should be submitted to the Associate Editor at the author's institution. Publication charge is $50.00 per journal page for ACT members with a minimum charge of $150.

MANAGING EDITOR: Ashley Lovell, Box T-0050, Tarleton State University, Stephenville, TX 76402. Phone: (254) 968-1984. Fax: (254) 968-9228. E-mail: lovell@tarleton.edu

ISSN 0891-5466

Texas Journal of Agriculture and Natural Resources

Volume 19 **2006**

CONTENTS

The Effect of *Aspergillus oryzae* on Performance of Swine

Jared E. Jackson
Randal M. Harp
Department of Animal Science, Tarleton State University,Stephenville, TX 76402
Barry D. Lambert
Joe M. Cadle
Department of Animal Science, Tarleton State University & Texas Agricultural Experiment Station, Stephenville, TX 76402
Grady E. Kaiser
Justin A. Stafford
Graduate Research Assistant, Tarleton State University Stephenville, TX 76402

ABSTRACT

An experiment was conducted focusing on the effects of *Aspergillius oryzae* (Amaferm®) on maternal and growth traits of swine. In stage one, sixty-one sows were assigned to either a group receiving 0.046 oz/d of *Aspergillius oryzae* top dress on the sow feed daily or to a control group which did not receive *Aspergillius oryzae*. Feed intake, body condition, return to estrus, piglet weaning weight, piglet gain, and piglet average daily gain were observed. Treatment showed no significant effect on feed intake, body condition, piglet weaning weight, or return to estrus of sows. There was a significant negative effect on piglet gain (P<0.01). Stage two utilized piglets (N=412) from stage one. Piglets reared from treatment sows received Amaferm®, and piglets reared from control sows received the control diet. Treatment and control were fed *ad libitum*, and treatment received *Aspergillus oryzae* at the rate of 0.024 oz/lbs of feed. Weight gain, average daily gain, feed intake, and feed-to-gain ratio were measured. Treatment had no significant effect on all observations. Amaferm® had no positive effect on maternal or growth factors in swine.

KEYWORDS: *Aspergillus oryzae,* Amaferm®, Monogastric Probiotic, Feed Additive, Average Daily Gain.

INTRODUCTION

The animal feeding industry is competitive industry with tight profit margins. Increasing costs of production coupled with a continuous search for products that increase production has drastically improved efficiency in all sectors of the livestock industry.

The product known as Amaferm® was discovered in 1945 during WWII by the chemist H.E. Kistner. In order to support the war effort, Kistner was using a culture of *Aspergillus oryzae* to extract more alcohol from grain used in manufacturing aviation fuel. The used mash, which was a result of the fermentation process, was fed to ruminant livestock. Greater growth rates were observed in the animals fed the product.

There has been research that suggests *Aspergillus oryzae* promotes microbial growth in ruminants (Beharka and Nagaraja, 1991; Yoon and Stern, 1996; Denigan et al., 1992 and Gomez-Alarcon et al., 1991). This increase in the density of the microflora of the rumen has been attributed to the increased degradation of fiber in the diet (Weimer, 1998). Increased degradation of fiber has helped increase weight-per-day-of-age and feed efficiency in ruminants (Bodine and Purvis II, 2003). However, there are no peer reviewed articles that have observed the effects of Amaferm® on non-ruminant digestion and translation into improved maternal and growth efficiency. Therefore, the objective of this study was to determine the effects of *Aspergillus oryzae* (Amaferm®) on performance of swine. This study focused on reproduction efficiency, growth, and growth efficiency.

MATERIALS AND METHODS

The experiment was divided into two stages that included maternal performance of lactating sows and growth efficiency of nursery pigs. The experiment was designed to mimic modern commercial swine operations.

Stage One

Sixty-one Yorkshire, Hampshire, and Duroc crossbred sows were randomly assigned into two groups (31 treatment and 30 control) as they entered the farrowing house.

The treatment group was hand fed 0.046 ounces of Amaferm® per day as a top dress, using 1 ounce wheat bran as a carrier. The control group received the same lactation diet and was fed a placebo of 1 ounce of wheat bran.

Table1. Lactation Diet Analysis

Component	Percent of Diet
Protein, %	15.9
Lysine, %	0.98
Fat, %	2.8
Calcium, %	1.22
Phosphorus, %	0.88

The lactation diet included soybean meal, corn, and a commercial sow mineral package (Table I). Two weeks prior to farrowing, sows were selected at random. There were five farrowings conducted throughout the year. At each farrowing, they were evenly assigned either treatment or control. Breed, size, parity and age was not used as selection criteria. It was strictly at random. Beginning and ending body condition score and daily feed intake of each sow was measured. Beginning body condition was recorded when sows were placed into farrowing crates. Ending body condition was taken when piglets were weaned and sows were removed from farrowing crates. A three-person panel performed body condition scoring, and the average of the three was recorded. A one to nine point scale was used with one indicating an emaciated condition and nine indicating an obese condition.

Four hundred fifteen pigs were born in the study of which 219 were born from treatment sows and 196 were born from control sows. Number of piglets born alive and weaned were recorded at the beginning and the end of stage one. Birth and weaning weights (adjusted to 21 days) were measured on digital platform scales and recorded. Adjustments were calculated utilizing formulas from (Boggs, etal., 1998). After weaning, sows were returned to the breeding/gestation facility, where they were observed twice daily for signs of estrus.

Stage Two

Four hundred twelve mixed Yorkshire, Hampshire, and Duroc crossbred nursery pigs were assigned to one of two groups (treatment or control) based on their dam's diet from stage one.

Table2. Nursery Pig Diet Analysis

Component	Percent of Diet
Protein, %	20.0
Lysine, %	1.9
Fat, %	8.0
Fiber, %	1.2
Calcium, %	1.4
Phosphorus, %	1.3

The treatment ration contained Amaferm® (0.024 oz per lbs of feed). The base ration was commercially available (ADM Alliance Nutrition, Quincy, Illinois), and was fed on an *ad libitum* basis (Table II).

There were four different feeding replications, which were split evenly between treatment and control. As each group of sows completed stage one, the progeny from the treatment sows were assigned the treatment group, and the progeny from the control sows were assigned the control group. The nursery facility contained eight 6 ft × 6 ft pens and had a capacity of twelve pigs per pen. Piglets were weaned, weighed, and placed in the nursery. The study was conducted for a period of thirty days at which time the animals were weighed on digital platform scales and moved to the finishing floor. Data collected for the nursery pigs included: beginning weight, ending weight, total weight gained, average daily gain, total feed intake for each group, and feed-to-gain ratio for each group.

The General Linear Model procedure of SAS (Statistical Analysis Software; of Cary, North Carolina) was used to analyze all data. Least square means were used to compile and separate means. The model contained the effect of treatment. A confidence level of 95 percent (P<0.05) was considered significant, and a confidence level of 99 percent (P<0.01) was considered highly significant.

RESULTS

After data collection, information was organized in five tables which included: sow feed intake factors, sow maternal factors, piglet growth factors, nursery pig growth factors and nursery pig feed efficiency. There was no death loss among sow experimental units for either treatment or control, however, three nursery pigs perished and were removed from the experiment.

Stage One

The hypothesis was that Amaferm® would not have an effect on sow maternal traits. Table III displays data concerning sow feed intake and body condition change.

Table 3. Stage One Comparison of Lactating Sow Feed Intake Factors

Factor	Amaferm®	SE	Control	SE	P value
Sow Feed Intake, lb	12.60	2.48	14.23	1.83	P>0.1623
BCS change	-1.23	0.18	-0.85	0.19	P>0.1630

There was no significant difference (P>0.1623) between intake of the treatment group and the control group. The intake of the treatment group was 12.60 pounds per day, and the intake of the control group was 14.23 pounds per day.

Also, body condition score data was obtained at parturition and at weaning. Treatment had no significant effect (P>0.1630) on body condition. The mean difference in body condition score for the treatment group decreased by -1.23, and the control group decreased by -0.85.

Table 4. Stage One Comparison of Lactating Sow Maternal Factors

Factor	Amaferm®	SE	Control	SE	P value
Initial Litter Size	7.8	0.54	8.0	0.57	P>0.1769
Number Weaned per Litter	7.5	0.80	6.9	0.84	P>0.1127
Percent Weaned, %	96.5	3.68	85.8	4.19	P>0.1349
Return to Estrus, days	4.5	0.18	5.0	0.19	P>0.1318
Mortality Rate, %	3.5	3.68	14.2	4.19	P>0.1349

Table IV shows the comparison of maternal trait performance data. Initial litter size was not significantly affected by the treatment (P>0.1769). The initial litter size mean of the treatment group was 7.8 compared to 8.0 for the control group. The number weaned was also not significantly affected by the treatment (P>0.1127). Similarly, the treatment group had a mean weaned litter size of 7.5 and the control group weaned 6.9 piglets. Calculations were conducted to derive the percentage of piglets born alive that survived until weaning. The treatment had no significant effect on percent weaned (P>0.1349). The treatment group had a weaning percentage of 96.5 percent compared to 85.8 percent weaned for the control group.

Upon completion of weaning data, the sows were observed for onset of estrus. The treatment had no significant effect on onset of estrus (P>0.1318). The mean number of days for return of estrus of the sows in the treatment group was 4.5 days, and the control group returned in 5.0 days to estrus.

Table 5. Stage One Comparison of Piglet Growth Factors

Factor	Amaferm®	SE	Control	SE	P value
Weaning Weights, lbs.	15.13	0.22	15.86	0.22	P>0.1490
Average Daily Gain, lbs./day	0.46	0.18	0.48	0.20	P>0.0904
Weight Gains, lbs.	9.54	0.51	10.28	0.49	P>0.0044

Table V displays piglet growth data. The treatment had no significant effect on piglet weaning weight (P>0.1490). The mean weaning weights for treatment and control were 15.13 pounds and 15.86 pounds, respectively. The treatment showed no significant effect on average daily gain from birth to weaning. The treatment group gained 0.46 pounds per day, and the control group gained at a rate of 0.48 pounds per day. However, the treatment had a highly significant negative effect on weight gains for birth to weaning (P>0.0044). The treatment group gained 9.54 pounds, and the control group gained 10.28 pounds.

Stage Two

The hypothesis was that Amaferm® would not affect gain in nursery piglets. Death losses were minimal with only two treatment nursery pigs and one control nursery pig perishing. These were removed from the study.

Table 6. Stage Two Comparison of Nursery Pig Growth Factors

Factor	Amaferm®	SE	Control	SE	P value
Average Daily Gain, lbs/day	0.77	0.42	0.81	0.40	P>0.1357
Total Weight Gain, lbs	22.40	0.57	24.22	0.53	P>0.0698

Table VI displays data collected on nursery pig growth. Weaning weights were assigned as beginning weights that were collected in stage one, and final weights were collected on day thirty post-weaning. The treatment had no significant effect on average daily gain (P>0.1357). The treatment group gained at a rate of 0.77 pounds per day, and the control group gained at the rate of 0.81 pounds per day. The treatment also had no significant effect on total weight gained in the nursery (P>0.0698). The treatment group gained 22.90 pounds, and the control group gained 24.22 pounds.

Table 7. Stage Two Comparison of Nursery Pig Feed Efficiency Factors

Factor	Amaferm®	Control	P value
Ave. Feed Intake, lbs/day	0.55	0.56	NA*
Ave. Feed Conversion Ratio, lbs of feed/lbs of gain	1.59	1.55	NA*

**The total amount of feed was measured; however, the intake of each pig could not be measured*

Feed intake data was collected as group data because the experimental design did not allow for individual intake data, but rather group intake data. Therefore, P values could not be obtained for the data. However, means were obtained and calculations were conducted. Table VII compares feed intake and feed-to-gain ratio.

The feed intake for the treatment group was 1.21 pounds per day while feed intake for control was 1.23 pounds per day. This information allowed for the calculation of feed-to-gain ratios for each group. The treatment group established a ratio of 1.59 pounds of feed to one pound of gain, and the control group established a ratio of 1.55 kilogram of feed to one kilogram of gain.

CONCLUSIONS

The hypothesis that Amaferm® would not improve maternal efficiency was confirmed by this experiment. It is concluded that Amaferm® had no significant effect on sow feed intake and body condition score during lactation. Statistical analysis concluded that Amaferm® did not have a significant effect on onset of estrus after weaning. The most prohibitive problem in this experiment was the N value of the sows.

The hypothesis that Amaferm® would not improve growth economic traits in nursery pigs was confirmed by this experiment. There were no significant differences derived for average daily gain or total weight gained in nursery pigs. However, there was a tendency (P>0.0698) that control pigs gained more weight post-weaning and showed a difference in pre-weaning than did their treatment counterparts.

This study does not address change in fiber digestion or change in microflora of the gastrointestinal tract of monogastrics. Therefore, more studies need to be conducted to determine if microfloral promoters could increase microfloral populations and, subsequently, increase fiber digestion in swine. Other studies should also be conducted to determine if Amaferm® loses efficacy when it goes through the monogastric digestive tract. With the data collected to date, Amaferm® showed to have a negative or no effect on maternal or growth traits.

REFERENCES

Beharka, A. A., and T. G. Nagaraja. 1991. Effect of *Aspergillus oryzae* extract (Amaferm®) on ruminal fibrolytic bacteria and in vitro fiber degradation. In proceedings from Dairy Day 1991 Report of Progress 640. pp. 1-3.

Bodine, T. N. and H. T. Purvis II. 2003. Effects of supplemental energy and/or degradable intake protein on performance, grazing behavior, intake, digestibility, and fecal and blood indices by beef steers grazed on dormant native tallgrass prairie J. Anim. Sci. 81: 304-317.

Boggs, D. L., R. A. Merkel, and M. E. Doumit. 1998. Livestock and Carcasses: An Integrated Approach to Evaluation, Grading, and Selection. Kendall/Hunt Publishing Company. Dubuque, Iowa.

Denigan, M.E., J. T. Huber, G. Alhabdhrami, A. al-Dehneh . 1992. Influence of feeding varying levels of Amaferm® on performance of lactating dairy cows. J. Dairy Sci. 75:1616-21.

Gomez-Alarcon, R.A., J. T. Huber, G. E. Higginbotham, F. Wiersma, D. Ammon, and B. Taylor. 1991. Influence of feeding *Aspergillus oryzae* fermentation extract on the milk yields, eating patterns, and body temperatures of lactating cows. J. Animal Sci. 69:1733-40.

Weimer, P. J. 1998. Manipulating ruminal fermentation: a microbial ecological perspective J. Anim. Sci. 76: 3114-3122.

Yoon, I.K. and M. D. Stern. 1996. Effects of Saccharomyces cerevisiae and *Aspergillus oryzae* cultures on ruminal fermentation in dairy cows. J. Dairy Sci. 79:411-417.

The Texas Journal of Agriculture and Natural Resource 19:8-22 (2006)

Economic Impact of Erath County's Dairy Industry

S. Hussain Ali Jafri
Department of Accounting, Finance and Economics, Tarleton State University, Stephenville, TX, 76402

David Buland

NRCS, USDA, P.O. Box 6567, Fort Worth, TX 76115

ABSTRACT

Of the 264 counties in Texas, Erath County boasts the highest dairy production, accounting for 27% of the state's total milk production. This study estimates the economic impact of Erath County's dairy industry at both the county and state levels. Combining primary and secondary data and adjusting for leakages, an input-output model was constructed and the economic impacts assessed using IMPLAN. Results place the industry's impact in Erath County at $543 Million, representing 36% of the county's economy, accounting for 5912 jobs or 31% of all employment in the county. At the state level, Erath County's dairy industry amounted to $772 Million and 10,926 jobs. Much of the core economic impacts were attributed to the hay and pasture, wholesale trade, motor freight transportation, and warehouse sectors.

Key Words: Dairy Industry, IMPLAN, Repurchase coefficient, Economic Impact

INTRODUCTION

Erath County boasts the highest dairy production of any county in Texas, accounting for 27% of state's total milk production. In 2001, milk sales accounted for 79% of the county's total agricultural income. Overall, milk production in Texas peaked in 1994, while productions levels in Erath County rose continually and peaked in 2000 (Milk Marketing Administrator's Reports, 1994-2000). Dairy producers are leaving the county because of low and inconsistent prices, uncertainties surrounding environmental regulations, and the lure of more friendly business environments elsewhere (Stephenville Empire Tribune, March 12 and 18, 2001). Most producers who leave are believed to be moving to counties in west of Texas or to the state of New Mexico. New Mexico milk production exceeded that of Texas in 2000. In 1995, milk production in New Mexico accounted for only 25% of the state's total milk output (Milk Marketing Administrator's Reports,).

The number of dairy producers in Erath County has been declining steadily, from 202 dairies in 1994 to only 138 in 2001 (data released recently indicates that there are only 106 dairies left in the county – Texas Dairy Review, July 2006). However, during this same period overall milk production increased—both from increased productivity as well as in the number of dairy cows in the county. This combination has led to larger dairies and to a more concentrated industrial structure. If this trend continues it may pose a major economic risk to the county's well-being, as the economic impact of possible large producers leaving will be felt more acutely than if smaller producers exited.

OBJECTIVES: This study seeks to estimate the economic impact of Erath County's dairy industry at the county and state level alike. The core output, employment and value-added effects will be identified first, a sensitivity analysis will follow which will investigate the various impacts associated with changes at the firm (1,000 cow operation), as well as with changes in the price of milk.

REVIEW OF LITERATURE

Using 1995 data from secondary sources, Nielsen et al. (1998) estimated the economic impact of Erath County's dairy industry. This study made no adjustments for local purchases of inputs and relied primarily on the Impact Analysis for Planning (IMPLAN), data sets managed by the Minnesota Implan Group (MIG, Inc.) for the county's dairy industry. The analysis was restricted to milk sales and made no attempt to account for additional income from the sales of calves, heifers, crops, government payments, or off-farm income. The study reported an output multiplier of 1.44 and an employment multiplier of 2.03. The county's dairies sold $185 Million (M) of milk in 1995, with an additional $265 M in indirect and induced effects. The model concluded that the industry generated $49 M in personal income and accounted for 3,157 additional jobs, representing 22% of total income and 25% of employment in the county.

At the regional level, in 1993 Jones et al. (1993) estimated the dairy industry's economic impact in the Cross Timbers Region of Texas (which includes Erath and surrounding counties). The study applied the IMPLAN model to estimate the direct and secondary effects of the dairy industry. The output multiplier for milk sales was 1.52, and for employment was 2.22. The multipliers for livestock sales were higher, with 1.85 for sales and 3.8 for employment. The dairy industry accounted directly and indirectly for $337 M or one-fifth of the region's sales, representing $136 M or 18% of personal income, and employing 5,150 or 16.5% of the region's civilian labor force.

Mulkey and Clouser (1991) used sales of dairy products in Okeechobee County, Florida to calculate the direct, indirect, and induced economic effects. They used multipliers generated by the U.S. Department of Commerce's Regional Input-Output Modeling Systems (RIMS). The output multiplier for the dairy sector was 1.58, and each million-dollar sale generated an additional 15 full-time equivalent jobs in the county. The earnings multiplier was 1.29, suggesting that every dollar of milk sales created an additional $0.29 of earnings for the other sectors in the Okeechobee County. The report also included the impact on the county in terms of lost output and jobs from the loss of a hypothetical dairy farm with 1,000 cows.

Hemmer and Buland (1998) examined the local economic impact of changes in the environmental conditions due to the presence of dairies in Maricopa County, Arizona. They analyzed the loss resulting from the loss of a 1,000 cow dairy operation looking at costs and benefits to Maricopa County. The study numbers were applicable to a per-farm basis. This study attempted to model the local dairy industry by using farm enterprise budgets and estimates of variable and fixed costs of a dairy operation. Unlike previous studies, they also attempted to estimate both the short and long-term impacts of a dairy operation within a defined region. Using selected discount rates, the study projected the costs to a community resulting from the loss of a typical large 1,000 dairy-head operation.

From this brief review of literature, we note that impact studies are becoming more common. Typically, the economic impact is higher when the impact region is larger and more inputs are bought locally (greater backward linkages involved in input-output relationships).

MATERIALS AND METHODS

This study's basic framework is built around a conceptual model that separates the dairy industry and the local economy into two separate entities (Figure 1). The dairy industry includes total annual revenues from milk sales and the corresponding expenses for producing milk, along with revenues from the sale of calves, bulls, and heifers, average capital expenditures, and other farm income such as custom-work, government payments, etc. The "local" economy is defined as the economic structure of Erath County at the regional level and the state of Texas at the state level. The dairy industry's interactions and backward linkages will be identified to estimate the output and employment that can be associated with the dairy industry present.

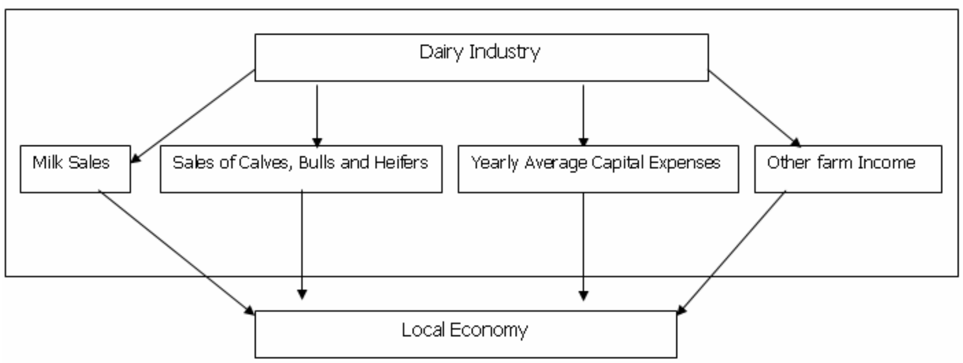

Figure 1: Conceptual Model.

Estimating the economic impact of an industry requires data on income, expenses, sources of inputs purchased, capital improvements, and taxes paid. Unlike the previous Nielsen et al. (1998) study, this research utilizes primary data acquired through a survey instrument in an attempt to improve and calibrate IMPLAN's production functions so they might better conform to local conditions. For example, the survey included questions on revenues received by producers for commodities other than milk, such as the sales of heifers and cattle, and government payments received. The expense categories included questions on the actual expenses incurred (operating and capital) and on the percentage purchased locally (within Erath County) and outside the area. For capital expenses, producers were asked to provide these data for the last five years. An annual average of these expenses was computed from the data provided.

Surveys were sent to all 140 dairy producers identified in the county within the first six months of the study. Forty usable surveys were returned. These forty producers were responsible for 47% of all milk produced in 2000 and owned 33% of all cows in the county in 2000. Two local accounting firms also provided reports summarizing information about their dairy clients that included estimated enterprise budgets for each client. The IMPLAN datasets included economic data from the U.S. Bureau of Economic Analysis, Agricultural Census, and other economic data that approximated production functions at the county level. At the time the study was initiated, the county's 1998 IMPLAN dataset was the most current available. This dataset was used for the dairy industry, and adjusted to 2000 figures from the survey data. For the state, the 1997 Texas IMPLAN model was used and later updated to the 1999 Texas model when the more recent version was available.

The National Agricultural Statistical Service (NASS) publishes state-level average monthly and annual estimates of milk prices paid to producers (NASS, 2000). Erath County's prices are close to the state average because the county is centrally located and is the state's largest producer. This study uses the NASS average annual prices for the state of Texas, the Federal Milk Marketing Administrator numbers for county-level production are more extensive than those in the NASS survey. Combining the Milk Marketing Administrator's production estimate of 1,502,226,552 lbs. multiplied by the NASS Texas average price of $13.30/cwt. calculated out to $199,796,131 for milk sales in the year 2000. The major portion of the economic impact analysis was performed using the IMPLAN input/output model.

IMPLAN and other input/output models estimate economic impacts of policies that occur through forward and backward linkages in the economy. Backward linkages include purchased inputs, supplies, and services. Forward linkages include further value-added economic activities, such as preparation and processing. By going beyond measuring direct impacts only, these models provide a more thorough representation of the economic effects of various policy options. Purchases and sales are adjusted for in/and out-of- region sources, and are then summed to estimates the economic impacts arising from an initial policy change. The IMPLAN model estimates impacts on total output (sales), personal income, value-added, taxes, and employment. The theoretical basis for the model comes from work by Wassily Leontief (Garbo, 2002).

IMPLAN's data sets are derived from sources that include national, state, and local data. Further details about data sources and methods can be found in the IMPLAN User's Guide. All of the impacts were calculated based upon the 1998 Erath County model constructed with all SAM sectors included, excluding federal defense spending (no apparent relationship was seen to exist between the dairy industry and the defense industry). This SAM model included all local industries and households as well as federal, state, and local government sectors except federal defense. Erath County is relatively small (population of 30,815) and contains only 128 of the 528 industrial sectors within the IMPLAN model. With so many sectors absent, economic multiplier effects are likely to be smaller in this case than in larger economic areas.

The Regional Purchase Coefficients (RPCs) are the percent of income and expenses purchased/spent by producers in Erath County and in Texas for the county and state models, respectively. This data was also collected from the survey respondents. Dairy farm expenditures and RPCs were calculated primarily from survey data with adjustments from the original Erath County IMPLAN data. The owner's draw, taxes, health insurance, other benefits, and labor expenses were excluded from these operating expense calculations and were treated separately later. Several survey categories were combined to better match the IMPLAN sectors and to minimize errors, using a pivot table and guidance from the base IMPLAN dataset.

The combination of the $210 M dairy sales sector, $18 M ranch fed cattle sector, and $12 M range fed cattle sector covers the output of these dairy farms in the 1998 IMPLAN model for Erath County's economy. The dairy sector includes milk sales only in the IMPLAN model, while the other 10% of sales (in particular dry cows and heifers) are in the ranch and range fed cattle sectors, two sectors that are interchangeable for Erath County where they have identical production functions and outputs within the IMPLAN dataset. Their separation in the IMPLAN model dates back to the 1980s, when the Forest Service attempted to separate cattle on federal land from cattle on private land. The remainder of the replacement heifers sector was imported using local wholesale and transportation margins modified from the other sectors. In this study the dairy industry includes all three sectors.

Erath County includes only 125 of the potential 512 IMPLAN industrial sectors. The dairy industry purchases products from 81 sectors. The smaller ranch and range fed cattle sectors combined purchase from 88 sectors. The IMPLAN dairy and cattle sectors combined purchase from 96 different industrial sectors within Erath County.

Each sector was examined individually to determine whether the IMPLAN RPC, the survey RPC, or the IMPLAN retail margin should be used. For example, if the product was not produced in the county, such as John Deere tractors, then the household purchase margin was used, if IMPLAN had one estimated available. If not available, the industrial or institutional margins were used. All RPCs were constrained by the amount produced in the county.

Wages

Wages and owner's draw were run as separate calculations.[1] Total wages were estimated at $17.2 M and local labor at 100% based on the survey. Based on lower than average incomes, 10% of gross income was deducted to account for taxes and savings; thus $15.5 M was the direct impact used. The household income figure used with the IMPLAN institution impact group was set at $20K - $30K for calculating the impacts. This income range was considered average, since most farm workers earnings fall in this range. As consumption patterns were not included in the survey, the IMPLAN household consumption expenditures were used for sector allocations with the corresponding IMPLAN Household RPCs.

Owner's Draw

Owners' draw represents the amount retained by the proprietor/owner for family expenses. The total owners' draw was placed at $4.2 M based on the interview data from the survey's final section. Based on higher average incomes, 25% of gross income was

1. Wages and Owners' draw were estimated independently. The impact from these expenditures was linked with consumption patterns. All other operating expenses had production backward linkages.

deducted to account for taxes and savings to estimate actual consumption. As in the previous case, the survey did not research owners' consumption patterns. In the absence of these details, the IMPLAN Households $60K - $70K sector (and the corresponding RPCs) was adapted to estimate the expenditures.

Capital Expenses

Besides operating expenses, producers occasionally incur expenses for capital improvements, purchases and/or construction of new equipment and vehicle, farm structures, silos, lagoons, and retention ponds (for complying with environmental regulations), and so on. The survey asked producers to estimate these expenditures for the last five years. Taking yearly averages and extrapolating the figures from the sample to the county dairy population provided estimates of capital expenses.

Texas Model

The Texas model was constructed from the 1999 MIG Texas data set using all federal, state, and local sectors except federal defense. The Texas dataset includes 497 industrial sectors, far more than the 125 industrial sectors active in Erath County. In 1999, Erath County accounted for only 0.21% of the state's total output (sales), but boasted 25.0% of the state's total dairy production. The dairy impact vectors were imported from the Erath County model into the Texas model. Again, the multiplier effects can be expected to be higher for the entire state than for the smaller economic area included in Erath County.

RESULTS AND DISCUSSION

Economic Impact at the County Level

It was estimated that the dairy industry's operating expenses for 2000 equaled (after adjusting for local RPCs) $200.9 M, spread over 97 of the 128 sectors within Erath County's economy. When these expenditures were imported into IMPLAN, the model calculated local purchases at $190.9 M after adjusting for the RPCs. These represent the direct economic effects of the operating expenses associated with the county's dairy industry. These expenditures by individual sectors were then processed by IMPLAN, and after several iterations, the model computed the indirect effects at $31.2M. Subsequently, the model estimated the induced effects of an additional $27.4 M. Thus, the total effect from the partial operating expenses in the aggregate equals $249.54 M in output (sales).

Wages were treated separately. As reported earlier, after adjusting for taxes and savings, $15.5 M was the direct impact figure used. The total effects inclusive of direct, indirect and induced effects equaled $18.84 M.

Owners' draw was also calculated separately. Owners' draw was placed at $4.2 M and an adjustment of 25% ($1 M) was deducted to reflect taxes and savings. The total effects—including direct, indirect, and induced effects equaled $3.81 M.

Adding together the effects associated with operating expenses, wages, and owners' draw gave a total impact of $272.2 M in output or sales (Table 1). To this last figure, the $17.2 M in wages paid and $4.2 M in owner's draw are added together to obtain a total economic impact from operating expenses of $294.2 M.

To non-labor expenses, wages, and owners' draw, we also added the actual taxes ($915,622) paid by dairy farmers in the county for the year 2000. This number was derived by obtaining information on the value of properties listed as dairies as obtained from the Erath County Appraisal District. As stated earlier, total direct expenses amounted to $223.2 M. Dividing the total impact of $294.2 M by $223.2 M provides an output multiplier of **1.32** (Table 5). This is a relatively conservative and smaller multiplier as compared with those previously obtained by researchers: (a) 1.44 obtained in the 1995 Nielsen's study (Nielsen, et al., 1998) of Erath County's dairy industry, (b) 1.5 reported in the Jones (1993) study of the dairy industry in the Cross-Timbers region (Jones, et al.1993), and (c) 1.58 obtained in the study of the dairy industry in Okeechobee County, Florida (Mulkey & Clouser, 1991). On reflection, our results appear to be reasonable and as expected, since Erath County represents only one county within the Cross-Timbers Region. It is also smaller in size and population than Okeechobee County, Florida. This study differs from the Nielsen study in the data collection methods; the Nielsen's study relied on the national IMPLAN baseline data whereas this study uses local survey data.

As mentioned earlier, the dairy producers' 2000 gross income from the sale of milk was estimated at $199.8 M. This amount represented about 90% of the dairy industry's total income. The remaining 10% was derived from the sale of cows and heifers, government payments, and off-farm income. The combined income for Erath County's dairy industry equaled $222.4 M. Adding this last figure to the economic impact of $294.2 M obtained by applying the multiplier effects provided $516.6 M for the total economic impact of the dairy industry from operating expenses alone and dairy industry sales (Table 5).

Average annual capital expenditures were estimated (direct impact) at $19.1 M. Using IMPLAN, the estimated indirect and induced impact flowing from these direct expenditures added another $7.5 M to give a total impact of $26.6 M from capital expenditures. Adding capital expenditures to the previous figure of $516.6 M (from operating expenses) provides a grand total of **$543.2 M** for the dairy industry's economic impact in Erath County (Table 5). This amount represented **36%** of the county's total output in 2000.

Employment Impact

The IMPLAN data estimated 1,386 workers in the county's dairy industry sector and another 325 workers in the range and ranch fed cattle. The economic structure created by the IMPLAN input-output model estimated that in 1998 there were 1,386 workers in the county's dairy industry sector and an additional 325 in the range and ranch fed cattle sectors, for a total of 1,711 workers in the combined Erath County dairy sector in 1998. USDA's National Agricultural Statistical Service (NASS) estimated that there were 79,000 milking cows in the county in 1998. This translated into roughly 2.16 jobs per 100 cows. According to NASS, the number of milking cows in 2000 was estimated to have grown to 91,400. Using the ratio of 2.16 jobs per 100 cows (for a total of 91,400 cows) yields approximately 1,980 jobs located on the county's dairy farms in 2000.

The direct impact on employment from the operating expenses of almost $200M provided 2,465 jobs; the indirect and induced economic impact created an additional 11,550 jobs, and the induced impact resulted in 600 more jobs created. By adding these three figures it becomes clear that for a total of 3,615 jobs are linked to operating expenses from the dairy industry in Erath County. Another 317 jobs are created from the capital expenses sector, for a total of 3,932 jobs (Table 1).

Combining the 3,932 jobs from the direct, indirect, and induced effects with the estimated 1,980 jobs on the dairy farms provides an estimated **5,912** jobs that can be attributed to the presence of the dairy industry in the county. The county's total employment equaled 19,354 in 2000. Thus, the dairy industry accounted for **31%** of Erath County's total employment that year.

Table 1: Output and Job-Creation in Erath County

Impact	Event	Direct	Indirect	Induced	Total
Output	Operating Expenses	$209.5 M	$32.8 M	$272.8 M	$272.8 M
	Capital Expenses	$19 M	$3.5 M	$4 M	$26.6 M
	Total	$228.5 M	$36.3 M	$276.8 M	$299.4 M
Employment	Operating Expenses	2465	550	600	3615
	Capital Expenses	190	48.3	78.6	317
	Total	2655	598.3	678.6	3932

Value-Added

The IMPLAN model also estimated the total value added profits, rent, wages and local taxes. This 'value added' provides a measure of net economic income for Erath County, together amounting to $123.1 M in 2000. This amount represented 18% of the $706.6 M in 2000 personal income for Erath County. The impact on wages for the county (direct and indirect wages) paid by the dairy industry amounted to $60 M also, which represented 18% of all the wages paid (total employee compensation in the county equaled $338 M according to IMPLAN). The direct taxes (property and school) paid by the county's dairy producers were estimated at $915,622 representing 4% of all property taxes collected by the county.

In addition to direct taxes, the model estimated that the county garnered $9,443,409 in indirect business taxes (mainly sales taxes) on expenditures incurred by the dairy industry. Adding the direct taxes to indirect taxes yields a total of $10.4 M that can be attributed to the dairy industry. Besides, the 1998 IMPLAN model is built on a national scale to model all 3,028 US counties simultaneously. IMPLAN estimates marginal taxes at the national, state, and county levels, and then makes adjustments—first so all the counties add up to the national estimate, and next so that all counties total the state estimate. As such, these tax estimates may not exactly reflect the current Erath County tax codes.

From the model results, we also extracted information on output and employment for the county's industries that were impacted the most by the presence of the dairy industry. These industries will top the list of those that either benefit or lose by the expansion or contraction of the dairy industry in the county. It is important to note that the dairy farm sector includes the dairy farm products as well as the ranch and range-fed cattle.

Significant output (sales) impacts occurred in numerous sectors, including wholesale trade, motor freight, transportation and warehouse, hay and pasture, real estate, and banking/credit agencies (Table 2). In terms of employment, those industries impacted most by the dairy industry included the hay and pasture industry, which tops the list for numbers of jobs linked to the dairy industry. Other industries of significance were wholesale trade, motor freight transportation and warehouse, banking & credit agencies, agricultural services, and medical and health services (Table 3).

Table 2: Core Industries in Erath County Impacted by the Dairy Industry ($ Millions)

Sector	Industry	Direct	Indirect/Induced	Total
447	Wholesale Trade	24.7	3.0	27.7
435	Motor Freight Transport & Warehouse	16.5	4.3	20.7
13	Hay & Pasture	15.0	1.6	16.6
462	Real Estate	6.8	8.0	14.8
456	Banking & Credit Agencies	9.3	3.7	13.0
493	Medical & Health Services	4.3	3.1	7.5
443	Electric Services	3.9	2.2	6.1
56	Maintenance & Repair Other Facilities	4.1	1.7	5.8
441	Communications	1.9	2.2	4.1
451	Automotive – Dealers, Repairs, & Services	0.6	2.05	3.1
454	Eating & Drinking	0.6	1.7	2.3
195	Drugs	1.2	0.9	2.1
459	Insurance Carriers	1.2	0.3	1.5

Table 3: Core Employment Impacts of the Dairy Industry on Erath County

IMPLAN Sector	Industry	Direct	Indirect+ Induced	Total
13	Hay and Pasture	746	79	825
447	Wholesale Trade	391	48	439
435	Motor Freight Transport and Warehouse	182	47	229
456	Banking and Credit Agencies	138	53	191
26	Agricultural- Forestry- Fishery Services	127	44	171
493	Medical and Health Services	89	50	138
454	Eating & Drinking	21	56	77
462	Real Estate	38	27	64
451/479	Automobile – Dealers, Repair Services	11	37	48
455	Miscellaneous Retail	14	30	44
450	Food Stores	11	22	33
449	General Merchandise Stores	10	22	32

Economic Impact at the State level

The state economic impact was also calculated with four types of expenses: operating, wages, owners' draw, and capital. Direct operating expenses were adjusted for the actual amount spent within the state— (the Regional Purchasing Coefficients or RPCs) by either adjusting the total by the percentage of respondents indicated, or by using IMPLAN RPCs. As expected, the RPCs at the state level were higher and the amounts of imports were lower than at the county level.

As expected, the multiplier effects were indeed higher at the state level than at the county level. At the state level, the direct effects for operating expenses equaled $204.4 M, as compared to $190.9 M at the county level, reflecting the higher RPCs at the state level. The indirect and induced effects are also correspondingly higher, amounting to $68.9 M and $178.2 M, respectively. The total effects from the operating expenses alone are $451.5 M. Wages and owners' draw were separately calculated following the approach used in the county calculations, with adjustments made as discussed in the previous section.

The state's total impact from wages ($21.8 M) and from owners' draw ($5.8 M) amounted to $27.6 M. At the state level the total effect from operating expenses equaled $479.1 M. We repeated the procedure by aggregating the operating expenses, wages, and owners' draw, and then processed the data into IMPLAN. The total effect was slightly higher—$485.9 M. The marginal difference of 1.4% reflected the rounding calculations within the model. To this last figure we added the direct impact of wages of ($17.2 M) and owner's draw ($4.2 M) to obtain a total economic impact from operating expenses at $507.3 M. Dividing this impact by total expenses ($223.2 M) yielded a multiplier of 2.28. As expected, this multiplier is higher than its counterpart at the county level (1.32). It is higher than that for the state's wine industry (1.92) (Michaud, et al., 1998) and the state's poultry industry (1.35) (Carey, et al., 1998). However, it is almost identical to that of the California's dairy industry (2.27) (Dryer, 2005).

As indicated in the previous section, the combined total income of the dairy industry in Erath County equaled $222.4 M. When this number is added to the total impact of $507.3 M from operating expenses it results in an impact of $729.8 M at the state level. (Table 4)

The direct impact of capital expenses was $19.1 M. When these were processed in the state's IMPLAN model, the indirect/induced impacts generated an additional $22.9 M to provide a total impact of $42.0 M for capital expenses at the state level. When we add $729.8 M impact from operating expenses to the $42 M associated with capital expenses, the total impact of Erath County's dairy industry on the state of Texas was **$771.8 M.** Please recall that the total impact at the county level was $543.3 M. Subtracting this figure from the state's total impact calculates to a difference of $228.5 M. This implies that Texas counties, other than Erath are directly or indirectly affected by the dairy industry by $228.5 M. With 254 counties and 0.21% of the state's total output coming from Erath County, there is little backward impact into Erath County from other Texas counties.

Employment Impact at the State Level

The model also estimated the number of state jobs created due to Erath County's dairy industry. As stated earlier, the RPCs at the state level were higher than at the county level. These added purchases translated into $228 M in additional output at the state level. Thus, we should expect higher job-creation at the state level.

The $200 M in operating expenses provides 5,211 jobs directly in the dairies. Once the indirect and induced effects were included, the total jobs figure increased to 8,170. As before, wages and owners' draw were analyzed separately, and once the direct, indirect, and induced effects were considered, these expenditures accounted for 195 and 55 jobs, respectively. Thus, operating expenses accounted for 8,420 jobs. We repeated the procedure by aggregating the operating expenses, wages, and owners' draw and then processed the data using IMPLAN. The total effect was slightly higher, at, 8,501 jobs. The difference reflects to rounding calculations within the model.

The indirect and induced jobs calculated with the state model added 255 jobs for a total of 445 jobs attributed to capital expenditures. Adding these 445 jobs to the 8,501 from operating expenses provided approximately 8,946 jobs (Table 4). To this last figure we added the dairy industry's direct jobs , estimated at 1,980, for a grand total of **10,926** jobs in the state that are associated with the presence of the dairy industry in Erath County. Table 5 summarizes all the results of this study at the county and state levels.

Table 4: Output and Job Creation in the State of Texas

Impact	Event	Direct	Indirect	Induced	Total
Output	Operating Expenses	$223 M	$72.7 M	$190.1 M	$485.9 M
	Capital Expenses	$19.1 M	$8 M	$14.9 M	$42 M
	Total	$242.1 M	$80.7 M	$205 M	$527.9 M
Employment	Operating Expenses	5361	866	2274	8501
	Capital Expenses	190	77.2	178	445
	Total	5551	943.2	2452	8946

Sensitivity Analysis Modeling

Besides estimating total impact, we also conducted a series of tests to determine the marginal impact of changes in production and in prices for the dairy industry, along with the consequent impacts these changes will have on output and employment in the county. These questions were posed:

(1) What will be the impact on the county in terms of output and employment when a large dairy (1,000 cows) decides to locate or to exit the county? This question was taking on increasing importance as local newspaper reports were covering the exits

of larger dairies from the county, as they were being denied permit renewals to operate by the Texas Commission on Environmental Quality (TCEQ).

Since the IMPLAN model assumes fixed coefficients, we modeled the change by adjusting total production. In 2000, NASS estimated 91,400 dairy cows in Erath County. A change in 1,000 cows provides a net change of 1.094% in total dairy production. Using previous IMPLAN estimates of output and employment, a 1.094% change translates into a change of $5.6 M in output, 61 jobs, and $1.3 M in value added. The change in wages will be $655,762.

(2) What will be the impact in terms of output, value-added and employment for the county if the price of milk changes by $1/cwt? Since dairy producers are price-takers, their fortunes increase or decrease with changes in the price of milk. Meanwhile, the price of milk is a contested issue in national farm policy debates. We conducted an exercise to measure the impact on dairy producers of a $1 increase or decrease in the price of milk and the consequent implications for output and employment for the rest of the county.

Since the IMPLAN model assumes fixed coefficients, we modeled this by assuming that all the impact would be entirely reflected in the owners' profits (owner's draw), and that no direct impacts on wages or other expenses would occur. Using the 2000 production figures for the county (1,502,226,552 lbs of milk), a $1 change in the price of milk will translate into a change in $15.0 M in the income received by dairy producers.

We assigned this change to owners' profits for a given year to directly affect the owners' income because all other expenses are either expended or committed. To estimate the impact of this change in owners' profits, we subtracted 25% of $15.0 M to adjust for taxes and savings, leaving $11.3 M as a direct loss in spending. Once the indirect and induced impacts are estimated using the IMPLAN model, the total output (sales) change equals $13.6 M. Subtracting $5.6 M in domestic and foreign trade leaves a final impact of $8 M sales of goods and services produced in Erath County. The corresponding employment change was 128.7 jobs and the Value added change was $4.9 M. The change in wages was $2.2 M.

SUMMARY

In 2000, Erath County has the largest production of milk in Texas accounting for 27% of the state's milk production. Revenues from milk production represented 79% of the county's overall agricultural income in 2001. Milk sales for 2000 were estimated at about $200 M, and total income from all sources was estimated at $222 M for dairy producers. This study attempted to estimate the dairy industry's economic impact on the county and on the state, and used the IMPLAN input-output model.

A survey instrument was distributed to all producers in the county. After three mailings, 40 out of the 135 producers responded, representing almost 30% of the producers, accounting for 33% of all cows in the county, and producing 47% of the county's milk in the year 2000. This survey data produced income and expense estimates while, adjusting for leakages at the county and state levels. The adjusted direct expenditures were then processed through the input-output model (IMPLAN) to calculate the re-spending or multiplier effects.

Table 5: Summary of Impacts

	Erath County	**Texas**
NASS Milk Price	$13.30	$13.30
Milk Income	$199,796,131	$199,796,131
Dairy Producer's Gross Income	$222,429,097	$222,429,097
Expenses	**$200,897,100**	**$200,897,100**
Property+ School Taxes	$915,622	$915,622
Wages (Pre-Tax)	$17,222,413	$17,222,413
Owners Draw (Pre-Tax)	$4,201,127	$4,201,127
Total Expenses/Income	$223,236,262	$223,236,262
Erath Output Impacts	**$294,202,950**	**$507,356,248**
Output Multiplier	**1.32**	**2.28**
Total Impact from Operating Expenses	$516,632,047	$729,785,345
Total Impact including Capital Expenses	**$543,256,573**	**$771,797,420**
JOBS IMPACTS		
Dairy Industry Jobs	1,980	1,980
Additional Jobs Created from Operating Expenses	3,615	8,501
Total Jobs	5,595	10,481
Employment Multiplier	**1.83**	**4.29**
Total Jobs including Capital Expenses	**5,912**	**10,926**
Value Added (Profits, Rent, Wages, Local Taxes)		
Direct Value Added	$29,004,256	$29,004,256
Additional Value Added	$94,109,426	$271,577,667
Total Value Added	$123,113,682	$300,581,923
Wages		
Direct Wages Paid by Dairy	$17,222,413	$17,222,413
Indirect Wages	$42,719,252	$116,609,876
Total Wages Paid	$59,941,665	$133,832,289
Property Income		
Rent paid by Dairies	$6,665,094	$6,665,094
Indirect Property Income	$28,506,353	$72,059,819
Total Property Income	$35,171,447	$78,724,913
Profits		
Dairy Owners Draw (Pre-Tax)	$4,201,127	$4,201,127
Proprietors Income	$13,440,443	$56,662,106
Total Profits	$17,641,570	$60,863,233
Taxes		
Dairy Property+ School Taxes	$915,622	$915,622
Indirect Business Taxes	$9,443,409	$26,245,864
Total Local Taxes	$10,359,031	$27,161,486

The overall multiplier for all expenditures was 1.32 in 2000, a smaller multiplier than that estimated by previous I-O studies of dairy production in this region. This is a conservative multiplier and is smaller than multipliers obtained in similar studies for this region as well as other parts of the country (Nielsen et al., Jones et al., Mulkey and Clouser). Applying this multiplier to a combined total income of $222 M yields a total impact of $294 M, and adding the last figure to the direct impact of $222 M results in the total impact (from operating expenses alone) of $516 M. Besides operating expenses, the study also estimated average annual capital expenditures incurred by dairy producers (averaged over five years). The direct capital expenditures were estimated at $19 M and the indirect and induced effects added another $8 M, for a total of $27 M. Thus, the overall impact of the county's dairy industry amounts to $543 M, or 36% of the county's total output. The dairy industry directly and indirectly created 5,912 jobs and was responsible for 31% of the county's employment. The total value-added (income) in the dairy industry equaled $123 M, representing 18% of the county's agriculture/ agribusiness sector's contribution to GDP. The dairy producers paid over $900,000 in county taxes in 2001, 75% of which were school taxes. In addition to the direct taxes, the model also estimated that $9 M in taxes was generated from all direct and induced effects connected with the dairy industry.

At the state level, the dairy industry contributed $772 M in output and provided 10,926 jobs (directly/indirectly). Once we subtract the impacts in Erath County, note that the dairy industry contributes $229 M in output to the rest of the state and creates 5,014 jobs.

Like most economic impact studies, this study does not attempt to estimate negative externalities and their associated costs to the county/region. The limited scope of this study cannot include these factors that instead are suggested for further research. A large dairy industry with Concentrated Animal Feed Operations (CAFOs) is expected to create negative externalities. These may include but not restricted to water and air pollution, stress on roads and bridges (with the continuous movement of inputs and milk), inflationary land/property values, tax burden, long-term economic/social instability, and so on. These negative externalities have received increased media and political attention of late. This study offers the community, public-policy officials, and the dairy industry an economic perspective of the county's dairy industry and its contributions to the overall economic well being there.

REFERENCES

Carey, John B., Sarah G. Birkhold, and Lynette L. Ryan. 1998 "Economic Impact of the Texas Poultry Industry." Texas Agricultural Extension Service, L-5214, July.

Dryer, Jerry. 2005. "California Dairy Business" Prepared for the California Milk Dairy Advisory Board. http://www.californiadairypressroom.com/pdfs/CompleteEconomic.pdf p.4

Garbo, Lorenzo. 2002. "Wassily Leontief (1906-1999): The Founder of Input-Output Analysis and the Laureate of 1973" in <u>Frontiers of Economics</u> , Abu N.M. Wahid (Ed), Greenwood Publishing.

Hemmer, Ronald. and David Buland. 1998. "Some Aspects of Arizona Department of

Environmental Quality (ADEQ), Enforcement in the Dairy Industry in Maricopa County – Arizona." United States Department of Agriculture (USDA), AAEA Session OS-7F, http://waterhome.brc.tamus.edu/NRCSdata/implan/

Jones, Lonnie L., Allen J. Wyse, Robert B. Schwart, Jr., Amy P. Pagano, and Ronald D. Lacewell. 1993. "Economic Analysis of the Dairy Industry in the Cross Timbers Region of Texas," Texas Agricultural Station and the Department of Agricultural Economics.

Michaud, Marc, Eduardo Segarra, and Tim Dodd. 1998. "From Texas Vineyards to the Final Consumer: An Economic Impact Analysis," Texas Journal of Agriculture and Natural Resources, Vol.11.

MIG, Inc. 2000 IMPLAN Pro, Version 2.0., User's Guide, MIG Inc. Stillwater, MN.

Milk Market Administrator's Reports. (January 1994 – January 2002). Southwest Marketing Area, Carrolton, TX, http://www.dallasma.com/

Mulkey,David and Rodney L. Clouser. 1991. "Economic Impact of the Dairy Industry in Okeechobee County, Florida." University of Florida Gainesville, Staff Paper, SP #91-40,

National Agricultural Statistical Service (NASS). 2000 (January – December). http://www.nass.usda.gov/Statistics_by_State/Texas/Publications/Agricultural_Facts/

Nielsen, Tommie G, Keith O. Keplinger, and Robert H. Neal. 1998. "Economic Impacts of the Erath County Dairy Industry: An Input-Output Analysis." Texas Institute Applied Environmental Research. http://brahma.tarleton.edu/publications/pr9606.pdf

Stephenville Empire Tribune. March 12, 2001, March 18, 2001.

Texas Dairy Review. 2006. 15 (9) July 2006

Livestock Show Ethics as Perceived by South Texas FFA Members and Advisors

Patricia F. Brown
Briscoe Jr. High School, Richmond, Texas 77469
Randall H. Williams
Texas A&M University – Kingsville, MSC 228, Kingsville, Texas 78363

ABSTRACT

Agriculture teachers believe in the value of a strong FFA program and in its ability to positively impact the lives of youth. Today this program is needed to shape the ethical development of thousands of young adults. The purpose of this study was to determine the perceptions of South Texas FFA students and their agriculture science teachers regarding ethical practices in livestock shows and the extent of their involvement in these practices. Surveys were distributed to randomly selected FFA members and advisors located within Area X in South Texas. Responses indicated that the majority of participants were able to distinguish between acceptable and unacceptable practices and that they neither partake in the listed unethical practices nor knew of others who did. Some relationships were found to exist between respondents' ethics scores and demographic categories.

KEY WORDS: FFA, livestock shows, ethical practices

INTRODUCTION

Since 1928, the FFA organization has prided itself on leadership and character development. To locate evidence of these values one needs to look no further than the FFA Creed. Thousands of young FFA members proudly declare their belief in "leadership from ourselves and respect from others … the ability of progressive agriculturists to serve our own and the public interest in producing and marketing the product of our toil …in being happy myself and playing square with those whose happiness depends upon me. " (Official FFA Manual 2000)

Judging contests (Career Development Events), fairs, and livestock shows were incorporated into the program to teach members how to select for quality livestock and build enthusiasm for raising quality animals. Yesterday's small county fairs are quickly expanding to become big business, with large monetary payments for award-winning animals. Shows prohibit unethical practices, but some individuals continue to push the limits of what is and is not acceptable. Youth organizations such as 4-H and FFA as well as the livestock industry are aware of the adverse affects of the negative publicity that stems from unethical treatment of show animals. Organizations such as People for the Ethical Treatment of Animals (PETA) thrive on such negative publicity and use it as a means to increase their influence over the general public. The few people that continue to use unethical practices cast a terrible shadow over the other participants.

At the 1995 National Youth Livestock Program Ethics Symposium, Goodwin (1995) stated, "the most powerful, effective, and safe way to address this issue is from the kids up". Dr. Goodwin envisions a stock show community that strives not only to teach youth real-world agriculture skills, but also to impart ethical decision-making skills that students can incorporate into their lives. The 4-H community adopted and implemented the *Character Counts!* Program, which consists of trustworthiness, respect, caring responsibility, fairness, and civic virtue, as one way to help instill morals and ethics into youth. (Josephson Institute of Ethics 2001)

This research will attempt to determine the size and scope of unethical practices in the South Texas region and serve as a reference point for FFA chapters looking to implement educational programs aimed at teaching ethical decision-making skills.

MATERIALS AND METHODS

Instrumentation. The survey consisted of four sections: demographics, perceptions of competition, scenarios and self-disclosure of participation in unethical livestock show practices. The instrument assigned a numeric value to participant's attitude towards common generalizations concerning the ethical status of FFA competition as well as determined their awareness of certain unethical livestock show practices. The scenarios collected information on participant's ability to distinguish between ethical and unethical show practices. The personal experience section ascertained whether the individual had participated in questionable practices, and determined if he or she knew of others who had. The ethical perceptions questions and scenarios were answered using a six point Likert-type scale.

Population and Administration. The population for this study consisted of FFA students from randomly selected high schools within Area X in South Texas. High school FFA programs from each of the six districts within the area were categorized based upon their district and program size. The number of agriculture science teachers within the department was the basis for determining program size.

A survey packet, which included a cover letter and surveys for each teacher within the department (twenty to be administered to students and one to be completed by the teacher), was prepared for each of the selected programs. Fifty-eight packets were prepared consisting of a total of 1,197 surveys. Twenty-four packets were prepared for single teacher programs, four programs from each district, totaling 504 surveys. Twelve packets were prepared for two teacher departments, two programs from each district, and consisted of 504 surveys. Three packets were prepared for three teacher departments, one in each of the three districts that have large programs, and consisted of 189 surveys.

Prepared packets were hand delivered to schools at district Leadership Development Events and were mailed to those schools that did not participate. The Agriculture Science teachers were asked to administer the instrument to students and complete one survey themselves before returning all completed instruments. Completed surveys were returned at the Area X LDE contest as well as by mail. Follow up calls were made to those schools that did not return their surveys by 14 November 2001.

Analysis of Data. All data were analyzed using the Statistical Analysis Systems (SAS, 1989). Categories within each demographic question were used to group respondents so comparisons between responses could be made. Mean scores were calculated for the perception of competition, level of awareness, and the scenario sections. These scores were then categorized as low, medium, or high. Innocence scores of none, low and high were calculated by summing the respondents' scores from the personal experience and knowledge of others participation section.

General linear models (GLM) were performed to determine whether dependence existed between the respondent's ethics scores and their demographic categories. A 95% confidence interval with a value of .05 was used to indicate significance. GLMs were used to test the hypothesis that demographic category and ethics score are independent versus that they are not independent. Three hundred twenty-five degrees of freedom were used to analyze variance.

RESULTS AND DISCUSSION

Demographics. A total of 398 surveys were returned. One hundred thirty four (34%) respondents were female and 261 (66%) were male. Ages ranged from eleven to fifty-seven with 340 (78.6%) respondents between the ages of 15 and 19, typical high school age students. The two most common ethnicity categories were White (50.4%) and Hispanic (45.5%). One hundred thirty-nine (36%) respondents resided in a rural or farm area. Ninety-seven (25%) lived in a town with a population less than 10,000. Fifty-six (15%) lived in a city with a population between 10,000 and 50,000 and the remaining ninety (24%) lived in a city with a population between 50,000 and 100,000.

Seventeen (4%) respondents participated solely in 4-H programs while 241(63%) only participated in FFA programs. One hundred and twenty-five (33%) respondents indicated that they participated in both 4-H and FFA programs. Three hundred seventy of the respondents participated in the programs as members. Twelve (86%) of the 14 agriculture science teachers were FFA members while in high school. The majority, 80.3%, of respondents had shown anywhere from 1 to10 years. Fifty-six (14%) respondents never participated in livestock shows. One hundred eighty-nine (49%) of the respondents had placed in the top 3 at a livestock show while 196 (51%) had not. The largest proportion of respondents, 41.7%, indicated that they had shown swine. Most of the respondents, 271(69%), exhibited their livestock projects at local county shows.

Ethical Perceptions of FFA Competition. Table 1 summarizes the respondents' level of agreement with each of the six negative comments regarding competition within the FFA program.

Perception of competition in the FFA program. A mean score was calculated for respondents to determine their overall perception. Scores were grouped as low ($\leq$3), medium (3.01-3.9), or high ($\geq$4) with low values indicating a negative perception of competition and large values indicating a less negative perception of competition (Table 2).

Ethical Perceptions of FFA Competition. Table 3 summarizes the respondents' perceived frequency of occurrence of the six comments regarding competition within the FFA program.

Table 1. Response to ethical perceptions of FFA competition questions

Questions	**1**	**2**	**3**	**4**	**5**	**6**
There is too much emphasis on competition in FFA.	17	22	102	168	49	37
Politics in competitive FFA activities tend to overshadow the quality of a project.	51	57	116	125	33	10
Competition encourages unethical practices.	25	34	113	127	38	53
In order to win, others will perceive them to be involved in unethical practices.	18	33	98	150	43	50
Large money prizes for top placing animals at livestock shows encourage unethical practices.	28	50	107	118	34	58
Pressure from family, peers and agriculture teachers encourages unethical practices on livestock projects.	12	31	98	131	58	64

Table 2. Mean scores for ethical perceptions of FFA competition

Low (≤3)		**Medium (3.01-3.9)**		**High (≥4)**	
Mean Score	**Frequency**	**Mean Score**	**Frequency**	**Mean Score**	**Frequency**
1	1				
1.8333	3	3.1666	25	4	33
2	4	3.3333	29	4.1666	27
2.1666	7	3.4	3	4.2	1
2.2	1	3.5	35	4.3333	13
2.3333	7	3.6	3	4.5	11
2.5	12	3.6666	23	4.6666	13
2.6666	18	3.8333	35	4.8333	10
2.8	1			5	7
2.8333	11			5.1666	2
3	26			5.3333	5
				5.4	1
				5.5	4
				5.6	1
				5.666	3
				5.8333	3
				6	5
TOTAL	**92**		**153**		**139**

Table 3. Respondents' perceived frequency of desired activity occurrence

Questions	0	1	2	3	4
Participants use non-approved methods to physically alter the appearance of an animal.	57	124	129	69	19
Judges of competitive activities are fair in their assessment of FFA projects.	22	30	99	129	118
Label guidelines and approved uses of drugs are followed by livestock show participants.	36	58	97	132	73
There is excessive parental involvement in competitive FFA activities.	13	40	111	122	109
Livestock exhibitors observe animal ownership deadlines.	18	26	94	135	121
Competitors make non-approved changes to animal ear tags or tattoos.	112	141	80	40	23

0= Does not occur
1= Rarely happens (0-25% of the time)
2= Sometimes happens (26-50% of the time)
3= Fairly common (51-75% of the time)
4= Very common (76-100% of the time)

Level of awareness of unethical practices occurring in livestock shows. Respondents' perceived frequency of occurrence mean scores were grouped as low (≤1.5), medium (1.51-2.69), or high (≥2.7) with low values indicating that desirable behavior is perceived not to occur often and large values indicating that desirable behavior is perceived to occur often (Tables 4).

Table 4. Mean scores for perceived frequency of desirable activity occurrence

Low (≤1.5)		**Medium (1.51-2.69)**		**High (≥2.7)**	
Mean Score	**Frequency**	**Mean Score**	**Frequency**	**Mean Score**	**Frequency**
0.833	1	1.6	1	2.800	1
1.167	5	1.667	16	2.833	22
1.333	8	1.833	30	3.000	19
1.400	1	2.000	42	3.167	21
1.500	13	2.167	42	3.333	12
		2.333	44	3.500	11
		2.500	44	3.666	2
		2.600	2		
		2.667	47		
TOTAL	**28**		**268**		**88**

Distinguishing between ethical and unethical practices. Scenarios were used to determine the participants' ability to differentiate between ethical and unethical livestock show practices. Mean scores for level of agreement with scenarios were grouped as low (≤ 3), medium (3.01-3.99), or high (≥ 4) with low values indicating that they strongly agree with the unethical scenario and high values indicating that they strongly disagree with the unethical scenario.

Eighty-four (21%) participants thought the unethical practices represented in the scenarios were ethical. The medium range consists of one hundred thirty-three (34%) participants whose responses to the scenarios fluctuated between agreement and disagreement. One hundred sixty-seven (45%) students indicated that they believe the practices in the scenarios to be unethical.

Participants' level of personal involvement and/or knowledge of others' involvement in unethical practices. A total innocence score was calculated for each respondent in order to determine their level of personal involvement. Individual responses to each question were categorized as 0 if the respondent had no involvement or knowledge of others' involvement or 1 if the respondent had been involved or had knowledge of others' involvement.

Total scores were categorized based on the number of practices they had participated in or had knowledge of others' participation as none, low, or high. One hundred sixty-six (42%) participants responded that they had not participated in the unethical practices nor did they have personal knowledge of others that had. One hundred fifty-two (38%) participants either had participated in or had knowledge of others participation in one or two of the unethical practices. Fifty-five (14%) participants either had participated in or had knowledge of others participation in three to five unethical practices.

Relationship between student's ethical perceptions and practices with those of their agriculture science teachers. Due to the lack of returned surveys from agriculture science teachers, there was not enough data to test the relationship between student and teacher responses.

Relationship between various demographic groups relative to ethical practices in junior livestock shows within South Texas FFA students. General Linear Model (GLM) procedures were performed between various demographic categories and the scores for each of the four ethics indicators. A value of ∀=.05 was used to determine interdependence (Table 5).

Table 5. Interdependence (p-value) of demographics and ethics scores

Category	Ethical perception score	Perceived practice Score	Scenario Score	Innocence Score
Sex	NS	NS	NS	NS
Ethnicity	0.0005	NS	NS	NS
Place in top 3 at show	NS	NS	NS	NS
Program membership	0.0351	0.0016	0.0466	0.05
Sex and ethnicity	0.0441	NS	0.0240	NS
Ethnicity and program membership	NS	NS	NS	0.0385

Analysis of variance with 325 degrees of freedom indicated significant interdependence between scores and demographic groups. Respondents who identified themselves as being white had a less negative perception of competition within the FFA program than those who identified themselves as being hispanic. Respondents who participated solely in the FFA program tended to have the least negative perception of competition followed by those who participated in both FFA and 4-H. Respondents who solely participated in the 4-H program had the most negative perception of competition. White female respondents had the least negative perception followed by white males and hispanic males. Hispanic females tended to have the most negative perception of competition within the FFA program. Respondents who participated in both 4-H and FFA programs perceived desirable behavior to occur more often then those who only participated in FFA. Respondents who solely participated in 4-H programs perceived desirable practices to occur less often than did all other respondents. Respondents who participated in both 4-H and FFA programs tended to more strongly disagree with the scenarios than did respondents who only participated in the FFA program. Respondents who solely participated in 4-H programs tended to disagree less frequently with the scenarios than all other respondents.

Female respondents more strongly disagreed with the scenarios than did male respondents and those with Hispanic ethnic origin disagreed more strongly than their white counterparts. Those respondents that solely participated in 4-H programs tended to have a higher level of personal experience or knowledge of others experience in unethical procedures than did other respondents. Respondents who solely participated in FFA programs tended to have lower levels of personal experience or knowledge of others participation in unethical practices. Hispanic 4-H members had the greatest amount of experience and/or knowledge of others participation in unethical procedures followed by both 4-H and FFA members, white FFA members, white 4-H members and lastly hispanic FFA members.

CONCLUSIONS

The majority of students (45%) never participated, nor were aware of others' participation in any of the unethical practices listed in the personal experience section; furthermore, they (43%) correctly identified the scenarios as involving unethical practices. They (43.5%) had an overall neutral perception of competition within the FFA program, which coincided with their perceived frequency of occurrence of desirable activities rate of 50%. Similar to the students, the majority of teachers had low levels of personal experience or knowledge of others participation in unethical practices. They perceived desirable activities to occur 50% of the time and correctly identified the scenarios as unethical. There is no noticeable teacher perception of competition within the FFA program because the scores were equally distributed between the three categories.

General linear models indicated some interdependence between various demographic groupings and ethic scores. Relationships were found to exist between respondents' program membership and each of the four ethics scores. Ethnicity proved to be a factor in all the respondents' ethics scores except for perceived frequency of practice occurrence.

REFERENCES

Goodwin, J., G. Briers, & T. Murphy. 1999. Measuring the ethical cognition effect of a videotape livestock show ethics education program. National Agriculture Education Research Meetings. 26: 95-107.

Goodwin, J. 1995. Real world agriculture and the natural animal: The measuring stick for what we do at the livestock show. National Youth Livestock Program Ethics Symposium Proceedings. 31-36.

Hogg, J.A. 2001. Agricultural teacher educators' & pre-service teachers' perceptions of competitive FFA activities. Dissertation. Texas Tech University, Lubbock.

Josephson Institute of Ethics. 2001. Character Counts. http://www.charactercounts.org/about.html

Murphy, T. E., J. S. Norwood, and R. Dubes. 1992. Unethical fitting and showing practices in junior livestock shows. Texas Journal of Agriculture and Natural Resources. 5: 99-106.

National FFA Organization. 2000. 2000-2001 Official FFA manual. Indianapolis, IN.

Nestor, J. N. 2000. Unethical practices in exhibiting animals as observed by West Virginia extension agents and high school agriculture teachers. Thesis. West Virginia University, Morgantown.

Rus, D. G. 1997. Evaluation of ethics perceptions. Thesis. Colorado State University, Fort Collins.

SAS Institute Inc. 1990. SAS/STAT user's guide. Cary, NC.

The Comparative Advantage of Upland Cotton Production in Texas

Xiaoling (Sherry) Yu
Department of Management, Tarim University, Xinjiang, China
Man (Mark) Yu and Frank Ewell
Department of Agribusiness, Agronomy, Horticulture, and Range Management,
Tarleton State University, Stephenville, TX 76402

ABSTRACT

This paper uses Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) to explore the relative yield, scale and overall advantage of upland cotton production by comparing different states of the U.S. and different districts of Texas. The study reveals that the comparative advantage in main upland cotton varies significantly across the U.S. and Texas.

KEYWORDS: Comparative Advantage, Cotton.

Texas leads the nation in cotton production and produces about 25 percent of the nation's cotton. Cotton is the top cash crop in Texas, generating $1.6 billion annually for farmers. The crop has a statewide economic impact of $5.2 billion, including money generated by supporting industries associated with harvesting, transporting, processing, and marketing cotton. Cotton ranks third behind the beef and nursery industries, making up 8 percent of all of the state's agricultural cash receipts, according to Texas Agricultural Statistics in 2003 (NASS, 2005).

In 2004, Texas cotton producers harvested a record 7.5 million bales on approximately 5.8 million acres. The previous record crop was in 1949 when 6 million bales were produced on 20 million acres. Upland cotton, the most common type of cotton grown, accounted for over 99 percent of the production (NASS, 2005). Modern technology played a major role in the record crop. Productivity in cotton production increased dramatically over the past few decades. Increased use of fertilizers, improved pest management, and improved cultivars have contributed to the enhancement. Currently, cotton production is facing challenges, such as increasing costs of production, shortage of irrigation water, and increased public concern on the negative impacts of agricultural production on the environment.

When comparing Texas cotton production to other cotton production regions in the nation, there are significant differences in yield and production costs. Many factors, such as weather, water, soil, topography, labor and other input costs, management practices, etc., have contributed to the disparities among different regions. The primary objective of this study is to evaluate the comparative advantage of upland cotton production in U.S. and in Texas.

Several previous studies have evaluated the comparative advantage in agricultural production. Pearson and Meyer (1973) evaluated comparative advantages of the four main coffee growing countries in Africa. The focus of the study was to calculate the domestic resource cost per unit of foreign exchange earned or saved (DRC). The study found that Uganda, Ethiopia, and Tanzania all had strong comparative advantages in coffee production with very little deviation among each country's respective indices. The Ivory Coast was found to be reasonably weaker in competition compared to the other three countries. External factors for this country were the primary reason for its disadvantage. This study was one of the first to attempt to tackle the complexity of comparative advantages among regions or countries. Its scope was relatively small, and resulted in a need for more data collection among a larger scope of producing regions.

Zhong et al. (2000) studied the comparative advantages in grain production across different regions of China. Several indicators, which includes: Net Social Profitability (NSP), Domestic Resource Cost (DRC) which are both used to measure price advantages or disadvantages, and Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregated Advantage Index (AAI) were used in the study. The study found that advantages in main grain crops were varied across different regions in China, and there is a potential to improve grain production efficiency in China through the reallocation of natural resources and restructuring of the grain sector. The study concluded that China can still compete with the rest of the world in grain production even if as a whole, the country was at a disadvantage in a particular crop production.

These are the earlier studies about the advantage in a specific crop production. However, there is no research that has studied the comparative advantage in cotton production.

MATERIALS AND METHODS

This study employs a set of indicators, which include the Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) to measure the relative yield and scale advantage of upland cotton production in Texas.

EAI is an indication of how efficiently a crop grows in one specific region. It is calculated by using the relative yield of one crop in one region related to the average yield of all crops in the same region to the yield of same crop in the nation related to the average yield of all crops in the nation. EAI can be expressed following:

$$EAI_{ij} = \frac{\mathrm{Y_{ij}} / \mathrm{Y_i}}{\mathrm{Y_{nj}} / \mathrm{Y_n}} \tag{1}$$

where, EAI_{ij} represents the Efficiency Advantage Index of the *j*th crop growing in the *i*th region; Y_{ij} is the yield of the *j*th crop in the *i*th region; Y_i represents the average yield of all crops in the *i*th region; Y_{nj} is the national average yield of the *j*th crop; and Y_n is the national average yield of all crops. If $\mathrm{EAI}_{ij} > 1$, then the yield of the *j*th crop in the *i*th region, relative to all other crops' yield growing in the same region is higher than that of the national average. It can be interpreted as in the *i*th region; there is a yield or an efficiency advantage in growing the *j*th crop. If $\mathrm{EAI}_{ij} < 1$, then the yield of the *j*th crop in the *i*th region, relative to all other crops' yield growing in the same region, is lower than that of the national average. It can be interpreted as in the *i*th region; there is no yield or efficiency advantage in growing the *i*th crop. By assuming a competitive market structure and no significant barriers for technology diffusion and adoption in agricultural production in the country, the EAI_{ij} can be taken as an indicator of relative efficiency due to natural resource endowments and other local economic, social and cultural factors.

The SAI indicates the extent of concentration of a certain crop growing in a region, relative to that ratio of same crop growing in the nation. It can be expressed as following.

$$SAI_{ij} = \frac{S_{ij}/S_i}{S_{nj}/S_n} \tag{2}$$

where, SAI_{ij} is the Scale Advantage Index of the *j*th crop in the *i*th region; S_{ij} represents the planted area of the *j*th crop in the *i*th region; S_i is the total planted area of all crops in the *i*th region; S_{nj} is the total planted area of the *j*th crop in the nation; and S_n represents the total planted area of all crops in the nation. If $SAI_{ij} > 1$, it implies the degree of concentration of the *j*th crop growing in the *i*th region is higher than average concentration ratio in the nation. It also indicates that producers in the *i*th region prefer to grow more *j*th crop, compared to other producers in the nation. If $SAI_{ij} < 1$, the degree of concentration of the *j*th crop growing in the *i*th region is lower than that average ratio in the nation. It indicates that producers in the *i*th region prefer to grow less *j*th crop, compared to other producers in the nation.

Assuming a competitive market structure and that producer can quickly adjust the crop mix by responding to the market price and cost changes, the concentration level is determined by economic factors or the profit level of certain crop growth in the region. For example, a low value of SAI implies producers do not want to increase the share of that crop production in the region because it is less profitable or restricted by natural (or other) conditions, while a high value of SAI implies producers want to increase the share of that crop production in the region.

The AAI is an aggregate indication of the overall comparative advantage of a certain crop in one region relative to the national average. It can be calculated as the geometric average of the EAI and SAI.

$$AAI_{ij} = \sqrt{EAI_{ij} * SAI_{ij}} \tag{3}$$

If $AAI_{ij} > 1$, then the *j*th crop in the *i*th region is considered to have a overall comparative advantage over the national average while $AAI_{ij} < 1$ indicates *j*th crop in the *i*th region does not have a overall comparative advantage over the national average.

The crop that will be studied in this research is upland cotton. The 2003 cotton and other crops' yields and production data are used in calculating the three indices. The primary source of data for this study is from the National Agricultural Statistics Service (NASS) at the United States Department of Agriculture (USDA), which include states' data in the United States and districts' data in Texas.

RESULTS AND DISCUSSIONS

1. Comparative advantage in upland cotton in the United States

Table 1 shows the summary of the calculation of comparative advantages for upland cotton in states of the United States. There are 13 major states that grew over 13 million acres of upland cotton in 2003. Texas leads the nation in upland cotton production, which accounted for over 43% of the production in 2003. Georgia ranked second in the nation and accounted for 10.01% of the production. There are 5 states (Texas, Georgia, Mississippi, Arkansas, and North Carolina) where the planted acres exceed 5% of the national total and hence these are referred to as major producing states. California led the nation in average yield per acre (1317 pounds per acre) in 2003. Arizona ranked second with an average yield of 1239 pounds per acre. The average yield of Texas upland ranked last in the nation at 478 pounds per acre, compared to 723 pounds per acre average in the nation.

Using the formula (1) to (3) above, Efficiency Advantage Index (EAI), Scale Advantage Index (SAI), and Aggregate Advantage Index (AAI) were calculated for 13 states and listed in Table 1.

Table 1. Comparative Advantage of Upland Cotton Production in Different States.

States	Share of Planted Acres (%)	Yield (lbs/acre)	EAI	SAI	AAI
Alabama (AL)	4.05	772	1.03	1.68	1.32
Arizona (AZ)	1.66	1239	0.95	1.90	1.35
Arkansas (AR)	7.55	916	0.88	0.81	0.84
Califonia (CA)	4.23	1317	1.46	0.90	1.14
Georgia (GA)	10.01	785	1.22	2.30	1.68
Louisiana (LA)	4.05	967	0.99	1.16	1.07
Mississippi (MS)	8.55	934	0.91	1.70	1.25
Missouri (MO)	3.08	862	1.02	0.19	0.44
North Carolina (NC)	6.24	646	1.10	1.17	1.13
Oklahoma (OK)	1.39	616	1.18	0.11	0.36
South Caralina (SC)	1.70	718	1.21	0.83	1.00
Tennessee (TN)	4.32	806	0.85	0.75	0.80
Texas (TX)	43.16	478	0.65	1.54	1.00
US	100.00	723	1.00	1.00	1.00

Figure 1 lists the Efficiency Advantage Index (EAI) of upland cotton production among 13 production states in 2003. It can be seen that California had the highest efficiency in producing upland cotton with an EAI of 1.46. Georgia ranked second with EAI 1.22. Texas had the lowest efficiency (EAI equals 0.65) in producing upland cotton, comparing to other states in the nation. This is because most cotton produced in Texas was dry-land cotton, which has a relatively low yield.

Figure 2 lists the Scale Advantage Index (SAI) of upland cotton production among 13 production states in the nation in 2003. Georgia led the nation with highest scale advantage, i.e., SAI equals 2.30. Other states that had scale advantages were Arizona 1.90, Mississippi 1.70, Alabama 1.68, Texas 1.54, North Carolina 1.17, and Louisiana 1.16. For the rest of seven states the scale efficiency was less than 1. In Missouri and Oklahoma, the EAI was only 0.19 and 0.11, respectively, which means both states had relatively small scale upland cotton production. Most of the cotton production practices in these states were similar to other southern states.

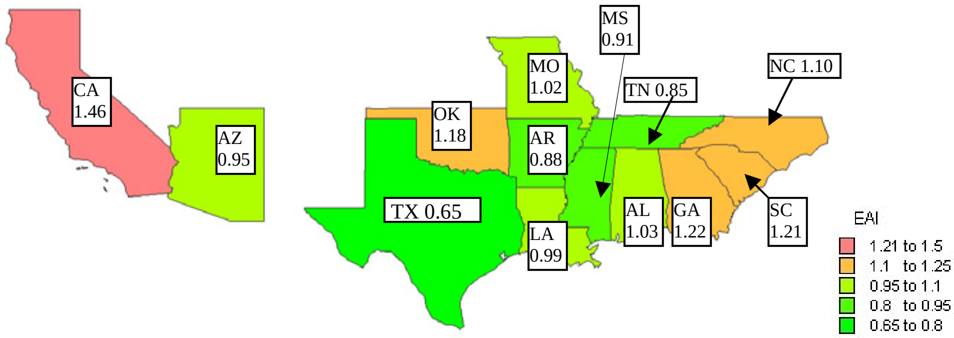

Figure 1. The Efficiency Advantage Index (EAI) of Upland Cotton Production among Major Production States, 2003.

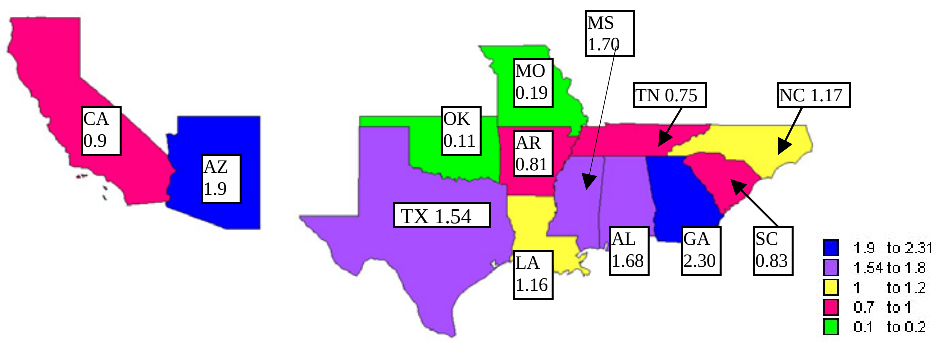

Figure 2. The Scale Advantage Index (SAI) of Upland Cotton Production among Major Production States, 2003.

Figure 3 indicates the Aggregate Advantage Index (AAI) of upland cotton production among the thirteen production states. Georgia has the highest overall efficiency in producing upland cotton compared to other states in 2003 with AAI equals 1.69. Other states that led the nation in AAI were Arizona 1.35, Alabama 1.32, California 1.14, North Carolina 1.23, Mississippi 1.25, Louisiana 1.07, South Carolina 1.00 and Texas 1.00. Only four states did not have any aggregate advantage in upland cotton production, Arkansas 0.84, Tennessee 0.80, Missouri 0.44, and Oklahoma 0.36. All these states are located in the northern portions of the cotton production belt.

In addition, Alabama, Georgia, and North Carolina had both efficiency and scale advantages in upland cotton production, with EAI, SAI and AAI values exceeded one. Arizona, Louisiana, Mississippi, and Texas had scale advantages, with SAI and AAI values greater than one. Among five major upland cotton production states (with production accounting for more than five percent of nation's production: Texas, Georgia, Mississippi, Arkansas, and North Carolina) in 2003, only Arkansas did not have overall comparative advantages**.**

Texas had scale advantage in 2003 (its planted acres accounted for 43.16 % of the nation), but it has no advantage in efficiency. Likewise, Texas' aggregate advantage index was close to one. When considering a combination of all factors, Georgia, Mississippi, North Carolina, and Alabama had strong comparative advantages in growing upland cotton. Arizona and Louisiana also had comparative advantages in the upland cotton production, but their low values of EAI and AAI indicated that these two states may have stronger comparative advantage for other crops. Missouri, Oklahoma, and South Carolina had comparative advantage in producing upland cotton, but the low values of SAI indicated that the expandability of upland cotton production is questionable in the three states.

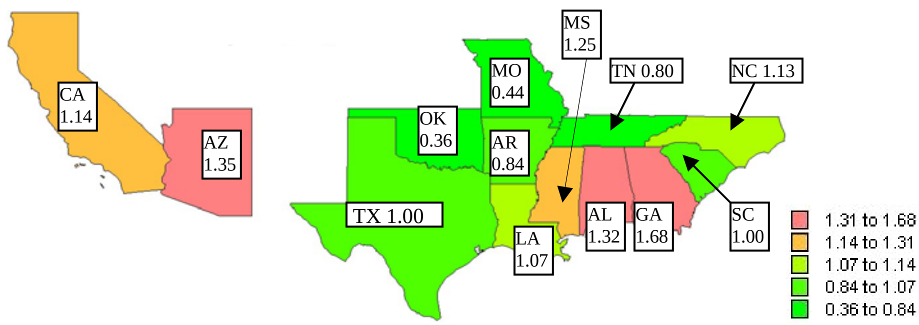

Figure 3. The Aggregate Advantage Index (AAI) of Upland Cotton Production among Major Production States, 2003.

2. Comparative advantage in upland cotton in districts of Texas

Texas is the largest cotton producing state in the country accounting for 43.16% of the total planted acreage in 2003. There are eight Agricultural Statistical Districts in Texas that produced upland cotton in 2003 (Figure 4). The Southern High Plains (District 1-S), located in the lower west side of the panhandle, led the state accounting for 52.34% of state's upland production. The Northern High Plains (District 1-N), located in the northern part of the panhandle, accounted for 15.81% of the state's upland cotton production. The Northern Low Plains (District 2-N) and Southern Low Plains (District 2-S) accounted for 7.36% and 8.91% of the state's production, respectively. The Blacklands (District 4) and Edwards Plateau (District 7) had relatively smaller production scale and produced 2.19% and 2.90%, respectively. There was also some cotton production in south Texas. The South Coastal Bend (District 8) produced 6.62% of state's upland cotton, whereas the Lower Valley (District 10-South) produced about 3.38% of the state's upland cotton.

Using equations (1) to (3), EAI, SAI, and AAI values are calculated for upland cotton for Texas districts and presented in Table 2. District 2-S led the state in efficiency in producing upland cotton with an EAI 1.91. Districts 8-S and 10-S had an EAI 1.67 and 1.58, respectively. The remaining five districts had EAI between 0.4 and 0.88, which indicated no efficiency advantage in upland cotton production.

Seven out of eight districts in Texas (except District 4) had scale advantage in upland cotton production. District 1-S led the state with SAI equals 4.33. This was followed by District 8-S with an SAI of 3.06.

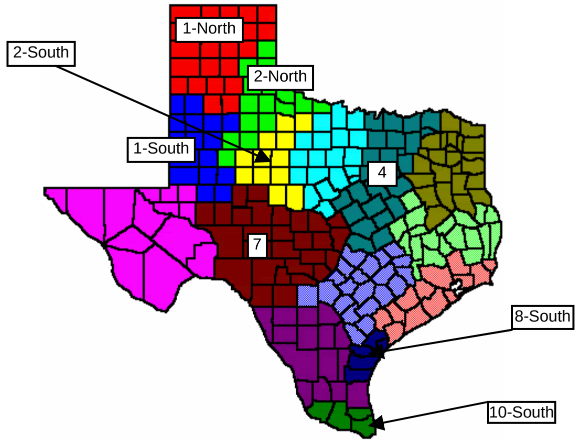

Figure 4. Texas Agricultural Statistical Districts (NASS)

Six out of eight districts in Texas with AAI greater than 1, indicates overall advantage in upland cotton production. District 8-S led the state with an AAI of 2.27. Followed by District 2-S with an AAI of 1.82. There were only two districts with AAI less than 1, i.e., District 1-N with AAI 0.98 and District 4 with AAI 0.39.

Overall, Districts 2-S, 8-S, and 10-S had the efficiency, scale and overall comparative advantages in upland cotton production. Districts 1-S, 2-N, 7, and 10-S had scale and overall advantages. District 1-N had only scale advantage. District 7 is the only district in Texas without any advantage in upland cotton production.

Table 2. Comparative Advantage of Upland Cotton Production in Different Districts in Texas, 2003.

	Share of Planted Acres (%)	Yield (lbs/acre)	EAI	SAI	AAI
District 1-N	15.81	687	0.87	1.10	0.98
District 1-S	52.34	402	0.66	4.33	1.70
District 2-N	7.36	335	0.72	2.13	1.24
District 2-S	8.91	343	1.91	1.72	1.82
District 4	2.19	240	0.40	0.38	0.39
District 7	2.90	449	0.83	1.48	1.11
District 8-S	6.62	783	1.67	3.06	2.27
District 10-S	3.87	607	1.58	1.86	1.72
Texas	100.00	478	0.65	1.54	1.00

CONCLUSIONS

This study provides a comparative advantage analysis of upland cotton production in U.S. and Texas in 2003. The analysis indicates that the comparative advantages in upland cotton production varied significantly across the United States and in Texas in 2003. There exists great potential to improve resource allocation and to increase upland cotton production through the restructuring of upland cotton production. As cotton producers are facing more and more competition from producers around the world, the research provides policy makers and producers more information to make their decisions on what and where to produce the upland cotton in the U.S. and the state of Texas in the future.

Since the data for this research only covered one year, 2003, the calculated results only reflected the upland cotton production in that year which may have a lot uncontrollable factors, such as rainfall, temperature, and etc. that may cause the variability of these indices. So, more research needs to be performed to study advantage changes in the long-run.

REFERENCES

NASS. 2005. National Agricultural Statistics Service, USDA.

Pearson, R. and P. Mayer. 1974. "Comparative Advantage among African Coffee Producer." *American Journal of Agricultural Economics.*

Zhong, F., Xu, Z., and Fu, L. 2000. Regional Comparative Advantage in China's Main Grain Crops. *Working paper of the research project of "Chinese Grain Market Policy with special emphasis on the domestic grain trade.* Centre for International Economic Studies, Adelaide University, Adelaide.

A Description of Chapter Participation in the 2000-2005 Texas FFA Leadership Development Events

Doug Ullrich
Dwayne Pavelock
Roger Hanagriff
Sam Houston State University, Department of Agricultural and Industrial Sciences, PO Box 2088 Huntsville, Texas 77341

Tom Maynard
Executive Directo,r Texas FFA Association, 614 East 12th Street Austin, Texas 78701

ABSTRACT

The Texas FFA conducts twelve events each fall that facilitate classroom learning, enabling students to apply leadership skills in competitive situations. These events are known as Leadership Development Events (LDEs). The study's purpose was to describe the level of participation of Texas FFA chapters in LDEs, beginning in 2000. The study's population was Texas FFA chapters participating in LDEs from 2000-2005 (N=~980). Data was reported by the 52 district teacher presidents to the Texas FFA executive director and compiled using an Excel spreadsheet. Each year, a 100% response rate was achieved.

The vast majority (785 chapters, or 80.10%) of FFA chapters participated in LDEs in 2005, meaning 195 (19.90%) programs did not participate. Nine Areas reported over 77 percent of its chapters participating in LDEs. The highest percentage participated in Chapter-level FFA Creed (64.69%) and Greenhand FFA Creed (48.47%), while Ag Issues (15.71%) and Greenhand FFA Skills Demonstration (18.98%) had the lowest participation. The greatest increases from 2000 to 2005 were in Job Interview (65.74%) and Public Relations (49.18%), while Greenhand Chapter Conducting and Ag Issues experienced slight decreases. Total participation for the six-year period increased by more than 18 percent.

KEY WORDS: *Agricultural Education, Agricultural Science, Agriscience, FFA, Career Development Events, Leadership Development Events*

INTRODUCTION

Agricultural education is a total educational program that involves three integral parts – classroom and laboratory, supervised agricultural experiences, and FFA (Fraze & Briars 1986; Newcomb, McCracken & Warmbrod 1986; Phipps & Osborne 1988; Staller 2001). These three essential and interdependent components identify an exemplary program when systematically and properly promoted. The agricultural education teacher has the primary responsibility of seeing that the curriculum is implemented and that the

FFA becomes an important function of that curriculum. The success or failure of the FFA organization may depend upon a multitude of factors, but the FFA advisor is perhaps the most important factor in the equation (Croom & Flowers 2001). Furthermore, administrators have viewed candidates' experience in FFA activities and programs as the most important job-related duty of an agricultural education instructor (Cantrell & Weeks 2004).

Morrison (1978) wrote, "From a very small beginning in 1931, hundreds of FFA chapters and thousands of FFA members are now involved in, what has become, a highly competitive activity," concerning the leadership development events held during the fall semester in Texas. Those many years ago the Sam Houston Vocational Agriculture Club, now the Sam Houston State University Collegiate FFA, recommended to C. L. Davis, the Texas FFA state supervisor, that a public speaking and a debate contest be held. "Some six or seven debate teams and seven or eight public speakers showed up for this humble beginning for the State FFA Invitational Leadership Contests" (Morrison 1978).

The role of leadership and career development events continues to focus on motivating students and encouraging leadership, personal growth, citizenship and career development (National FFA Career Development Events 2006). Contests are an integral part of the FFA at the local, state and national levels (Binkley & Byers 1982). These competitions are amplified by the shear numbers of chapters and students involved in the various events. Leadership contests, judging contests and livestock shows are three activities of the FFA that hold a high priority in numerous Texas agricultural education programs (Fraze & Briars 1986).

The National FFA Organization invests more than $7 million dollars annually to maintain existing programs and develop new programs for its membership (Croom & Flowers 2001). Career development events motivate students and encourage leadership, personal growth, citizenship and career development (National FFA 2006).

Supporting FFA and many other student organizations, as well as various extracurricular activities, Dworkin, Larson, and Hansen (2003) found that young people viewed extracurricular activities as an important growth experience in which psychological skills such as goal setting, time management and emotional control were learned. Adolescents reported characteristics such as leadership, wisdom, and social intelligence were acquired through life experiences fostered by extracurricular activities (Steen, Kachorek & Peterson 2003). Also, many youth organizations such as Boys and Girls Inc., provide youth development experiences that are aimed at providing a healthy transition from adolescence to adulthood (Gambone & Arbreton 1997).

Various research studies have found a close association between participation in leadership activities and student career development (Dormoody & Seevers 1994; Gleim & Gleim 2000; Wigenback & Kahler 1997). FFA activities provide a vehicle for the development of leadership and personal competencies necessary for occupational success, and students who participate in FFA activities tend to enter an agricultural occupation (Bowen & Doerfort 1989; Fraze & Briers 1986; Garten 1984).

Many agricultural education teachers expend tremendous time and effort developing their own skills, and committing time and effort in the development of those skills of students is remarkable. The instruction in career development skills and personal motivation to youth provides the teacher with a sense of accomplishment. The prestige of having won a state career development event and advancing to national competition may be one of the intangible rewards teachers earn in a life devoted to teaching (Croom, Moore & Armbruster 2005).

This study was part of a larger study conducted to identify and describe the participation levels of FFA chapters in Texas beginning in 2000. This study only utilized the participation levels for the Leadership Development Events. The specific objectives of this study were to:

1. Describe the participation, by Area, of Texas FFA chapters in any of the Leadership Development Events in 2005;
2. Describe the participation rate of Texas FFA chapters in Greenhand-level Leadership Development Events in each of the ten Areas in 2005;
3. Describe the participation rate of Texas FFA chapters in Chapter-level Leadership Development Events in each of the ten Areas in 2005;
4. Describe the participation rate of Texas FFA chapters in open-level Leadership Development Events in each of the ten Areas in 2005; and
5. Describe the participation rate and level of change in participation of Texas FFA chapters participating in Leadership Development Events in 2000-2005.

MATERIALS AND METHODS

The population of this study (N=~980) was the FFA chapters in Texas participating in fall career development events from 2000-2005. In Texas, fall career development events are called the State Leadership Development Events (LDEs) and those events occurring in the spring are called Career Development Events to simplify the management of each of the various contests.

The Texas FFA executive director created a reporting questionnaire for each of the 52 district teacher presidents or their representatives. This instrument gathered data concerning various FFA and teacher activities for each year, and represented the activities of the 980 FFA chapters in Texas. The data was submitted to the state FFA office and compiled using an Excel spreadsheet. All 52 district teacher presidents of the Vocational Agriculture Teacher Association of Texas, and each area teacher president or coordinator of the 10 areas of the Vocational Agriculture Teacher Association of Texas submitted data each year for a 100% response rate.

Data entry error is an issue that was reduced through a data review process in which the data submitted to the state office by the district and area teacher presidents, or their designate, was returned for their review. Corrections were made as necessary. To meet the needs of this study, only data specific to participation in the fall Leadership Development Events was utilized. Figure 1 illustrates the Texas Area organization with each geographic area having between four and seven administrative districts totaling 52 districts. District size ranges from 7 to 33 chapters, with an average of 23 chapters per district.

Simple descriptive statistics were used to analyze the data for this study. Frequencies were computed for selected events. Sums and percentages were calculated when necessary.

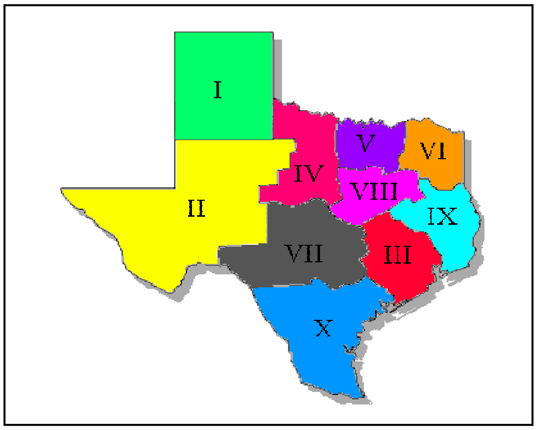

Figure 1. Texas FFA Association Areas.

RESULTS

The first objective was to describe the participation rate of Texas FFA chapters in Leadership Development Events (LDEs) in each of the ten Areas during the fall semester of 2005. The data were organized and compiled according to FFA Area participation. The frequency of FFA chapter participation in the fall 2005 Leadership Development Events is illustrated in Table 1.

Table 1. Frequency of Chapter Participation in District LDEs by Area in 2005

FFA Area	Total Chapters in Area	Number of Chapters Participating	Percentage of Chapters Participating
Area I	89	75	84.27
Area II	78	63	80.77
Area III	146	122	83.56
Area IV	76	62	81.58
Area V	116	90	77.59
Area VI	90	70	77.78
Area VII	100	78	78.00
Area VIII	100	82	82.00
Area IX	89	76	85.39
Area X	96	67	69.79
Event Total	980	785	80.10

The findings showed that 785 (80%) of the 980 chapters in good standing in Texas participated in at least one of the fall FFA LDEs. The highest participation rate was found in Area IX (85.39%), followed by Area I (84.27%) and Area III (83.56%). The area with the lowest participation rate was Area X (69.79%). There were 195 (19.9%) programs that did not participate in even one LDE.

Specifically, data concerning the number of FFA chapters in good standing were identified. The level of participation in at least one Leadership Development Event (LDE) during the Fall of 2005 was identified. The events for which data were reported for participation by Greenhands only were: FFA Creed Speaking, FFA Quiz, Chapter Conducting, and FFA Skills Demonstration. The events for which data were reported for participation only by Chapter members were: Senior Creed Speaking, Senior FFA Quiz, Senior Chapter Conducting, and Senior FFA Skills Demonstration. Other events not designated specifically as Greenhand or Chapter events, referred to as Open events, included: Ag Issues Forum, Public Relations, Job Interview, and Radio Broadcasting.

Participation in Greenhand events was limited to FFA members enrolled in their first year and first semester in an agricultural science program. Such enrollment must be for obtaining high school credit toward graduation. Some participants may be 8th grade students as long as the course being taken will merit high school credit. Other participants, with the exception of FFA Creed participants, may be 10th, 11th or 12th grade students who have not previously been enrolled in an agriscience course for high school credit. FFA Creed contestants must be an 8th or 9th grade student. Data concerning chapter participation in Greenhand LDEs, the second objective, are shown in Table 2.

Table 2. Number of Chapters by Area Participating in Greenhand LDEs in 2005

	Chapters in Area	FFA Creed	FFA Quiz	Chapter Conducting	FFA Skills Demonstration	Area Totals
Area I	89	56	38	17	18	129
Area II	78	73	22	17	10	122
Area III	146	90	85	41	31	247
Area IV	76	43	36	30	17	126
Area V	116	57	61	23	19	160
Area VI	90	49	48	19	14	130
Area VII	100	60	44	27	25	156
Area VIII	100	56	52	32	24	164
Area IX	89	57	55	24	17	153
Area X	96	32	26	13	11	82
Event Total	980	573	467	243	186	1469

The third objective was to describe Chapter, or senior, level student participation. Eligibility for this level requires only enrollment for the current school year in a high school agriscience course, as well as FFA membership. While not likely, those eligible for Greenhand events are eligible to compete in Chapter events, but cannot participate in the same type of event at both levels. Greenhand participation at the Chapter level does occur due to the limited membership of some chapters. It should further be noted that this opportunity became available with the 2002 events. Previously, participants could only participate in one event at any level with the exception of the FFA Creed. Data concerning chapter participation in Chapter LDEs are shown in Table 3.

Table 3. Number of Chapters by Area Participating in Chapter LDEs in 2005

	Chapters in Area	FFA Creed	FFA Quiz	Chapter Conducting	FFA Skills Demonstration	Area Totals
Area I	89	73	40	17	17	147
Area II	78	74	29	15	10	128
Area III	146	100	87	42	48	277
Area IV	76	46	36	22	25	129
Area V	116	66	49	21	25	161
Area VI	90	49	48	22	23	142
Area VII	100	64	45	27	36	172
Area VIII	100	62	58	27	30	177
Area IX	89	59	53	21	32	165
Area X	96	41	32	17	22	112
Event Total	980	634	477	231	268	1610

The fourth objective was to describe the number of chapters participating in LDEs open to all members. Again, Greenhand and Chapter level members may participate in these events. It should also be noted that members may compete in two of the 12 different events, but as previously stated, may not compete in the same type of event at both the Greenhand and Chapter levels. Data concerning chapter participation in Open LDEs, the fourth objective, are shown in Table 4.

Table 4. Number of Chapters by Area Participating in Open LDEs in 2005

	Chapters in Area	Ag Issues Forum	Public Relations	Job Interview	Radio Broadcasting	Area Totals
Area I	89	11	26	39	48	124
Area II	78	8	15	30	47	100
Area III	146	29	52	69	90	240
Area IV	76	12	16	16	48	92
Area V	116	14	31	38	53	136
Area VI	90	15	23	33	42	113
Area VII	100	18	35	40	59	152
Area VIII	100	24	31	38	60	153
Area IX	89	15	26	31	61	133
Area X	96	8	18	24	36	86
Event Total	980	154	273	358	544	1329

The fifth objective was to describe the total number of chapters, yearly event averages, and level of change in chapters participating in LDEs from 2000-2005. Again, the 2002 event began allowing students to participate in any two events for which they were eligible and it is possible that some increases in the total number of teams from year to year has been due in part to this rule change. However, this rule change should not have affected the total number of chapters participating. Furthermore, some events have seen fluctuating increases and decreases during this time, leading one to conclude that the increase in the total number of teams is not directly attributable to this rule change. Table 5 shows data concerning statewide chapter participation in LDEs from 2000-2005.

Table 5. Statewide Chapter Participation in LDEs from 2000-2005

Event	2000	2001	2002	2003	2004	2005	Six-Year Average	% Change, 2000 to 2005
Greenhand Creed	531	533	520	545	559	573	544	+ 7.91
Greenhand Quiz	395	408	440	469	457	467	439	+ 18.23
Greenhand Chapter Conducting	259	246	252	243	275	243	253	– 6.18
Greenhand Skills	161	171	213	197	192	186	187	+ 15.53
Senior Creed	552	570	569	592	598	634	586	+ 14.86
Senior Quiz	381	415	477	482	530	477	460	+ 25.20
Senior Chapter Conducting	221	223	242	234	243	231	232	+ 4.52
Senior Skills	232	252	282	265	266	270	261	+ 16.38
Ag Issues Forum	155	152	149	164	149	154	154	– 0.65
Public Relations	183	200	204	222	235	273	220	+ 49.18
Job Interview	216	250	309	305	302	358	290	+ 65.74
Radio Broadcasting	443	466	473	474	504	544	484	+ 22.80
Total Entries	3729	3886	4130	4192	4310	4410	4110	+ 18.26

The six-year period in which chapter participation has been tracked (2000-2005) has seen some impressive increases in the level of participation. Events with the greatest increases during this period include Job Interview (65.74%), Public Relations (49.18%), Senior FFA Quiz (25.20%), & Radio Broadcasting (22.80%).

Disturbingly, Greenhand Chapter Conducting saw its level of participation decrease over the six-year period by 6.18%, and Ag Issues experienced a decrease of 0.65%. As previously mentioned, these events require perhaps the greatest amount of time for preparation, student knowledge, and number of team members.

Another positive aspect is that during the six-year period, total team participation increased by more than 18%. This increase has been constant as none of the five years following 2000 saw total team participation decrease from the previous year.

DISCUSSION

The researchers recommend detailed study seeking answers to the following questions:

1. Why do some FFA chapters choose not to participate in any of the Leadership Development Events? A glaring weakness identified was that during the Fall 2005 Leadership Development Events, 195 (19.90 percent) FFA chapters did not participate in any event at the initial, or district, level. Certainly, some programs choose other methods for providing students the opportunity to apply classroom and laboratory concepts in a different setting. Yet the focus on leadership development through competitive means is a valued commodity among high schools, and leadership qualities are prized assets among college admissions boards and employers.

2. Is there a relationship between the teacher's length of service, gender, professional membership, school size, chapter size, education, educational materials, prior teacher experiences, and program budget in regard to participation in Leadership Development Events? Teachers tend to place a higher emphasis and value on those educational opportunities and areas with which they have a higher comfort level. Such does not justify denying students the opportunity for their own personal growth and leadership development through competitive events such as those included in the study. It is noteworthy, however, that those events with the lowest levels of participation require a combination of more members on a team, leading to a higher degree of research, advanced preparation, and team practice versus individual preparation, as well as a higher degree of knowledge on the part of the teacher/advisor.

3. What do administrators identify as the reasons that agricultural education programs/FFA chapters in their schools choose not to participate in Leadership Development Events? Perhaps they are indifferent to the entire agriscience program or do not understand the value of these types of student learning opportunities. Regardless, it is ultimately the student that suffers.

4. What are the characteristics of agricultural education programs/FFA chapters that consistently participate in Leadership Development Events? Some chapters may excel in selected aspects of the agriscience program and FFA organization while seeing less value in other aspects. Tradition and teacher efficacy are likely to play major roles, but do student demographics have any measurable effect?

5. Agriscience teachers have massive demands on their time from instructional responsibilities, SAEP management and supervision, competitive events, and school-related responsibilities. Given these factors, it is difficult to expect these teachers to individually train teams for all events, especially in single-teacher departments. What resources do teachers need in order to assist them in preparing students for these types of competition?

6. Some of the increased levels of participation in certain events may be attributed to the allowance, beginning in 2002, for students to participate on two teams instead of being restricted to one. However, these increases continued in the years after 2002 at a sizeable rate, which warrants some merit. Was it simply a perception that led to these increased participation rates?

REFERENCES

Binkley, H.R. & Byers, C.W. (1982). Handbook on student organizations in vocational education. Danville. IL: Interstate Printers and Publishers.

Bowen, B.E., & Doerfort, D.L. (1989). Occupational aspirations of state FFA contest and award winners. Journal of Agricultural Education, 30(2). 49-54.

Cantrall, J. & Weeks, B. (2004). Criteria public school administrators consider when hiring first-year agricultural education teachers. Journal of Southern Agricultural Education Research. 54(1). 267-275.

Croom, D.B. and Flowers, J.L. (2001). Factors influencing an agricultural education students perceptions of the FFA organization. Journal of Agricultural Education, 42. 28-37.

Croom, B., Moore, G., & Armbruster, J. (2005). National FFA career development events: An introspective inquiry. Proceedings of the 2005 AAAE Southern Region Conference. Little Rock, AR. 121-420.

Dworkin, L.B., Larson, R., & Hansen, D. (2003). Adolescents' accounts of growth experiences in youth activities. Journal of Youth and Adolescence, 32(1). 17-26.

Fraze, S.D., & Briers, G.E. (1986). The relationship between participation in selected FFA activities and the career choice of program completers in vocational agriculture in Texas. Journal of the American Association of Teacher Educators in Agriculture, 28(1). 17-25.

Gambone, M.A. & Arbreton, A.J. (1997). Safe Havens: The contributions of youth organizations to healthy adolescent development. New York: Ford Foundation, Carnegie Corp. (ERIC Document Reproduction Service No. ED 408 383).

Gleim, R.R. & Gleim J.A. (2000). Factors that encouraged, discouraged and would encourage students in secondary agricultural education programs to join the FFA. Proceedings of the 27th Annual National Agricultural Education Research Conference. 251-263.

Morrison, G. H. (1978). History of the state FFA leadership contests. Texas Future Farmer, June/July. 6-7.

Staller, B. (2001). What in the world does integral mean anyway? Is FFA optional? News & Views. The National Association of Agricultural Educators, Inc., Alexandria, Virginia.

Steen, T.A., Kachorek, L.V., & Peterson, C. (2003). Character strengths among youth. Journal of Youth and Adolescence, 32 (1). 5-16.

National FFA Organization. (1991). National FFA Contest Bulletin. Washington, DC: National FFA Organization.

National FFA Organization (2006). National FFA Career Development Events Handbook (2006). Indianapolis, IN. National FFA Orgnization.

Performance of Ten Cotton Varieties in the Northern Texas High Plains

Thomas Marek
Texas A&M Research and Extension Center, 6500 Amarillo Blvd. West, Amarillo, TX 79106
David Bordovsky
Chillicothe-Vernon Research and Extension Center, P.O. Box 1658, 11708 Hwy 70 South, Vernon, TX 76385

ABSTRACT

Results of a four-year study conducted in the northern Texas High Plains indicate that cotton *(Gossypium hirsutum L.)* can be successfully grown and can provide a viable alternative to other currently produced higher water use crops. However, it is essential that producers be aware of the differing production requirements as compared to those in more southern type environments. Regardless of the variety selected, it is very likely that the cotton lint harvested will have a lower micronaire than that typical of warmer environments. Also, as fewer growing degree-days are generally experienced, planting must occur at times when soils are warm enough for rapid growth early in the growing season. Due to the colder regime, little to no insect problem was encountered during the time frame of this study. Producers should also be aware that northern Texas cotton production is subject to early termination.

KEYWORDS: cotton production, variety trials, cotton quality

INTRODUCTION

Historical Perspective

Historic crop production records indicate that a minor acreage of cotton *(Gossypium hirsutum L.)* has been grown in the northern Texas High Plains since 1968 (USDA-NASS 2004). The bulk of this acreage has been recorded in Deaf Smith County. Total cotton acreage in the 17 northern most counties of the Texas High Plains

[1] Acknowledgement and appreciation is extended to Tommy Moore, Senior Research Associate, Mrs. Erica Cox, Research Assistant and Curtis Schwertner, Technician II for their cooperation in the conduction of this research. Special thanks to Bridget Guerrero, Extension Associate, for editing. This study was supported solely with funding of the Texas Agricultural Experiment Station- Amarillo & Vernon, TX.

[2] Mention of a trademark does not constitute any suitability or endorsement of the product for any purpose or application by the Texas A&M University System - Texas Agricultural Experiment Station.

was less than 20,000 acres per year until 1998. By 2002, cotton acreage had increased to almost 80,000 acres in these same counties.

Cotton production was reported for the three counties in the Oklahoma panhandle as early as 1951 and continued at very low levels until 1969. No cotton production was recorded from 1970 through 2002 (last year of available records). Producers generally produced other crops that were more profitable (USDA-NASS 2004).

Conversely, cotton acreage in southwest Kansas was not reported in crop production statistics until 2001, although it was recorded in other parts of Kansas as early as 1991. Acreage increased from 5,100 acres in 2001 to 44,000 acres in 2002 in southwest Kansas (USDA-NASS 2004). Agricultural popular press articles touted the ability of growers in Kansas to produce cotton, haul it to Texas for ginning, and apparently still maintain the ability to make a profit (Griekspoo 2004). If cotton could be grown profitably in Kansas, Texas growers felt the same could be done in the northern Panhandle of Texas (Smith 2001). In 2004, a newly, constructed cotton gin located in the northern part of Texas contracted for the processing of over 100,000 bales (Carson County Gin, White Deer, TX). Average production is anticipated at two bales or more per acre. Future plans are to locate another gin further north and west in Texas.

When considering the production of cotton, planting date is of prime consideration. Cotton is a warm season crop and as such prefers warm soil temperatures (Hake et al. 1990). Early planting in the high plains often finds seeds placed in relatively cold soils for germination with little growing degree-day (GDD) accumulation. Delaying planting until soils are warmer increases the risk of having fewer growing degree-days during the later portion of the growing season to adequately mature the crop. Conversely, an early fall freeze can terminate the crop. Typically, soils in northern Texas normally warm considerably by mid-May with the expectation of adequately warmer soils within a short time thereafter (see Figure 1). Cotton planting dates later than early June certainly run the risk of incurring cold temperatures in the fall while the crop is maturing.

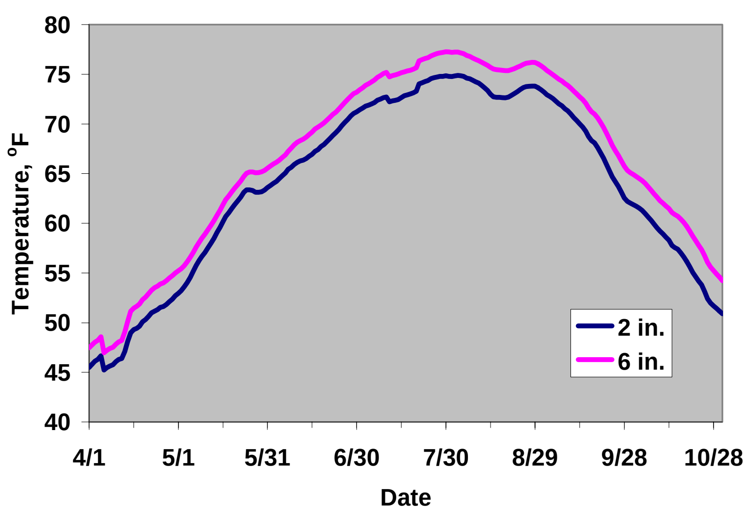

Figure 1. 1995-2003 average daily minimum 2 & 6-inch soil temperatures (10 day running average) at the North Plains Research Field, Etter, TX.

In recent years, producers have experienced a declining groundwater table, increased water district regulations on irrigation water use, increasing cost of groundwater pumpage, and the high water use requirements of traditionally grown crops such as corn. These concerns have resulted in growers taking a second serious look at cotton, a crop using much less water use than corn *(Zea mays idenata)*, thus reducing irrigation pumpage costs, conserving the groundwater resource, and meeting the reduced pumpage requirements of regional water districts.

In the past decade, little research has been supported on cotton to aid growers in the northern Texas High Plains. It has generally been assumed that cotton grown in the northern regions would have a reduced quality because of a short growing season and a reduced number of growing degree-days. It was also expected that problems might be encountered with reduced micronaire and with the number of bolls that failed to open. To aid northern Texas High Plains growers in their decisions, a small, "pilot type" study was initiated in 1999 and continued for three years at the North Plains Research Field (NPRF) near Etter, Texas. The objective of this study was to evaluate ten cotton varieties and two planting dates with respect to yield and fiber properties of cotton and to determine if there were other potential production problems for growers to consider. This article reports the results of the four year study at the NPRF.

MATERIALS AND METHODS

These studies were conducted at the Texas A&M University- Texas Agricultural Experiment Station's – North Plains Research Field near Etter, Texas (36° 00′ N. latitude, 101° 59′ W. longitude, 3,618 feet elevation). Plot preparation was similar in each of the study years. Each year plots were established on land that was not used for cotton tests the prior year. Following harvest, however, that year's stalk residue was shredded and disked in and planted to either corn or soybeans. Trifluralin (2 pts/ac in 1999, 1.5 pts/ac in 2000 and 2002) or pendimethalin (3 pts/ac in 2001) were applied and incorporated preplant for weed control. The plot area was then listed and beds cultivated immediately prior to planting. Seed beds were established on 30 inch centers. The plot size per variety was 3 rows by 50 feet in length. Total plot size was 0.52 acres. No fertility was applied in 1999 or 2000. In 2001, 180 lbs/ac N was applied as 32-0-0 and in 2002 80 lbs/ac N was applied as anhydrous ammonia. Planting was accomplished using a John Deere 71 Flex Planter™. Monthly meteorological data experienced during this study and long term averages are shown in Table 1. Irrigation water use requirements and GDD's for 1999-2002 as computed from the North Plains Evapotranspiration (NPET) network are included (Tables 1 and 2). Specifically, the daily and cumulative seasonal cotton evapotranspiration rates and requirements as related to a well-watered grass reference (ETos; The ASCE standardized reference evapotranspiration equation, Allen, 2005) per crop year are provided in Figures 2 through 5. Each year, three irrigations were applied at specific times to maintain a high soil moisture profile level during the crop season (Table 2) and plots were arranged in a split plot design with three replications using two planting dates as main plots and varieties as split plots. Plots were planted on May 7 and June 7 in 1999, May 15 and 30 in 2000, May 15 and 31 in 2001, and May 16 and 31 in 2002 and analyzed accordingly (Statistix7 2000). The analysis was conducted by year due to different varieties and some missing replication values. No insecticides were applied during any of the study years. Harvest aid materials were applied if a killing freeze was not anticipated or received by the long-term average first freeze date of

October 15 in each of the years. This was done to assess a "typical" or average duration production period. Prep™ (2 pts/ac) and Ginstar™ (8 oz/ac) were applied on October 19 in 1999, and Prep (2.33 pts/ac) and Ginstar (8 oz/ac) were applied on October 3 in 2000. Harvest dates were November 12, November 30, October 30, and December 17 in 1999, 2000, 2001, and 2002, respectively. The same varieties (Table 3) were not used each year of the study. Changes in varieties were made each year to accommodate requests and potentially represent varieties to be used by producers within the region. As northern Texas has no broadleaf herbicide ban, in 2000, 2001 and 2002, hormone herbicide drift applied within the surrounding area by producers significantly damaged the young cotton plants. The amount of damage varied between years. In 2002, damage was significant enough to cause part of the study to be abandoned. In that event, two replications of some of the varieties from each planting date were harvested and analyzed as two separate studies. As a result, there is no valid planting date comparison for 2002.

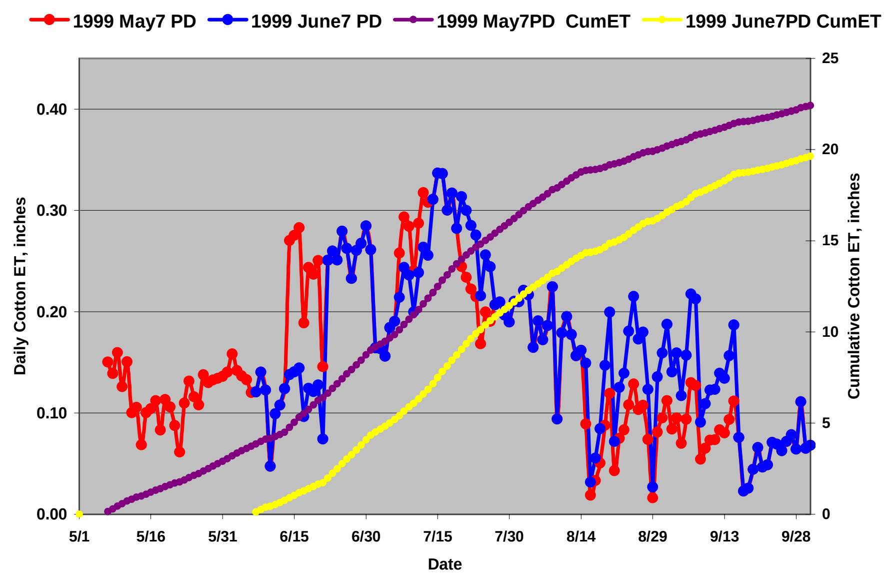

Figure 2. 1999 daily and seasonal cotton ET data at the North Plains Research Field, Etter, TX.

Table 1. Climatic data for 1999-2002 and long term average, North Plains Research Field, Etter, TX.

	Average Maximum Air Temperature, °F				Average Minimum Air Temperature, °F				Monthly Rainfall, Inches				Growing Degree Days Cotton				Long Term Averages			
	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002	1999	2000	2001	2002	Max temp	Min temp	Rain, in	Cotton GGD
May	78.4	84.4	78.1	81.6	49.7	51.4	50.5	48.6	3.11	0.75	2.95	0.49	169	277	182	201	80.6	50.0	1.83	207
June	87.0	85.5	90.4	92.7	59.9	60.0	60.5	62.8	5.16	2.57	1.80	1.36	403	383	464	532	88.9	60.8	2.72	446
July	91.6	95.0	96.7	92.6	62.6	64.7	65.7	64.4	0.67	0.64	2.12	1.01	530	616	657	573	94.0	64.3	1.11	594
Aug	94.6	97.4	91.6	91.8	61.7	62.6	61.9	63.2	1.26	0.00	1.59	3.98	563	620	519	542	93.8	62.4	1.71	561
Sept	82.3	90.3	85.7	83.3	53.6	54.0	53.9	55.4	1.69	0.28	1.03	1.10	262	400	300	285	85.4	54.2	1.03	312
Oct	76.9	70.0	75.2	63.3	39.1	46.2	40.3	40.0	0.57	6.66	0.00	3.44	52	64	82	25	71.3	41.4	2.67	56
Nov	69.9	51.8	62.0	57.3	30.6	25.6	36.6	29.5	0.00	0.06	0.98	0.08	0	0	0	0	60.3	30.6	0.28	0
Total	-	-	-	-	-	-	-	-	12.46	10.96	10.47	11.46	1980	2360	2204	2159	-	-	11.34	2176

Table 2. Irrigation dates and gross applied irrigation amounts, 1999-2002, NPRF cotton variety trial, Etter, TX.

1999		2000		2001		2002	
July 07	4.0	June 15	4.0	June 27	4.0	May 21	6.75
July 21	4.0	July 24	4.0	July 23	4.0	June 11	3.92
August 10	4.0	August 24	4.0	August 09	4.0	July 16	5.34
Total	12.0		12.0		12.0		16.01

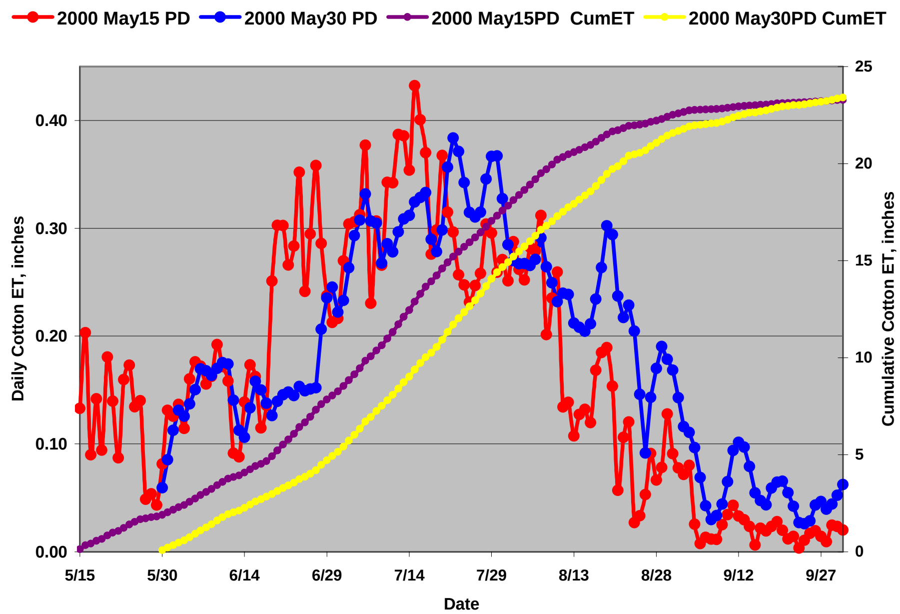

Figure 3. 2000 daily and seasonal cotton ET data at the North Plains Research Field, Etter, TX.

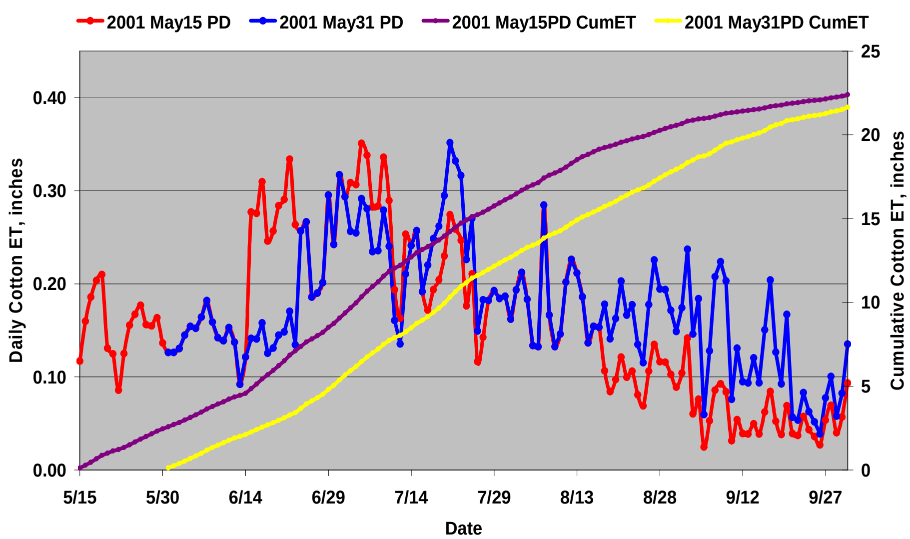

Figure 4. 2001 daily and seasonal cotton ET data at the North Plains Research Field, Etter, TX.

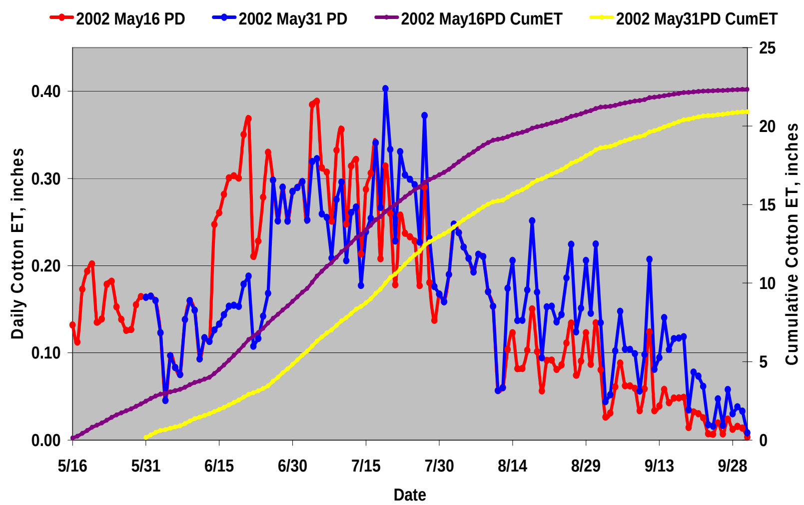

Figure 5. 2002 daily and seasonal cotton ET data at the North Plains Research Field, Etter, TX.

Table 3. **Cotton varieties tested at the North Plains Research Field in 1999 through 2002.**

1999	2000	2001	2002
All Tex Express	2379	BXN16	BXN 16
DP 2156	AFD Rocket	PM 2200 RR	PM 2200 RR
DP 2379	DP 2156	PM 2280 BG/RR	PM 2280 BG/RR
PM 2200 RR	PM 183	PM 2326 BG/RR	PM 2326 BG/RR
PM 2326 RR	PM 2326 BG/RR	PM 2326 RR	PM 2326 RR
PM 280	PM 2326 RR	PM 2379 RR	PSC 355
PM HS26	PM HS26	PM HS26	SG 215 BG/RR
Stoneville BXN47	PSC 355	Pyramid	Sphinx
Tamcot Luxor	Pyramid	Sphinx	ST 2454 R
Tamcot Sphinx	Sphinx	ST2454R	ST 3539 BR

RESULTS

Planting date

Significant differences in yield due to planting date were observed in 1999 but were not observed in 2000 or 2001. In 1999, the earlier planting date yielded 185 lbs/ac more lint. In 1999, the only fiber properties affected were micronaire and uniformity. Planting date influenced the percent lint and the loan value. Cotton planted in late May not only yielded less, but also had a lesser percentage of lint and a lower loan value than the earlier planted cotton. The lower loan value was the result of value penalties imposed because of the low micronaire. Micronaire values between 3.5 and 4.9 receive no penalty or a small premium. Cotton with values outside this range receives progressively greater penalties as the micronaire increases or decreases further. Two of three years loan values were higher for the early-planted cotton. Planting dates in 2000 or 2001 did not influence fiber properties.

Varieties

Two glyphosate tolerant and eight standard varieties were grown in 1999. The fiber properties for each variety averaged across planting dates are presented in Tables 4, 6, 8, 10 and 11. Yields were considered excellent and ranged up to 1069 lbs/ac lint. Data regarding fiber differences between the two planting dates are shown in Tables 5, 7, and 9. Micronaire readings were all below the acceptable range and ranged from 2.4 to 3.0. Fiber lengths ranged from 1.03 to 1.12 (33/32nds to 36/32nds) inches and were all considered acceptable. Fiber strength was excellent and was high enough to warrant a small premium. Differences in percent lint are also noted between the varieties. The large differences were probably the result of immature bolls that accumulated with the lint during the harvest operation and contributed little to the final lint weight. When the value per acre is considered (yield x loan), some varieties are twice as valuable as others from the study data.

In 2000, eight standard varieties, one glyphosate tolerant variety, and one stacked gene variety were grown. Yields ranged from 436 to 600 lbs/ac lint (Table 6). Reduced yields were partially the result of hormone herbicide damage received early in the growing season. Micronaire values were considerably higher than the previous year and were all in the upper end of the acceptable range. However, fiber length and strength were greatly reduced. Some varieties received a small loan penalty for low fiber strength. Other fiber properties differed among varieties but differences had little influence on loan value. Total loan value per acre ranged from $181 up to $463.

In 2001, three standard varieties, one stacked gene variety, and six varieties with herbicide tolerance were included. Yields ranged from 695 lbs/ac up to 915 lbs/ac lint. Total per acre value ranged from $318 up to $467. Differences were observed among varieties for all fiber properties measured (Table 8). The most influential of these on fiber value was the micronaire. Some varieties had a micronaire in the acceptable range (no penalty) while others were low and received a penalty. In general, all micronaire readings were on the low side. Most varieties received a premium for strength with two being neutral.

Included in the study of 2000 and 2001 were HS 26, 2326 RR, and 2326 BG/RR varieties. HS 26 is the parent variety of 2326 RR and 2326 BG/RR. In 2000, the yield and value per acre were greater for 2326 BG/RR; however, the increase was probably not great enough to cover the increased seed cost and technology fee assessed. In 2001, the yield was greater for 2326 BG/RR but the value was slightly reduced because of shorter fiber length. In 2000, micronaire, fiber length, strength, elongation, and leaf content differences were neutral while uniformity was slightly poorer for 2326 BG/RR. In 2001, differences were found in micronaire, fiber length, uniformity, elongation, leaf content, Rd, and +b but not in strength. With little to no insect problems, little advantage was gained from the gene technology for insect control. Also, none of the varieties were treated with glyphosate during the growing season to control weeds. This technology can be profitable in fields with a history of heavy weed infestations or if reduced or minimum tillage is practiced.

Table 4. Yield and fiber quality by variety- NPRF cotton variety trial. Etter, TX. 1999.

Variety	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
D&PL 2379	3.0	1.07	82.3	30.1	7.3	1.8	76.9	9.0	19.8	1069	45.53
D&PL 2156	2.7	1.05	81.5	29.1	6.9	1.8	77.7	9.0	19.5	1006	42.64
PM HS26	2.8	1.07	82.3	32.0	7.2	1.8	77.6	9.0	18.7	1000	45.22
PM 2326RR	3.0	1.10	82.8	32.2	7.1	1.8	77.1	9.1	18.2	980	47.78
Tamcot Sphinx	2.7	1.09	81.6	32.0	6.7	1.8	76.1	9.1	18.3	870	44.55
PM 280	2.5	1.12	81.3	31.3	6.4	1.7	77.7	9.0	16.2	860	42.36
D&PL 2200RR	2.6	1.09	81.4	30.4	6.7	2.2	77.6	8.9	16.2	805	42.74
Tamcot Luxor	2.7	1.08	82.0	29.9	6.5	2.2	76.4	8.7	18.6	800	43.40
All Tex Express	2.4	1.03	80.9	30.0	6.1	2.0	77.4	8.9	16.0	714	37.78
Stoneville BXN 47	2.4	1.05	80.4	27.9	6.1	2.2	76.2	9.6	13.9	606	39.16
$LSD_{.05}$	0.3	0.02	1.0	1.7	0.4	n.s.	n.s.	0.6	2.4	126	3.60

Table 5. Yield and fiber quality by planting date- NPRF cotton variety trial. Etter, TX. 1999.

Planting Date	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
1	2.8	1.07	81.9	30.4	6.8	1.8	77.4	8.8	18.8	964	45.17
2	2.5	1.08	81.4	30.5	6.6	2.1	76.7	9.2	16.3	779	41.07
$LSD_{.05}$	0.3	n.s.	0.4	n.s.	n.s.	n.s.	n.s.	n.s.	2.2	60	2.42

Table 6. Yield and fiber quality by variety- NPRF cotton variety trial. Etter, TX. 2000.

Variety	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
PM 2326 BG/RR	4.4	0.98	79.2	26.0	6.6	2.5	73.9	8.4	26.2	600	43.84
D&PL 2379	4.7	0.99	79.5	25.6	7.0	2.2	72.7	8.5	25.4	562	43.05
AFD Rocket	4.5	1.00	79.9	25.2	6.3	2.3	72.9	8.6	27.2	558	45.06
Tamcot Pyramid	4.5	0.98	79.0	23.2	6.1	1.8	73.2	8.6	28.2	554	42.68
D&PL 2156	4.2	0.96	79.1	24.0	5.9	1.7	73.8	8.7	25.3	541	42.64
PM HS 26	4.3	1.00	80.2	26.5	6.6	2.5	72.9	8.2	24.8	501	45.83
PM 2326 RR	4.6	1.00	80.2	26.0	6.6	3.0	72.6	8.4	25.5	484	45.89
PM 183	4.8	0.92	78.2	23.0	6.1	1.0	73.2	9.5	25.3	472	38.52
PSC 355	4.0	1.04	81.3	27.4	7.0	3.7	70.9	8.1	23.1	450	47.68
Tamcot Sphinx	4.4	0.99	79.6	25.4	5.9	2.2	72.7	8.7	24.4	436	44.48
$LSD_{.05}$	0.4	0.02	0.8	1.4	0.4	0.7	1.0	0.4	2.8	144	2.91

Table 7. Yield and fiber quality by planting date- NPRF cotton variety trial. Etter, TX. 2000.

Planting Date	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
1	4.5	0.99	79.6	25.1	6.4	2.4	72.8	8.5	25.2	509	44.30
2	4.4	0.98	79.6	25.4	6.4	2.2	72.9	8.7	25.9	522	43.64
$LSD_{.05}$	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

Table 8. Yield and fiber quality by variety- NPRF cotton variety trial. Etter, TX. 2001.

Variety	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
Tamcot Pyramid	3.1	1.03	80.1	27.6	6.5	1.5	78.6	8.9	24.6	915	45.33
PM 2326 BG/RR	3.5	1.02	81.3	30.4	7.4	1.2	78.9	8.7	24.2	911	48.32
PM 2326RR	3.7	1.06	82.6	31.1	7.0	1.8	77.7	8.7	24.0	871	53.61
PM 2379 RR	3.6	1.04	81.8	30.6	7.7	1.2	79.4	8.7	24.2	863	50.93
PM 2280 BG/RR	3.0	1.08	80.5	30.1	6.5	1.2	79.7	8.4	23.6	858	47.53
Tamcot Sphinx	3.4	1.05	81.0	30.4	6.2	1.5	77.6	8.6	23.3	844	49.98
PM HS26	3.4	1.05	81.7	31.2	7.3	1.3	78.4	8.3	22.5	789	50.53
PM 2200RR	3.1	1.06	80.1	30.4	6.0	1.0	80.5	8.7	22.7	747	48.30
Stoneville ST2454R	3.6	1.03	81.0	29.0	6.8	1.3	78.6	8.7	25.1	728	48.52
Stoneville BXN16	3.1	1.04	80.7	29.1	5.9	1.0	80.4	8.2	23.5	695	45.73
$LSD_{.05}$	0.3	0.02	0.6	1.2	0.4	0.5	1.0	0.3	1.2	166	3.95

Table 9. Yield and fiber quality by planting date- NPRF cotton variety trial. Etter, TX. 2001.

Planting Date	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
1	3.3	1.04	81.1	29.9	6.7	1.4	79.0	8.5	23.8	840	48.50
2	3.4	1.05	81.0	30.0	6.7	1.2	79.0	8.7	23.7	804	49.25
$LSD_{.05}$											

Table 10. Yield and fiber quality by variety for the early planting date, cotton variety trial. Etter, TX. 2002.

Variety	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
Tamcot Sphinx	3.3	1.08	81.6	28.4	7.7	3.0	71.0	10.5	22.1	794	48.48
PM 2326 BG/RR	3.4	1.05	81.9	30.2	9.3	3.5	73.5	10.0	21.9	774	48.18
PM 2280 BG/RR	3.2	1.12	81.3	29.1	7.7	4.0	75.7	9.6	22.7	730	47.30
PM 2326 RR	3.2	1.10	83.2	30.5	7.9	2.5	73.5	10.8	17.8	589	48.33
$LSD_{.05}$	n.s.	0.03	0.9	n.s.	0.9	n.s.	1.0	n.s.	4.1	n.s.	n.s.

Table 11. Yield and fiber quality by variety for the late planting date- NPRF cotton variety trial. Etter, TX. 2002.

Variety	Micronaire	Length, inches	Uniformity	Strength (gm/tex)	Elongation	Leaf content	Rd	+b	lint percent	yield, lbs/acre	Loan, cents/lb
PM 2326 BG/RR	3.1	1.05	81.1	28.1	9.6	2.5	74.5	11.3	22.9	786	44.98
Tamcot Sphinx	3.1	1.08	81.3	29.3	7.6	2.0	73.9	11.5	23.8	673	47.25
PM 2200 RR	3.5	1.08	81.1	27.9	8.3	1.5	76.1	10.6	22.1	559	51.43
Stoneville BXN 16	3.0	1.06	80.4	26.9	8.2	1.5	76.3	10.0	22.1	539	46.35
PSC 355	2.8	1.13	81.0	27.8	9.6	3.5	71.6	12.0	18.9	534	40.10
PM 2326 RR	3.0	1.07	82.6	28.8	8.7	3.0	74.4	11.1	18.0	434	46.63
$LSD_{.05}$	0.5	0.05	2.2	2.1	1.7	n.s.	3.4	1.1	2.4	199	7.43

In 2002, the study suffered a major setback due to severe damage from hormone herbicide drift. In order to salvage some information from the study year, the planting dates were analyzed as separate studies and the number of replications reduced to two. While some of the varieties are identical for both planting dates, one has four varieties and the other six varieties. The first planting date portion contained one standard variety, one glyphosate tolerant variety and two varieties with stacked gene technology. Yields ranged from 589 lbs/ac up to 794 lbs/ac (Table 10). The production value per acre ranged from $285 to $385. Significant differences in fiber length, uniformity, elongation and Rd were observed. Micronaire was again below an acceptable range. Strength and fiber length were considered acceptable.

The second planting date in 2002 contained two standard varieties, three varieties with herbicide tolerance, and one stacked gene variety. Yield ranged from 434 lbs/ac up to 786 lbs/ac. Significant differences among varieties in lint percent, yield, and loan were observed (Table 11). The production value per acre ranged from $202 up to $354. Significant differences among varieties were observed for all fiber properties except leaf content. Micronaire was low while fiber length and strength were acceptable. Although a statistical comparison between planting dates could not be made, it was observed that the average yield of all varieties in the first planted date group was double the average yield of all varieties in the second planted group.

DISCUSSION

Results of this four-year study indicate that cotton can be successfully grown in the northern Texas High Plains. It must be emphasized that several things must be taken into consideration from a cotton production standpoint. Regardless of the variety chosen, it is very likely that any lint harvested will have a lower micronaire than desired. Lint with a micronaire greater than 4.9 or less than 3.5 will be penalized. Fewer growing degree-days on the northern Texas High Plains illustrates that care must be exercised to plant the crop when soils are warm enough (near 60 degrees F at the two inch soil depth) for rapid growth early in the growing season. It also indicates that the crop is generally subject to early termination at the end of the growing season. Nighttime low temperatures may also reach levels below that cotton will not grow or an associated and early fall freeze may prematurely terminate the crop. Due to the low temperatures incurred, no insect damage was encountered during the time frame of this study. Producers deciding to grow cotton should become familiar with common cotton insects, economic thresholds and the respective control procedures. In the event of insects, early and rapid treatment is essential as boll development on the lower portion of the plant is essential. Use of genetically modified cotton varieties to control certain cotton insects appears unjustified at this time for the region. This may change with time. Also, use of varieties that are genetically modified to tolerate certain herbicides is probably justified based on experience from other cotton growing regions. This will be especially true in reduced or minimum tillage production systems.

REFERENCES

Allen, R., I. Walter, R. Elliott, T. Howell, D. Itenfisu, M. Jensen and R. Synder. 2005. The ASCE standardized reference evapotranspiration equation. Reston, Virginia. ASCE.

Griekspoor, Phyllis, J. 2004. Cotton's become king on more Kansas farms. The Wichita Eagle. September 8.

Hake, K., K. El-Zik, S. Johnson-Hake and J. Mauney. 1990. Cotton Growth and Development for Production Agriculture. National Cotton Council of America.

Smith, Ron. 2001. Expanding cotton's northern range comes with opportunity, risk. Ron. Southwest Farm Press. February 15.

Statistix7 analytical software for Windows 95, 98, NT, 2000. Analytical Software. Tallahassee Florida. Copyright 1985, 2000.

USDA - National Agricultural Statistics Service. http://www.nass.usda.gov. Accessed September 8, 2004.

Weed Control Programs in Peanut (*Arachis hypogaea*) With Diclosulam and Ethalfluralin Combinations

W. James Grichar
Texas Agricultural Experiment Station, Beeville, Texas 78102
Peter A. Dotray
Texas Agricultural Experiment Station, Lubbock, Texas 79403
Brent A. Besler
Syngenta Crop Protection, Wynnewood, OK 73098
Vernon B. Langston
Dow AgroSciences, The Woodlands, Texas 77382

ABSTRACT

Field studies were conducted during the 1998 and 1999 growing seasons to evaluate diclosulam (Strongarm) alone and in combination with ethalfluralin (Sonalan) for devil's-claw, Palmer amaranth, pitted morningglory, Texas panicum, and yellow nutsedge control. Diclosulam alone applied preplant incorporated, preemergence, or postemergence controlled Palmer amaranth and pitted morningglory greater than 81%, devil's-claw at least 80%, Texas panicum 33 to 97%, and yellow nutsedge 48 to 88% four weeks after treatment (WAT). When ethalfluralin was applied in combination with diclosulam, early-season (4 WAT) Palmer amaranth was controlled at least 97%, devil's-claw was controlled at least 87%, pitted morningglory was controlled greater than 90%, Texas panicum was controlled greater than 80%, and yellow nutsedge control was at least 72%. When rated 14 WAT, ethalfluralin applied in combination with or followed by diclosulam controlled Palmer amaranth and pitted morningglory at least 87%, devil's-claw 100%, and yellow nutsedge at least 86%. Diclosulam alone controlled no greater than 79% yellow nutsedge regardless of rate or application method. Texas panicum control (14 WAT) with ethalfluralin in combination with or followed by diclosulam or diclosulam alone was less than 90% regardless of rate or application method.

KEYWORDS: *Amaranthus palmeri* S. Wats, *Cyperus esculentus* L., devil's-claw, *Ipomoea lacunose* L., Palmer amaranth, *Panicum texanum* Buckl., pitted morningglory, preemergence, preplant incorporated, *Proboscidea louisianica* (Mill.) Thellung, postemergence. Texas panicum, yellow nutsedge.

This research was supported by the Texas Peanut Producers Board and Dow AgroSciences. Use of the trade or common names does not imply endorsement or criticism of the products by the Texas Agricultural Experiment Station or judgment of similar products not mentioned.

INTRODUCTION

Broadleaf weeds such as devil's-claw [*Proboscidea louisianica* (Mill.) Thellung], Palmer amaranth (*Amaranthus palmeri* S. Wats), and pitted morningglory (*Ipomoea lacunosa* L.) are a continuing problem in certain peanut growing areas of the southwestern U.S. Dowler (1998) ranks pigweed spp., morningglory spp., Texas panicum (*Panicum texanum* Buckl.), and yellow nutsedge (*Cyperus esculentus* L.) among the ten most common and troublesome weeds in Texas peanut, and these weeds are found in all peanut growing areas of the state (Grichar et al. 1999).

Control of many broadleaf weeds and annual grasses in Texas can be achieved with a preplant application of a dinitroaniline herbicide such as trifluralin (Treflan), pendimethalin (Prowl), or ethalfluralin (Sonalan) (Wilcut et al. 1995). However, weeds such as Palmer amaranth and Texas panicum can escape control due to extremely high weed populations, improper soil incorporation, large seed size, or an inadequate herbicide rate (Grichar and Colburn 1996). Dinitroaniline herbicides do not adequately control devil's-claw, pitted morningglory, or yellow nutsedge (Wilcut et al. 1995).

Imazapic (Cadre) provides more effective control of yellow nutsedge than any of the currently registered herbicides in peanut including imazethapyr (Pursuit) (Grichar et al. 1992; Richburg et al. 1995; Dotray and Keeling 1997). Imazapic also has a longer period of residual weed control than imazethapyr when applied postemergence (POST) (Grichar et al. 1992). The 18-mo crop rotation restriction following imidazolinone herbicide use on peanut with cotton (*Gossypium hirsutum* L.) limits the use of the imidazolinone herbicides, especially in areas where cotton follows peanut in a rotation (Grichar et al. 1999; Richburg et al. 1994; Matocha et al. 2003).

Diclosulam is a triazolopyrimidine sulfonanilide herbicide registered for use in soybean [*Glycine max* (L.) Merr.] and peanut (Barnes et al. 1998; Bailey et al. 1999a,b; Smith et al. 1998; Grichar et al. 1999; Grey et al. 2001) and controls broadleaf weeds and nutsedge species. Diclosulam applied preplant incorporated (PPI) offers less risk and more consistent control than preemergence (PRE) applications which require rainfall or irrigation to move the herbicide into the soil where weed seed germination occurs (Grey et al. 2001).

Peanut varieties have shown excellent tolerance to diclosulam (Bailey et al. 1999b, 2000; Bailey and Wilcut 2002; Main et al. 2000, 2002; Price et al. 2002). Price et al. (2002) reported that diclosulam systems provided yields equivalent to metolachlor (Dual) followed by imazapic. Bailey and Wilcut (2002) reported that peanut yields were indicative of the level of weed management provided by diclosulam-containing systems that included POST herbicides. Main et al. (2002) reported that 'Georgia Green', 'C-99R', and 'MDR-98' were not affected by diclosulam applied PPI at 0.3, 0.5, or 0.88 oz product/A.

In south Texas, no problems have been reported with diclosulam (Grichar et al. 1999). However, in west Texas, diclosulam has caused peanut stunting and reduction in yield (Grichar et al. 2001; Karnei et al. 2001, 2002; Murphree et al. 2003). Karnei et al. (2001, 2002) reported that, under weed-free conditions, diclosulam at 0.88 oz product/A caused 8 to 10% late-season peanut injury while rates lower than 0.88 oz product/A resulted in less than 3% injury. They also reported that plots treated with diclosulam applied PPI at 0.88 oz/A yielded 480 lbs/A less than diclosulam at 0.3 oz product/A. While the untreated check plot yielded greater than 3000 lbs/A, plots treated with diclosulam at 0.4 oz product/A applied PPI produced 2400 lbs/A, and plots treated with diclosulam at the same rate applied PRE yielded 2600 lbs/A. In growth chamber studies, Grichar et al. (2001) reported that diclosulam rate was a factor in reduced peanut germination in only one of three studies. In that study, germination decreased as diclosulam rate increased. They concluded that poor seed quality could reduce peanut seed germination. Murphree et al. (2003) reported diclosulam applied PRE at 0.44 oz product/A injured peanut 15 to 40% when rated 14 days after treatment (DAT) in 2001, but injury was less than 8% in 2002. When rated late-season, all injury decreased to less than 5% and peanut yields were not affected.

The objective of this research was to evaluate weed control with diclosulam applied PPI, PRE, or POST alone or in combination with ethalfluralin compared to the commercial standard of ethalfluralin and imazapic in different peanut growing areas of Texas.

MATERIALS AND METHODS

Field studies were conducted during the 1998 and 1999 growing season at Texas Agricultural Experiment Stations near Yoakum and Lubbock, TX. Soil type at the Yoakum, Texas site was a Tremona loamy fine sand (thermic Aquic Arenic Palenstalf) with less than 1% organic matter and pH 7.2 while the soil type at Lubbock, Texas was an Amarillo sandy clay loam (fine-loamy, mixed, thermic Aridic Paleustalfs) with less than 1% organic matter and pH 7.8.

The experimental design was a randomized complete block replicated four times at Yoakum and three times at Lubbock. A factorial arrangement of treatments was used. Ethalfluralin (Sonalan HFP, Dow AgroSciences) or no ethalfluralin, diclosulam (Strongarm 84WG, Dow AgroSciences) rate, and diclosulam application method were factors at Yoakum and ethalfluralin or no ethalfluralin and diclosulam rates were factors at Lubbock . Plots, two rows 25 ft long spaced 36 in apart at Yoakum and four rows 30 ft long spaced 38 in apart at Lubbock, contained natural infestations of pitted morningglory (densities greater than 2 plants/ft^2), Texas panicum (densities were 1 to 2 plants/ft^2), yellow nutsedge (densities were 2 to 3 plants/ft^2), Palmer amaranth (densities were 2 to 3 plants/ft^2), and devil’s-claw (densities were 0.5 plants/ft^2).

PPI applications of diclosulam and ethalfluralin were incorporated with a tractor-driven power tiller to a depth of 2 inch at Yoakum or a spring tooth harrow field cultivator to a depth of 3 inch at Lubbock. Preemergence herbicides were applied immediately after peanuts were planted. Postemergence herbicides were applied when Texas panicum was at 4 to 6 leaf stage while pitted morningglory and yellow nutsedge was at the 10 to 12 leaf stage (approximately 3 wk after PPI application) at Yoakum. At Lubbock, imazapic (Cadre 70DG, BASF Corp.) was applied POST when Palmer amaranth and devil’s-claw were at the 2 to 8 leaf stage. Herbicides were applied with a CO_2 backpack sprayer using Teejet 11002 (Spraying Systems Co., Wheaton, IL 60189) flat fan nozzles which delivered a spray volume of 20 gal/A at 30 PSI at Yoakum or Teejet 80015 flat fan nozzles which delivered 10 gal/A at 25 PSI at Lubbock. Postemergence applications of diclosulam and imazapic included an organosilicone based surfactant (Kinetic HV, Helena Chemical Co., Memphis, TN 38119) at 0.25% (v/v) at Yoakum or crop oil concentrate (Agridex, Helena Chemical Co., Memphis, TN 38119) at 1% (v/v) at Lubbock.

Herbicide treatments at Yoakum included ethalfluralin at 2.0 pt/A in combination with diclosulam at 0.3 or 0.44 oz product/A applied PPI, ethalfluralin applied PPI followed by (fb) diclosulam at 0.3 and 0.44 oz product/A applied PRE or POST or diclosulam alone at 0.3 or 0.44 oz product/A applied PPI, PRE, or POST. Ethalfluralin at 2.0 pt/A applied alone or ethalfluralin at 2.0 pt/A applied PPI fb imazapic at 1.44 oz product/A applied POST were the herbicide standards (Table 1). At Lubbock, diclosulam was applied PPI at 0.3, 0.44, or 0.88 oz product/A alone or in combination with ethalfluralin at 2.0 pt/A. Ethalfluralin fb imazapic at 1.44 oz product/A applied POST was the herbicide standard (Table 2). An untreated check was included at both locations.

Georgia Green was planted both years at Yoakum and Tamrun 88 (1997) and AT 120 (1998) was planted at Lubbock. Seeding rates at both locations were 90 lb/A with a planting depth of approximately 1.5 to 2.0 inch. Weed control was visually estimated approximately 4 and 14 wk after POST application using a scale of 0 (no weed control) to 100 (complete weed control). Peanut injury (stunting) was rated at Lubbock 3 wk after PPI treatment on a scale of 0 (no peanut stunting) to 100 (complete peanut death). All weed control data was subjected to ANOVA to test the effects of herbicide, diclosulam rate, and timing of herbicide application. Means were compared with the appropriate Fisher's protected LSD test at the 5% level of probability. Peanut yields were not determined due to difficulty in digging plots because of the high weed populations and reluctance to use equipment under such weedy conditions.

RESULTS AND DISCUSSION

At Lubbock, results from each year are presented separately, with the exception of Palmer amaranth ratings taken four weeks after treatment (WAT), due to a treatment by year interactions. Since there was no significant year by treatment interactions at Yoakum, all weed control data were combined over years.

Peanut Stunting. At Lubbock in 1998, peanut injury (8%) was observed 3 WAT following diclosulam at 0.88 oz product/A with or without ethalfluralin (Table 1). In 1999, peanut injury was noted with diclosulam at 0.88 oz/A with or without ethalfluralin or ethalfluralin fb imazapic applied POST. No injury was observed 14 WAT in either year (data not shown). Peanut stunting due to diclosulam was not noted at Yoakum (data not shown).

Palmer Amaranth Control. Combined over years, Palmer amaranth was controlled 97 to 100% by all herbicide treatments when rated 4 WAT (Table 1). In 1998, at 14 WAT, diclosulam alone at 0.3 or 0.44 oz product/A and ethalfluralin fb imazapic applied POST controlled Palmer amaranth less than 88% while ethalfluralin fb diclosulam at any rate provided at least 98% control. However, in 1999, all herbicide treatments controlled Palmer amaranth at least 93%.

Table 1. Peanut injury and weed control near Lubbock, Texas with diclosulam applied preplant incorporated.[a]

				Control								
		Peanut stunt		AMAPA[b]			PROLO					
Herbicide and rate		3 WAT		4 WAT	14 WAT		4 WAT		14 WAT			
Ethalfluralin	Diclosulam	1998	1999		1998	1999	1998	1999	1998	1999		
------Product/A-------		----------------------------------				%				----------------------------------		
2.0 pt	0	0	0	97	90	97	77	0	0	0		
	0.3 oz	0	0	98	99	100	97	90	100	100		
	0.44 oz	0	0	100	98	100	97	87	100	100		
	0.88 oz	8	4	100	99	100	97	92	100	100		
0	0.3 oz	0	0	100	81	93	83	80	93	100		
	0.44 oz	0	0	97	87	97	94	82	97	92		
	0.88 oz	8	2	100	91	98	92	89	98	85		
2.0 pt	Imazapic[c]	0	4	99	78	100	98	100	100	100		
LSD (0.05)		3	2	NS	9	6	11	7	6	11		

[a]Bayer code for weeds and abbreviations: AMAPA, Palmer amaranth; PROLO, devil's-claw; NS, not significant; WAT, weeks after treatment.

[b] 4 WAT ratings combined over years.

[c]Imazapic at 1.44 oz/A applied postemergence after ethalfluralin applied preplant incorporated.

Devil's-claw Control.

Devil's-claw control 4 WAT in 1998 was at least 92% (Table 1) with all herbicide treatments except diclosulam alone at 0.3 oz product/A (83%) and ethalfluralin alone (77%). In 1999, 4 WAT, diclosulam alone controlled devil's-claw 80 to 89% while ethalfluralin in combination with diclosulam controlled 87 to 92%. Ethalfluralin alone controlled no devil's-claw; however, ethalfluralin fb imazapic applied POST provided 100 % control.

When rated late-season in 1998, ethalfluralin in combination with diclosulam or fb by imazapic applied POST provided complete control while diclosulam alone controlled devil's-claw 93 to 98% (Table 1). In 1999, ethalfluralin in combination with diclosulam, diclosulam alone at 0.3 oz product/A, or ethalfluralin fb imazapic provided 100% control while diclosulam alone at 0.88 oz product/A devil's-claw 85%.

Pitted Morningglory Control.

There was a significant ethalfluralin by diclosulam rate by application timing interaction for pitted morningglory control at the 4 and 14 WAT ratings. When rated 4 WAT, diclosulam at 0.3 oz product/A in combination with ethalfluralin applied PPI controlled pitted morningglory 94% while PRE or POST applications of diclosulam following ethalfluralin PPI controlled pitted morningglory 91 and 98%, respectively

(Table 2). When ethalfluralin was applied in combination with or fb diclosulam at 0.44 oz product/A, pitted morningglory was controlled at least 96%.

Table 2. Weed control near Yoakum using diclosulam.[a]

Herbicide and rate			Control					
		Appl.	IPOLA		PANTE		CYPES	
Ethalfluralin	Diclosulam	timing	4 WAT[b]	14 WAT	4 WAT	14 WAT	4 WAT	14 WAT
--------Product/A--------			--------------------------------%----------------------------					
None	0.3 oz	PPI	97	99	78	73	88	79
		PRE	93	96	97	66	80	77
		POST	94	87	33	66	58	70
	0.44 oz	PPI	94	98	85	83	84	78
		PRE	94	89	95	70	74	61
		POST	95	88	40	54	48	78
2.0 pt	0.3 oz	PPI	94	93	98	70	87	88
		PRE	91	89	81	70	83	86
		POST	98	87	97	86	72	90
	0.44 oz	PPI	96	94	97	63	96	94
		PRE	97	94	99	89	80	89
		POST	100	97	94	75	76	91
2.0 pt	None	PPI	28	32	97	95	0	0
2.0 pt	Imazapic[c]	POST	89	83	99	74	88	96
LSD (0.05)			2	3	8	23	6	17

[a]Bayer code for weeds: IPOLA, pitted morningglory; PANTE, Texas panicum; CYPES, yellow nutsedge.
[b]Abbreviations: PPI, preplant incorporate; PRE, preemergence; POST, postemergence; WAT, weeks after treatment.
[c]Imazapic at 1.44 oz/A applied POST after ethalfluralin applied PPI.

At 4 WAT, when diclosulam was applied PPI at 0.3 oz/A without ethalfluralin, pitted morningglory control was 97%, but control was less than 95% when diclosulam alone was applied PRE or POST. Diclosulam alone at 0.44 oz/A controlled pitted morningglory 94 to 95% regardless of application method. Richburg et al. (1997) reported that diclosulam controlled pitted morningglory in soybean equal to or greater than imazaquin. Grichar et al. (1999) reported that ethalfluralin plus diclosulam at 0.3 to 1.2 oz product/A applied PPI controlled pitted morningglory at least 98% regardless of rate.

When rated 14 WAT, ethalfluralin in combination with or fb diclosulam at 0.3 oz product/A controlled pitted morningglory 87 to 93% while control with ethalfluralin in combination with or fb diclosulam at 0.44 oz product/A was 94% to 97% following all diclosulam application timings (Table 2). Without ethalfluralin, diclosulam alone at 0.3 or 0.44 oz product/A controlled pitted morningglory at least 98% when applied PPI.

Diclosulam alone applied PRE controlled pitted morninglory 96% at the 0.3 oz product/A and 89% at the 0.44 oz product/A rate. Diclosulam alone applied POST at either rate controlled morningglory no better than 88%. A PPI application of ethalfluralin alone controlled pitted morningglory 32% while ethalfluralin fb imazapic applied POST controlled pitted morningglory 83%.

Bailey et al. (1999a,b) reported that ethalfluralin plus diclosulam applied PPI at rates up to 0.44 oz product/A controlled pitted morningglory greater than 90%. They also reported that pitted morningglory was controlled at least 93% with imazapic-containing systems.

Texas Panicum Control.

When rated 4 WAT, diclosulam alone applied PPI at 0.3 and 0.44 oz product/A controlled Texas panicum 78 and 85%, respectively. Diclosulam alone at 0.3 and 0.44 oz/A applied PRE controlled Texas panicum at least 95% while POST applications controlled no greater than 40%. Ethalfluralin in combination with or fb diclosulam at 0.3 or 0.44 oz product/A controlled Texas panicum greater than 90% except for ethalfluralin applied PPI fb diclosulam applied PRE at 0.3 oz product/A which controlled 81% (Table 2). Generally, control of annual grasses can be achieved with PPI applications of dinitroaniline herbicides (Wilcut et al. 1995). Wilcut et al. (1987a,b) reported that the minimum input necessary to achieve consistent Texas panicum control was a dinitroaniline herbicide combined with at least one cultivation.

When rated 14 WAT, diclosulam alone at 0.3 oz/A controlled Texas panicum 66 to 73% while diclosulam alone at 0.44 oz/A controlled Texas panicum 54 to 83% regardless of application method (Table 2). In other studies, diclosulam did not control annual grasses (Bailey et al. 1999a,b; Grey et al. 2001; Grichar et al. 1999). Ethalfluralin in combination with or fb diclosulam at 0.3 oz/A controlled Texas panicum 70 to 86% regardless of application method. Ethalfluralin in combination with diclosulam at 0.44 oz/A applied PPI controlled Texas panicum 63% while ethalfluralin fb diclosulam at 0.44 oz/A applied PRE or POST controlled Texas panicum 89 and 75%, respectively.

Yellow Nutsedge Control.

When rated 4 WAT, diclosulam alone at 0.3 or 0.44 oz product/A applied PPI or PRE controlled yellow nutsedge 74 to 88% while diclosulam applied POST at those rates controlled yellow nutsedge less than 60%. Ethalfluralin in combination with or fb diclosulam applied PRE at 0.3 oz/A controlled yellow nutsedge 83 to 87% while diclosulam at 0.44 oz product/A applied in combination with or following ethalfluralin controlled yellow nutsedge 80 to 96% (Table 2). Ethalfluralin fb diclosulam at either rate applied POST controlled no greater than 76% yellow nutsedge early season. Imazapic applied POST following ethalfluralin controlled yellow nutsedge 88%. Grichar et al. (1999) reported that diclosulam at 0.2 oz product/A applied PPI provided inconsistent control of yellow nutsedge. They also reported that diclosulam at rates greater than 0.3 oz/A controlled at least 90% yellow nutsedge. Scott et al. (2001) reported that adding diclosulam to metolachlor applied PRE improved control (99%).

When rated 14 WAT, diclosulam alone controlled less than 80% yellow nutsedge regardless of rate or application timing while ethalfluralin applied PPI fb imazapic applied POST controlled yellow nutsedge 96% (Table 2). Ethalfluralin in combination with or fb diclosulam applied PPI or PRE controlled yellow nutsedge at least 86% while POST applications of diclosulam following ethalfluralin controlled yellow nutsedge at least 90%. Wilcut et al. (1999) determined that soil applications of diclosulam resulted in reduced shoot dry weights of both yellow and purple nutsedge (*Cyperus rotundus* L.). Grey et al. (2001) reported that increasing the rate of diclosulam applied PPI suppressed yellow nutsedge; however, additional POST herbicides were needed for acceptable control.

CONCLUSION

These data show that diclosulam offers peanut growers another option for use in their herbicide programs. Devil's-claw, Palmer amaranth, pitted morningglory, Texas panicum, and yellow nutsedge control with ethalfluralin and diclosulam soil-applied at 0.3 and 0.44 oz product/A was similar to the commercial standard, imazapic applied POST, which is widely used in the Texas peanut growing regions. POST applications of diclosulam controlled pitted morningglory as well as soil-applied applications. However, POST applications of diclosulam were inconsistent for yellow nutsedge and Texas panicum control.

REFERENCES

Bailey, W. A., J. W. Wilcut, D. L. Jordan, S. D. Askew, J. D. Hinton, and V. B. Langston. 1999a. Weed management in peanut (*Arachis hypogaea*) with diclosulam preemergence. Weed Technol. 13:450-456.

Bailey, W. A., J. W. Wilcut, D. L. Jordan, C. W. Swann, and V. B. Langston. 1999b. Response of peanut (*Arachis hypogaea*) and selected weeds to diclosulam. Weed Technol. 13:771-776.

Bailey, W. A., J. W. Wilcut, J. F. Spears, T. G. Isleib, and V. B. Langston. 2000. Diclosulam does not influence yields in eight Virginia market-type peanut (*Arachis hypogaea*) cultivars. Weed Technol. 14:402-405.

Bailey, W. A. and J. W. Wilcut. 2002. Diclosulam systems for weed management in peanut (*Arachis hypogaea* L.). Weed Technol. 16:807-814.

Barnes, J. W., L. R. Oliver, and J. L. Barrentine. 1998. Potential of diclosulam (Strongarm) for weed control in soybeans. Proc. South Weed Sci. Soc. 51:61-62.

Dotray, P. A. and J. W. Keeling. 1997. Purple nutsedge control in peanut as affected by imazameth and imazethapyr application timing. Peanut Sci. 24:113-116.

Dowler, C. C. 1998. Weed survey-southern states. Proc. South. Weed Sci. Soc. 51:299-313.

Grey, T. L., D. C. Bridges, and E. F. Eastin. 2001. Influence of application rate and timing of diclosulam and weed control in peanut (*Arachis hypogaea* L.). Peanut Sci. 28:13-19.

Grichar, W. J., P. R. Nester, and A. E. Colburn. 1992. Nutsedge (*Cyperus* spp.) control in peanuts (*Arachis hypogaea*) with imazethapyr. Weed Technol. 6:396-400.

Grichar, W. J. and A. E. Colburn. 1996. Flumioxazin for weed control in Texas peanuts (*Arachis hypogaea* L.). Peanut Sci. 23:30-36.

Grichar, W. J., P. A. Dotray, and D. C. Sestak. 1999. Diclosulam for weed control in Texas peanut. Peanut Sci. 26:23-28.

Grichar, W. J., C. A. Gerngross, R. L. Lemon, S. A. Senseman, B. A. Besler, and V. B. Langston. 2001. Interaction of peanut variety, diclosulam rate, and temperature on seed germination. Proc. South. Weed Sci. Soc. 54:200.

Karnei, J. R., P. A. Dotray, J. W. Keeling, and T. A. Baughman. 2001. Diclosulam performance in Texas High Plains peanut. Proc. South. Weed Sci. Soc. 54:37.

Karnei, J. R., P. A. Dotray, J. W. Keeling, and T. A. Baughman. 2002. Weed control and peanut response to diclosulam. Proc. South. Weed Sci. Soc. 55:32.

Main, C. L., J. A. Tredaway, and G. E. MacDonald. 2000. Weed management systems for control of Florida beggarweed (*Desmodium tortuosum*) and sicklepod (*Senna obtusifolia*). Proc. South. Weed Sci. Soc. 53:33-34.

Main, C. L., Ducar, J. T., and G. E. MacDonald. 2002. Response of three runner market-type peanut cultivars to diclosulam. Weed Technol. 16:593-596.

Matocha, M. A., W. J. Grichar, S. A. Senseman, C.A. Gerngross, B.J. Brecke, and W. K. Vencill. 2003. The persistence of imazapic in peanut (*Arachis hypogaea*) crop rotations. Weed Technol. 17:325-329.

Murphree, T. A., P. A. Dotray, J. W. Keeling, T. A. Baughman, and W. J. Grichar. 2003. Response of five peanut varieties to diclosulam and flumioxazin in Texas peanut. Proc. South. Weed Sci. Soc. 56:34.

Price, A. J., J. W. Wilcut, and C. W. Swann. 2002. Weed management with diclosulam in peanut (*Arachis hypogaea*). Weed Technol. 16:724-730.

Richburg, J. S., III, J. W. Wilcut, and G. R. Wehtje. 1994. Toxicity of foliar and/or soil applied AC 263,222 to purple (*Cyperus rotundus*) and yellow (*C. esculentus*) nutsedge. Weed Sci. 42:398-402.

Richburg, J. S., III, J. W. Wilcut, and G. Wiley. 1995. AC 263,222 and imazethapyr rates and mixtures for weed management in peanut (*Arachis hypogaea*). Weed Technol. 9:801-806.

Richburg, J. S., III, J. L. Barrentine, L. B. Braxton, T. C. Geselius, D. L. Grant, V. B. Langston, K. D. Redding, B. R. Sheppard, and S. P. Nolting. 1997. Performance of diclosulam on key broadleaf weeds in southern soybeans. Proc. South. Weed Sci. Soc. 50:161.

Scott, G. H., S. D. Askew, and J. W. Wilcut. 2001. Economic evaluation of diclosulam and flumioxazin systems in peanut (*Arachis hypogaea*). Weed Technol. 15:360-364.

Smith, M. C., D. R. Shaw, and S. M. Schraer. 1998. Soybean weed control with Strongarm, FirstRate, and Frontier. Proc. South. Weed Sci. Soc. 51:62-63.

Wilcut, J. W., A. C. York, W. J. Grichar, and G. R. Wehtje. 1995. The biology and management of weeds in peanut (*Arachis hypogaea*). In H. E. Pattee and H. T. Stalker, eds. Advances in Peanut Science Amer. Peanut Res. Educ. Soc., Inc., Stillwater, OK. pp. 207-244.

Wilcut, J. W., G. R. Wehtje, and M. G. Patterson. 1987a. Economic assessment of weed control systems for peanuts (*Arachis hypogaea*) with herbicides and cultivations. Weed Sci. 35:711-715.

Wilcut, J. W., G. R. Wehtje, and R. H. Walker. 1987b. Economics of weed control in peanuts (*Arachis hypogaea*) with herbicides and cultivations. Weed Sci. 35:711-715.

Wilcut, J. W., J. S. Richburg, III, and L. B. Braxton. 1999. Behavior of Strongarm in purple and yellow nutsedge. Proc. Amer. Peanut Educ. Soc. 31:29.

Use of Sulfentrazone in a Peanut (*Arachis hypogaea*) Herbicide Program

W. James Grichar
Texas Agricultural Experiment Station, Beeville, Texas 78102

ABSTRACT

Field experiments were conducted at two Texas peanut growing locations to study weed control and peanut response to sulfentrazone. Sulfentrazone applied preemergence caused up to 96% peanut stunting when rated 4 weeks after planting. The severity of stunting increased as sulfentrazone rate increased. Eclipta control varied between 89 and 100% while Texas panicum control was never less than 73% regardless of rate. Yellow nutsedge control with sulfentrazone increased as the rate of sulfentrazone increased with control no higher than 81%. Purple nutsedge control varied from 83 to 100% and was not rate dependent. Peanut yields reflect the effect of sulfentrazone injury on plant growth and development as peanut yields decreased as sulfentrazone rate increased.

KEYWORDS: *Arachis hypogaea* L.; *Cyperus esculentus* L.; *Cyperus rotundus* L.; *Eclipta prostrata* L.; *Panicum texanum* Buckl; peanut stunt; preemergence.

INTRODUCTION

Broadleaved weeds such as elipta (*Eclipta prostrata* L.) and pitted morningglory (*Ipomoea lacunosa* L.) are an increasing problem in certain peanut growing regions of the southwestern United States. Dowler (1998) ranks *Ipomoea* spp., Texas panicum (*Panicum texanum* Buckl.), and yellow nutsedge (*Cyperus esculentus* L.) among the ten most common and troublesome weeds in peanut in Texas. These weeds are found in all peanut growing areas of the state (Grichar et al. 1999).

Control of many annual grass and broadleaved weeds in Texas can be achieved with a preplant incorporated (PPI) application of a dinitroaniline herbicide such as trifluralin (Treflan), pendimethalin (Prowl), or ethalfluralin (Sonalan) (Wilcut et al. 1995). However, these herbicides do not adequately control *Ipomoea* or *Cyperus* spp. (Wilcut et al. 1995). Some weeds escape control with the preplant herbicides because of extremely high weed populations, improper soil incorporation, or an inadequate herbicide dose (Grichar and Colburn 1996). Sulfentrazone is a member of the phenyl triazolinone herbicide group (Theodoridis et al. 1992). Herbicides in this family function through inhibition of protoporphyrinogen oxidase (PPO) in the chlorophyll biosynthetic pathway which leads to a buildup of toxic intermediates (Hancock 1995; Matringe et al. 1989; Witkowski and Halling 1989). Unlike other members of this herbicide family, such as the diphenyl ethers, sulfentrazone offers excellent soil activity (Dayan et al. 1996;

This research was supported by the Texas Peanut Producers Board and FMC Corporation. Use of trade or common names does not imply endorsement or criticism of the products by the Texas Agricultural Experiment Station or judgment of similar products not mentioned.

Vidrine et al. 1994). Sulfentrazone is currently registered in the U.S. for weed control in soybean [*Glycine max* L. (Merr.)] as a mixture with chlorimuron (Canopy XL, E.I. du Pont de Nemours and Co., Agricultural Enterprise, Banley Mill Plaza, Wilmington, DE 19898) and in tobacco (*Nicotinia tabacum* L.) it is sold as a single pre-packaged product (Spartan, FMC Corporation, Agricultural Chemical Group, 1735 Market Street, Philadelphia, PA 19103) (Anonymous 2001). Sulfentrazone is primarily absorbed by the roots and causes necrosis and death of emerging weeds after response to light (Anonymous 1995; Wehtje et al. 1997).

The objectives of this research were to determine the spectrum of control with sulfentrazone on various weeds commonly found in peanut fields in Texas and to determine the effect of sulfentrazone on peanut growth and development.

MATERIALS AND METHODS

Field studies were conducted during the 1997 growing season at two locations near Yoakum and Pearsall in the south Texas peanut growing areas. Schedule of events, soil characteristics, and rainfall during the experiment as well as peanut varieties used are shown in Table 1. The experimental design at all locations was a randomized complete block replicated 3 to 4 times depending on location. Plots, two rows 25 ft long spaced 38 in apart, contained natural infestations of eclipta, yellow and purple nutsedge (*Cyperus rotundus* L.), or Texas panicum. Cyperus densities were 6 to 10 plants/ft^2 while eclipta and Texas panicum densities were 2 to 4 plants/ft^2.

Herbicide treatments included sulfentrazone (Authority 4E, FMC Corp.) alone at 0.25, 0.31, or 0.37 lb ai/A applied preemergence (PRE) or in sequence with ethalfluralin (Sonalan HFP, Dow AgroSciences) at 0.75 lb ai/A applied preplant incorporated (PPI) followed by sulfentrazone at the above mentioned rates applied PRE. Ethalfluralin alone at 0.75 lb/A applied PPI or ethalfluralin followed by imazapic (Cadre 70 DG, BASF Corp.) applied postemergence (POST) were used as comparisons and an untreated check was included at each location. Applications of ethalfluralin PPI were made 2 to 3 in deep with a tractor-driven power tiller one to two hours prior to peanut planting. Sulfentrazone was applied PRE within 3 h of peanut planting. Applications of imazapic POST were applied when weeds were 6 to 8 in tall (approximately 4 wk after planting [WAP]) and included a non-ionic surfactant (Kinetic, Helena Chemical Co.). Herbicides were applied with a CO_2 pressurized backpack sprayer using Teejet 11002 flat fan nozzles (Spraying Systems Corporation, Wheaton, IL 60188) which delivered a spray volume of 20 gal/A at 30 PSI. Peanut stunting and weed control were estimated visually 4 and 12 WAP, respectively, using a scale of 0 (no peanut stunting or weed control) to 100 (complete crop death or weed control), relative to the untreated check. Weed control data were transformed by the arscine square root function and data means were separated using Fisher's Protected LSD test at P=0.05. Non-transformed data for weed control are presented since arcsine transformation did not affect conclusions.

Peanut yields were determined at Pearsall by digging the pods, air drying in the field for 6 to 8 d, and harvesting individual plots with a combine. Weights were recorded after soil and trash were removed from the samples. Peanut yield means were separated using Fisher's Protected LSD test at P=0.05. Yields were not obtained at Yoakum due to severe crow (*Corvus corax*) damage which occurred several days after peanuts were dug.

Table 1. Schedule of events, peanut varieties, soil characteristics, and rainfall for conducting peanut herbicide study at two Texas locations,1997.

	Location	
Events, other parameters[a]	Pearsall	Yoakum
Planting date	June 4	May 14
PPI application	June 4	May 14
PRE application	June 4	May 14
Variety	GK-7	GK-7
Soil type		
Sand (%)	78	96
Silt (%)	10	2
Clay (%)	12	2
CEC	6.5	2.6
pH	7.3	6.8
Organic matter	1.0	0.2
Rainfall (inch)		
June	4.5	6.0
July	1.2	7.51
August	1.6	1.12

[a]Abbreviations: CEC, cation exchange capacity; PPI, preplant incorporated; PRE, preemergence.

RESULTS AND DISCUSSION

Peanut injury. Although peanut plants exhibited chlorosis and some necrosis after sulfentrazone was applied, only peanut stunting will be discussed because those symptoms lasted season-long and had the most effect on peanut yield. Field and weather conditions were different at each test location; therefore, peanut stunting data was analyzed separately by location. At both locations, peanut stunting with sulfentrazone was visible when rated 4 WAP; however, peanut stunting was greater at the Pearsall, Texas location (Table 2). Imazapic caused no peanut stunting at either location. At Pearsall, Texas sulfentrazone at 0.25 lb/A resulted in 73% peanut stunting and peanut stunting was at least 90% with rates greater than 0.25 lb/A. Peanut stunting was 10% with sulfentrazone alone at 0.25 lb/A at Yoakum, Texas and increased as the rate of sulfentrazone increased. When sulfentrazone was applied PRE following ethalfluralin applied PPI, peanut stunting was similar to or greater than sulfentrazone alone. At both locations, peanuts never recovered fully from the sulfentrazone stunting throughout the growing season (data not shown).

Table 2. Peanut injury (4 weeks after planting), weed control (12 weeks after planting), and peanut yield with sulfentrazone at two Texas locations.

Herbicide	Rate/A	Appl timing[a]	Peanut injury Pears	Peanut injury Yoak	Weed control[b,c] CYPES	CYPRO	ECLAL	PANTE Pears	PANTE Yoak	Yield[d]
	Lbs ai		%							Lbs/A
Check	-	-	0	0	0	0	0	0	0	2294
Ethalfluralin	0.75	PPI	0	0	0	0	0	100	100	2980
Sulfentrazone	0.25	PRE	73	10	48	100	89	73	83	2163
Sulfentrazone	0.31	PRE	90	34	63	84	93	89	81	1501
Sulfentrazone	0.37	PRE	96	53	81	96	100	100	78	218
Ethalfluralin+ sulfentrazone	0.75 0.25	PPI PRE	80	29	41	94	96	100	88	1597
Ethalfluralin+ sulfentrazone	0.75 0.31	PPI PRE	90	93	50	95	98	100	75	1162
Ethalfluralin+ sulfentrazone	0.75 0.37	PPI PRE	93	43	68	83	95	100	75	1016
Ethalfluralin+ imazapic	0.75 0.06	PPI POST	0	0	70	100	44	100	99	2813
LSD (0.05)			6	12	28	21	24	9	12	931

[a]Abbreviations: Pears, Pearsall; PPI, preplant incorporated; PRE, preemergence; Yoak, Yoakum.
[b]Bayer Code for weeds: CYPES, yellow nutsedge; CYPRO, purple nutsedge; ECLAL, eclipta; PANTE, Texas panicum.
[c]Yellow nutsedge and eclipta were present at the Yoakum location while purple nutsedge was present at Pearsall.
[d]Yield from the Pearsall location only.

Sulfentrazone has been reported to injure soybean (Li et al. 1999; Taylor-Lovell et al. 2001). Injury symptoms on soybean include chlorosis, discoloration of veins, and reduced internode length (Taylor-Lowell et al. 2001). Hulting et al. (1997) reported significant differences in soybean tolerance to sulfentrazone and found that soybean height was found to be a good indicator of susceptibility. Variation in soybean response may be due to differential tolerance to the peroxidative stress from the herbicide because no differences in either uptake or translocation have been demonstrated (Dayan et al. 1997). Differential variety responses with sulfentrazone have also been observed in potato (*Solanum tuberosum* L.) (Kazarian et al. 2000; Wilson et al. 2002). Grichar et al. (2003) noted 10% or less potato stunting with sulfentrazone at 0.10 and 0.12 lb ai/A. However, when sulfentrazone rate increased to 0.19 lb ai/A or greater, potato stunting was at least 25% at one location. This increase in potato stunting was attributed to the irrigation that was applied 48 h after the PRE application and to the coarse soil (91% sand) at that location (Grichar et al. 2003).

Other research also has shown an increase in sulfentrazone injury when a significant rainfall event moved the herbicide into the crop root zone (Taylor-Lovell et al. 2001). Grey et al. (1997) reported that the availability of sulfentrazone increased with higher pH and coarser textured soil resulting in increased crop injury potential. Also, sulfentrazone injury to soybean was more likely in soils low in organic matter content and under conditions of high moisture (Wehtje et al. 1997). At both locations, total rainfall during the month of planting (May-Yoakum; June-Pearsall) was at least 4.5 inch with an organic matter content of both soils 1.0% or less (Table 1).

Yellow nutsedge control.

At 12 WAT, sulfentrazone alone applied PRE at 0.37 lb/A controlled yellow nutsedge 81% while all other rates controlled 63% or less (Table 2). Ethalfluralin plus imazapic controlled only 70% yellow nutsedge. Lack of yellow nutsedge control may be attributed to high populations (6 to 10 plants/ft^2) and continuous emergence from planting to harvest due to frequent irrigations which provided environmental conditions conducive for yellow nutsedge growth. Other studies have reported at least 90% control of yellow nutsedge with sulfentrazone (Krausz et al. 1998; Niekamp et al. 1999).

Purple nutsedge control.

Sulfentrazone, with and without etalfluralin, control of purple nutsedge varied from 83 to 100% while ethalfluralin plus imazapic controlled purple nutsedge completely (Table 2). Grichar et al. (2003) reported that sulfentrazone at rates lower than 0.15 lb ai/A provided variable purple nutsedge control while rates above 0.2 lb/A provided greater than 80% control when applied PRE. Wehtje et al. (1997) reported sulfentrazone was more effective when placed in the root zone at a higher pH relative to a lower pH. They speculated that better control at the higher pH may be relative to the ionization of sulfentrazone. Sulfentrazone has a pKa of 6.6. Both anionic and molecular (uncharged) forms would be present at a pH 6.2 and the molecular form would be predominant at pH 4.2. The anionic form may be preferentially absorbed by roots of purple nutsedge or less subject to absorption by soil colloids (Wehtje et al. 1997).

Eclipta control.

Sulfentazone alone or in combination with ethalfluralin controlled eclipta no less than 89% while ethalfluralin plus imazapic controlled eclipta 44% (Table 2). Ethalfluralin alone did not control eclipta. Sulfentrazone provides excellent control of many broadleaved weeds including common waterhemp (*Amaranthus rudis* Sauer) and morninglory species but somewhat inconsistent control of common ragweed (*Ambrosia artemisiifolia* L.) and common cocklebur (*Xanthium strumarium* L.) (Krausz et al. 1998; Niekamp et al. 1999; Vidrine et al. 1996). Krausz and Young (2003) reported that sulfentrazone at 0.25 lb/A controlled ivyleaf morningglory (*Ipomoea hederacea* L.) 100%.

Texas panicum control.

At Pearsall, sulfentrazone alone at 0.25 lb/A controlled 73% Texas panicum, but when the rate of sulfentrazone was increased to 0.37 lb/A or ethalfluralin was applied PPI followed by sulfentrazone applied PRE, Texas panicum control was 100%. Bailey et al. (2002) reported that sulfentrazone applied PRE at 0.1 to 0.2 lb ai/A controlled goosegrass

(*Eleusine indica* L.) and large crabgrass (*Digitaria sanguinalis* L.) no more than 47%. However, when sulfentrazone dose was increased to 0.25 lb ai/A, control of these annual grasses increased to 76%. They reported that increasing doses of sulfentrazone PRE correlated to linear increases in annual grass control. Other research indicated adequate control of several grass species with the use of sulfentrazone at higher doses (Hancock 1995).

At Yoakum, ethalfluralin alone or ethalfluralin followed by imazapic applied POST controlled Texas panicum at least 99% (Table 2). Sulfentrazone alone or following ethalfluralin applied PPI controlled 75 to 88% Texas panicum. In other research, Grichar et al. (2006) reported that sulfentrazone at 0.2 lb ai/A failed to control Texas panicum when rated 12 WAT. They found early season Texas panicum control with sulfentrazone was less than 40% and did not improve during the growing season.

Peanut yield.

Ethalfluralin followed by imazapic produced a yield of 2813 lb/A while the untreated check yielded 2294 lb/A (Table 2). Peanut yields with sulfentrazone reflect the effect of herbicide injury on peanut growth and development. As sulfentrazone rate increased, peanut yield decreased. These data are in contrast to the work in the southeastern U.S. where sulfentrazone could be applied either PPI or PRE with little or no risk to peanut (Grey et al. 2004).

CONCLUSIONS

Although sulfentrazone provided control of eclipta, Texas panicum, and purple nutsedge in peanut, the severe peanut stunting and subsequent yield reduction noted with sulfentrazone is too great for its use as an effective herbicide. The chance of peanut injury is high under the coarse sands normally reserved for peanut production in the southwestern U.S.

REFERENCES

Anonymous. 1995. Authority Technical Bulletin. Philadelphia, PA: FMC Corporation Agricultural Products Group. 4 p.

Anonymous. 2001. Spartan herbicide label. EPA Reg No. 279-3189. Philadelphia, PA: FMC Corporation. 4 p.

Bailey, W.A., H. P.Wilson, and T. E. Hines. 2002. Response of potato (*Solanum tuberosum*) and selected weeds to sulfentrazone. Weed Technol. 16:651-658.

Dayan, F.E., H. M. Green, J. D. Weete, and H. G. Hancock. 1996. Postemergence activity of sulfentrazone: Effects of surfactants and leaf surfaces. Weed Sci.44:797-803.

Dayan, F.E., J. D. Weete, S. O. Duke, and H. G. Hancock. 1997. Soybean (*Glycine max)* cultivar differences in response to sulfentrazone. Weed Sci. 45:634-641.

Dowler, C.C. 1998. Weed survey-southern states. Proc. South. Weed Sci. Soc. 51:299-313.

Grey, T.L., R. H. Walker, G. R. Wehtje, and H. G. Hancock. 1997. Sulfentrazone absorption and mobility as affected by soil and pH. Weed Sci. 45:733-738.

Grey, T.L., D. C. Bridges, H. G. Hancock, and J.W. Davis. 2004. Influence of sulfentrazone rate and application method on peanut weed control. Weed Technol.

18:619-625.

Grichar, W.J. and A. E. Colburn. 1996. Flumioxazin for weed control in Texas peanuts (*Arachis hypogaea* L.). Peanut Sci. 23:30-36.

Grichar, W.J., P. A. Dotray, and D. C. Sestak. 1999. Diclosulam for weed control in Texas peanut. Peanut Sci. 26:23-28.

Grichar, W.J., B.A. Besler, and K.B. Brewer. 2003. Purple nutsedge control and potato (*Solanum tuberosum*) tolerance to sulfentrazone and halosulfuron. Weed Technol. 17:485- 490.

Grichar, W.J., B.A. Besler, and P.A. Dotray. 2006. Weed control and peanut (*Arachis hypogaea*) response to sulfentrazone. Crop Protect. (25:753-757).

Hancock, H.G. 1995. Sulfentrazone: A broad spectrum herbicide for soybeans. Proc. South. Weed Sci. Soc. 48:44.

Hulting, A.G., L. M. Wax, and F.W. Simmons, 1997. Tolerance levels of soybean cultivars to sulfentrazone. Proc. North Cent. Weed Sci. Soc. 52:37.

Kazarian, D.E., S. J. Nissen, and A.L. Thompson. 2000. Sulfentrazone and flumioxazin for broadleaf weed control in potatoes. Proc. North Cent. Weed Sci. Soc. 53:76.

Krausz, R.F. and B.G.Young. 2003. Sulfentrazone enhances weed control of glyphosate in glyphosate-resistant soybean (*Glycine max*). Weed Technol. 17:249-255.

Krausz, R.F., G. Kapusta, and J.L. Matthews. 1998. Sulfentrazone for weed control in soybean (*Glycine max*). Weed Technol. 12:684-689.

Li, Z., R. H. Walker, G. Wehtje, and H. G. Hancock. 1999. Use of seedling growth parameters to classify soybean (*Glycine max*) cultivar sensitivity to sulfentrazone. Weed Technol. 13:530-535.

Matringe, M., J. M. Camadro, P. Labbe, and R. Scalla. 1989. Protoporphyrinogen oxidase as a molecule target for diphenyl ether herbicides. Biochem. 260:231-235.

Niekamp, J. W., W. G. Johnson, and R. J. Smeda. 1999. Broadleaf weed control with sulfentrazone and flumioxazin in no-tillage soybean (*Glycine max*). Weed Technol. 13:233-238.

Taylor-Lovell, S., L. M. Wax, and R. Nelson. 2001. Phytotoxic response and yield of soybean (*Glycine max*) varieties treated with sulfentrazone or flumioxazin. Weed Technol. 15:95-102.

Theodoridis, G., J. S. Baum, and F. W. Hotzman. 1992. Synthesis and herbicidal properties of aryltriazolinones. A new class of pre- and post-emergence herbicides. In Baker, D.R.,

Vidrine, P.R., D. L. Jordan, and J. M. Girlinghouse. 1994. Efficacy of F6285 in soybeans. Proc. South. Weed Sci. Soc. 47:62.

Vidrine, P.R., J. L. Griffin, D. L., Jordan, and D.B. Reynolds. 1996. Broadleaf weed control in soybean (*Glycine max*) with sulfentrazone. Weed Technol. 10:762-765.

Wehtje, G.R., T. L. Walker, T.L. Grey, and H. G. Hancock. 1997. Response of purple (*Cyperus rotundus*) and yellow nutsedge (*Cyperus esculentus*) to selective placement of sulfentrazone. Weed Sci. 45:382-387.

Wilcut, J.W., A. C. York, W. J. Grichar, and G. R. Wehtje. 1995. The biology and management of weeds in peanut (*Arachis hypogaea*). In Patee, H.E., Stalker, H.T., eds. Advances in Peanut Sciences. Amer. Peanut Res. Educ. Soc., Inc., Stillwater, OK. pp 207-244.

Wilson, D.E., S. J. Nissen, and A. Thompson. 2002. Potato (*Solanum tuberosum*) variety and weed response to sulfentrazone and flumioxazin. Weed Technol. 16:567-574.

Witkowski, D.A. and B. P. Halling. 1989. Inhibition of plant protoporphyrinogen oxidase by the herbicide acifluorfen-methyl. Plant Physiol. 90:1239-1242.

Enhancement of Vegetable Crop Growth with Biosolids and Yard-Waste Compost on a Calcareous Clay Soil

J.J. Heitholt
J.J. Sloan
Texas Agricultural Experiment Station, 17360 Coit Road, Dallas, TX 75252

ABSTRACT

Research is needed to determine if organic matter residuals available near urban centers will benefit vegetable crops when incorporated into calcareous clay soil common to the Southern Great Plains of the United States. Therefore, a field plot study was conducted on a Houston Black clay in north Texas where organic matter amendments were incorporated into the soil in the late summer of 2001 and the early fall of 2002. Cumulative application rates for the two years were 26 tons ac^{-1} for waste water residuals (biosolids) and 31 or 93 tons ac^{-1} for a low and high rate of municipal yard waste compost (MYWC), respectively. An untreated check that received no chemical fertilizer treatment was included as a control. The sequence of crops consisted of soybean (spring-summer 2002), turnip and beet (fall-winter 2003), and sweet corn (spring 2003). The yield of the edible portion of all four crops increased when soil was treated with biosolids as compared to untreated soil and was followed in rank by the high rate of MYWC, the low rate of MYWC, and finally the check. These findings suggest that biosolids and MYWC applied to this clay soil has yield-enhancing potential worth further investigation.

KEY WORDS: fertility, root-to-shoot ratio, soil amendment, yield

INTRODUCTION

Home gardeners in several urban areas of the southwest USA are forced to deal with heavy clay soils that are highly calcareous and serve as a poor media to raise vegetables. Numerous soil amendments are available to improve the tilth of these soils but how these amendments affect vegetable crop productivity remains uncharacterized. Logan et al. (1997) reported that yield of six vegetable crops were similar when grown after soil was amended with biosolids as compared to control plots. In Iowa, Delate (2002) reported that yield of corn (*Zea mays* L.) grown using conventional practices during a three-year study was numerically higher (118 - 142 bu ac^{-1}) compared to corn raised organically (102 - 121 bu ac^{-1}). In contrast, soybean yield was similar (31 – 42 bu ac^{-1}) between the two production methods. Ozores-Hampton and Peach (2002) recently reviewed the production of biosolids, rules regulating their application to vegetable crops, and their general effects on vegetable production. In their report, biosolids applied to a calcareous soil at rates up to 10 tons acre^{-1} were shown to increase yield of several vegetable crops.

Acknowledgements: The authors thank Robert Alexander, Damie Barber, Joe Farr, Faraz Haghighi, Mary Ann Hegemann, and Jeff Stowers for technical support and Dr. Allen Knutson for advice regarding the spinosad application.

Numerous other soil amendments have been tested on vegetable crops. Hunter et al. (1995) reported green manure from cowpea (*Vigna unguiculata*) at rates of 3.4 and 6.7 tons ac^{-1} incorporated into the soil led to sweet corn yield equal to that of soil receiving 45 lbs ac^{-1} each of N, P, and K. Roe et al. (1997) found specific mixtures of biosolid-yard waste compost and synthetic fertilizer to increase vegetable crop yield. Duval et al. (1998) compared the yield of turnip (*Brassica rapa* L.) and mustard greens (*Brassica hirta* L.) when soils were treated with leonardite (a product containing 80% humic acid that is also high in Ca, Na, Mg, Fe, and S) or conventional fertilizer but did not find any growth differences. Warman (1995) reported that soil treated with dairy manure compost at rates of 0, 10.1, 20.2, 40.6 and 81.3 tons ac^{-1} did not affect sweet corn yields but did increase soil moisture and soil N, P, K, and Mg availability. Wu et al. (1993) demonstrated that sweet corn yields from N, P, and K fertilizer (at 134, 58, and 58 lbs ac^{-1}, respectively) were significantly higher than three treatments containing only two of these elements and the untreated check. Additionally, all fertilized plots out-yielded the untreated check.

Addition of biosolids to vegetable crops raises the concern that the edible portion of the plants may contain unhealthy levels of heavy metals for human consumption. However, Dixon et al. (1995) demonstrated that uptake of metals such as Pb, Zn, Cu, Ni, and Cd by plants grown in a biosolids-treated area was less than control plots possibly because the increased pH of the biosolids-treated soil reduced the availability of these metals. Meanwhile, Warman et al. (1995) exposed beet (*Beta vulgaris*) plants to varying rates of compost/biosolids that was high in heavy metal concentration. However, the heavy metal concentrations of the beet tissue were only slightly increased as the compost/biosolids rate increased.

It is logical to suspect that each production region will need to test various soil amendments with its own soil types and in response to its own weather conditions. Therefore, the objective of this study was to quantify growth of selected vegetable crops grown in north Texas on a calcareous soil treated with biosolids or MYWC during a two-year period.

MATERIALS AND METHODS

Plot Layout. Experimental plots consisted of four replicate rectangular areas, each surrounded by two layers of 4 in diameter landscape timbers (Home Depot, Richardson, TX) laid flat at soil level to contain the soil and the amendments. The east and west sides of each replicate were 43.3 ft long and the north and south sides were 7.9 ft wide. Each replicate was divided into four plots measuring 7.9 ft by 7.9 ft (62.4 ft^2) separated by a 3.9 ft by 7.9 ft buffer area of soil that was planted but otherwise left untreated. The two end plots of each replicate terminated on one side at the landscape timbers and were only bordered by the buffer area on the opposite side. Replicates were separated by a 40-in walkway composed of weed cloth covered with 2 in of small red gravel.

Organic Matter Treatments. A Houston Black clay soil was treated with selected soil amendments (MYWC and biosolids) in the late summer of 2001 and in the fall of 2002. The MYWC was found to contain a relatively high concentration of K whereas the biosolids had elevated concentrations of N, P, Cu and Zn (Table 1). The soil organic matter treatments and their cumulative application rates were (1) an untreated control, (2) a low level (30.8 tons ac^{-1}) of municipal yard waste compost (designated MYWC-Low), (3) a high level (92.5 tons ac^{-1}) of MYWC (MYWC-High), and (4) waste water biosolids at 25.9 tons ac^{-1} (Table 2). We did not include a chemical fertilizer control because our long-term goal is to keep the entire area free from synthetic fertilizers and pesticides. Organic matter applications supplied a considerable amount of plant available N to the soil assuming an annual mineralization rate of 20% for compost and 30% for biosolids (Table 2). The experiment used a Latin square design with four replications. Treatments were surface applied on 18 Sept. 2001 and again on 17 Oct. 2002. All plots, including the untreated control, were cultivated with a motorized, walk-behind garden tiller immediately after surface application of the amendments.

Table 1. Properties and composition of the municipal yard waste compost (MYWC) and biosolids applied in 2001 and 2002.

	MYWC		Biosolids	
Property or Element	2001	2002	2001	2002
Organic Matter (%)	35.7	42.5	41.8	47.3
pH	7.63	7.95	9.68	9.56
Electrical Conductivity (µS cm^{-1})	2.06	1.50	5.80	8.71
Total N (%)	1.28	1.01	3.08	3.50
P (%)	0.189	0.214	0.865	1.22
K (%)	0.329	0.380	0.064	0.070
Mg (%)	0.374	0.369	0.290	0.427
Cu (ppm)	12	29	135	182
Zn (ppm)	62	101	455	358

Table 2. Annual and cumulative organic matter application rates for the low and high rates of municipal yard waste compost (MYWC) and the single application rate of waste water biosolids.

	2001		2002		Cumulative	
Organic matter amendment	Application rate (dry wt.)	Plant available N †	Application rate (dry wt.)	Plant available N	Application rate (dry wt.)	Plant available N
	tons/ac	lbs/ac	tons/ac	lbs/ac	tons/ac	lbs/ac
MYWC – Low	11.6	77	19.2	81	30.8	158
MYWC – High	34.9	230	57.6	242	92.5	472
Biosolids	14.3	297	11.6	264	25.9	561

†Plant available N (supplied by the supplements) assuming an annual mineralization rate of 20% for compost and 30% for biosolids from the organic N component. Values include inorganic N present in the amendments. Prior to planting soybean, nitrate-N level was 11 ppm.

Crop Sequence. Annual cereal rye (*Secale cereale*, cv. Elbon) was planted in the fall of 2001 following the first organic matter applications. In the spring of 2002, the rye was cut and incorporated in the soil. On 15 May 2002, vegetable soybean (*Glycine max* L. Merr., cv. Envy, Maturity Group III) seed was inoculated with Cell-Tech 2000 liquid *Bradyrhizobium japonicum* and then hand planted at 3.4 seed ft^{-2} (or 148,000 seed per acre) using six rows (running north and south) spaced 14 in apart. On 11 July, three leaves per plot (3rd uppermost fully expanded trifoliolate) were harvested to determine relative water content using the equation (fresh weight – dry weight) / (turgid weight – dry weight). On 15 July (growth stage R6, Fehr and Caviness 1977), plant height and main stem node number were determined from five plants per plot and then 3.3 ft of plants (including roots) were harvested from the two center rows (rows 3 and 4) and divided into seed, carpels, leaves, stalk (stems and petioles), roots, and nodules. The number of plants, pods, seeds, and nodules were counted and fresh mass of pods and nodules were obtained. All plant parts were dried at 158°F until constant weight for dry matter determination. On 26 July 2002, 3.3 ft of two of the four remaining rows (rows 2 and 5) were harvested for mature seed yield. These two rows harvested at R8 were unbordered on one of their three sides but all plots were treated equally and the unbordered situation was only 11 days in duration. After the R8 harvest, all seed and stalks were harvested and removed from the site. The second soil amendment application was applied several weeks later (Table 2).

On 17 October 2002, half of each plot was sown to beet (cv. Early Wonder Tall Top) and the other half was sown to turnip (cv. Purple Top White Globe). Row spacing was 14 in and the seeding rate was approximately 16 seed ft^{-2} (697,000 seed ac^{-1}). Consequently, each species was grown in a three-row subplot with rows running north and south. In early December, plots were thinned to approximately 6.5 plants ft^{-2}. On 15 Jan. 2003, 3.3 ft of bordered row was harvested from each species and plot. Plants were divided into roots and leaves for fresh and dry weight determination.

In April 2003, sweet corn (cv. TenderTreat) seed was sown in all plots using a 21-in row spacing with four rows (that ran north to south) in each plot. Seeding rate was approximately 1.4 seed ft^{-2} (61,000 seed per ac^{-1}) but plots were thinned to 1 plant ft^{-2} after three weeks. In mid-July 2003, the entire above-ground portion of the plants was harvested from 3.3 ft sections of the center two rows of each plot and separated into ears, leaves, and stalks. Ears were weighed fresh with and without husks. Dry weight on all parts was recorded as described earlier for the other crops.

Other Experimental Concerns. When planting for each crop, seed were sown in all buffer areas at identical seeding rates and row spacings as the treated areas. All crops were watered as needed and an organically-classified pesticide was applied only once when a solution of spinosad at 0.3 lbs per 100 gallons of water (0.4 g L^{-1}) was sprayed on sweet corn ears to runoff just after silk emergence with a single-wand hand-pump sprayer. The statistical analysis consisted of Proc ANOVA using SAS. Sources of variation were row (i.e., replicate), column, and treatment. Means were separated using LSD calculated using the error mean square and the t-value with 6 degrees of freedom.

RESULTS

Relative water content of soybean leaves averaged 0.76 and was not different among treatments (data not shown). Likewise, the number of main stem nodes averaged 8.8 and was not different among treatments (data not shown). Fresh and dry vegetable soybean seed yield at growth stage R6 increased as a result of the biosolids and MYWC-High application above that of the MYWC-Low and the untreated control (Table 3). The same was true of the total aboveground biomass. At final maturity, growth stage R8, seed yield of the biosolids treatment was greater than the other three treatments. Fresh and dry seed weight at R6 were correlated with plant available N (r=0.987* and r=0.997**, respectively.)

Table 3. Effect of soil-applied municipal yard-waste compost (MYWC) at two rates or soil-applied biosolids at one rate on the growth and seed yield of ‘Envy’ vegetable soybean grown on a Houston Black clay from 15 May to mid July 2002 near Dallas, TX. The growth stage R6 harvest occurred on 15 to 19 July and R8 was reached on 26 July 2002.

	Seed yield			Total biomass
Treatment	Fresh at R6 †	Dry at R6 ‡	Dry at R8 §	Dry at R6 ¶
	--------------------------- lbs ac^{-1} --------------------------			
Check	2370	679	1710	2870
MYWC - Low #	2790	804	1500	3180
MYWC - High	3870	1170	2010	4210
Biosolids	3960	1280	2420	4070
LSD (0.05)	486	220	328	835

† R6 indicates green pods were fully expanded and the seed filled the pod cavity. Seed were weighed immediately after shelling.

‡ Same as above (†) except the seed were weighed after oven drying at 140°F for three days.

§ R8, growth stage at which all pods were brown.

¶ The total biomass includes the roots and nodules.

MYWC (Low), MYWC (High), and Biosolids were applied at 11.6 tons ac^{-1}, 34.9 tons ac^{-1}, and 14.3 tons ac^{-1}, respectively.

The biosolids-induced soybean seed yield increase was associated with greater shoot-to-root ratio, a greater harvest index, and with increased aboveground biomass production (Table 4). Since seed size at R6 averaged 0.20 lbs per 100 seed (89 mg per seed) and was not different among treatments (data not shown), the yield component most closely associated with seed yield was seed number. Biosolids inhibited development of nodules whereas nodules were prominent on roots of the other three treatments.

Table 4. Effect of soil-applied municipal yard-waste compost (MYWC) at two rates or soil-applied biosolids at one rate on the harvest index, nodule biomass, shoot:root ratio, seed number, and plant height of 'Envy' vegetable soybean grown on a Houston Black clay from 15 May to mid July 2002 near Dallas, TX. The growth stage R6 harvest occurred on 15 to 19 July and R8 was reached on 26 July 2002.

Treatment	Harvest index	Nodule biomass		Shoot: root ratio	Number of seed at R6	Plant height
		Fresh	Dry			
		---- lbs ac^{-1} ----			no. ft^{-2}	in.
Check	0.23	149	38	9.1	90	14
MYWC - Low †	0.26	183	43	9.8	108	14
MYWC - High	0.27	132	34	11.0	135	16
Biosolids	0.31	12	4	16.8	141	12
LSD (0.05)	0.03	116	27	2.0	32	ns ‡

† MYWC (Low), MYWC (High), and Biosolids were applied at 11.6 tons ac^{-1}, 34.9 tons ac^{-1}, and 14.3 tons ac^{-1}, respectively.

‡ ns indicates that the treatments were not different statistically.

Except for turnip shoot mass of MYWC-High vs. MYWC-Low, beet and turnip dry matter yields (both shoot and root) were increased by biosolids and by MYWC-High (Table 5). Biosolids increased absolute shoot growth to a greater extent than root growth for both of these root crops. However, the shoot:root ratios (dry weight) averaged 3.23 for beet and 1.34 for turnip and were not significantly different among treatments (data not shown). Turnip root yield was correlated with plant available N (r=0.95*).

Table 5. Effect of soil-applied municipal yard-waste compost (MYWC) at two rates or soil-applied biosolids at one rate on dry shoot, dry root, and total dry biomass yield of "Early Wonder Tall Top' beet or 'Purple Top White Globe' turnip and grown on a Houston Black clay from November 2002 to January 2003 near Dallas, TX. Application rates listed refer only to the 17 Oct. 2002 application. Cumulative soil amendment rates are listed in Table 2.

Crop	Treatment	Shoot yield	Root yield	Total yield
		-----------	lbs ac^{-1}	-----------
Beet	Check	277	69	345
	MYWC - Low at 19.3 tons ac^{-1}	326	104	430
	MYWC - High at 57.8 tons ac^{-1}	503	187	689
	Biosolids at 11.6 tons ac^{-1}	1205	357	1560
	LSD (0.05)	145	49	179
Turnip	Check	930	708†	1640
	MYWC - Low at 19.3 tons ac^{-1}	978	743	1720
	MYWC - High at 57.8 tons ac^{-1}	1335	1200	2535
	Biosolids at 11.6 tons ac^{-1}	2670	1680	4350
	LSD (0.05)	363	388	699

† Fresh root yields for turnip were 1.91, 1.96, 3.35, and 5.31 tons ac^{-1} for the Check, MYWC-Low, MYWC-High, and Biosolids, respectively (LSD = 1.35).

Sweet corn ear yield (both fresh and dry weight) and leaf biomass were increased by biosolids but not by MYWC-High or MYWC-Low (Table 6). The ear yield increase of the biosolids treatment was greatly attributed to an increase in harvest index and to a lesser extent by overall growth. The yield component most closely associated with the difference between the biosolids treatment and the untreated check treatment was dry weight per ear (0.36 oz. dry weight vs. 0.12 oz. dry weight or 10.2 g vs. 3.56 g) whereas the number of ears was extremely variable. The low ear weight for plants grown on the untreated plots suggests an N deficiency, an expected outcome for corn. Based on the plant available N supplied by the biosolids amendments (Table 2), N was probably not limiting for the biosolids treatment even though the corn crop was preceded by a beet and turnip crop following the second annual application of the organic matter amendments.

Table 6. Effect of soil-applied compost at two rates or soil-applied biosolids at one rate on yield and biomass traits of sweet corn (cv. TenderTreat) grown on a Houston Black clay from April 2003 to July 2003 near Dallas. Application rates listed refer only to the 17 Oct. 2002 application. Cumulative rates are listed in Table 1.

Treatment	Ears	Biomass					Harvest index †
		Fresh ear	Dry ear	Dry stalk	Dry leaf	Dry total	
	no. ft^{-2}	-------------------		tons ac^{-1}	--------------		
Check	1.07	1.21	0.18	0.97	0.50	1.65	0.11
MYWC - Low ‡	0.99	1.76	0.28	1.08	0.50	1.96	0.15
MYWC - High	0.98	2.06	0.40	1.17	0.64	2.21	0.17
Biosolids	1.44	3.61	0.70	1.23	0.97	2.92	0.23
LSD (0.05)	ns	1.49	0.31	ns	0.27	0.91	0.07

† Harvest index = dry ear weight / total above-ground dry weight.
‡ MYWC (Low), MYWC (High), and Biosolids applied at 19.3 tons ac^{-1}, 57.8 tons ac^{-1}, and at 11.6 tons ac^{-1}, respectively.

DISCUSSION

The yield responses found on our calcareous clay soil support the findings of several other labs that researched biosolids applied to other soil media. Perez-Murcia (2006) found that a peat mixture with 30% composted sewage sludge (CSS) increased broccoli (*Brassica oleracea*) growth above that of mixtures containing 0, 15, or 50% (CSS). Ozores-Hampton et al. (1999) found that a yard-trimmings-biosolids co-compost stimulated tomato (*Lycopersicon esculentum* Mill.) seedling growth.

Preparation methods of biosolids and MWYC may also play a role in the release of N and their ultimate effects on plant growth. Sloan and Basta (1995) found that lime-stabilized biosolids, similar to the biosolids used in this study, increased soil solution NO_3-N concentrations over time to a greater extent than more stable forms of wastewater biosolids. Claassen and Carey (2004) found that poorly-cured MYWC initially immobilized soil N for up to 16 months before becoming a net positive source of mineralized N. However, the relatively quick response to biosolids reported in the current study contrasts with the slower response found by Hemphill et al. (1982). In that report, the first three years of sweet corn yields from $(NH_4)_2SO_4$-treated soil was greater than or equal to yields obtained from sewage sludge-treated soil. However, in the seventh year of that same experiment, Kiemnec et al. (1990) reported sweet corn yields were similar between $(NH_4)_2SO_4$-treated soil and biosolids-treated soil.

Whether soil-N availability explains the yield differences may depend on the crop being studied. Although we did not anticipate that N would affect soybean yield, the correlation between seed yield at R6 and plant available N suggests that N did play a role. Since soybean nodule biomass was inhibited by biosolids to a much greater degree than both MYWC-treated plants, the actual difference in concentration of nitrogen compounds in the rooting zone between the biosolids and MYWC treatments may have been even greater than suggested by Table 2. This hypothesis is supported by the findings of Claassen and Cary (2004) who reported that a biosolids plus yard waste co-compost mixture released more N than a yard waste compost alone.

Conversely, N is not normally considered a fertility requirement for inoculated/nodulated soybean in Texas and nodules were numerous in the check plots, suggesting appreciable N_2 fixation was likely to have occurred. Therefore, it may not be appropriate to attribute the biosolids-induced soybean yield increase to N alone. Regardless, the soybean responses reported here provide indirect evidence that the current soybean fertility recommendation on this particular calcareous soil for both N and non-N elements needs to be revisited.

A strong correlation between turnip root yield and plant available N in the soil was also found suggesting that N was a primary element limiting yield in the unfertilized turnip plots. Although it is likely than the increased plant available N in the amended plots had something to do with the increased beet and sweet corn yields, these two traits were not correlated. Therefore, nutrients other than N may have been the primary cause of their yield responses. Our observations, especially with biosolids, raise the possibility that lower application rates might be warranted. The plant available N (287 and 264 lbs ac^{-1} applied in 2001 and 2002, respectively) resulting from biosolids might likely be considered excessive depending on the crop to be grown. Regardless, a reduced biosolids rate (lower than 11.6 tons ac^{-1}) should be researched in future studies.

The availability of other elements such as P in biosolids (0.86 – 1.22%) and K in the MYWC (0.33 – 0.38%) may have also played a role in our results. However, Bierman and Rosen (1994) reported that yield response of sweet corn to P from triple superphosphate fertilizer was equal to or better than P from sewage-sludge ash. In the case of our vegetable soybean, pretreatment soil test results did not indicate non-N mineral nutrient deficiencies in the control plots. Mehlich-3 extractable P level was 18 ppm, which is in the middle sufficiency range for soybean as recommended by the Texas Cooperative Extension Soil Water and Forage Testing Laboratory.

Our biosolids findings, and to a lesser extent our results with the high rate of MYWC, raise at least two additional ideas. First, biosolids and MYWC may have contributed an excellent balance of nutrients required for these four vegetable crops, a balance that might be difficult to mimic with synthetic fertilizer. Bañuelos et al. (2004) found that total and water extractable essential plant nutrients (N, P, K, S, B, Cu, Zn) were increased in the 0 - 6 in soil depth following two years of biosolids applications at rates less than half the rate used in our study. Bierman et al. (1995) reported that ash from sewage sludge increased pH and soil Zn concentration. Zinc and Cu are frequently limiting in the calcareous soil used in our study. Heitholt et al. (2002) found that application of Cu to this soil type (and to a lesser extent Zn application), increased fruit yield (seed plus pod walls) of greenhouse-grown soybean. In strawberry, soil-applied composted municipal sludge or composted yard waste showed minimal effect on plant fresh weight (Funt and Hummell 1996). However, both amendments reduced leaf tissue Fe concentration. Clearly, further experiments with the species used in our study comparing biosolids, MYWC, and selected blends of inorganic elements on a calcareous soil are needed to confirm whether or not a conventional fertility program could have achieved the yields obtained by the biosolids and compost treatments.

Although soil nutritional changes due to the amendments are likely to be a primary factor related to the yield increases observed from the soil-applied biosolids and MYWC-High treatments, we must mention other factors. Although not measured here, possible changes in soil bulk density, soil gas exchange, or root-soil water relations could have contributed to our growth observations. Because soybean leaf relative water content was similar among treatments in our study, we cannot support the idea that biosolids improved plant water relations.

CONCLUSIONS

Our results indicated that vegetable crop yields on this calcareous soil can be markedly increased by adding biosolids or slightly increased by adding MYWC. Depending on the crop, yield increases are most likely due to increased plant available N, P, and K but trace nutrients supplied by the organic matter treatments cannot be ruled out. The yield increase for soybean was associated with increased shoot-to-root ratio, harvest index, and overall biomass production. For beet and turnip, the biosolids-induced yield increase was associated with an increase in biomass. The corn ear yield increase from biosolids was associated primarily with a higher harvest index and weight per ear but total biomass was also important. Even though Hemphill et al. (1982) and Dixon et al. (1995) reported little change in heavy metal concentration in the edible portion of their vegetable products, we acknowledge that many consumers are still likely to reject produce grown on biosolids-treated soil. However, we suggest that a biosolids treatment might be included as a standard treatment in future fertility research in order to identify soil amendments that will optimize vegetable production on Blackland soils in north Texas.

REFERENCES

Bañuelos, G.S., S. Sharmasarkar, and S. Pasakdee. 2004. Utilization of biosolids as a fertilizer for canola. Compost Science and Utilization 12:61-68.

Bierman, P.M. and C.J. Rosen. 1994. Phosphate and trace metal availability from sewage-sludge incinerator ash. Journal of Environmental Quality 23:822-830.

Bierman, P.M., C.J. Rosen, P.R. Bloom, and E.A. Nater. 1995. Soil solution chemistry of sewage-sludge incinerator ash and phosphate fertilizer amended soil. Journal of Environmental Quality 24:279-285.

Claassen, V.P. and J.L. Carey. 2004. Regeneration of nitrogen fertility in disturbed soils using composts. Compost Science and Utilization 12:145-152.

Delate, K. 2002.Using an agroecological approach to farming systems research. HortTechnology 12:345-354.

Dixon, F.M., J.R. Preer, and A.N. Abdi. 1995. Metal levels in garden vegetables raised on amended soil. Compost Science and Utilization 3(2):55-63.

Duval, J.R., F.J. Dainello, V.A. Haby, and D.R. Earhart. 1998. Evaluating leonardite as a crop growth enhancer for turnip and mustard greens. HortTechnology 8:564-567.

Fehr, W.R. and C.E. Caviness. Stages of soybean development. 1977. Special Report 80. Iowa State University, Ames, IA.

Funt, R.C. and A.K. Hummell. 1996. Evaluation of composted municipal sludge and composted yard waste on strawberries. Advances in Strawberry Research 15:29-33.

Heitholt, J.J., J.J. Sloan, and C.T. MacKown. 2002. Copper, manganese, and zinc fertilization effects on growth of soybean on a calcareous soil. Journal of Plant Nutrition 25:1727-1740.

Hemphill, Jr., D.D., T.L. Jackson, L.W. Martin, G.L. Kiemnec, D. Hanson, and V.V. Volk. 1982. Sweet corn response to application of three sewage sludges. Journal of Environmental Quality 11:191-196.

Hunter, D.J., L.G.G. Yapa, N.V. Hue, and M. Eaqub. 1995. Comparative effects of green manure and lime on the growth of sweet corn and chemical properties of an acid oxisol in Western Samoa. Communication in Soil Science and Plant Analysis 26:375-388.

Kiemnec, G.L., D.D. Hemphill, Jr., M. Hickey, T.L. Jackson, and V.V. Volk. 1990 Sweet corn yield and tissue metal concentration after seven years of sewage sludge applications. Journal of Production Agriculture 3:232-237.

Logan, T. J., L. E. Goins, and B. J. Lindsay. 1997. Field assessment of trace element uptake by six vegetables from N-Viro Soil. Water Environment Research 69:28-33.

Ozores-Hampton, M. and D.R.A. Peach. 2002. Biosolids in vegetable production systems. HortTechnology 12:336-340.

Ozores-Hampton, M., C.S. Vavrina, and T.A. Obreza. 1999. Yard trimming-biosolids compost: Possible alternative to sphagnum peat moss in tomato transplant production. Compost Science and Utilization 7:42-49.

Perez-Murcia, M.D., R. Moral, J. Moreno-Caselles, A. Perez-Espinosa, and C. Paredes. 2006. Use of composted sewage sludge in growth media for broccoli. Bioresource Technology 97:123-130.

Roe, N.E., P.J. Stoffella, and D. Graetz. 1997. Composts from various municipal solid waste feedstocks affect vegetable crops. II. Growth, yields, and fruit quality. Journal of the American Society of Horticultural Science 122:433-437.

Sloan, J.J. and N.T. Basta. 1995. Remediation of acid soils by using alkaline biosolids. Journal of Environmental Quality 24:1097-1103.

Warman, P.R. 1995. Influence of rates and timing on incorporation of dairy manure compost on sweet corn yield, composition and soil fertility. Compost Science and Utilization 3(3):66-71.

Warman, P.R., T. Muizelaar, and W.C. Termeer. 1995. Bioavailability of As, Cd, Co, Cr, Cu, Hg, Mo, Ni, Pb, Se, and Zn from biosolids amended compost. Compost Science and Utilization 3(4):40-50.

Wu, P., Q. Dai, Q. Tao. 1993. Effect of fertilizer rates on the growth, yield, and kernel composition of sweet corn. Communications in Soil Science and Plant Analysis 24:237-253.

The Texas Journal of Agriculture and Natural Resource 19:93-101 (2006)

Stalk Persistence of Interseeded Wheat and Rye Cover Crops Treated at Two Growth Stages and Six Rates of Glyphosate

J. W. Sij
Texas Agricultural Experiment Station, Vernon, TX 76385
B. L. S. Olson
Kansas State University Northwest Research and Extension Center, Colby, KS 67701
J. P. Ott
Texas Cooperative Extension, Hondo, TX 78861
T. A. Baughman
Texas Cooperative Extension, Vernon, TX 76385

ABSTRACT

Cotton seedlings are easily damaged by wind and wind blown soil in the semiarid Southern Great Plains. Cover crops offer protection to seedling cotton. The 3-year study was conducted near Vernon, Texas to determine biomass persistence of chemically terminated wheat and rye cover crops following six application rates of glyphosate. Treatments were applied at the boot or at the 50% heading stage of growth. The amount of standing biomass at 0 to 1 ft, 1 to 2 ft, and > 2 ft was estimated 4 wks after application and expressed as a percentage of the total biomass or percent persistence. Percent control or kill was also recorded. A successful treatment was defined as >90% control and >15% standing residue above 1 ft. Results indicate that rye and wheat provided acceptable stubble persistence when terminated with at least 0.38 lb ai/ac glyphosate at 50% heading. Higher application rates of glyphosate did not increase control (>90% kill) of the cover crop, were less cost effective, and resulted in decreased stalk persistence. Observations on early plant development, increased biomass, stand establishment under adverse environments, and seedling survival under cold, wet conditions favor rye as the cover crop of choice in semiarid environments.

KEYWORDS: conservation tillage, cover crops, soil erosion, stalk persistence, glyphosate, seedling protection

INTRODUCTION

The use of cover crops has been mostly confined to regions in the U.S. that generally receive adequate seasonal rainfall for dryland production. In the southeastern U.S., wheat (*Triticum aestivum* L.) and rye (*Secale cereale* L.) have been studied as fall/winter cover crops prior to planting summer crops, like cotton (*Gossypium hirsutum*

L.), soybean [*Glycine max* (L.) Merrill], and corn (*Zea mays* L.) (Gallaher, 1977; Moschler et al., 1967; Munawar et al. 1990). Cover crops are terminated in early spring with a herbicide, usually glyphosate [N-(phosphono-methyl)glycine] or paraquat (1, 1' dimethyl-4, 4'-bipyridinium ion). Rye, wheat, oat (*Avena sativa* L.), barley (*Hordeum vulgar* L.), triticale (x *Triticosecale* Wittmack), or mixtures with legumes have been used with success as cover crops (Clark et al., 1994; Coale et al., 2001; Daniel et al., 1999a, b; Moschler, et al., 1967). Cover crops used in conservation tillage systems are known to result in many benefits for subsequent crop production in the same year of production in regions of high rainfall or under irrigation in semiarid environments. However, there is limited research on the use of cover crops in dryland crop production systems in semiarid environments like the Texas Rolling Plains.

In the southeastern U.S., rye has been shown to be superior to other winter cover crops because of its winter hardiness, susceptibility to chemical termination, and production of large amounts of biomass (Bauer and Reeves, 1999; Daniel et al., 1999a; Moschler et al., 1967). Although legumes initially provide comparable biomass and nitrogen for the subsequent crop, they do not persist following chemical termination as well as small grains (Clark and Barnett, 1995; Daniel et al., 1999a).

Cover crops offer wind protection, help capture and retain soil moisture, and prevent soil erosion. In a semiarid environment like the Southern Great Plains, soil moisture is the most limiting factor in cotton production. Soil moisture conservation afforded by a cover crop is critical for summer crop production (Daniel et al., 1999b; Gallaher, 1977). However, cover crops must extract a portion of the soil moisture for their development. The type of cover crop and the timing of its termination are critical to maximizing biomass production while minimizing soil moisture loss. Munawar (1990) reported soil moisture content was significantly higher for early-season termination than late-season termination of rye due to depletion of soil moisture by the growing cover crop. Winters and Musick (1993) in the semiarid High Plains of Texas observed that wheat extracted soil water to a depth of 7.9 ft at anthesis. Thus, a small grain cover crop can certainly impact soil moisture availability to the succeeding crop.

Additional environmental factors in the semiarid Southern Great Plains include high winds and blowing sand that can damage or destroy seedlings (Reichenberger, 2003) and cause extensive soil erosion. Intense rainfall events in this region also contribute to soil erosion. Extending soil cover duration offers more effective soil erosion control, particularly within row crops with slow seedling development and on erosion prone soils (Tiki, 2003). However, a full cover crop may not be necessary to protect soil from erosion. Sij et al. (2003) found interseeding two rows of rye between 40-inch cotton rows (which produces 50% ground cover) in the fall reduced seasonal sediment displacement and water run off by 63% and 53%, respectively, compared with conventional production practices.

To be effective for an extended period of time, a cover crop must have some degree of persistence during cotton seedling development. Little research has been conducted on persistence of a small grain cover crop following chemical termination at different growth stages, an important consideration in conservation tillage systems in semiarid environments. In Louisiana, Williams et al. (2001) found that the growth stage at the time of glyphosate application was the most critical factor in attaining a satisfactory level of growth termination. Since cover crops must extract valuable soil moisture in order to develop, minimizing water use while maximizing biomass and persistence of the biomass is extremely important in low rainfall regions where dryland crop production is practiced. Hence, the growth stage of the cover crop at which it is terminated is important in maximizing stalk persistence while minimizing soil moisture extraction. If termination of the cover crop is too early, there is little standing biomass to protect seedlings from damaging winds and conserve soil moisture. Late termination of a cover crop results in excessive use of valuable soil moisture that would be available to the subsequent crop (Clark and Barnett, 1995). Since fiber development increases as plants mature (Bolsen, 1984), increased stalk persistence is a function of plant growth stage. Therefore, the timing of termination should allow for persistence of the cover crop while minimizing soil moisture use by limiting excessive plant development.

The objective of the three-year field study was to determine which of the cover crops, rye or wheat, has superior stalk persistence following various application rates of glyphosate at the boot or the 50% heading stage of growth. Six herbicide rates were included to offer the grower an assessment of the most economical treatment that terminates each cover crop, yet allows acceptable persistence of the cover crop.

MATERIALS AND METHODS

This study was initiated in the fall of 2000 at the Texas Agricultural Experiment Station near Vernon, Texas, a semiarid region typical of the southern Great Plains. The study was conducted over 3 yr to determine stalk persistence of terminated wheat and rye when treated with different rates of glyphosate. All the plots were established in mid-October on conventionally-prepared ground each year. The soil is classified as a Miles fine sandy loam (fine-loamy, mixed, thermic Udic Paleustalf). Paired rows on 10-in centers were planted on a 40-in spacing to either wheat or rye at 60 lb/ac to simulate a small grain crop interseeded between crop rows (in this case only 50% of the land area has cover). 'TAM 202' wheat and 'Bates' rye were used and no fertilizer was applied. Each plot consisted of one set of paired rows 15 ft long with a set of paired rows between each plot as a border to minimize herbicide drift between plots. All treatments were replicated four times. The study area was maintained weed free during the experiment via mechanical or hand hoeing. No nutrient deficiencies were observed during the course of this study.

Glyphosate was applied at the boot or 50% heading growth stage of each small grain using a two-nozzle CO_2 backpack sprayer equipped with XR110015 tips and calibrated to deliver 15 gal/ac at 40 PSI. Treatments included 0.13, 0.25, 0.38, 0.50, 0.75, and 1.0 lb ai/ac glyphosate plus 17 lbs ammonia sulfate/100 gal of finished spray solution. A wooden panel was sectioned into 6- x 6-in squares and inserted between the treated rows. The amount of standing biomass above 2 ft, between 1 and 2 ft, and below 1 ft was determined visually and expressed as a percentage of the total plot biomass. Stalk persistence and percent control (i.e. kill), were recorded 4 weeks following each herbicide treatment.

Data were subjected to analysis of variance for a randomized complete block arrangement of treatments. Year was considered a random variable. Means were separated using protected LSD and were considered different at $P < 0.10$, unless otherwise noted. Treatments were defined successful with > 90% control (kill) and > 15% biomass above 1 ft.

RESULTS AND DISCUSSION

There was a significant rate by cover crop by timing interaction for percent control. The 0.13 lb ai/ac treatment averaged about 50% control for both growth stages and cover crop species. Control at the 0.13 lb ai/ac rate differed between application time and species (Fig. 1).

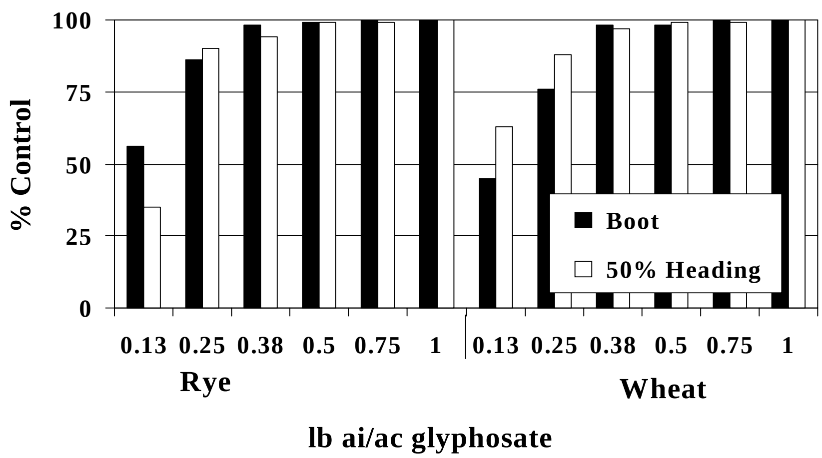

Figure 1. Percent control at two plant growth stages for wheat and rye terminated with six rates of glyphosate. Data were taken 4 weeks after treatment.

Wheat treated at the boot stage did not differ in percentage control from rye treated at 50% heading, averaging 45% and 35% control, respectively. Conversely, rye treated at the boot stage (resulting in 56% control) did not differ in percentage control from wheat treated at 50% heading (63% control). However, all glyphosate application rates greater than 0.13 lb ai/ac followed a similar pattern between species with regard to application time.

For rye, a 0.25 lb ai/ac rate applied at boot increased control to 86% and to 90% when applied at 50% heading. For wheat, the 0.25 lb ai/ac rate applied at boot increased control to 78% and to 89% when applied at 50% heading. However, effective control (> 90% kill) of the standing cover crop was not achieved at either application stage or with either species until 0.38 lb ai/ac of glyphosate was applied. This is half the rate Williams et al. (2001) suggested was required for control of wheat in the boot to early heading in Louisiana. Our results indicated higher rates of glyphosate did not significantly ($P >$ 0.10) increase the level of control 4 wk post treatment (Fig. 1). Cultivar tolerance to glyphosate or environmental factors may have contributed to differences in small grain sensitivity between the two locations.

The timing of glyphosate application on percent stalk persistence was significant. Stalk persistence of wheat and rye above 1 ft decreased linearly (boot stage:

y = -0.75x + 33.67, R^2 = 0.90; 50% heading stage: y = -0.87x + 46.38, R^2 = 0.99) with increasing rates of glyphosate, regardless of the crop's growth stage at the time of application (Fig. 2).

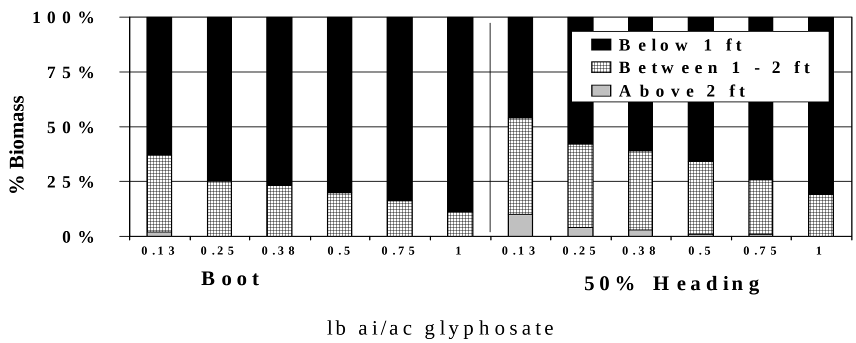

Figure 2. Average percent biomass at two plant growth stages for wheat and rye following termination with different rates of glyphosate. Data were taken 4 wk after treatment.

Even though control was > 90% at the 0.38 lb ai/ac rate, higher rates of glyphosate negatively impacted stalk persistence. Nevertheless, every application rate and time resulted >15% standing biomass above 1 ft, except when $\geq$ 0.25 lb ai/ac glyphosate was applied to rye in the boot stage (11% persistence, Table 1). At any given application rate, stalk persistence was increased when herbicide application was delayed until the 50% heading growth stage ($P \leq 0.05$). Presumably, a greater degree of lignification had taken place between boot and heading resulting in greater straw strength.

There was a significant difference in percent stalk persistence between cover crops and herbicide rate, but no interaction between application timing and herbicide rate. Figure 3 shows a linear decrease in average percent persistence for each cover crop as application rate increased. Stalk persistence of wheat and rye above 1 ft also decreased linearly as application rates increased (rye: y = -1.21x + 43.96, R^2 = 0.79; wheat: y = -0.70x + 44.34, R^2 = 0.94).

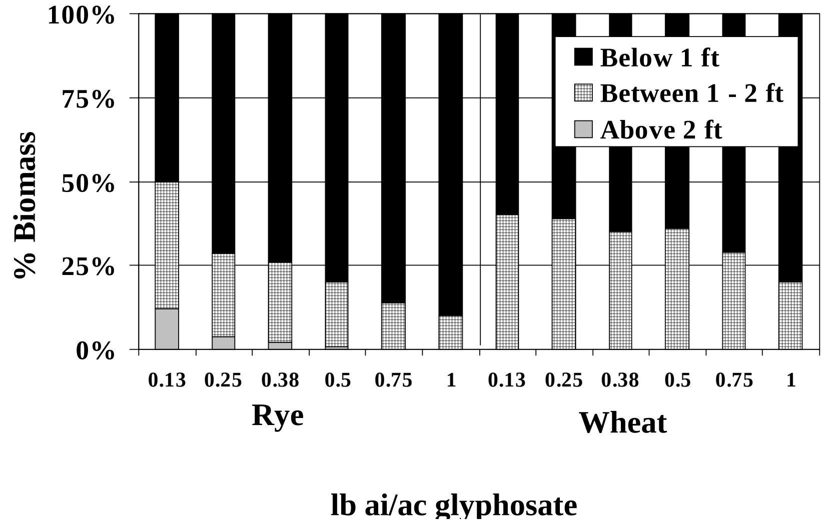

Figure 3. Percent biomass of wheat and rye following termination with different rates of glyphosate averaged across the boot and 50% heading growth stages. Data were taken 4 wk after treatment.

Across all herbicide applications, rye appeared to be more sensitive than wheat to glyphosate in the boot stage. However, rye treated during 50% heading averaged somewhat more standing biomass above 1 ft than wheat (37% for rye versus 31% for wheat, Fig 4).

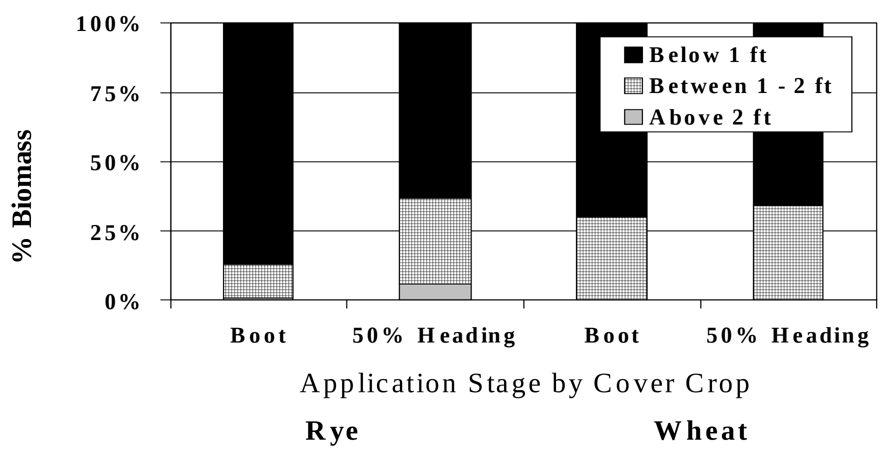

Figure 4. Percent biomass of wheat and rye following termination at two plant growth stages averaged across all rates of glyphosate. Data were taken 4 wk after treatment

Table 1 provides a summary of results and those treatments considered successful in maintaining standing residue of a terminated cover crop.

Table 1. Summary of cover crop response to glyphosate treatments at two growth stages.

Species	Stage	lb ai/ac	% Control[1]	% Persistence[1]	Successful[2]
Rye	Boot	0.13	56	35	No
		0.25	86	13	No
		0.38	98	11	No
		0.50	99	9	No
		0.75	100	7	No
		1.00	100	2	No
	50% Heading	0.13	35	66	No
		0.25	90	44	No
		0.38	94	41	Yes
		0.50	99	29	Yes
		0.75	99	22	Yes
		1.00	100	18	Yes
Wheat	Boot	0.13	45	39	No
		0.25	76	37	No
		0.38	98	34	Yes
		0.50	98	30	Yes
		0.75	100	24	Yes
		1.00	100	19	Yes
	50% Heading	0.13	63	42	No
		0.25	89	40	No
		0.38	97	37	Yes
		0.50	99	38	Yes
		0.75	99	29	Yes
		1.00	100	19	Yes

[1] % Control LSD (0.05) = 5; % Persistence LSD (0.05) = 4.
[2] Successful treatment: > 90% control and > 15% residue above 1 ft.

With rye, only the 0.13 lb ai/ac rate resulted in >15% of the residue extending above 1 ft. In wheat, all herbicide treatments at both growth stages resulted in at least 15% residue above 1 ft 4 wk after treatment. For both cover crops, all herbicide treatments at 50% heading resulted in at least 15% of the residue above 1 ft.

None of the application rates were considered effective (> 90% control and > 15% stalk persistence) when applied to rye in the boot stage (Table 1). Even though the 0.13 lb ai/ac treatment on rye in the boot stage achieved greater than 15% stalk persistence, the treatment did not kill >90% of the plant population. An application rate of at least 0.38 lb ai/ac was considered successful for rye at 50% heading and for wheat at boot as well as 50% heading. Delaying application time until the 50% heading growth stage in wheat did not significantly increase stalk persistence above 1 ft, although one can assume soil moisture demand increased during the period of rapid growth between boot and 50% heading. This was also true for the rye crop, but rye reached 50% heading prior to wheat reaching the boot stage when both crops were seeded on the same planting date in the fall. Soil moisture requirements for plant development between the boot and 50% heading stages were not determined in this study.

CONCLUSIONS

Results from this study show both rye and wheat provided acceptable stubble persistence when terminated with at least 0.38 lb ai/ac glyphosate at 50% heading. Wheat terminated at the boot stage retained more stubble biomass above 1 foot than rye. However, development of rye to the 50% heading stage preceded wheat development to the boot stage by 5 to 7 days. It is unknown if early development of rye would result in soil moisture conservation. Other factors and observations from the present study favor rye as the cover crop of choice in semiarid environments. Rye produced biomass earlier and in greater quantity than wheat; hence, seeding rate could conceivably be less than that of wheat and provide cost savings. Rye is considered more drought tolerant than wheat, and rye can establish stands under less favorable environmental conditions than wheat. Rye also appeared to be more winter hardy and less susceptible to excess soil moisture than the wheat variety used in this study. Based on this study and previous work, the large amount of biomass from rye indicates that seeding an entire area to the cover crop is probably not necessary. Interseeding of a small grain cover crop between rows of the previous summer crop (25 to 50% of the land area) may offer many of the benefits of a complete cover crop but with less expense and presumably less soil moisture extraction, an important consideration in semiarid environments.

REFERENCES

Bauer, P.J., and D.W. Reeves. 1999. A comparison of winter cereal species and planting dates as residue cover for cotton grown with conservation tillage. Crop Sci. 39:824-1830.

Bolsen, K.K. 1984. Feeding value of wheat silage and hay as wheat crop alternatives. p. 55-64. *In* G.W. Horn (ed.) Proc. Natl. Wheat Pasture Symp., Okla. Agric. Exp. Stn. MP-115.

Clark, L.E., and J.L. Barnett. 1995. Winter cover crops in conservation tillage systems for cotton production in the Rolling Plains of Texas. Arkansas Agri. Expt. Sta. Special Report 169. p. 116-120.

Clark, A.J., A.M. Decker, and J.J. Meisinger. 1994. Seeding rate and kill date effects on hairy vetch-cereal rye cover crop mixtures for corn production. Agron. J. 86:1065-1070.

Coale, F.J., J.M. Costa, G.A. Bollero, and S.P. Schlosnagle. 2001. Small grain winter cover crops for conservation of residual soil nitrogen in the mid-Atlantic Coastal Plain. Am. J. Alternative Agric. 16(2):66-72.

Daniel, J.B., A.O. Abaye, M.M. Alley, C.W. Adcock, and J.C. Maitland. 1999a. Winter annual cover crops in a Virginia no-till cotton production system: I. Biomass production, ground cover, and nitrogen assimilation. J. Cotton Sci. 3:74-83.

Daniel, J.B., A.O. Abaye, M.M. Alley, C.W. Adcock, and J.C. Maitland. 1999b. Winter annual cover crops in a Virginia no-till cotton production system: II. Cover crop and tillage effects on soil moisture, cotton yield, and cotton quality. J. Cotton Sci. 3:84-91.

Gallaher, R.N. 1977. Soil moisture conservation and yield of crops no-till planted in rye. Soil Sci. Soc. Am. J. 41:145-147.

Moschler, W.W., G.M. Shear, D.L. Hallock, R.D. Sears, and G.D. Jones. 1967. Winter cover crops for sod-planted corn: Their selection and management. Agron. J. 59:547-551.

Munawar, A., R.L. Blevins, W.W. Frye, and M.R. Saul. 1990. Tillage and cover crop management for soil water conservation. Agron. J. 82:773-777.

Reichenberger, L. 2003. Cotton under cover: No-till planting helps cotton withstand tough conditions. The Furrow 108(1):20-21.

Sij, J.W., J.P. Ott, B.L.S. Olson, T.A. Baughman, and D.G. Bordovsky. 2003. Dryland cropping systems to enhance soil moisture capture and water-use efficiency in cotton. Proc. Beltwide Cotton Conf. January 6-10, 2003. Nashville, TN.

Titi, A.E. 2003. Implications of soil tillage for weed communities. p. 147-185. *In* A.E. Titi (ed.) Soil tillage in agroecosystems. CRC Press, Boca Raton, FL.

Williams, B.J., D.J. Boquet, and D.K. Miller. 2001. Wheat cover crops: Benefits and management. Louisiana Agriculture. 44(3):16-17.

Winter, S.R., and J.T. Musick. 1993. Wheat planting date effects on soil water extraction and grain yield. Agron. J. 85:912-916.

Natural Gas Price Impact on Irrigated Agricultural Water Demands in the Texas Panhandle Region

Bridget Guerrero
Stephen Amosson
Thomas Marek
Texas A&M Research and Extension Center, 6500 Amarillo Blvd. West, Amarillo, TX 79106
Lal Almas
Department of Agricultural Business and Economics, West Texas A&M University, Canyon, TX 79016

ABSTRACT

Rising natural gas prices led to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped is unknown. The objective of this study was to estimate reduction in irrigation water pumped resulting from high natural gas prices in the Northern Texas High Plains.

Farm Service Agency irrigated acreage data were utilized to analyze eight major crop categories. The years having a January natural gas price below $3.00 were grouped as "low price years" and years above $3.00 were designated "high price years". These groups were evaluated for changes in crop composition and abandonment. In addition, four years of Agri-Partner demonstration data with comparable variance in natural gas prices and rainfall totals during the summer crop growing season were used to estimate change in water use by crop.

Overall, water pumped for irrigation in the Northern Texas High Plains was estimated to decrease 17.8 percent from low to high natural gas price years. Of this total decrease, changes in crop composition accounted for 2.3 percent, crop abandonment for 4.1 percent and the remaining 11.4 percent attributed to lower water use by crop. Reduction in water pumped over a 60-year planning horizon was computed at 13.9 million acre-feet.

KEYWORDS: economics, natural gas, irrigation water demand

INTRODUCTION

Population in the United States has increased from 23 million to over 221 million since 1870. Coupled with industrial growth, we are now more dependent upon energy than ever before. Natural gas is a very important component of the energy mix, is a driving force in our economy, heats American homes, and plays a vital part in U.S. agriculture. Natural gas meets one-fourth of the United States' total energy needs (AGA, 2004). In agriculture, natural gas represented four percent of the total energy consumed on U.S. farms in 2002 (Miranowski, 2004). Natural gas powered approximately 30 percent of irrigated acres in Texas in 2000 (Figure 1) (Marek et al., 2004). However, in

Region A, natural gas is far more important in the energy mix. According to Leon New, Texas Cooperative Extension engineer (New - personal communication, 2005), it is estimated that 60 percent of the irrigation wells are powered by natural gas and these groundwater wells account for 80 percent of all irrigation water pumped. Thus, water pumped using natural gas accounts for about 48 percent of the total irrigation water pumped in Region A. This study quantifies the change in irrigation demand due to high natural gas prices from this effective percentage of irrigation water pumped using natural gas.

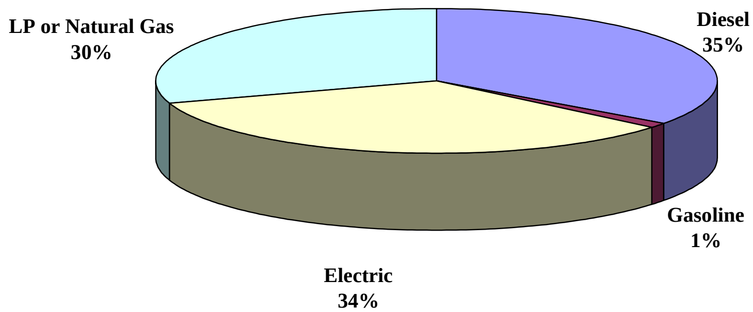

Figure 1. Percent of irrigated acres by utilized power unit source, Texas, 2000.
Source: Marek et al., 2004.

Volatility of natural gas prices has had a noticeable impact on agriculture. Former Agriculture Secretary Ann Veneman stated, "Price volatility in natural gas and liquid petroleum gases such as propane impacts farmers who rely heavily on heating, drying and irrigation, and affects the cost of other energy intensive inputs such as fertilizers and pesticides" (Veneman, 2004). In today's dynamic environment, farmers must be willing to adapt to changes in order to thrive. Due to the increase in natural gas prices, many farmers have adapted by limiting irrigation or changing their cropping patterns and practices.

Sixteen Water Planning Regions were formed in the state of Texas pursuant to the Senate Bill 1 planning effort, which required all areas of the state of Texas to conduct a comprehensive water planning program. The plans that were created as a result of this legislation are the most detailed, encompassing regional level water plans created to date. The Panhandle Water Planning Region (Region A) is comprised of 21 counties in the Texas Panhandle. In the Senate Bill 1 effort (2001), it was determined that 89 percent of current and 86 percent of projected water use was by irrigated crop production in Region A. Several of the heavily irrigated counties were not projected to meet the current maximum 1.25 percent annual depletion rate recommended by the water planning group. However, fluctuating natural gas prices have changed these conditions and had a noticeable impact on agricultural irrigation water demands. Natural gas price spikes starting in 2000 led to changes in crop composition, water use, and therefore, future water supplies in the region.

The New York Mercantile Exchange nearby monthly futures indicates that during the 1990s, the price of natural gas was quite stable at around $2 per thousand cubic feet. Since the summer of 2000, however, prices have been relatively volatile and have averaged about $4.75 per thousand cubic feet (mcf), with a high of $9.78 in

December 2000 and a low of $2.01 in January 2002. The current trend in natural gas prices is increasing as the average price in 2003 was $5.51, whereas, the average price in 2004 was 15 percent higher at $6.31 (Figure 2).

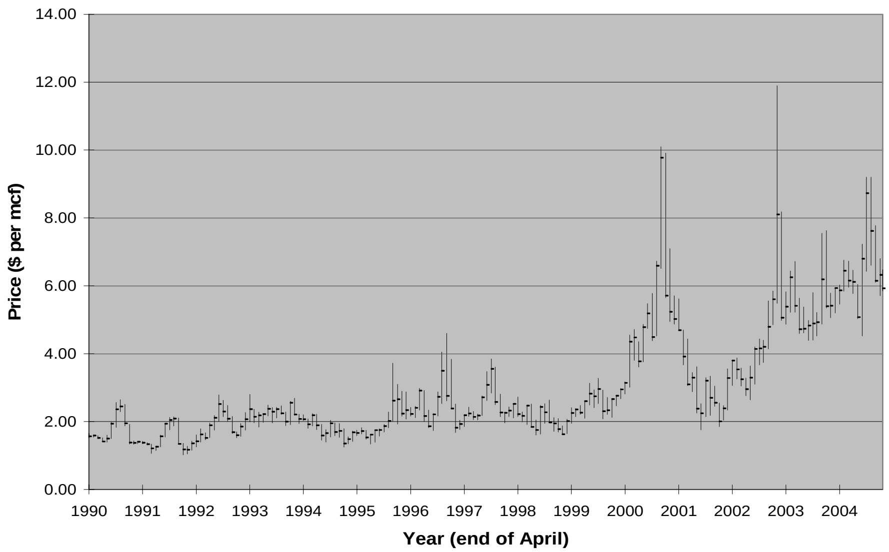

Figure 2. Natural Gas Futures Price (Nearby Monthly, 04/1990 – 02/2005).
Source: New York Mercantile Exchange

Natural gas is the major source of energy used to power irrigation pumps in Region A and is an important factor in determining irrigation costs. Escalating natural gas prices are having an adverse affect on irrigated producer profitability. For example, the estimated cost of natural gas used for irrigating corn in the region rose from $78.40/acre to $140.00/acre from 2003 to 2005 (Amosson et al., 2004). Similarly, the projected cost of anhydrous fertilizer used in corn production increased from $20.80/acre to $38.00/acre while the price for corn remained unchanged.

While it is widely recognized that a change in water use is occurring, the magnitude of the change is unknown. The primary objective of this project is to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A in an effort to determine whether a more rigorous study is warranted in the future to refine projected water use estimates for future water planning efforts. Results of this study could have significant implications to current as well as future water planning efforts in the region. Specific objectives of this regional study are to evaluate changes in crop composition, abandonment scenarios and water use reductions by crop due to increasing natural gas prices and project the change in water use due to higher natural gas prices.

MATERIALS AND METHODS

This analysis evaluates the potential impact of rising natural gas prices on irrigation water use demand in Region A. Farm Service Agency (FSA) was utilized as the source for irrigated acreage data in this study. Crops were grouped into eight major categories: corn, wheat, sorghum, cotton, soybeans, peanuts, hay, and pasture and other. The New York Mercantile Exchange was the source used for nearby monthly natural gas futures prices. Annually, the majority of producers within Region A make their planting decisions in January. Accordingly, years having a January natural gas price below \$3.00 were grouped together as the "low price years" and include 1998, 1999, 2000, and 2002. Conversely, years with a January price above \$3.00 were grouped together as the "high price years" and include 2001, 2003, and 2004. These two groups were then compared and contrasted for changes in crop composition and abandonment due to rising natural gas price.

Similar year groupings were made of Agri-Partner data (New, 1998-2004) to estimate the impact on water use by crop resulting from high natural gas prices. (Agri-Partner is an Extension irrigation production monitoring program.) However, only years of similar rainfall data for the growing season were used. Rainfall data were taken from the National Climatic Data Center's annual climatological summaries for the Amarillo International Airport Station. As a result, the 2000 and 2002 Agri-Partner water use by crop data were grouped together for the low price years, whereas, 2001 and 2003 data were used for the high price years. Due to the differing growing season for wheat, 2003 and 2004 data were utilized for the high price years due to similar rainfall amounts received for the September through May period. Since there was no Agri-Partner data available for water use by crop for hay and pasture and other, the water use for these crops were decreased by the same amount as corn, which was a modest decrease.

The Region A Water Use Demand Model (TAMA model, Marek et al., 2004) developed in Senate Bill 2 – Task 2 was the projection source used in this analysis to determine the change in total irrigation water use from the low price base years to the high price base years. It was also used to project the change in future irrigation water demand due to higher natural gas prices.

The TAMA model is a deterministic simulation model utilizing acreage and crop evapotranspiration (ET) based approach to calculate by crop, county estimations of irrigation demand. The model additionally uses average rainfall and soil profile extraction potential on a county basis. The respective model crop ET per county is derived from a proportional ET matrix based on meteorological station data of the North Plains ET network. Finally, a grower or application factor derived from county demonstration data is included to reflect actual producer application practices (expressed as a percentage of ET) by crop and on a county basis.

To determine the change in total irrigation water use, four scenarios were analyzed. First, total water use during the low price base years was determined using the low price acreage and crop composition. Then, the low price acreage was combined with the high price crop composition to establish the effect of the change in crop composition on total water use. Next, high price acreage and crop composition were used to determine the impact of abandonment on water use. Finally, the high price base was combined with the Agri-Partner data to identify the effect of change in water use by crop on total irrigation water use.

RESULTS

Total irrigation water use was evaluated for the baseline years of 1998, 1999, 2000, and 2002, which experienced relatively low natural gas prices. These years were compared to the years of 2001, 2003, and 2004, which had relatively high natural gas prices. The components that make up the change in water use were analyzed and presented on an individual basis and include change in crop composition, abandonment, and change in irrigation water use by crop. Finally, the potential impact on projected irrigation water use is presented over a 60-year planning horizon.

Crop Composition

The FSA planted irrigated acres by crop for the 21 counties in Region A are shown below (Figure 3) for the years of 1998 through 2004. Initial price spikes in 2000 did appear to alter producer crop composition somewhat. The most significant change, as a result of higher natural gas prices, was that corn acreage decreased 28 percent (163,543 acres) from 2000 to 2001. In that same time period, wheat acreage increased 7 percent and sorghum acreage increased 35 percent.

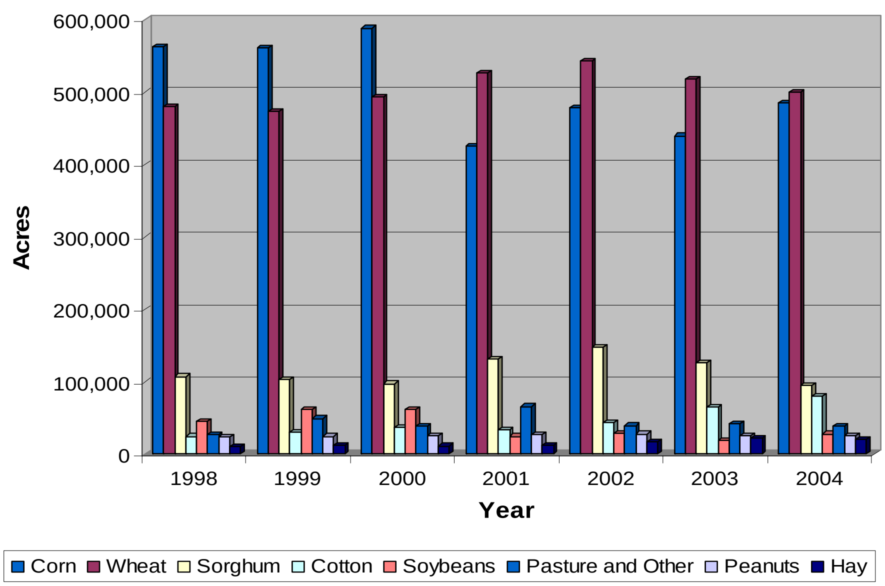

Figure 3. FSA planted irrigated acres by crop in Region A, 1998-2004.
Source: Farm Service Agency

A comparison was made regarding the crop composition during the low price years versus the high price years (Figures 4 & 5). Corn and soybean acreage, as a percentage of total crop composition, decreased by five and two percent, respectively. Corn is considered a high water use crop, and it appears that most of the corn acreage was replaced with either wheat or cotton of which both can utilize considerably less water per irrigated acre. In effect, wheat acreage increased four percent, cotton acreage increased two percent, and pasture and other acreage increased one percent. Sorghum, peanuts, and hay acreages remained unchanged relative to their percentage of total crop composition.

The estimated change in total irrigation water applied due to the change in crop composition was determined by comparing two scenarios. In the first scenario, the total water use during the low price base years was determined with the TAMA model using the low price acreage and crop composition. Then, another scenario was completed with the TAMA model keeping the low price total acreage constant while changing to the high price crop composition. The net change between these two scenarios resulted in a decrease in total irrigation water use of 36,316 acre-feet or 2.3 percent.

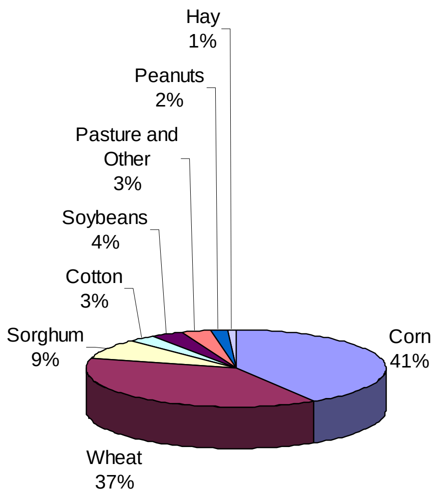

Figure 4. Crop composition during low natural gas price years, Region A.

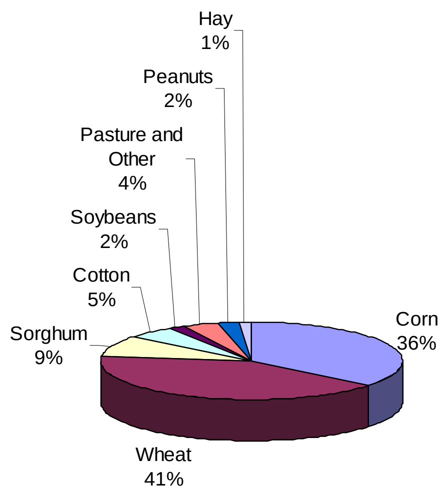

Figure 5. Crop composition during high natural gas price years, Region A.

Abandonment

The amount of irrigated crop acreage was compared between low and high natural gas price years to determine the level of abandonment in irrigated acreage (Figure 6). Total average irrigated acreage decreased 4.6 percent from 1,319,861 acres during the low price years to 1,259,165 acres during the high price years. This resulted in a total loss of about 60,696 irrigated acres during high natural gas price years.

The reduction in irrigation water applied due to abandonment was estimated by the difference in the water pumped between the low natural gas price crop acreage and the high natural gas price acreage assuming the same crop composition. The impact of acreage abandonment on total water use was an additional decrease of 63,876 acre-feet or 4.1 percent.

Water Use by Crop

Four years of Agri-Partner data (2000-2003) were used to estimate the impact on water use by crop resulting from high natural gas prices (New, 1998-2004). These four years were selected because of the similar variance in natural gas prices and similar rainfall totals that occurred during the respective summer cropping seasons. For wheat, the 2001 data was dropped from the analysis and replaced with 2004 data which experienced similar natural gas prices as that of 2001 but received nominal rainfall during the growing season more consistent with the other three years.

Agri-Partner water use by crop data were grouped together with the years 2000 and 2002 representing the low price years, and 2001 and 2003 as the high price years.

The results indicate that irrigation water applied to each crop decreased during the high natural gas price years. However, the reduction in water pumped was more significant in some crops than in others. For example, water applied to peanuts, corn and cotton decreased 4.7 percent, 8.1 percent and 8.6 percent, respectively; whereas, soybean, wheat and grain sorghum irrigation was reduced 18.2 percent, 18.7 percent and 22 percent, respectively (Table 1).

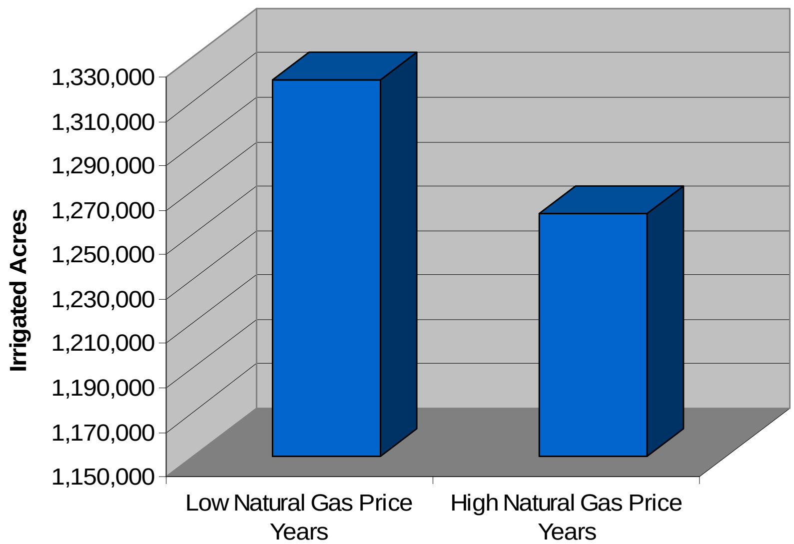

Figure 6. Average Total Irrigated Acreage during Low and High Natural Gas Price Years, Region A.

Table 1. Water applied by crop through center pivot irrigation during low and high natural gas price years.

Crop	**Low Natural Gas Price Years** Average Ac-In (2000, 2002)	**High Natural Gas Price Years** Average Ac-In (2001, 2003)*	**% Change**
Corn	20.45	18.81	-8.05
Grain Sorghum	12.84	10.02	-21.99
Cotton	12.22	11.17	-8.62
Peanuts	19.89	18.96	-4.66
Soybeans	16.82	13.76	-18.16
Wheat	10.61	8.63	-18.71

*High natural gas price years used for wheat were 2003 and 2004 due to similar rainfall amounts for the Sept – May period.
Source: Agri-Partner Demonstration Results (New, 1998-2004)

While the magnitude of the irrigation decrease is unknown, the relative results between crops are consistent with expectations. Producers reduced irrigation less on the higher marginal value crops and more on the lower marginal value crops, where marginal value is defined as the price of the crop multiplied by the change in production level due to the application of an additional inch of irrigation water.

The estimated reduction in total irrigation water applied due to the change in water use by crop was determined utilizing the high price base acreage and crop composition. The long-term average irrigation water pumped by crop in the TAMA model was reduced by a similar percentage as was observed between low and high natural gas price years (Table 1) to estimate the reduction in irrigation. The largest decreases in irrigation water applied by crop occurred in wheat, corn, and sorghum with reductions of 82,260 acre-feet, 55,968 acre-feet, and 20,658 acre-feet, respectively. The remaining crops exhibited only slight decreases due to the limited amount of acreage of these crops within the region. The estimated total effect of change in water use by crop on irrigation water applied was a considerable decrease of 180,019 acre-feet or 11.4 percent.

Summary

The total effect on irrigation water applied considering the change in crop composition, abandonment, and water use by crop during high natural gas price years is a total annual decrease of 280,211 acre-feet or 17.8 percent (Figure 7). Of this total decrease, changing crop composition accounts for 2.3 percent (36,316 acre-feet), crop abandonment 4.1 percent (63,876 acre-feet), and the remaining 11.4 percent (180,019 acre-feet) is attributed to the lower water use by crop.

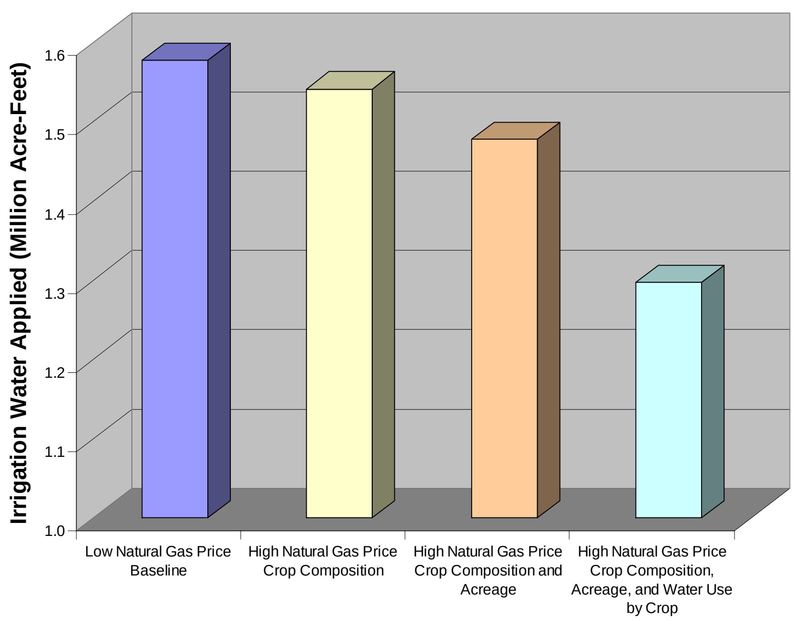

Figure 7. Estimated change in annual irrigation water applied due to change in crop composition, abandonment, and water use by crop during high natural gas price years, Region A.

Potential Impact on Future Irrigation Demand

It is clear that high natural gas prices do, in fact, have an effect on water use in Region A. As a result, persistent high prices will likely cause future water demand to also be lower. To measure this effect, the acreage, crop composition, and water use by crop from the high natural gas price base years were projected in terms of annual irrigation water applied through 2060. The total water use resulting from the low natural gas price baseline over the planning horizon is 78,515,801 acre-feet, whereas, the total water use from the high natural gas price baseline is 64,575,291 acre-feet. The reduction in water pumped consists of 1,806,714 acre-feet from the change in crop composition, 3,177,852 acre-feet from abandonment, and 8,955,944 acre-feet from the change in water use by crop. Therefore, the total water savings generated over a 60-year planning horizon is estimated to be 13,940,510 acre-feet or 17.8% of the total projected irrigation water applied during the low natural gas price baseline (Table 2).

DISCUSSION

Rising natural gas price has lead to a noticeable decrease in irrigation; however, the magnitude of the reduction in water pumped is unknown. The primary objective of this project was to estimate the reduction in irrigation water pumped resulting from high natural gas prices in Region A. Specific objectives of the project were to evaluate the change in crop composition, abandonment and water use by crop due to rising natural gas prices and estimate and project the change in irrigation water use due to higher natural gas prices.

Table 2. Estimated water savings (acre-feet) generated with persistent high natural gas prices.

	2010	2020	2030	2040	2050	2060	Total
Low Natural Gas Price Baseline Water Applied	15,387,518	14,992,967	14,203,863	12,625,656	11,047,451	10,258,346	78,515,801
Reduced Water Pumped:							
Crop Composition	354,079	345,001	326,843	290,527	254,211	236,053	1,806,714
Abandonment	622,795	606,826	574,888	511,011	447,135	415,197	3,177,852
Water Use by Crop	1,755,185	1,710,180	1,620,171	1,440,152	1,260,133	1,170,123	8,955,944
Total Water Savings	2,732,059	2,662,007	2,521,902	2,241,690	1,961,479	1,821,373	13,940,510
High Natural Gas Price Baseline Water Applied	12,655,459	12,330,960	11,681,962	10,383,966	9,085,972	8,436,972	64,575,291

Overall, water pumped for irrigation in Region A was estimated to decrease 17.8 percent from the low natural gas price years to the high natural gas price years. Of this total decrease, changing crop composition accounted for 2.3 percent, crop abandonment 4.1 percent with the remaining 11.4 percent being attributed to lower water use by crop. The reduction in water pumped on irrigated crops over the 60-year planning horizon is expected to total 13.9 million acre-feet. Realistically, these estimates understate what the total reduction in irrigation would be over time. High natural gas prices will reduce the number of producers able to cover their fixed cost associated with irrigated production. As crop specific and irrigation equipment gets older and begins to wear out, they may consider producing lower water use crops or may not be able to economically justify replacing irrigation equipment increasing the level of abandonment from what is estimated.

The change in water pumped in high natural gas years is significant enough to warrant additional study. Failure to account for the affects of higher natural gas prices may lead to inaccurate projections of future water use resulting in the adoption of errant policies. A more sophisticated study that includes additional years of data, more data on water use by crop, factors in rainfall, identifies/evaluates fixed and variable costs associated with irrigation, and takes into account the impact of crop prices on irrigation water use is necessary for a better projection of how natural gas prices will affect crop composition, abandonment, and water use.

REFERENCES

Amosson, S., J. Smith, L. Almas, F. Bretz, B. Guerrero, and M. Freeman. 2004. Texas Crop and Livestock Enterprise Budgets for the Texas High Plains Projected for 2005. December 2004. B-1241 (C1 and C2) and B-1241 (L1 and L2). Texas Cooperative Extension, College Station, Texas. 108 pp.

American Gas Association. 2004. Frequently Asked Questions about Natural Gas Market Trends. Available: http://www.aga.org/Template.cfm?Section=Overview_and_FAQs&template=/ContentManagement/ContentDisplay.cfm&ContentID=14578 Accessed Nov. 9, 2004.

Farm Service Agency. 1998-2004. Irrigated Crop Acres by County. United States Department of Agriculture, Texas Farm Service Agency, College Station, TX.

Marek, T., S. Amosson, L. New, F. Bretz, L. Almas, and B. Guerrero. 2004. Senate Bill 2 – Region A Task 2 Report Agricultural (Irrigation and Livestock) Water Demand Projections. Prepared for Freese and Nichols, Inc. Texas A&M University Agricultural Research and Extension Center, Amarillo, Texas. August 27, 2003. Revised November 2, 2004. 31 pp.

Marek, T., S. Amosson, L. New, F. Bretz and B. Guerrero. 2004. Southern Plains On-Farm Irrigation Acreage, Pumping Plant, and Energy Source Distribution Data. Texas A&M University Agricultural Research and Extension Center, Amarillo, Texas. September 22, 2004. 41 pp.

Miranowski, John A. 2004. Energy Consumption in U.S. Agriculture. In: Conference materials of the Agriculture as a Producer and Consumer of Energy Conference, June 24-25, 2004, Arlington, VA. Available: http://www.farmfoundation.org/projects/documents/miranowski.ppt. Accessed August 17, 2004.

National Climatic Data Center. 1997-2004. Annual Climatological Summary. Available: http://cdo.ncdc.noaa.gov/ancsum/ACS. Accessed March 4, 2005.

New, L. 1998-2004. Agri-Partner Irrigation Result Demonstrations. Texas A&M University Agricultural Research and Extension Center, Amarillo, Texas.

New, L. 2005. Personal Communication. Texas Cooperative Extension, Amarillo, Texas. February 28, 2005.

New York Mercantile Exchange. 1990-2004. Natural Gas Prices, Nearby Futures.

Senate Bill 1. 2001. Regional Water Plan – Panhandle Water Planning Area. Prepared for the Panhandle Water Planning Group through a contract with the Panhandle Regional Planning Commission, Amarillo, Texas. Vol. 1.

Veneman, Ann M. 2004. Remarks by Agriculture Secretary Ann M. Veneman to the USDA Conference on Agriculture as a Producer and Consumer of Energy. United States Department of Agriculture. Arlington, VA. Release No. 0259.04. June 24, 2004.

The Texas Journal of Agriculture and Natural Resource 19:113-118 (2006)

In Vitro Dry Matter Disappearance of Three Different Forage Sources

M. L. McMillan
S. P. Jackson
Department of Agricultural Sciences, Sam Houston State University, Huntsville 77341
S. F. Kelley
Department of Animal and Food Sciences, Texas Tech University, Lubbock 79409

ABSTRACT

Fresh 7 day growth Bermudagrass-clipping lawn pellets *(Cynodon dactylon* L.), alfalfa hay, sun-cured, mid-bloom pellets (*Medicago sativa* L.), and Coastal hay, sun-cured, 43-56 days growth bermudagrass hay pellets (*Cynodon dactylon* L.) were used to study the effects of forage source on dry matter disappearance in an in-vitro ruminal culture system. Rumen fluid was collected from a cannulated steer receiving 100% bermudagrass hay diet and transported to the Texas Tech University Ruminant Nutrition Laboratory. Tubes were prepared in triplicate with substrate and McDougall's Buffer. Incubation times of cultures with forage substrate were 12, 24, and 48 hours. As expected, there was a linear increase ($P < .0005$) in dry matter disappearance for both the Coastal hay pellets and the alfalfa pellets over the 12h, 24h, and 48h time periods. Furthermore, there was a significant ($P < .05$) quadratic increase in dry matter disappearance over the 12h, 24h, and 48h, time period for the Coastal hay pellets. However, while the bermudagrass-clipping lawn pellets had adequate dry matter disappearance, there was no difference ($P > .05$) between the 12h, 24h, and 48h time period.

Differences amongst treatment diets at hour 12 and hour 24 were different ($P < .05$) between the alfalfa pellets, Coastal hay pellets, and the bermudagrass-clipping lawn pellets. However, at hour 48, dry matter disappearance was higher for the alfalfa pellets, but was not significantly different for the Coastal hay diet or the bermudagrass-clipping lawn pellets. Therefore, this study indicates that alfalfa pellets are most digestible in an in vitro culture system followed by the bermudagrass-clipping lawn pellets, and the Coastal hay pellets.

Keywords: Ruminant Nutrition

INTRODUCTION

Many studies have discovered differences in digestibility between C_3 and C_4 plants. It has been well documented that C_3 plants, in most situations, are more digestible than C_4 plants. In general, C_4 plants contain a greater proportion of vascular bundles than C_3 plants whereas, C_3 plants have a larger proportion of leaf mesophyll tissues that have large intracellular spaces that allows for digestion to take place more rapidly in the rumen Hanna et al., 1973). C_4 plants also tend to produce more dry matter that is less digestible than C_3 plants.

Stage of maturity is also an important factor that plays a role in plant digestibility. As the plant matures, the amount of cellulose, hemi-cellulose, and lignin begin to increase. This causes the plant to become less digestible to the animal.

Common bermudagrass from domestic lawns and Coastal bermudagrass hay are C4 plants. Alfalfa is a legume that is a C3 plant. Research has indicated that alfalfa should be more digestible than the grasses. However, stage of maturity may play a big role in the digestibility of these forages. The objective of the study was to determine the digestibility of bermudagrass-clipping pellets, alfalfa pellets, and Coastal bermudagrass hay pellets.

MATERIALS AND METHODS

Bermudagrass-clipping lawn pellets, alfalfa pellets, and Coastal bermudagrass hay pellets were analyzed in an in vitro fermentation culture to determine dry matter disappearance. Chemical composition of bermudagrass-clipping lawn pellets, alfalfa pellets, and Coastal bermudagrass hay pellets is listed in Table 1. Dry matter disappearance was determined by a modified two-stage Tilley and Terry procedure (Galyean, 1997). Twenty liters of ruminal fluid were collected from a cannulated steer receiving a 100% forage diet, strained through four layers of cheesecloth to remove feed particles, and stored in a plastic container for transporting. Upon arrival, rumen fluid was buffered with McDougall's artificial saliva. Before ruminal fluid collection, approximately 0.5 g of each sample was placed in a 50-mL plastic centrifuge tube for digestion (triplicate tubes per sample). One part strained ruminal fluid was mixed with four parts McDougall's artificial saliva and 30 mL of mixed solution were added to each in vitro tube. Oxygen was displaced with the flow of CO_2 into the top of each tube and capped to maintain anaerobic conditions. Triplicate blank tubes for each incubation time were filled with 30 mL of one part strained ruminal fluid with four parts McDougall's artificial saliva and were incubated in 39° C water bath as for sample tubes. Samples were incubated for 12, 24, and 48 hours.

After incubation, samples were removed from water bath and frozen at -4° C to stop fermentation. Tubes were subsequently thawed at 22° C and centrifuged for 15 minutes at 2,000 x g. After centrifugation, ruminal fluid was suctioned off by vacuum, leaving undigested substrate and microbial residue in tube. Thirty milliliters of acidified pepsin solution were then added to each tube and incubated in 39° C water bath for 48 hours. The pepsin solution was prepared by adding 6.6 g of pepsin, and 100 mL of a 1 N HCl solution to a 1-L flask and filling to volume with deionized water. Following incubation with acidified pepsin, tube contents were filtered onto a pre-weighed Whatman 541 filter paper (Whatman International Ltd., Maidstone, England) using a Buchner funnel and vacuum pump. Filter papers containing the residue from each tube were dried in a 60° C drying oven for approximately 24 hours, after which filter papers were weighed to calculate IVDMD. The mean residue weight from the three blank tubes per incubation time was subtracted from each sample residue weight. The IVDMD values that were calculated for each incubation time were determined by dividing final substrate weight – blank from each incubation period by initial substrate weight and multiplied by 100.

Table 1. Chemical Composition of Alfalfa Pellets (*Medicago sativa* L.), Bermudagrass-Clipping Pellets *(Cynodon dactylon* L.), and Coastal Bermudagrass Hay Pellets *(Cynodon dactylon* L.)[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

Satistical Analysis: Time expressed as 12h, 24h, and 48h was analyzed as a completely randomized design in the GLM procedure of SAS (1999). Tube was considered the experimental unit with three replications per treatment group.

Treatment expressed as alfalfa pellets, Coastal hay pellets, and bermudagrass-clipping lawn pellets were also analyzed as a completely randomized design in the GLM procedure of SAS (1999). Tube was again considered the experimental unit with three replications per treatment group.

RESULTS

The effects of time at 12h, 24h, and 48h, was different ($P < .05$) for the alfalfa pellets and the Coastal hay pellets. The alfalfa pellets had a DM disappearance over the 12h, 24h, and 48h time period that was linear ($P < .0005$) but was not quadratic. The Coastal hay pellets were linear ($P < .0001$) as well as quadratic ($P < .05$). The bermudagrass-clipping lawn pellets were not different ($P > .05$) for dry matter disappearance over the 12h, 24h, and 48h time period. The bermudagrass-clipping lawn pellets were also not linear or quadratic ($P > .05$) for DM disappearance over the 12h, 24h, and 48h time frame. The effects of time on treatment for in vitro dry matter disappearance are listed in Table 2.

At hour 12, the alfalfa pellets had the highest amount of DM disappearance. The alfalfa pellets had a much higher ($P < .001$) DM disappearance than the coastal hay pellets and a slightly higher difference ($P < .05$) than the bermudagrass-clipping lawn pellets.

At hour 24, the alfalfa pellets became more different ($P < .0001$) than the Coastal hay pellets and the bermudagrass-clipping lawn pellets ($P < .0005$). The Coastal hay pellets and bermudagrass-clipping lawn pellets were also different ($P<.02$) for DM disappearance.

At hour 48, the alfalfa pellets were again different from the Coastal hay pellets (P < .0001) and the bermudagrass-clipping lawn pellets (P < .0002). The Coastal hay pellets and bermudagrass-clipping lawn pellets were not different (P > .05) at hour 48 for DM disappearance. The effects of treatment on time for in vitro DM disappearance are listed in Table 3.

Table 2. Effects of Time on Treatment for In Vitro Dry Matter Disappearance, %

	Time				Contrast	
Item	12h	24h	48h	SEM	Linear	Quadratic
Alfalfa Pellets	40.71[a]	52.05[b]	59.22[c]	1.66	P<.0005	NS
Coastal Hay Pellets	23.94[a]	26.51[b]	34.50[c]	0.711	P<.0001	P<.05
Bermudagrass-Clipping Pellets	34.28[a]	34.27[a]	39.24[a]	2.3	NS	NS

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

Table 3. Effects of Treatment on Time for In Vitro Dry Matter Disappearance, %

	Treatment			
Item	Alfalfa Pellets	Coastal Hay Pellets	Bermudagrass-Clipping Pellets	SEM
12h	40.71[a]	23.94[b]	34.28[c]	1.84
24h	52.05[a]	26.51[b]	34.27[c]	1.54
48h	59.22[a]	34.50[b]	39.24[b]	1.66

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

DISCUSSION

The ultimate indication of the quality of forages is obtained by feeding them and measuring the animal responses of interest, such as milk production or weight of gain. Such feeding trials account for all important factors, including unknown or unexpected factors (Collins and Fritz, 2003). However, feeding and grazing trials can become expensive. Therefore, laboratory chemical analysis can provide useful and relatively inexpensive information about potential animal responses.

In these analyses, alfalfa showed a linear increase in digestibility over time and was also more digestible than the Coastal hay pellets or the bermudagrass-clipping lawn pellets. Collins and Fritz (2003) stated that forage species can differ markedly in forage quality. In general, legumes are higher in quality than grasses. Therefore, results indicating higher digestibility of alfalfa in vitro agrees with these findings.

Coastal hay pellets also increased ($P < .05$) in DM disappearance over time showing a linear and quadratic increase in digestibility. Collins and Fritz (2003), state that grasses are generally higher in NDF than cool-season legumes. This may partially explain the lower digestibility of the Coastal hay pellets when compared to the alfalfa pellets (Table 1). Another factor to consider when explaining digestibility between the Coastal hay pellets and the alfalfa pellets is the difference between C3 and C4 morphology. While legumes are C3 plants, grasses such as coastal bermudagrass hay are C4 plants. C4 plants tend to have a greater percentage of area occupied by less digestible vascular bundles, epidermis, and sclerenchyma tissues than C3 plants (Akin and Burdick, 1975). Therefore, results of digestibility between the alfalfa pellets and Coastal hay pellets are not uncommon.

Results for bermudagrass-clipping lawn pellets were much different from alfalfa and Coastal hay pellets. While bermudagrass-clipping lawn pellets were more digestible than Coastal hay pellets and less digestible than alfalfa pellets, they were not more digestible over time. This suggests that the majority of digestion took place in the first twelve hours. One reason for this may be due to the maturity of the plant. Because the bermudagrass-clippings were harvested at such a premature state (7 day growth), digestibility of the forage was extremely high. Collins and Fritz (2003) stated that forage quality nearly always declines as forages age or undergo reproductive development. In fact, maturity at harvest is usually considered to be the primary factor affecting forage quality.

Other factors effecting digestibility of the bermudagrass-clipping lawn pellets may be the amount of NDF (Table 1). The bermudagrass-clipping pellets tend to have a higher amount of NDF than the alfalfa pellets but a lower percent of NDF than the Coastal bermudagrass hay. This would be expected because alfalfa is a C3 legume and the grasses are C4 plants. Legumes tend to have faster cell wall digestion and particle size reduction and therefore the rumen empties more quickly and allows more forage to be consumed. Ash and silica content could also further reduce digestibility (Johnson, et. al., 1998)

IMPLICATIONS

Alfalfa is a C3 legume that is more digestible than common bermudagrass from domestic lawns or Coastal bermudagrass hay which are both C4 grasses. The difference in plant morphology, NDF, and plant maturity are major factors in the digestibility of these forage sources. While bermudagrass-clippings from domestic lawns were not as digestible as alfalfa, crude protein levels were higher. Therefore, more protein can be provided to the animal from the bermudagrass-clipping lawn pellets than from the alfalfa pellets.

REFERENCES

Akin D. E. and D. Burdick. 1975. Percentage of tissue types in tropical and temperate grass leaf blades and degradation of tissues by rumen microorganisms. Crop Sci. 15:661-68.

Collins, M. and J. O. Fritz. 2003. Forage Quality. In: R. F Barnes, C. J. Nelson, M. Collins, and K. J. Moore (Eds.). Forages: An introduction to grassland agriculture, 6th ed., Ames: Iowa State Univ. Press. Galyean, M. L. 1997. Laboratory Procedures in Animal Nutrition Research. http://www.asft.ttu.edu/home/mgalyean.

Hanna, W. W., W. G. Monson, and G. W. Burton. 1973. Histological examination of fresh forage leaves after *in vitro* digestion. Crop Sci.13:98.

Johnson M. L., C. M. Parsons*, G. C. Fahey, Jr., N. R. Merchen, and C. G. Aldrich. 1998. Effects of Species Raw Material Source, Ash Content, and Processing Temperature on Amino Acid Digestibility of Animal By-Product Meals by Cecectomized Roosters and Ileally Cannulated Dogs. J. Anim. Sci. 76:1112–1122.

SAS. 1999. SAS/STAT Users Guide. SAS Institute Inc. Cary, N.C.

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

Texas Organization Board Members' Communication Methods and the 2002 Farm Bill

Christa L. Kraatz
USDA-Farm Service Agency, San Marcos, TX 78666
Gary J. Wingenbach
Tracy A. Rutherford
Department of Agricultural Leadership, Education, and Communications
Texas A&M University, College Station, Texas 77843-2116

ABSTRACT

Extension education programs continue to intersect stakeholders' interests with the U.S. Farm Bill. The purpose of this study was to identify organizational communication methods and their relationship to Texas agricultural and natural resource organization board members' perceptions of the 2002 Farm Bill. Respondents believed their organizations met their primary farm bill objectives. A significant positive relationship existed between perceived organizational communication methods and factors influencing the 2002 Farm Bill. Because of their local contact base, extension educators should study other organizations and the public's interest in future farm bills to determine what provisions, issues, or programs are most needed to benefit society.

KEYWORDS: Agriculture Commodity Organizations, Communications, 2002 Farm Bill

INTRODUCTION

During farm bill development, messages are communicated about the provisions, issues, or programs that become the new farm bill. National agricultural organization board members and congressional leaders disseminate these messages to other organization leaders, lobbyists, and state-level organizational board members who communicate the provisions, issues, or programs to their respective organizational members. After the farm bill becomes a new law, state-level organizational board members adhere to the advice from national and congressional leaders and lobbyists. State-level board members may allow such advice to shape their perceptions of national farm policy (Catchings & Wingenbach, 2004).

Organizations have been studied to determine the effectiveness of leaders' and members' organizational communication methods, especially their message formation and communication techniques, much like the provisions in the farm bill (Conrad, 2000). Organizations can enhance their communication methods by creating environments that require people to communicate because of a shared purpose (Conrad, 2000).

Organizational communication improves the process for establishing policies and norms. Leaders or board members' behavior and decision-making can influence the behaviors of other members in the organization (Franklin, 1975). Franklin developed a

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

model (Figure 1) that suggests four major social-psychological factors exist—organizational climate, managerial leadership, peer leadership, and group process—to describe critical group and organizational conditions and practices influencing communication methods (Bowers, 1975; Likert, 1967; Likert & Bowers, 1973). The model demonstrated that "the major causal pattern for these factors is from organizational climate to managerial leadership to peer leadership, finally resulting in group process" (Franklin, 1975, p. 154). Such a model, working dynamically as combined methods, may be useful in determining selected Texas agricultural organization board members' communication methods for the 2002 Farm Bill.

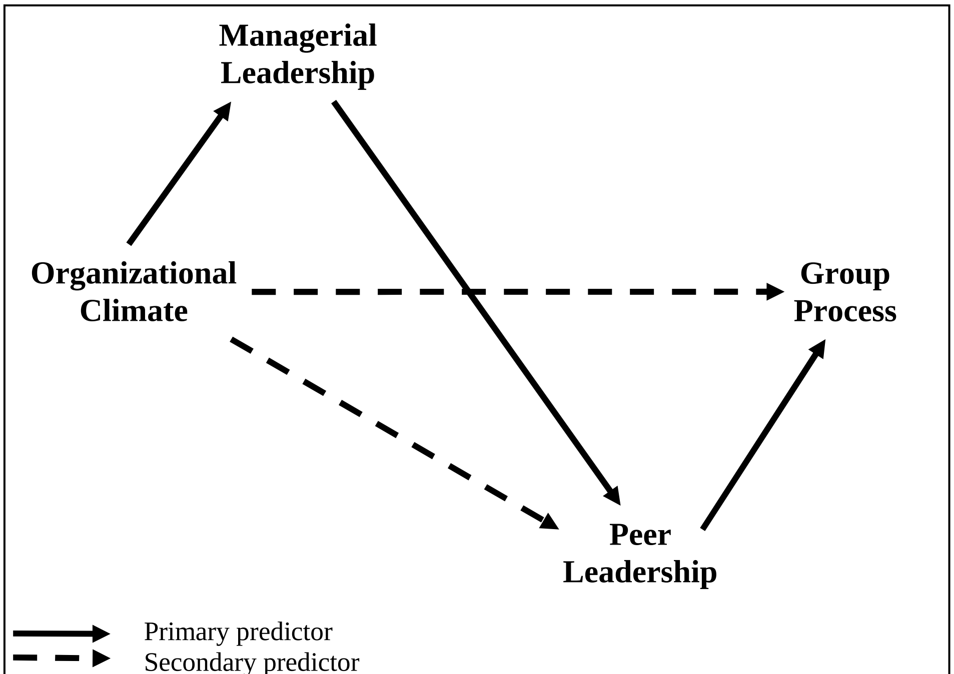

Figure 1. Relations among four factors. Adapted from "Down the organization: Influence processes across levels of hierarchy," by J. L. Franklin, 1975, *Administrative Science Quarterly, 20*, p. 154.

Sulak (2000) recommended additional research to understand organization leaders and members' needs in farm bill policy. Perceptions belong to individuals, but communication processes define how individuals share perceptions to enlighten others (members). Organizational communication methods may influence members' perceptions. Organizational communication effectiveness depends on the individual's understanding, perceptions, and behaviors in an organization (Wilson, 1964).

The purpose of this study was to identify organizational communication methods and their possible relationship to Texas commodity-specific, general agricultural, and natural resource organization board members' perceptions of the 2002 Farm Bill. Three objectives guided this study:

1. Determine perceptions of organizational communication methods used by commodity-specific, general agricultural, and natural resource organizations;

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

2. Determine board members' perceptions of factors influencing the 2002 Farm Bill outcome; and
3. Determine if organizational communication methods were related to board members' perceptions of factors influencing the outcome of the 2002 Farm Bill.

MATERIALS AND METHODS

The purpose, objectives, and selected methods used to report the results of this study were part of a larger research project (Catchings, 2004). Similarities in research design and demographics reported herein are evident elsewhere (Catchings, Wingenbach, & Rutherford, 2005), but are reported in full in this study.

An *ex-post facto* correlational design was used because the 2002 Farm Bill had been enacted and implemented prior to the study; potential respondents would have established their perceptions of the farm bill prior to data collection. The target population (N=300) included all (according to the Texas Department of Agriculture) Texas commodity-specific, general agricultural, and natural resource organization board members who had a vested interest in the 2002 Farm Bill. Personal communications with organizational leaders/directors determined the target population for these organizations.

The sample was purposefully selected from memberships in the Texas Farm Bureau, selected agricultural commodity organizations (cotton, wheat, corn, or grain sorghum), and the Texas Wildlife Association. The sample (n=160) produced 70 respondents for a response rate of 44%. Electronic mail (e-mail) reminders were sent to all Texas organization's executive officers every two weeks. Despite repeated and unsuccessful follow-up procedures to non-respondents, a response rate of 44% merits caution in generalizing the results of this study beyond the respondent group.

The conceptual schema was based on Sulak's (2000)research, which focused on National Commodity board members perceptions of the 1996 Farm Bill, and Catchings and Wingenbach (2004) which focused on selected Texas commodity board members' perceptions of the 2002 Farm Bill. Data were collected (February to March 2004) from the sample using a modification of Sulak's, Catchings and Wingenbach's, and Franklin's (1975) surveys. Minor editing and word changes were made to the final version of the research instrument used in this study. Researchers used a cross-sectional and uniform questionnaire, which illustrated similarities and differences of perceptions and communication processes between selected Texas agricultural organizations.

Data were derived from three parts of the instrument. Part one contained 17 organizational communication statements, from Franklin's (1975) model, where participants recorded their perceptions of organizational communication methods. Statements ranged from organizational climate, managerial leadership, and peer leadership, to decision-making practices, human resource primacy, motivational conditions, and communication. Responses were recorded using a Likert-type scale (1=Strongly Disagree—4=Strongly Agree, 0=No Opinion). Questions such as "My organization wants to meet its primary objective" and "Information is widely shared in my organization" represented peer leadership items. Cronbach's alpha for the scale measuring perceptions of organizational communication methods was .93.

Part two contained Likert-type (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion) statements measuring respondents' agreement levels with 10 factors, derived from earlier studies (Catchings & Wingenbach, 2004; Sulak, 2000), that may

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

have influenced the outcome of the 2002 Farm Bill. Examples included "Farm organizations influence on the 2002 Farm Bill," and "Non-farm organizations influenced the 2002 Farm Bill more than farm organizations." Cronbach's coefficient alpha for the scale measuring perceptions of factors influencing the outcome of the 2002 Farm Bill was .68. Due to the relatively low coefficient alpha level, caution is warranted against generalizing the results of this scale beyond the respondent group. The final section collected demographics such as age, education, residence, family ownership of farm or ranch, and organization affiliation. Content validity was established by Catchings and Wingenbach (2004), Sulak (2000), and Franklin (1975). A pilot test with Texas Farm Bureau Association participants, who were not part of sample, was administered in early February 2004. Based on pilot test feedback, the final survey length was reduced.

Mixed-mode techniques were used to collect data by e-mail first, followed by postal surveys (Schaefer & Dillman, 1998). Dillman (2000) stated that as e-mail and Internet surveys gain favor with surveyors, a formidable barrier to their use is the fact that many people do not have access to the Internet. The mixed-mode (used in this study) compensated for the weaknesses of each method (Dillman, 2000). Organization leaders or directors were sent an e-mail with instructions to distribute the Internet address of the online survey to their organizational members. Online data were kept in a password-secured database. Correct follow-up procedures such as telephone calls and e-mail messages, were sent (every two weeks) to non-respondents. Descriptive statistics and multivariate analyses were conducted to determine if significant relationships existed between board members' organizational communication methods and perceptions of factors influencing the outcome of the 2002 Farm Bill.

RESULTS

Respondents were mostly board members from commodity-specific (57%), general agriculture (30%), or conservation and natural resources (10%) organizations. The majority was 36 or older (83%). Most of them had attended college or had completed an undergraduate degree (77%), were raised on a farm or ranch (67%), and the majority currently lived on farm or ranch (60%).

Selected Texas agricultural organization respondents (n=70) rated their levels of agreement to organizational communication methods. A Likert-type scale (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion) was used to measure agreement levels that ranged from 3.02 to 3.61 for each item (Table 1).

Respondents strongly agreed (M=3.61, SD=.49) that their organizations wanted to meet their primary objectives for the 2002 Farm Bill. They strongly agreed (M=3.51, SD=.59) that information about important events or situations was shared in their organizations (Table 1). Overall, respondents agreed with 16 organizational communication methods (Appendix). There was no disagreement with any of the organizational communication methods.

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

Table 1. Means (M) and Standard Deviations (SD) for Selected Texans' perceptions of organizational communication methods used in their organizations.

	CS (n=40)		GA (n=21)		C/NR (n=7)		Total (N=70)	
Organizational Communication Methods	M[a]	SD	M[a]	SD	M[a]	SD	M[a]	SD
My organization wants to meet its primary objectives.	3.63	.49	3.60	.50	3.50	.55	3.61	.49
Information about important events or situations is shared within my organization.	3.49	.60	3.65	.59	3.17	.41	3.51	.59

Note. Key: CS=Commodity-specific; GA=General Agriculture; C/NR=Conservation/Natural Resources. See appendix for all organizational communication methods.
[a]Likert-type scale: (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion).

Members of all selected Texas agricultural organizations rated their level of agreement with 10 statements measuring factors that may have influenced the outcome of the 2002 Farm Bill. A Likert-type scale (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion) was used to measure agreement levels that ranged from 2.51 to 3.74 for each statement (Table 2).

Respondents strongly agreed with four statements: Farm organization coalitions were essential for enacting the 2002 Farm Bill (M=3.74, SD=.54); Farm organizations strongly influenced the 2002 Farm Bill (M=3.71, SD=.52); Farm organizations influenced the 2002 Farm Bill more than non-farm organizations (M=3.55, SD=.64); and My respective organizations strongly influenced the 2002 Farm Bill (M=3.51, SD=.56) (Table 2). There was no disagreement with any of the factors influencing the outcome of the 2002 Farm Bill (Appendix).

Table 2. Means (M) and Standard Deviations (SD) for selected Texans' perceptions of factors influencing the outcome of the 2002 Farm Bill.

	CS (n=40)		GA (n=21)		C/NR (n=7)		Total (N=70)	
Statements	M[a]	SD	M[a]	SD	M[a]	SD	M[a]	SD
Farm organization coalitions were essential for enacting the 2002 Farm Bill	3.93	.27	3.45	.76	3.40	.55	3.74	.54
Farm organizations strongly influenced the 2002 Farm Bill	3.88	.34	3.57	.60	3.00	.71	3.71	.52
Farm organizations influenced the 2002 Farm Bill more than non-farm organizations	3.63	.59	3.48	.75	3.20	.45	3.55	.64
My organizations strongly influenced the 2002 Farm Bill	3.62	.54	3.45	.51	2.75	.50	3.51	.56

Note. Key: CS=Commodity-specific; GA=General Agriculture; C/NR=Conservation/Natural Resources. See appendix for all statements of factors influencing the outcome of the 2002 Farm Bill.
[a]Likert-type scale: (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion).

Respondents' perceptions of organizational communication methods and the influencing factors affecting the outcome of the 2002 Farm Bill were summed and correlated, using Pearson's Product-moment correlations (Borg & Gall, 1989), to determine if significant relationships existed (Table 3). A significant positive (moderate)

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

relationship (r=.33) existed between perceived organizational communication methods and perceived levels of factors influencing the 2002 Farm Bill outcome.

Table 3. Significant correlations among selected variables (N=70).

Variables	1[a]	2[b]
1. Perceptions of factors influencing the outcome of the 2002 Farm Bill	—	.33**
2. Perceptions of organizational communication methods used by selected Texas agricultural organizations		—

Note. Four-point (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion) scales were summed to determine respondents' overall perceptions of factors influencing the outcome of the 2002 Farm Bill and perceived organizational communication methods.
[a]Perceptions of factors influencing the farm bill ranged from 5-37 (M=29.85, SD =5.48).
[b]Perceptions of communication methods ranged from 38-146 (M=58.82, SD=13.00).
**Significant at .01 level.

DISCUSSION

Respondents wanted their respective organizations to meet their primary objectives and information needs in their organizations. Organizational communication methods found in this study coincided with Franklin's (1975) peer leadership factor. An implication exists in that organizations should set objectives through a shared communication process (Conrad, 2000). Shared purposes contribute to the completion of organizational objectives. More research involving Texas farm, non-farm, and other organizations is needed to gather members' perceptions and use of organizational communication methods. Because of their local contact base, extension agents should study other organizations' interests in future farm bills to determine what provisions, issues, or programs are most needed to benefit society.

Respondents' strong agreement levels were congruent with the overall organizational factors influencing the outcome of the 2002 Farm Bill. Overall, the results showed farm organization leaders believed their organizations influenced the outcome of the 2002 Farm Bill, which was congruent with another study (Catchings & Wingenbach, 2004). Catchings and Wingenbach found a shift between national (Sulak, 2000) and state-level commodity board members' perceptions (Catchings & Wingenbach) of organizational influencers. The shift could be related to the House Committee on Agriculture hearings that allowed commodity groups to present specific recommendations for the new farm bill (Catchings & Wingenbach, 2004; Mark, Daniel, & Parcell, 2002). This study illustrated such inferences could be the result of a heterogeneous, rather than homogeneous (Catchings & Wingenbach) respondent group's collective perception of their organizations' input to the 2002 Farm Bill.

More research is needed to show if non-farm organizations have the same influence as farm organizations on agricultural policy at the national level (Catchings, Wingenbach, & Rutherford, 2005). The findings showed farm organization leaders believed they affected the 2002 Farm Bill outcome, but non-farm organization leaders also viewed farm organizations as having affected the 2002 Farm Bill. An implication, concurrent with previous studies (Catchings & Wingenbach, 2004; Catchings, Wingenbach, & Rutherford, 2005; Mark, Daniel & Parcell, 2002), is that more research is needed to gather non-farm organizational board members input. Such input will be beneficial to policy makers as new farm bills are developed, written, and enacted.

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

There was a significant positive (moderate) relationship (r=.33) between perceived organizational communication methods and perceived levels of factors influencing the 2002 Farm Bill outcome. As perceptions of communication methods increased, so too did perceptions of the factors influencing the outcome of the 2002 Farm Bill. Alternatively, the opposite holds true for these two variables. Additional research should explore, beyond a descriptive sense, if this relationship has a causal element to it. Does one factor cause the other to change? Which factor precedes the other? Answers should be sought from the same groups in this study, with a larger response rate, and/or a more diverse group of farm bill stakeholders.

Mark, Daniel, and Parcell's (2002) study found farm bill stakeholders' perceptions changed over time. This study did not measure perceptions over time, but showed that different agricultural organization board members' perceptions could change when considering their respective affiliations. Extension agents may use these findings to note that as perceptions change, so too can they be manipulated to produce perceptions that are positive toward any organizational issue. Positive perceptions can be increased when specific organizational communication methods are used. Based on Franklin's (1975) work, peer leadership items were perceived highly in this study. These perceptions are useful for understanding the phenomena under study and for incorporating into public media campaigns for agricultural legislation matters.

Even the small respondent group in this study helps us understand that information about farm policy is useful to policy makers (Mark, Daniel, & Parcell, 2002). More research is needed to identify which organizational communication methods increase perceptions of organizational influencers and vice versa. Researchers should study other organizations, not just as outsiders, but also as members of respective organizations, such as the Cooperative Extension Service. Such research could assess the variables correlating to organizational influence on farm policy and organizational communication methods to determine if they concur or differ with this study.

REFERENCES

Borg, W. R., & Gall, M. D. (1989). *Educational research: An introduction* (5th ed.). New York: Longman.

Bowers, D. G. (1975). *The ideas of Rensis Likert*. Ann Arbor, Michigan: University of Michigan Press.

Catchings, C. (2004). *Relationship of organizational communication methods and leaders' perceptions of the 2002 Farm Bill: A study of selected commodity-specific, general agricultural, and natural resources organizations*. Unpublished master's thesis, Texas A&M University, College Station.

Catchings, C. L., Wingenbach, G. J., & Rutherford, T. A. (2005). Selected Texas agricultural organization board members' perceptions of communication methods and the 2002 Farm Bill. In J. Kotrlik (Ed.), *Proceedings of the 55th Annual Southern Agricultural Education Research Conference, Little Rock, AR*, 269-279.

Catchings, C., & Wingenbach, G. J. (2004). Selected Texas agricultural commodity board members' perceptions of the 2002 U.S. farm bill. In R. Telg (Ed.), *Proceedings of the Agricultural Communications Section of the Southern Association of*

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

Agricultural Scientists, Tulsa, OK. Retrieved July 29, 2004, from http://agnews.tamu.edu/saas/2004/FarmBill.pdf

Conrad, C. (2000). *Strategic organizational communication: Toward the twenty-first century.* (5th ed.). Orlando, FL: Harcourt Brace College Publishers.

Dillman, D. (2000). *Mail and Internet surveys: The tailored design method*. New York, NY: John Wiley & Sons.

Franklin, J. L. (1975). Down the organization: Influence processes across levels of hierarchy. *Administrative Science Quarterly, 20,* 153-164.

Likert, R. & Bowers, D. G. (1973). Improving the accuracy of P/L reports by estimating the change in dollar value of the human organization. *Michigan Business Review*, *25*, 15-24.

Likert, R. (1967). *The human organization*. New York City, NY: McGraw-Hill.

Mark, D. R., Daniel, M. S., & Parcell, J. L. (2002). Gauging perception of farm programs. *Journal of Extension*, *40*(4), Article rb2. Available at: http://www.joe.org/joe/2002august/rb2.shtml

Schaefer, D., & Dillman, D. A. (1998). Development of standard e-mail methodology: Results of an experiment. *Public Opinion Quarterly*, *62*, 378-397.

Sulak, M. (2000). *The impact of the 1996 Farm Bill on members of national commodity organizations as perceived by selected organizational leaders*. Unpublished doctoral dissertation, Texas A&M University, College Station.

Wilson, H. E. (1964). *Communication in administrative organizations.* Unpublished doctoral dissertation, Ohio State University, Columbus.

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

APPENDIX

Table 1. Means (M) and Standard Deviations (SD) for Selected Texans' perceptions of organizational communication methods used in their organizations.

	CS (n=40)		GA (n=21)		C/NR (n=7)		Total (N=70)	
Organizational Communication Methods	M[a]	SD	M[a]	SD	M[a]	SD	M[a]	SD
My organization wants to meet its primary objectives.	3.63	.49	3.60	.50	3.50	.55	3.61	.49
Information about important events or situations is shared within my organization.	3.49	.60	3.65	.59	3.17	.41	3.51	.59
I encourage members to exchange opinions and ideas.	3.47	.56	3.55	.61	3.20	.45	3.48	.56
Information is shared in my organization.	3.53	.51	3.37	.83	3.00	.89	3.43	.67
Organizational objectives are announced with no opportunity to raise questions or give comments.	3.43	.73	3.35	.75	3.40	.55	3.40	.71
Decision makers have access to all available information in my organization.	3.47	.51	3.30	.66	3.17	.41	3.39	.55
My informational needs, as a director, are adequately met within my organization.	3.54	.51	3.20	.52	3.00	.71	3.39	.55
My organization makes decisions and solves problems well.	3.43	.50	3.26	.45	3.50	.55	3.39	.49
Organizational members have knowledge that is communicated to decision makers.	3.42	.50	3.30	.57	3.20	.45	3.37	.52
My organization plans and coordinates its efforts collaboratively.	3.49	.51	3.15	.49	3.33	.52	3.37	.52
Organizational objectives are announced and explained with opportunities to ask questions.	3.34	.75	3.25	.79	3.00	.71	3.29	.75
Organizational members are receptive to my ideas and suggestions.	3.35	.54	3.16	.50	3.25	.50	3.28	.52
Members in my organization listen to me.	3.26	.55	3.32	.48	3.25	.50	3.28	.52
Decisions are made at levels with the most adequate and accurate information available.	3.26	.55	3.25	.55	3.20	.45	3.25	.54
Organizational objectives are created and are discussed, and sometimes modified by members before being issued throughout the entire organization.	3.24	.60	3.30	.66	2.83	.41	3.22	.61
Specific alternative objectives are	3.32	.53	2.70	.92	2.83	.41	3.08	.73

The Texas Journal of Agriculture and Natural Resource 19:119-128 (2006)

	CS (n=40)		GA (n=21)		C/NR (n=7)		Total (N=70)	
Organizational Communication Methods	M[a]	SD	M[a]	SD	M[a]	SD	M[a]	SD
crafted by leaders, then members are asked to discuss them, indicating the objective they think is best for the organization.								
After decisions are made, people affected by those decisions are asked for their ideas.	3.11	.79	2.90	.91	2.75	.96	3.02	.83

Note. Key: CS=Commodity-specific; GA=General Agriculture; C/NR=Conservation/Natural Resources.
[a]Likert-type scale: (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion).

Table 2. Means (M) and Standard Deviations (SD) for selected Texans' perceptions of factors influencing the outcome of the 2002 Farm Bill.

	CS (n=40)		GA (n=21)		C/NR (n=7)		Total (N=70)	
Statements	M[a]	SD	M[a]	SD	M[a]	SD	M[a]	SD
Farm organization coalitions were essential for enacting the 2002 Farm Bill	3.93	.27	3.45	.76	3.40	.55	3.74	.54
Farm organizations strongly influenced the 2002 Farm Bill	3.88	.34	3.57	.60	3.00	.71	3.71	.52
Farm organizations influenced the 2002 Farm Bill more than non-farm organizations	3.63	.59	3.48	.75	3.20	.45	3.55	.64
My organizations strongly influenced the 2002 Farm Bill	3.62	.54	3.45	.51	2.75	.50	3.51	.56
The 2002 Farm Bill impacts conservation programs more than previous farm bills	3.03	.66	3.05	.62	3.20	.45	3.05	.63
Non-farm organizations influenced the 2002 Farm Bill more than farm organizations	2.95	.70	3.19	.75	3.00	.00	3.03	.70
The 2002 Farm Bill impacts natural resources issues more than previous farm bills	2.97	.63	2.86	.73	3.25	.50	2.95	.65
Interests of the environmentalists were opposites of farmers for the 2002 Farm Bill	2.82	.69	2.95	.78	2.40	.89	2.82	.74
Non-farm organizations strongly influenced the 2002 Farm Bill	2.66	.75	2.45	.89	2.75	.50	2.60	.78
The 2002 Farm Bill impacts farm production more than previous farm bills	2.36	.72	2.62	.74	3.25	.50	2.51	.74

Note. Key: CS=Commodity-specific; GA=General Agriculture; C/NR=Conservation/Natural Resources.
[a]Likert-type scale: (1=Strongly Disagree—4=Strongly Agree, or 0=No Opinion).