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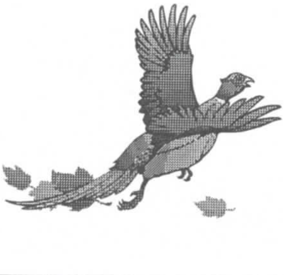

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CONTENTS

Effects of Protein Levels Fed During Winter on Subsequent Performance of Steers Grazing Tobosagrass

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ABSTRACT

The effect of level of supplementation on winter weight gain and subsequent spring performance was determined in a 3-year study at the Texas Tech Experimental Ranch, near Justiceburg, Texas. One of the objectives of this research was to determine if level of supplementation might influence spring gain. Cottonseed cubes (41% crude protein) were fed during the winter season to cross-bred steers grazing tobosagrass (*Hilaria mutica*) range. The average daily gain (ADG) for the control steers was 0.03, 0.26 and 0.22 lb head^{-1} day^{-1} during the winter of years 1, 2 and 3. The spring gains were 1.91, 1.09 and 1.68 lb hd^{-1}. The winter ADG for steers supplemented with 1.5 lb head^{-1} day^{-1} was 0.61, 0.63 and 0.68, while ADG in spring was 1.78, 1.46 and 1.09. The winter ADG for steers supplemented at the rate of 3.00 lb head^{-1} day^{-1} was 0.93, 0.95 and 1.00, while the spring ADG was 1.76, 1.32 and 1.61 for years 1, 2 and 3. We found no compensatory gain in the spring on tobosagrass rangeland. Heavier steers at the conclusion of winter supplementation remained the heaviest at the end of the spring.

KEYWORDS: winter supplement, compensatory gain, range, beef cattle, spring grazing

The production and marketing strategy used by most stocker operators in the southern Great Plains is to purchase cattle in the spring and to sell in the fall whereas cow-calf operators produce calves in the spring and sell in the fall. For both operators this pattern results in the most rapid weight gain when range grasses are most nutritious and productive. However, it also results in seasonal price patterns of highest cattle prices in the spring and lowest prices in the fall (Ethridge et al., 1990). Therefore, opportunity exists for the development of stocker operations to take advantage of the seasonal price patterns.

Maintaining cattle at a low plane of nutrition during winter is a common practice. Compensatory weight gain in the spring can therefore have a sizable economic impact on cattle production (Owens et al., 1993). If winter dietary restriction could be overcome by spring and summer grazing, a more economical approach to cattle feeding may be feasible. The magnitude of compensatory growth depends on several factors, such as age when restrictions begin, severity, duration, type of restriction,

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realimentation diet and time, as well as genetic growth potential and breed type (Fox et al., 1972; Coleman and Evans, 1986; Lewis et al., 1990). Drouillard et al. (1991) found that cattle compensated for winter restrictions such that daily gain above 0.61 lb day^{-1} during the winter was not beneficial. Ives et al. (1993) related compensatory gain to energy intake and stated that 1.7 times maintenance was the critical energy intake when compensatory gain can be expected. No real benefit was realized from increased winter gains except a shorter finishing period (White et al., 1987).

Tobosagrass is a perennial warm season grass that dominates clay and clay loam soils of semi-arid rangeland throughout the southwestern United States and northern Mexico. Due to its wide distribution, tobosagrass constitutes an important forage resource to the range livestock producers of this region (Anderson, 1982). Tobosagrass is generally considered to have low palatability due to the accumulation of old growth which tends to be refused by the grazing animal. Substantial declines in crude protein (CP) and dry matter digestibility have been reported with tobosagrass maturation (Britton and Steuter, 1983). Crude protein in mature tobosagrass can drop below 5.0%, which is an unacceptable nutritional level (Nelson et al., 1970). During the dormant period, tobosagrass crude protein was found below 4.5% and dry matter digestibility below 35% (Britton and Pitts, 1988). In contrast, from April to July, tobosagrass ranged from 16.0% to 5.0% protein concentration (Britton and Steuter, 1983). Pitts (1989) reported a range from 10.0% to 13.0% in crude protein and 36.0% to 60.0% for *in vitro* digestible dry matter (IVDMD) during the same season.

Tobosagrass rangelands are not considered good for grazing stocker cattle, given their poor quality. However, the increasing occurrence of retained ownership programs and the poor distribution and quantity of rainfall on wheat pastures has increased interest in protein supplementation of stocker cattle grazing tobosagrass.

The first objective of this research was to evaluate the performance of steers fed different levels of protein supplementation during the winter. A second objective was to determine how the level of supplemental protein fed during winter might affect performance in spring for steers grazing tobosagrass.

EXPERIMENTAL PROCEDURES

Study Area

Field research was conducted at the Texas Tech Experimental Ranch from 1989 to 1992. The ranch is in southeast Garza County, 16 miles southeast of Post, near Justiceburg, Texas. The ranch lies in the Rolling Plains at a mean elevation of 2400 ft. The research area was dominated by clay flat range sites with gently sloping Stamford Clay soils (fine, montmorillonitic, thermic Typic Chromusterts) (Richardson et al., 1965).

Perennial vegetation was dominated by tobosagrass with alkali sacaton (*Sporobolus airoides*) present in depressions. Associated species include buffalograss (*Buchloe dactyloides*) and plains pricklypear (*Opuntia phaecantha*), with an overstory of honey mesquite (*Prosopis glandulosa* var, glandulosa).

The climate is warm, temperate and subtropical. Temperature is variable with an average daily minimum of 27°F in January and hot summers with an average daily maximum temperature in July of 95°F. Periods of drought occur frequently. Approximately 50% of the annual precipitation (19 inches) occurs from April through July (Richardson et al., 1965).

Research Animals

Studies summarized here were conducted with crossbred *Bos taurus* x *Bos indicus* Mexican steers. The average initial weight for the 3 years of evaluation ranged from 386 to 452 lb head^{-1}, and age ranged from 8 months to yearlings.

Stocking rate for pastures was based on standing crop at the beginning of supplementation each year. Estimated stocking for the study period assumed a 50% removal of available forage. Forage production was determined by randomly clipping ten 2.7-ft^2 quadrats in each pasture, according to Pieper (1978). An attempt was also made to maintain similar forage allowances in all pastures (Table 1).

Three levels of cottonseed meal cubes (CSM) (41% CP solvent extracted) were evaluated; 0.00 (control=CON), 1.5 (low supplement=LS) and 3.00 (high supplement=HS) lb head^{-1} day^{-1} on an as-fed basis. Supplement treatments were randomly allocated to pastures during the 3-winter study. Cattle were group-fed three days per week, between 1100 and 1200 h to avoid grazing interruption. Free access to a mineral mix (7% P, 13% Ca, 50% NaCl) was always available.

Two replications per level of supplementation were used each year. During the winter, six herds were composed of 15 to 41 steers for an average stocking rate of 1 steer per 4 acres over the 3 years. Six pastures were used for the winter supplementation period. Pasture areas were 55, 60, 67, 69, 73 and 87 acres. All pastures were deferred in the growing season for winter use in each year of evaluation. In spring, three herds were composed, and to determine the effect of previous nutrition status on the following grazing season, all steers were moved to six ungrazed pastures within three cells. Cattle grazed from late March to early July. Cell areas were 235, 225 and 168 acres with an average of 39 to 61 steers stocked in each cell.

Each year the steers were obtained from Lubbock Feedlots, Inc. Steers were vaccinated at the feedlot with a 7-way-vaccine, given a parasiticide (ivermectin), as well as Vitamins A-B complex and E. On arrival at the Justiceburg ranch, steers were turned into a small pasture of dormant old world bluestem (*Bothriochloa* sp). Cattle were watched closely for signs of illness and offered supplement to become familiar with the pelleted feed. After a few days, steers were moved to the tobosagrass study site.

Cost of additional weight gain by supplemented steers was estimated at two different CSM costs ($205 and $240 ton^{-1}). These costs were derived for the period of December to March from sales reports during the 3 years of evaluation and were calculated using the following equation: cost of additional gain=feed cost ($ head^{-1} day^{-1}) per gain (lb head^{-1} day^{-1} above control).

During the first two winters, six mature bifistulated (esophageal and ruminal) steers were used to obtain forage diet samples from each grazed pasture. Fistulated steers were kept in an adjoining pasture of similar vegetation. Forage samples were collected by permitting the steers to graze each pasture for 30 to 45 minutes after an overnight fast. Samples were dried at 104°F then ground through a Wiley mill equipped with a 0.02 inch mesh screen. Masticated samples were analyzed for dry matter, ash and Kjeldahl nitrogen (AOAC, 1991). Crude protein was estimated as

6.25 x N. *In vitro* organic matter disappearance was determined as described by Tilley and Terry (1963).

Table 1. Forage standing crop and treatments for supplementation trials conducted at the Texas Tech Experimental Ranch in 1989-90, 1990-91 and 1991-92.

Year	Cell	Pasture	Supplement level	Forage available†	Forage allowance‡
				lb acre^{-1}	lb head^{-1}
1989-90	1	A	HS§	854	3696
		B	LS	1608	3801
	2	A	HS	1514	3746
		B	CON	1495	3700
	3	A	LS	1512	3742
		B	CON	1440	3565
1990-91	1	A	LS	1877	3940
		B	CON	1651	3164
	2	A	LS	905	2745
		B	CON	1651	3164
	3	A	HS	1574	5918
		B	HS	1569	4538
1991-92	1	A	CON	2260	3696
		B	HS	1451	3801
	2	A	CON	1005	3746
		B	HS	992	3700
	3	A	LS	1512	3742
		B	LS	1441	3565

†Forage was sampled in each pasture of each cell before steers were allowed to graze.

‡Total forage available per steer at the beginning of the study.

§HS=high supplement, 3.00 lb head^{-1} day^{-1} cottonseed cubes, LS=low supplement, 1.5 lb head^{-1} day^{-1} cottonseed cubes, CON=control, no supplement.

On 13 Dec 1989, 104 steers, with an initial average weight of 386 lb, were individually weighed, implanted with Ralgro® and allocated to treatment groups. Supplementation began on 14 Dec 1989 and continued until 9 Mar 1990. Steer weights were recorded at the start of the supplementation period and 10 Mar 1990 when supplementation was terminated. Weights were also recorded on 7 Jul to determine gain during spring season.

The second year of study began on 10 Dec 1990, using 149 steers with an average weight of 454 lb. Steers were turned out on old-world bluestem pasture and moved to tobosagrass site on 20 Dec. All steers were weighed, implanted with Ralgro® and allocated to treatments on 27 Dec 1990. Supplementation began on this date and continued until 14 Mar 1991. Individual steer weights were taken at the beginning of supplementation and 15 Mar 1991. Steers remained on fresh pastures until 7 Jul, when individual steer weights were taken to determine gain during the spring.

On 8 Jan 1992, 189 steers averaging 397 lb arrived at the Texas Tech Experimental Ranch. These cattle remained on the old world bluestem pasture for 10 days. Steers were moved to tobosagrass pastures on 18 Jan and allocated to treatments. Steers had been previously weighed and implanted. Supplementation began on 25 Jan and ended on 9 Apr. At each weighing date, steers were placed in corrals the evening prior to weighing, held overnight without water and feed, and weighed the following morning. The same procedure was done on 4 Jul to determine winter feeding effects on spring gain.

Gain data were analyzed as a completely randomized (CRD) design. Pastures (REP) were the experimental units. Mean separation was accomplished by using the Least Significant Different (LSD) at 0.05 level, when the analysis of variance indicated a significant difference.

RESULTS AND DISCUSSION

Dietary Nutritive Values

During the first winter (1989-90), the highest CP levels and IVOMD values from esophageal samples were measured at the beginning of supplementation in December, whereas the lowest values were detected in the January-February period (Fig.1). In the last part of the winter, dietary CP and IVOMD values increased again closer to those found at the beginning. The CP values measured during the winter in this type of vegetation ranged from 4.0% to 6.0%. IVOMD had a similar pattern with values from 22.5% to 38.0%.

In the second winter (1990-91), CP and IVOMD values from the esophageal samples followed similar patterns to the previous winter (Fig. 2). The highest values of CP and IVOMD were again detected at the beginning and the end of the winter. As in the first year, the lowest values were measured at mid-winter. The protein values were a little lower than the previous winter and ranged from 3.5% to 4.1% while IVOMD ranged from 32.0% to 40.0%. Forage nutrients values during this winter were more uniform compared to the previous winter (Villalobos, 1995).

Steer Performance

First Year

Average daily gain (ADG) during winter was proportional to the level of protein supplementation (Fig. 3). Steers in the HS treatment gained the most ($P \leq 0.05$) while the CON group gained the least ($P \leq 0.05$). Steers in the CON treatment maintained initial body weight, showing an ADG of 0.028 lb head^{-1} day^{-1}. In contrast, steers in the LS and HS groups had ADG of 0.59 and 0.93 lb head^{-1} day^{-1}

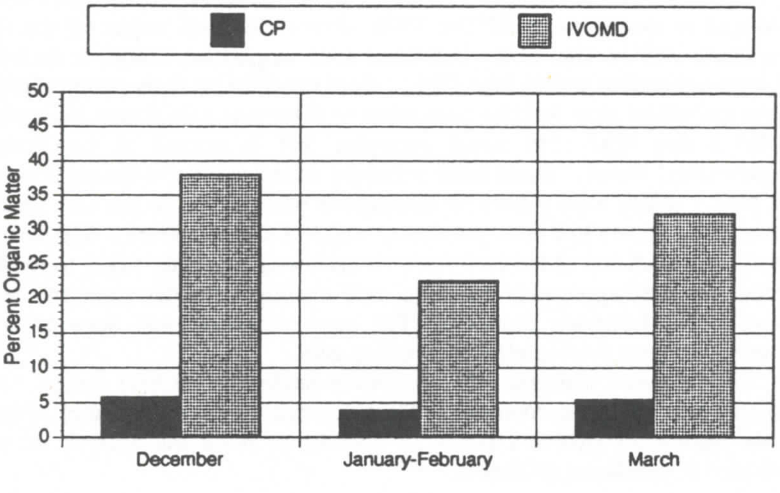

Figure 1. Dietary crude protein concentration (% of organic matter) and *in vitro* organic matter digestibility (IVOMD) of esophageal fistulated steers (1989-1990) grazing dormant tobosagrass.

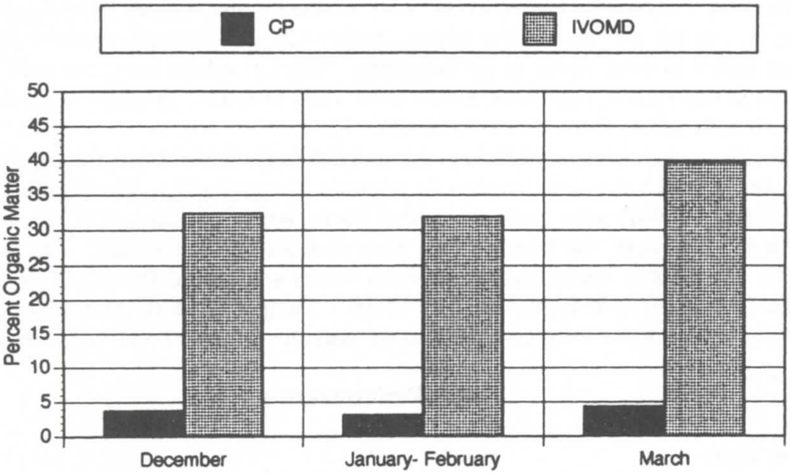

Figure 2. Dietary crude protein concentration (% of organic matter) and *in vitro* organic matter digestibility (IVOMD) of esophageal fistulated steers (1990-1991) grazing dormant tobosagrass.

During the spring season, ADG was opposite of winter gain (Fig. 3). Steers that gained more in the winter season gained less in the spring. However, differences were not detected among treatments. HS and LS treatments showed a similar ($P \geq 0.05$) ADG of 1.76 and 1.78 lb $head^{-1}$ day^{-1}, in the spring period, whereas steers in the winter CON group gained more ($P \leq 0.05$) than those that were supplemented during the winter, with an ADG of 1.91 lb $head^{-1}$ day^{-1}. In this case, the winter weight differences were minimized but maintained at the end of the grazing season. The total gain (winter+spring) was different ($P \leq 0.05$) among treatments. The steers that were heaviest after wintering remained heaviest at the end of the spring; however the weight margins varied. At the end of the grazing season, the steers that were in the HS group gained 57.0 and 24.0 lb $head^{-1}$ more ($P \leq 0.05$) than those that were in the CON and LS treatments, respectively. In contrast, at the end of the spring, steers in the LS rate gained 33.0 lb $head^{-1}$ more ($P \leq 0.05$) than those that were in the CON group. This indicates that no compensatory gain was shown for this kind of vegetation in this first year of study.

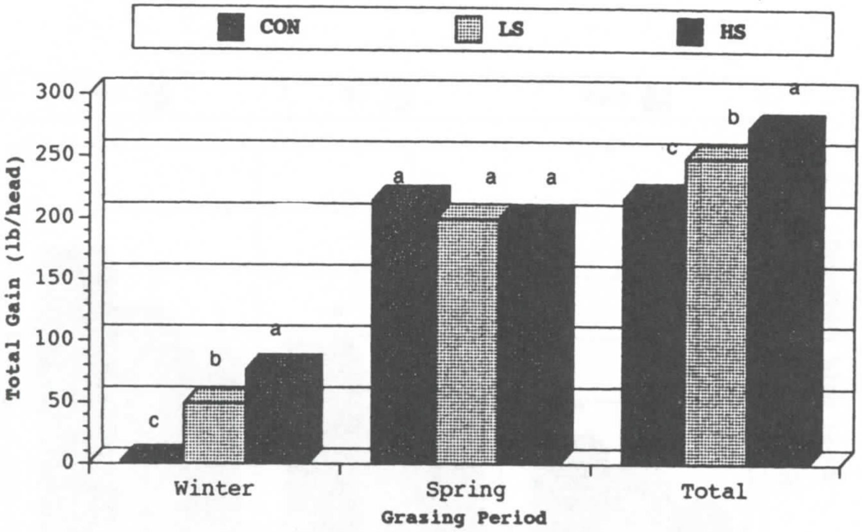

Figure 3. Total gain (lb hd^{-1}) of steers fed 3 levels of cottonseed meal pellets while grazing dormant and spring season on a tobosagrass range, 1989-1990. CON=Control (no supplement), LS=Low supplement (1.5 lb hd^{-1} day^{-1} cottonseed meal pellets), HS=High supplement (3.00 lb hd^{-1} day^{-1} cottonseed meal pellets). Letters denote differences among treatments within periods ($P \leq 0.05$).

Second Year

The response obtained during the second winter was similar for the two levels of supplementation to that observed in the previous year (Fig. 4). However, the CON steers gained 87.0% more than in the first year. This was probably due to the mild winter in the second year. During this year ADG between the two levels of supplementation was similar ($P \leq 0.05$). In addition, the ADG for CON and LS was similar ($P \leq 0.05$) at the end of the winter (Fig. 4). However, differences were detected between HS and CON. Steers in the HS gained 73.0% more ($P \leq 0.05$) than CON steers. (Villalobos, 1995).

During the second spring, steers that gained more in the winter also gained more during spring (Fig. 4). The ADG between CON and LS was similar ($P \geq 0.05$) at 1.10 lb head^{-1} day^{-1} for both treatments. In contrast, HS steers gained more ($P \leq 0.05$) than CON and LS steers, with an ADG of 1.30 lb head^{-1}. Similar to the previous year, steers that were heaviest at the end of the winter remained heaviest at the end of the spring grazing season. Steers in the HS group at the end of the grazing season gained about 79.3 and 48.5 lb head^{-1} more than those in the CON and LS group. The total gain for the LS steers was 31.0 lb head^{-1} more than those in the CON group which also indicated that compensatory gain was not shown in the second year.

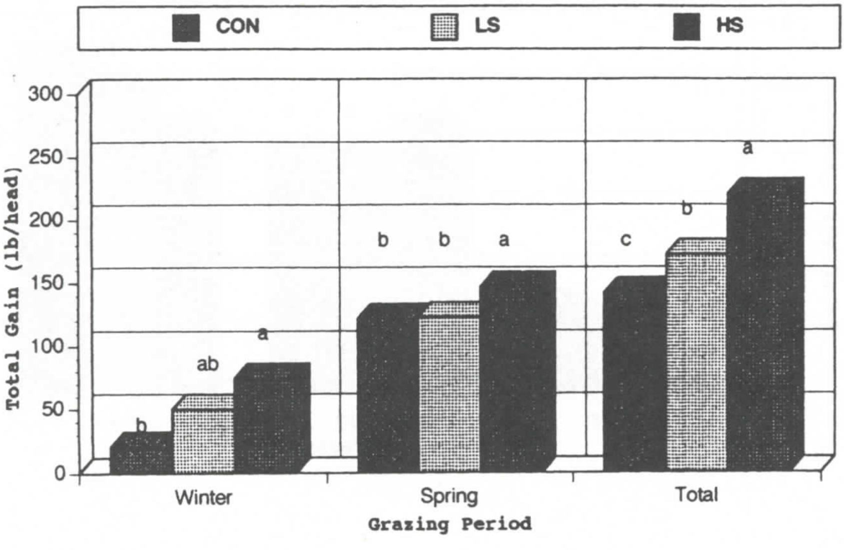

Figure 4. Total gain (lb hd^{-1}) of steers fed 3 levels of cottonseed meal pellets while grazing dormant and spring season on a tobosagrass range, 1990-1991. CON=Control (no supplement), LS=Low supplement (1.5 lb hd^{-1} day^{-1} cottonseed meal pellets), HS=High supplement (3.0 lb hd^{-1} day^{-1} cottonseed meal pellets). Letters denote differences among treatments within periods ($P \leq 0.05$).

Third Year

Winter gains in the third year were again proportional to the level of protein supplementation. However, differences were not detected ($P \geq 0.05$) between the 2 levels of supplementation. The HS steers had ADG of 1.0 lb head^{-1} day^{-1} while the steers in the LS treatment average 0.66 lb head^{-1} day^{-1} (Fig. 5). In the winter period, the gain obtained from the two levels of supplementation was higher ($P \leq 0.05$) than the CON.

In spring, ADG was similar ($P \geq 0.05$) between the CON and the HS groups (Fig. 5). The CON steers showed an ADG of 1.67 lb head^{-1} day^{-1}, whereas ADG for the HS group was 1.61 lb head^{-1}. This gain was 13.0% and 10.0% higher ($P \leq 0.05$) for the CON and HS steers than for LS steers. Again, the heaviest cattle at the end of the winter remained the heaviest at the end of the spring. The total gain for HS steers was 57.0 lb head^{-1} more ($P \leq 0.05$) than CON steers and 40.0 lb head^{-1} more ($P \leq 0.05$) than steers in the LS treatment. Steers in the LS rate gained just 18.00 lb head^{-1} more than those in the CON. According to the economic analysis (Table 2), the response of steers to winter supplementation was remarkably high during colder rather than milder winters and increased steer performance easily offset supplemental costs.

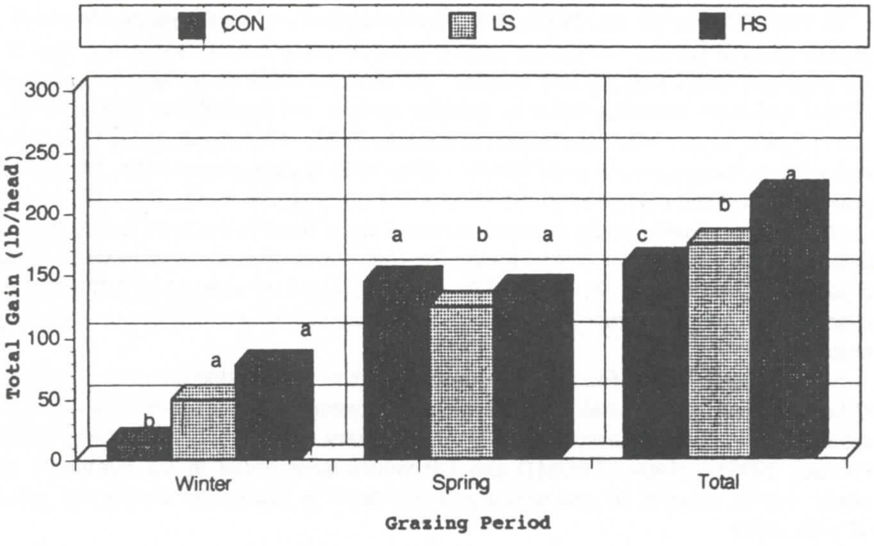

Figure 5. Total gain (lb hd^{-1}) of steers fed 3 levels of cottonseed pellets while grazing dormant and spring season on a tobosagrass range, 1991-1992. CON=Control (no supplement), LS=Low supplement (1.5 lb hd^{-1} day^{-1} cottonseed meal pellets), HS=High supplement (3.00 lb hd^{-1} day^{-1} cottonseed meal pellets). Letters denote differences among treatments within periods ($P \leq 0.05$).

Table 2. Cost of added gain by steers grazing dormant tobosagrass at the Texas Tech Experimental Ranch, supplemented with two levels of cottonseed cubes in the winters of 1989-90, 1990-91 and 1991-92.

	Supplement Level (lb head^{-1} day^{-1})			
	1.5†	1.5‡	3.0†	3.0‡
	------------------------------$ lb^{-1}	--------------------------		
1989-90	0.26	0.31	0.33	0.40
1990-91	0.40	0.48	0.43	0.52
1991-92	0.32	0.39	0.38	0.46

†Feed cost ($ lb^{-1}) $0.10 lb^{-1} cottonseed meal cubes.
‡Feed cost ($ lb^{-1}) $0.12 lb^{-1} cottonseed meal cubes.

DISCUSSION

In 1989-90, diet CP and IVOMD of the tobosagrass declined from the first to the second grazing period. A similar pattern was followed during the second winter. As livestock select first for leaf fraction, the nutritive value of the diet will change as leaf and stem fractions differ in nutrient content and digestibility (Poppi et al., 1981; Fisher et al., 1987; McCollum and Horn, 1990). Our results agree with these researchers; forage protein and IVOMD values were always greater in the December grazing period and decreased in the January-February period during the years of this study. Forage crude protein content increased again from mid-winter to late winter in both years. Protein content of forage for both years of study were close to those reported by Britton and Steuter (1983). They reported an average of 5.0% CP in tobosagrass during February and March, which covers the months in our sampling periods.

Values for IVOMD followed a pattern similar to protein content in the forages. Other research has noted similar relationship between digestibility *in vitro* and diet crude protein content (Campbell, 1989; Brandyberry et al., 1992; Park et al., 1989; Gunter, 1993). Higher IVOMD and CP values were found in the beginning of winter which dropped in mid-winter and recovered in late winter during the years of evaluation.

In many supplementation trials, year effects contribute more to the variation in response than the supplement treatments (McCollum and Horn, 1990). In the current study, winter animal performance for the two levels of supplementation showed little variation during the 3 years, with an ADG range from 0.93 to 1.00 lb head^{-1} day^{-1} for the HS steers and 0.61 to 0.68 lb head^{-1} day^{-1} for the LS steers. In contrast, the CON gain had wide variation, from 0.02 lb head^{-1} day^{-1} to 0.26 lb head^{-1}.

Our research agrees with Parker et al. (1974), who illustrated described increased winter weight gains of cottonseed meal supplemented weaning calves. Bellido et al.

(1981) and Smith (1981) also reported improved weight gains of range livestock as a result of protein supplementation. Soybean meal cubes fed at 1.10 lb head^{-1} day^{-1} increased gains by 0.50 lb head^{-1} day^{-1} for supplemented versus non-supplemented steers according to Cantrell et al. (1985). Judkins et al. (1987) observed increased weight gains by supplemented heifers compared to non-supplemented heifers.

Spring gains showed a greater variation between years than those detected during the winter. The ADG of CON steers ranged from 1.10 to 1.91 lb head^{-1}. Also, LS steers gained from 1.10 to 1.78 lb head^{-1}. These values agree with those of Pitts (1989) who found an average of 1.47 lb head^{-1} day^{-1} for the CON and 1.56 lb head^{-1} day^{-1} for steers that were supplemented at 0.00 and 1.5 lb head^{-1} day^{-1} during a 3-year study in similar vegetation at the same time of year. Steers in the HS rate gained 1.32 lb head^{-1} day^{-1} to 1.76 lb head^{-1}. Spring gains were more closely related to rainfall quantity and distribution. The ADG in the spring of 1990 and 1992 exceeded ADG in the spring of 1991. In both years spring rainfall was above the long term average and was well distributed during the winter months (Fig. 6). In contrast, the lowest ADG for all treatments occurred in the second spring. This gain was related to rainfall in the research area where adequate precipitation did not occur until June 1991 (Fig. 6).

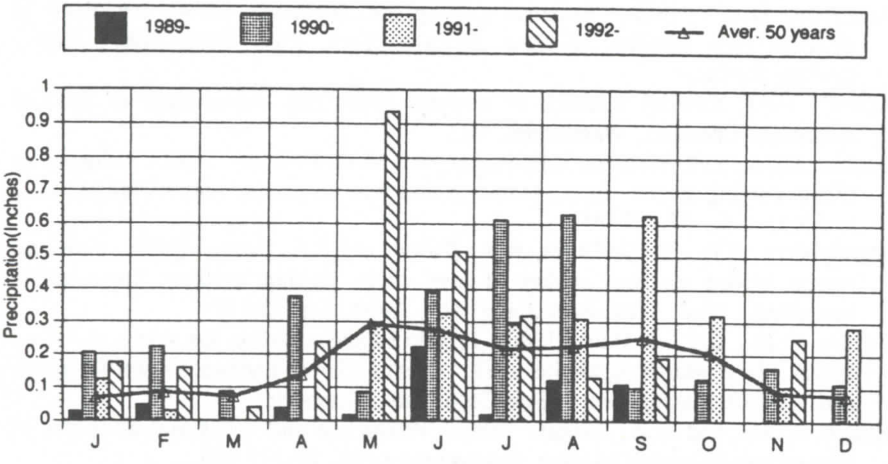

Figure 6. Precipitation at the Texas Experimental Ranch from 1989, 1990, 1991 and 1992. Average precipitation is taken from the Garza County Soil Survey.

One of the objectives of this research was to determine if level of supplementation might influence spring gain. We found no compensatory gain in the spring on tobosagrass rangeland. Heavier steers at the conclusion of winter supplementation remained the heaviest at the end of the spring.

Two options for ranchers grazing livestock tobosagrass range are to sell cattle in March or April when prices are higher or to sell in July to take advantage of spring gains. However, they would have to accept that the extra pounds would be offset by lower prices in the summer months. One important finding of this study was that 99%, 87% and 92% of the total gain for CON steers was made during spring in all 3 years. By comparison, LS steers achieved 80%, 71% and 71% of total weight gain in spring and 72%, 66% and 64% of total gain by HS steers was acquired during the spring in Years 1, 2 and 3. This indicated that steers in the CON groups only maintained weight during the winter.

Results indicate that protein supplementation is beneficial to steers grazing tobosagrass rangelands during the winter. Consequently, winter gain seemed to favor spring performance. The level of supplementation should be determined by expected response coupled with economic and management considerations. The implications for the performance of animals up to a commercial slaughter weight in the feedlot requires further investigation.

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Mixed-Brush Reestablishment Following Herbicide Treatment in the Davis Mountains, West Texas

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ABSTRACT

Regeneration of *Mimosa biuncifera* (catclaw mimosa), *Acacia greggii* (catclaw acacia), and associated vegetation was assessed following application of the herbicide tebuthiuron (1.7 kg a.i. ha^{-1}) in the Davis Mountains, Texas. Density and foliar cover of shrubs, foliar cover of herbaceous vegetation, and presence of catclaw seed banks were assessed on herbicide-treated and untreated control sites. Tebuthiuron did not completely kill catclaw shrubs, nor did it prevent shrub regeneration within six years of treatment. Regrowth occurred from basal crowns, aerial stem sprouts, and seedlings of both species. *Aloysia gratissima* and *A. wrightii* (whitebrush) were effectively eliminated by herbicide treatment and showed no indication of regeneration on treated sites. Within the herbicide treatment, *Aristida* sp. (perennial threeawn) and *Bouteloua curtipendula* (sideoats grama) had higher foliar cover, perhaps in response to shrub reductions. Catclaw seeds were not detected in the seed bank, although seedlings did emerge on treated sites, suggesting a transient seed pool. Although tebuthiuron treatment impacted vegetation composition and abundance, significant potential remains for mixed-brush communities to dominated these sites.

KEYWORDS: *Acacia greggii*, catclaw, *Mimosa biuncifera*, seed bank, tebuthiuron, Trans-Pecos

Catclaws [*Mimosa biuncifera* Benth (catclaw mimosa) and *Acacia greggii* Gray (catclaw acacia)] and associated shrubs are distributed in mountains and valleys throughout the Trans-Pecos Natural Region of far-west Texas. These mixed-brush vegetation assemblages typically form dense thickets which have likely encroached upon grasslands during the past century, as well as increased in abundance throughout their range (Powell, 1988). Because of their density and spinescent nature, these shrubs have become a serious deterrent to physical movement by

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livestock and wildlife (McGinty et al., 1992). Furthermore, based on studies in similar ecosystems, it is perceived that these shrubs compete substantially with herbaceous forage species for limited resources (*e.g.* water), thus reducing forage production potential (Morton et al., 1990).

Catclaw shrubs can be effectively top-killed when treated with 1.7 kg a.i. ha^{-1} of tebuthiuron (Spike 20P), aerially applied in a dry pelleted form (Nelson and Vick, 1988; McGinty et al., 1992). However, initial treatment costs are high, in excess of \$108.68 ha^{-1}, making long-term shrub suppression critical to the cost-effectiveness of the treatment. Based on an assumed cost of \$108.68 ha^{-1} and a 4% discount rate, the treatment would have to last in excess of 50 years to recoup initial treatment costs (McGinty et al., 1992). However, preliminary results from herbicide applications made annually from 1988 to 1992 in the Davis Mountains of West Texas on this shrub complex indicate that within four years of initial treatment, shrubs begin to reestablish on treated sites (McGinty et al., 1992).

From this preliminary work it appears that a pivotal question in the treatment and control of these species is: what mechanisms of reproductive biology allow catclaw shrubs to rapidly recolonize a site? The objectives of this study were to quantitatively assess mechanisms of plant establishment for *A. greggii* and *M. biuncifera* following tebuthiuron application in the Davis Mountains, Texas. We hypothesized that new plant recruitment must arise from either viable seeds or resprouts from existing vegetative structures. Seeds may be present as a persistent seed bank, or come from off-site seed recruitment. In either situation, seeds would be present in the seed bank. The specific objectives of this study were to: 1) assess the number of catclaw and associated shrubs developing on these sites, 2) determine what proportion of shrubs arise from seed and vegetative structures, 3) determine the presence and relative abundance of catclaw shrub seed banks, 4) relate the presence of a seed bank and new stem sprouts to the reestablishment potential of catclaw shrubs, and 5) assess response of herbaceous foliar cover to herbicide treatment.

METHODS

Study Area

The study was located on an Igneous Hill and Mountain range site within a desert grassland vegetation zone (Turner, 1977; Jaco, 1980) on the McCoy Land and Cattle Co. Seven Springs Ranch, about 12 km south of Toyahvale, Jeff Davis and Reeves Counties, Texas. The area occurs in a transition zone between the Davis Mountain range and the Pecos Plain in the northeastern Chihuahuan Desert (Powell, 1988). Study sites were on predominantly SE slopes at elevations between 1,370 to 1,575 m. Area winters are typically cool and dry, while summers are hot. Precipitation totals 30 to 36 cm annually and occurs mainly from July through August. Soils are primarily a Brewster stony loam series, Lithic Haplustoll (Turner, 1977), which occur in rough topography where slopes often exceed 7%.

Climax vegetation consists of short- and midgrasses, with some perennial forbs and woody shrubs (Turner, 1977; Jaco, 1980). Extant herbaceous species included *Aristida* sp. (perennial threeawn), *Bouteloua eriopoda* (black grama), *Bouteloua gracilis* (blue grama), *Bothriochloa barbinodis,* and *Schizachyrium* sp. (bluestem grasses). The shrub component included *Acacia greggii* (catclaw acacia), *Aloysia* sp. (whitebrush), *Mimosa biuncifera* (catclaw mimosa), and *Opuntia* sp. (cacti). Catclaw shrubs were the dominant shrubs found in draws and on hillside slopes. Nomenclature follows Hatch et al. (1990).

Commercial applications of Spike 20P pelleted herbicide were made during August of 1988, 1989 and 1991 at 1.7 kg a.i. ha^{-1}. Four study sites were selected, each represented by an herbicide-treated and untreated control site, yielding four replicates. Study sites were grazed following treatment.

Vegetation Assessment

Three categories were inventoried for each shrub species: 1) seedlings -- small plants with no attachment to mature crowns or root systems, 2) basal sprouting plants -- top killed individuals exhibiting sprouting from basal regions, and 3) aerial sprouting stems -- shoots arising from stems of mature plants that had been top-killed. An entire plant was considered an individual, irrespective of the number of stems emerging from the crown. Foliar cover and density of shrubs were assessed using 20 stratified random 20.0 m^2 circular quadrats per replicate (n=80 per treatment). Herbaceous vegetation was evaluated with a modified canopy coverage method (Daubenmire, 1959), using 20 stratified random quadrats (25 x 50 cm) sampled in each treatment replication (n=80 per treatment). Samples were collected between July and October 1993.

The shrub seed bank was assessed by collecting 30 stratified random soil samples (1.9 x 5 cm) from each treatment replicate using an Oakfield soil sampler between July and October 1993 (n=120 per treatment). Soil samples were sieved through U.S. standard 10 to 18 sieves (2 to 1 mm) to isolate shrub seeds, which were then removed and compared with voucher specimens for identification.

Significant differences ($P \leq 0.05$) among treatments were tested using a completely random one-way analysis of variance with SPSS/PC+ V4.0 (SPSS Inc. 1990). Density data were subjected to a square root transformation $[(x + 0.5)^{1/2}]$ prior to analysis, whereas cover data were subjected to an arcsine transformation [arcsine $(x)^{1/2}$] prior to analysis. Means and standard errors are presented as untransformed values.

RESULTS AND DISCUSSION

Woody Vegetation

By the third through sixth years following treatment, total live plants of *Mimosa biuncifera* were significantly fewer in the herbicide treatment (Table 1). McGinty et al. (1992) noted almost complete control of *Mimosa* for the first two years following initial herbicide treatment in the same area. *Mimosa* density was also significantly lower on treated sites for seedlings and aerial sprouts (Table 1), indicating the herbicide effectively reduced stem density. However, the presence of seedlings and residual mature plants indicated a strong replacement potential for shrubs, and that long-term efficacy of the herbicide may be limited. This is further supported by high foliar cover of *Mimosa* basal sprouts and seedlings on treated sites relative to controls, which characterized the fairly rapid replacement of *Mimosa* tissues following herbicide treatment.

Table 1. Mean density per ha (± 1 *SE*) for three categories of woody plant species found in herbicide (tebuthiuron) treated and control sites on the Seven Springs Ranch (*n*=80).

	Basal Sprouts		Seedlings		Aerial Sprouts		Total (All Categories)	
Species	Herb	Control	Herb	Control	Herb	Control	Herb	Control
MIBI†	758.0 (200.0)	358.0 (110.0)	75.0 (37.0)*	0.0 (0.0)	425.0 (117.0)*	8733.0 (632.0)	1258.0 (275.0)*	9092.0 (596.0)
ACGR	208.0 (147.0)	0.0 (0.0)	33.0 (26.0)	0.0 (0.0)	47.0 (30.0)*	425.0 (187.0)	283.0 (155.0)	425.0 (171.0)
ALOY	0.0 (0.0)*	825.0 (290.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)*	1225.0 (224.0)	0.0 (0.0)*	2055.0 (446.0)
ACCO	42.0 (30.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	108.0 (100.0)	42.0 (30.0)	108.0 (100.0)
AGAV	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	42.0 (18.0)*	0.0 (0.0)	42.0 (18.0)*	0.0 (0.0)
COER	150.0 (79.0)	33.0 (33.0)	0.0 (0.0)	0.0 (0.0)	242.0 (127.0)	0.0 (0.0)	392.0 (156.0)*	33.0 (33.0)
OPUN	75.0 (37.0)	17.0 (12.0)	0.0 (0.0)	0.0 (0.0)	108.0 (43.0)	133.0 (37.0)	183.0 (54.0)	150.0 (38.0)
PRGL	1050.0 (481.0)	892.0 (403.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	175.0 (107.0)	1050.0 (481.0)	1066.0 (417.0)

† MIBI=*Mimosa biuncifera;* ACGR=*Acacia greggii;* ALOY=*Aloysia* sp.; ACCO=*Acacia constricta*; AGAV=*Agave* sp.; COER=*Condalia ericoides*; OPUN=*Opuntia* sp.; PRGL=*Prosopis glandulosa.*

*Significant difference within row for a given sprout location ($P \leq 0.05$) .

Mature plant density and foliar cover of *Acacia greggii* was significantly lower on herbicide-treated than control sites (Tables 1 and 2). Mean density and foliar cover of basal sprouts and seedlings, however, did not appear to be affected by herbicide treatment. The total number of *A. greggii* plants was also not affected by the herbicide, which suggests that the *Acacia* was more tolerant of the herbicide than *Mimosa*, results supported by McGinty et al. (1992). Basal sprouts, aerial sprouts, and total number of live plants of *Aloysia* sp. were, however, significantly less on treated than control sites (Table 1). Tebuthiuron appears an effective means to control *Aloysia*. Similar reductions have been noted in Texas using pelleted tebuthiuron (Scifres et al., 1979; Meyer and Bovey, 1980).

Prosopis glandulosa was not significantly affected by the tebuthiuron treatment (Table 1), comparable to results obtained by Scifres et al. (1979). *P. glandulosa* has been shown to have significant control by soil applied tebuthiuron on clay-loam soils in south central Texas (Meyer and Bovey, 1979) and southern New Mexico (Herbel et al., 1983), but success has been limited in deep, fine-textured soils in Arizona (Herbel et al., 1983). Herbel et al. (1983) noted good results for *P. glandulosa* were obtained in the southwestern United States on loamy-sand to sandy-loam soils with 1.0 to 1.2 kg a.i. ha^{-1}, but that fine-textured soils required higher application rates to achieve plant mortality. Basal sprouts and new seedling growth of woody plants were often found only where the base of a top-killed plant remained. The amount of organic matter and clay content in the soil affects the absorption of tebuthiuron (Coffman et al., 1993; Duncan and Scifres, 1983). Tebuthiuron is not an herbicide recommended for use on *Prosopis glandulosa* (Welch, 1991).

Several species showed no response to herbicide treatment, but their representation in the community was so small that sample size was insufficient for definitive interpretations. *Opuntia* sp., *Acacia constricta* (whitethorn acacia), and *Condalia ericoides* (javelinabush) density and foliar cover estimates were not significantly different between treatments (Tables 1 and 2), although Herbel et al. (1983) noted good control of *A. constricta* with tebuthiuron on coarse-textured soils. Tebuthiuron appears to have little impact on *Opuntia* sp. when applied at labeled rates (Scifres et al., 1979; Herbel et al., 1985). *Agave* sp. were not present in any control sites, however, total plant density and mean foliar cover were significantly greater on the herbicide-treated sites (Tables 1 and 2). This may have been related to minor site differences that were not readily apparent, but it was perhaps in response to a reduction in the abundance of competing species.

Herbaceous Vegetation

Five grass taxa and one forb dominated the understory on all of the sites (Table 3). Three species showed significant differences between treatments; *Aristida* sp., *Bouteloua curtipendula*, and *Hilaria mutica* (tobosa grass). Mean foliar cover of *Aristida* sp. and *B. curtipendula* were significantly greater on the treated than control sites (Table 3). Once shrub dominance was reduced, these two grasses appeared to respond favorably to release from competition. *H. mutica*, however, exhibited lower foliar cover in the herbicide treatment (Table 3). Tebuthiuron may have directly affected individual plants, as occurred with *Sporobolus flexosa* (mesa dropseed) in southern New Mexico (Herbel et al., 1985). Negative effects on grass production have been noted in south Texas where application rates over 2.24 kg a.i. ha^{-1} of tebuthiuron were applied (Scifres and Mutz, 1978). However, minor

Table 2. Mean foliar percent cover (±1 *SE*) for three categories of woody plant species found in herbicide (tebuthiuron) treated and control sites on the Seven Springs Ranch (n=80).

	Basal Sprouts		Seedlings		Aerial sprouts		Total (All Categories)	
Species	Herb	Control	Herb	Control	Herb	Control	Herb	Control
MIBI[†]	3.1 (0.94)[*]	1.1 (0.27)	0.1 (0.04)[*]	0.0 (0.00)	2.1 (0.54)[*]	48.8 (3.31)	5.2 (1.15)[*]	50.0 (3.21)
ACGR	0.5 (0.25)	0.0 (0.00)	0.1 (0.04)	0.0 (0.00)	0.2 (0.14)[*]	1.8 (0.80)	0.7 (0.35)	1.8 (0.80)
ALOY	0.0 (0.00)[*]	2.0 (0.55)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)[*]	8.4 (1.48)	0.0 (0.00)[*]	10.4 (1.84)
OPUN	0.1 (0.05)	0.0 (0.02)	0.0 (0.00)	0.0 (0.00)	0.2 (0.08)	0.3 (0.09)	0.3 (0.09)	0.3 (0.09)
ACCO	0.1 (0.07)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.2 (0.16)	0.8 (0.67)	0.3 (0.19)	0.8 (0.67)
PRGL	1.0 (0.43)	1.9 (0.85)	0.0 (0.00)	0.0 (0.00)	0.1 (0.08)	0.4 (0.25)	1.1 (0.44)	2.3 (0.88)
COER	0.0 (0.02)	0.1 (0.07)	0.0 (0.00)	0.0 (0.00)	0.4 (0.19)[*]	0.0 (0.00)	0.4 (0.19)	0.1 (0.07)
AGAV	0.1 (0.04)	0.0 (0.00)	0.0 (0.00)	0.0 (0.00)	0.4 (0.13)[*]	0.0 (0.00)	0.4 (0.13)[*]	0.0 (0.00)

[†] MIBI=*Mimosa biuncifera*; ACGR=*Acacia greggii;* ALOY=*Aloysia* sp.; OPUN=*Opuntia* sp.; ACCO=*Acacia constricta*; PRGL=*Prosopis glandulosa*; COER=*Condalia ericoides*; AGAV=*Agave* sp.

[*] Significant difference within row for a given sprout location ($P \leq 0.05$).

variation in range site characteristics between treatment and control sites may have been the dominant influence. Herbicide treatment had no apparent effect on foliar cover for *B. gracilis*, *Heteropogon contortus* (tanglehead), and *Solanum* sp. (nightshade) (Table 3).

Table 3. Mean foliar cover (%) (± 1 *SE*) for herbaceous plants found in herbicide treated and control sites on the Seven Springs Ranch (n=80).

Species	Herbicide	Control	F Prob.
Aristida sp.	4.3 (0.22)	0.5 (0.50)	0.005*
Bouteloua curtipendula	19.0 (3.18)	8.0 (1.79)	0.003*
Hilaria mutica	0.6 (0.40)	5.0 (2.03)	0.033*
Bouteloua gracilis	3.7 (0.91)	3.2 (0.84)	0.672
Heteropogon contortus	4.7 (1.12)	2.5 (1.03)	0.154
Solanum sp.	0.5 (0.26)	1.2 (0.53)	0.235
Total	32.8 (7.09)	20.4 (6.72)	

*Significant difference within row ($P \leq 0.05$)

Seed Bank

From 240 soil samples, no seeds of *M. biuncifera* or *A. greggii* were found. Five *Acacia constricta* seeds were encountered, and all were present in untreated control areas. Granivory by rodents has been noted as an important mechanism in reducing seed banks in desert environments (Soholt, 1973; Kemp, 1989). Javelinas (*Dicotyles tajaccu*) reportedly utilize catclaw and mesquite (*Prosopis* sp.) seeds as a food source (Sowles, 1980). During the study several groups of javelinas were observed rooting around the base of *Mimosa* plants, and mule deer (*Odocoileus hemionus*) were observed eating seed pods and leaves of *M. biuncifera* and *A. greggii* near a study site. Kemp (1989) contends that shrubs in hot deserts rely on the annual production of relatively small seed crops for reproduction rather than the accumulation of large persistent seed banks. Small annual seed crops permit greater opportunity to respond to favorable environmental conditions for seed germination, and avoid reliance on a persistent seed bank which is subject to predation by rodents and ants which seek relatively large shrub seeds as a food source. Our failure to detect appreciable shrub seed density indicates an absence of persistent seeds and suggests dependence on other reproductive strategies (e.g. a transient seed bank and vegetative sprouting).

Synthesis and Conclusions

Initial response of *Mimosa biuncifera* and *Aloysia* sp. to tebuthiuron application in these communities was very favorable (McGinty et al., 1992), with 91-100%

control (initial density was 1,436-2,152 ha^{-1}) in the first year following treatment. *Acacia greggii* showed control levels of 42-60% (initial density was 0-1,507 ha^{-1}) during this period. For nearby areas treated in the same manner, however, plant densities after herbicide application were 1,250 ha^{-1} for *M. biuncifera*, and 300 ha^{-1} for *A. greggii* by 1993. *Aloysia* sp. still showed no regeneration, whereas *Prosopis glandulosa* was not affected.

In the 2 to 6 years following herbicide treatment a substantial number of mixed-brush plants reestablished. Although no seeds of *M. biuncifera* or *A. greggii* were found in soil samples, seedling plants were encountered, demonstrating the probable existence of at least a transient seed pool. This is indicative of the potential role seeds play in recolonizing herbicide treated areas. The primary source of regeneration, though, was by resprouting from crowns and aerial stems. It appears the herbicide initially impacted catclaw shrubs, but after a brief quiescent period, they initiated new growth from existing tissue (Tables 1 and 2). Marked differences were noted in herbaceous vegetative cover, with significantly greater cover for several species on treated sites, notably *B. curtipendula*.

Treatment with tebuthiuron at 1.7 kg ha^{-1} on mixed-brush in the Davis Mountains of West Texas effected notable compositional shifts in vegetation following initial treatment. The effects appear to be relatively short-lived, though, with respect to plant density and foliar cover of key species of the shrub community complex. With the cost-effectiveness of herbicide treatment in this instance dependent on a treatment life in excess of 50 years, it appears that a tebuthiuron treatment regimen for catclaw and associated shrubs will not recover costs.

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

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ABSTRACT

Field studies were conducted in 1992 and 1993 to evaluate endothall alone and in various herbicide programs for weed control in Texas peanut production. Endothall alone controlled less Texas panicum and southern crabgrass than bentazon + paraquat. The addition of Cadre (AC 263,222) or Pursuit (imazethapyr) to endothall improved weed control and provided early season control of Texas panicum, southern crabgrass, yellow nutsedge, and pitted morningglory.

KEYWORDS: yellow nutsedge, *Cyperus esculentus*, Texas panicum, *Panicum texanum*, pitted morningglory, *Ipomoea lacunosa*, Cadre, Pursuit

Endothall has contact herbicide activity similar to paraquat and is registered for use in the U.S. in alfalfa (*Medicago sativa* L.) and clover (*Trifolium* spp.) as a desiccant, in cotton (*Gossypium hirsutum* L.) as a harvest aid, in sugar beets (*Beta vulgaris* L.) for broadleaf weed control, and in aquatic situations for control of aquatic weeds and algae (Anonymous, 1994).

Texas panicum (*Panicum texanum* Buckl.), yellow nutsedge (*Cyperus esculentus* L.), pigweed (*Amaranthus* spp.), and morningglory (*Ipomoea* spp.) can be difficult to control in southwestern peanuts (Grichar and Boswell, 1986; Grichar, 1991a; Grichar, 1991b; Grichar, 1992; Grichar et al., 1992; Grichar et al, 1994; Grichar, 1994). Paraquat (Gramoxone) alone or in combination with 2,4-DB (Butoxone) or bentazon (Basagran) are currently the standards for postemergence broadleaf weed control in southeastern peanut production (Wilcut et al., 1989; Wilcut, 1991; Wilcut et al., 1991). Not only does the bentazon plus paraquat mixtures control more broadleaf weed species than paraquat alone but the bentazon also reduces paraquat-induced foliar injury to peanut by reducing paraquat absorption into peanut foliage (Wehtje et al., 1992; Wilcut et al., 1993). However, little paraquat is used in southwestern peanuts due to the potential for early season peanut leaf burning and desiccation.

Although paraquat applied postemergence to the peanut plant injures the foliage (Brecke and Colvin, 1988; Wehtje et al., 1986; Wilcut and Swann, 1990), peanut rapidly recovers under good growing conditions and yield is unaffected. Peanut

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tolerance to paraquat is not cultivar dependent (Knauft et al., 1990; Wehtje et al., 1991) and seedling tolerance to paraquat is not influenced by seed size. Paraquat can be applied from crop emergence until 28 d after emergence (Anonymous, 1994); however, paraquat applied after this 28 d period increased the chance of significant yield reductions (Wehtje et al., 1986).

Endothall has recently been investigated for weed control in peanuts (Brecke and Colvin, 1994; Colvin and Johnson, 1992; Johnson and Colvin, 1992a, Johnson and Colvin 1992b, Johnson et al., 1994; Wehtje et al., 1991). Peanut injury in the southeast with endothall has ranged from 10% to as high as 50%, according to time of application (Colvin and Johnson, 1992; Johnson et al., 1994). The authors concluded that the level of phytotoxicity with endothall was similar to that from bentazon plus paraquat (Johnson et al., 1992a; Johnson et al., 1992b; Johnson et al., 1994).

Brecke and Colvin (1994) reported variable control of tall morningglory (*Ipomoea purpurea* (L.) Roth) with endothall but they felt that this was due to differences in size of tall morningglory at treatment. They concluded that the application of endothall must be made after the initial flush of weeds have emerged but before the largest weeds exceed 4 to 6 inches in height (Brecke and Colvin, 1994). Johnson et al. (1994) found that the mono (N,N-dimethylalkylamine) salt of endothall was more necrotic to peanut than those treated with the dipotassium salt of endothall. They reported that at rates of 0.5 to 1.0 lb ai acre $^{-1}$, the mono salt of endothall resulted in similar amount of peanut injury as the standard treatment of bentazon plus paraquat.

Endothall is a contact herbicide that produces rapid, necrotic lesions on treated plant tissue (MacDonald et al., 1993). Research indicated that endothall inhibits lipid, protein, and mRNA biosynthesis (MacDonald et al., 1993). The effects of endothall on ion leakage, chlorophyll fluorescence, and oxygen consumption are similar to those exhibited by compounds that affect respiration, suggesting that endothall causes plant death through an alteration of normal respiratory function, inhibiting the ability of the plant cells to maintain cellular integrity (MacDonald et al., 1993).

The objectives of this research were to evaluate weed control, peanut tolerance, and peanut yields from herbicide programs containing endothall with a standard commercial program.

MATERIALS AND METHODS

Field studies were conducted in Lavaca County at the Texas Agricultural Experiment Station near Yoakum, TX. The soil was a Tremona loamy fine sand (thermic Aquic Arenic Paleustalfs) with less than 1% organic matter and a pH of 7.2.

Studies were established on different irrigated fields in 1992 and 1993. Peanuts had previously been planted in each of these fields for the past 15 years. 'Florunner' peanut at 90 lb acre^{-1} was planted 11 May 1992 and 20 May 1993. No preplant incorporated (PPI) herbicide was applied to the test area. Weed populations were determined at herbicide application. The 1992 area was naturally infested with mixed populations of Texas panicum (60%) and southern crabgrass (40%) (>4 to

5 total plants ft^{-2}), pitted morningglory (*Ipomoea lacunosa* L.) (>1 plant ft^{-2}), and yellow nutsedge (>4 plants ft^{-2}). The 1993 test site was naturally infested with mixed populations of southern crabgrass (70%) and Texas panicum (30%) (>3 total plants ft^{-2}) and yellow nutsedge (>4 plants ft^{-2}).

EPOST treatments were applied 8 Jun 1992, and 10 Jun 1993 while LPOST treatments were applied 18 Jun 1992 and 24 Jun 1993. Annual grasses were 1 to 2 inches tall at early postemergence (EPOST) and 4 to 6 inches tall at late postemergence (LPOST). Pitted morningglory was 2 to 4 inches tall at EPOST and 6 to 8 inches tall at LPOST, while yellow nutsedge varied from 4 to 6 inches tall at EPOST and 8 to 10 inches tall at LPOST.

Herbicide treatments included endothall alone at 0.5, 0.75, and 1.0 lb ai acre^{-1}, endothall at 0.5 lb ai acre^{-1} applied in combination with either AC 263,222 at 0.063 lb ai acre^{-1}, imazethapyr at 0.063 lb acre^{-1}, or 2,4-DB at 0.25 lb ai acre^{-1} applied EPOST or LPOST. Bentazon at 0.5 lb ai acre^{-1} + paraquat at 0.12 lb ai acre^{-1}, applied EPOST or LPOST were included as comparison treatments.

Herbicides were applied with a compressed-air bicycle sprayer through Teejet 11002 flat fan nozzles (Spraying Systems Co., Wheaton, IL) which delivered a spray volume of 20 gal acre^{-1} at 26 psi. Imazethapyr (Pursuit) and AC 263,222 (Cadre) + endothall and bentazon + paraquat were applied with a nonionic surfactant (X-77) at 0.25% (v/v) of the spray volume.

A factorial arrangement of treatments with factors consisting of herbicide treatments and timing of application (EPOST vs LPOST) in a randomized complete block experimental design with four replications was used. Each plot consisted of two rows spaced 36 inches apart and 25 feet long. In both years, paraquat + bentazon was the standard treatment. Sprinkler irrigation was applied on a two week schedule throughout the growing season as needed.

Data collected included visual estimates of crop injury and weed control on a scale of 0% (no control or peanut injury) to 100% (complete control or death of the peanuts) relative to the untreated check, and peanut yield. Weed control and peanut injury were visually estimated early and late-season during both years.

Peanut yields were obtained by digging each plot separately, air-drying in the field for 4 to 8 days, and harvesting peanut pods from each plot with a combine. Weights were recorded after soil and foreign material were removed from the plot samples. Visible weed control data were subjected to arcsine transformation prior to analysis of variance. Untransformed data were used for presentation. Peanut yields were subjected to analysis of variance, and significant differences ($P \leq 0.05$) among means were determined with Fisher's Protected Least Significant Difference.

RESULTS AND DISCUSSION

Data analysis revealed significant year by treatment interaction, therefore data were analyzed separately for each year.

Annual grass control

In 1992, when rated two weeks after LPOST treatment (2WAT), only the EPOST application of endothall alone at 0.5 and 1.0 lb ai acre^{-1}, endothall + AC 263,222, or endothall + imazethapyr provided early season control of the annual grasses

(Texas panicum and southern crabgrass) equal to the standard of bentazon + paraquat (EPOST) (Table 1). Endothall alone controlled ≤70% of the annual grasses while paraquat + bentazon controlled 63 to 79%. In previous studies, it was found that Texas panicum can be controlled with paraquat or a paraquat plus bentazon mixture (Wehtje et al., 1986; Wehtje et al., 1992). However, if Texas panicum is larger than the five- to six-leaf stage, bentazon will reduce paraquat efficacy (Wehtje et al., 1992). Although application timing was not significant, a trend toward better grass control with EPOST treatments of bentazon + paraquat, endothall at 0.5 and 1.0 lb ai acre^{-1} and endothall + 2,4-DB was apparent (Table 1). No differences in control were noted for timing of application with endothall + AC 263,222 or endothall + imazethapyr combinations. However, the LPOST application of endothall + AC 263,222 resulted in better annual grass control than the LPOST endothall + imazethapyr combination.

Late season annual grass control (6 WAT) in 1992 was <70% for all herbicide treatments (Table 1). Endothall alone controlled 45 to 61% of the annual grasses while bentazon + paraquat controlled 46 to 65%. Poor grass control (<70%) was evident with endothall + AC 263,222 or endothall + imazethapyr although these herbicides (AC 263,222 and imazethapyr) do have residual activity (Richburg et al., 1994; Wixson and Shaw, 1991; Wixson and Shaw, 1992). Imazethapyr has been reported to provide less control of annual grasses than AC 263,222 (Grichar et al., 1994; Wilcut et al., 1993).

In 1993, endothall + imazethapyr, or endothall + AC 263,222 provided early season annual grass control comparable with bentazon + paraquat (Table 2). Endothall alone controlled 59 to 84% of annual grasses. The EPOST application resulted in better annual grass control with bentazon + paraquat or endothall alone at 0.75 and 1.0 lb ai acre^{-1} than the LPOST application. Earlier work by Brecke and Colvin (1994) indicated weed size was an important factor in effective control with endothall.

Annual grass control 10 WAT with EPOST and LPOST applications endothall + AC 263,222 or endothall plus imazethapyr applied EPOST was ≥78% (Table 2). Endothall at 1.0 lb ai acre^{-1} applied EPOST or LPOST was comparable to bentazon + paraquat applied EPOST, but these herbicide treatments provided <50% annual grass control.

Pitted morningglory control

Only in 1992 was the pitted morningglory population uniform enough to provide accurate assessment. Only the EPOST applications of paraquat and the 0.5 lb ai acre^{-1} rate of endothall controlled less morningglory than the LPOST application of bentazon + paraquat when rated 2 WAT (Table 1).

Morningglory control 10 WAT was less with bentazon + paraquat applied EPOST or LPOST and endothall at 0.75 lb ai acre^{-1} applied LPOST than the EPOST endothall + 2,4-DB application (Table 1). Since annual grass pressure was so great, after the initial flush of morningglory was killed, the high numbers of annual grass plants likely prevented germination and additional flushes of morningglory in plots which did not have a residual herbicide. Therefore, few differences were seen in late season morningglory control between herbicide treatments. Brecke and Colvin (1994) reported inconsistent control of tall morningglory [*Ipomoea purpurea* (L.) Roth] regardless of application timing. They concluded that the variation in control was due to differences in weed growth. They stated that endothall must be applied after the initial flush of weeds have emerged but before the largest weeds exceed 5 inches in height.

Yellow nutsedge control

In 1992, endothall alone failed to provide effective (<50%) early season yellow nutsedge control, while bentazon + paraquat provided 90% control (Table 1). Endothall + AC 263,222 resulted in ≥89% control of yellow nutsedge while endothall + imazethapyr controlled 65 to 73% early season (Table 2). AC 263,222 has provided better control of yellow nutsedge in field experiments than currently registered herbicides in peanut (Wilcut and Richburg, 1992).

Late season yellow nutsedge control with LPOST applications of endothall + AC 263,222 or endothall + 2,4-DB was comparable with bentazon + paraquat applied LPOST. Postemergence imazethapyr applications can control yellow nutsedge (Grichar et al., 1992; Richburg et al., 1994; Wiley et al., 1991). However, imazethapyr needs to be applied when yellow nutsedge is 2 to 4 inches tall for greatest efficacy (Brecke and Colvin, 1994; Richburg et al., 1994; Wiley et al., 1991). Grichar et al. (1992) reported late season yellow nutsedge control with imazethapyr was higher with PPI applications than other applications.

In 1993, endothall control of yellow nutsedge 3 WAT alone varied from 30 to 68% and was not rate dependent (Table 2). Bentazon + paraquat applied LPOST provided 23 to 61% better nutsedge control than any of the endothall alone treatments. The addition of imazethapyr or AC 263,222 improved yellow nutsedge control over all endothall treatments except for the endothall at 0.5 lb ai acre^{-1} applied EPOST. Bentazon + paraquat control was 20% less with the EPOST treatment than the LPOST treatment.

Nutsedge control 10 WAT was ≤60% with all herbicide treatments. Endothall combinations with AC 263,222 and imazethapyr provided poor control. Inconsistent yellow nutsedge control, especially later in the growing season, has been reported with imazethapyr (Grichar et al., 1992).

Peanut injury

Peanut injury was not rated at the Yoakum location in 1992 because heavy rains fell soon after EPOST application and prevented entry into the field to provide an accurate assessment. Injury (peanut burn) in 1993 with endothall was comparable with bentazon + paraquat applied EPOST (Table 1). Previous work in the Southeast indicated peanut injury from applications of paraquat alone averaged 30% and did not differ with timing of paraquat application (Wilcut and Swann, 1990). However, provided the rate of paraquat is not excessive (≤0.25 lb ai acre^{-1}), and the applications are restricted to early in the growing season (not later than 28 days after emergence), yield has not adversely affected (Wehtje et al., 1986).

Peanut yield

In 1992, endothall alone resulted in 13 to 36% yield reduction when compared with the EPOST bentazon + paraquat application (Table 1).

In 1993, a series of record setting cool temperatures in early to mid October

Table 1. Control of Texas panicum, morningglory, and yellow nutsedge with contact herbicides alone and in combinations, Lavaca County, TX, 1992.

			Weed control‡						
			2 WAT§			6 WAT			
Treatment	Rate	Application time†	Grass	Morningglory	Nutsedge	Grass	Morningglory	Nutsedge	Peanut yield
	lb ai acre^{-1}		%						lb acre^{-1}
Bentazon	0.5	EPOST	79	75	90	65	73	61	2151
+paraquat	0.12								
Bentazon	0.5	LPOST	63	90	90	46	88	88	1474
+paraquat	0.12								
Endothall	0.5	EPOST	66	75	45	45	95	70	1661
Endothall	0.5	LPOST	53	96	15	48	95	46	1880
Endothall	0.75	EPOST	43	95	35	58	95	53	1607
Endothall	0.75	LPOST	53	89	33	61	88	73	1380
Endothall	1.0	EPOST	70	93	31	45	93	48	1570
Endothall	1.0	LPOST	41	95	43	48	90	50	1516
Endothall	0.5	EPOST	82	90	93	63	89	79	1779
+AC 263,222	0.063								
Endothall	0.5	LPOST	85	98	89	65	99	86	1316
+AC 263,222	0.063								
Endothall	0.5	EPOST	74	93	73	61	90	63	1825
+imazethapyr	0.063								
Endothall	0.5	LPOST	69	100	65	60	96	70	1552
+imazethapyr	0.063								

Table 1, continued.

			Weed control‡						
			2 WAT§			6 WAT			
Treatment	Rate	Application time†	Grass	Morningglory	Nutsedge	Grass	Morningglory	Nutsedge	Peanut yield
	lb ai acre^{-1}		%						lb acre^{-1}
Endothall	0.5	EPOST	56	98	33	44	100	75	2088
+2,4-DB	0.25								
Endothall	0.5	LPOST	34	99	8	53	99	85	1797
+2,4-DB	0.25								
LSD (0.05)									
Treatment			15	9	26	15	11	24	449
Appl. time			NS	NS	NS	NS	NS	NS	NS
Treatment X Appl. time			NS	NS	NS	NS	NS	NS	NS

†Application timing: EPOST=early postemergence, LPOST=late postemergence.

‡Grass=Annual grasses, a mixed stand of 60% Texas panicum and 40% southern crabgrass; Morningglory=pitted morningglory; Nutsedge=yellow nutsedge.

§WAT=weeks after LPOST treatment.

Table 2. Control of southern crabgrass and yellow nutsedge with contact herbicides alone and in combinations, Lavaca County, TX, 1993.

				Weed control§				
				3 WAT¶		10 WAT		
Treatment	Rate	Application time†	Peanut injury (5 DAT)‡	Grass	Nutsedge	Grass	Nutsedge	Peanut yield
	lb ai acre^{-1}			%				lb acre^{-1}
Bentazon	0.5	EPOST	33	89	71	40	28	874
+paraquat	0.12							
Bentazon	0.5	LPOST	11	68	91	15	50	946
+paraquat	0.12							
Endothall	0.5	EPOST	25	70	68	5	30	723
Endothall	0.5	LPOST	26	70	45	10	10	1160
Endothall	0.75	EPOST	30	71	55	15	20	1160
Endothall	0.75	LPOST	26	59	55	25	40	803
Endothall	1.0	EPOST	38	84	30	41	23	874
Endothall	1.0	LPOST	33	70	35	40	25	651
Endothall	0.5	EPOST	23	99	95	78	30	1240
+AC 263,222	0.063							
Endothall	0.5	LPOST	23	96	73	84	58	1312
+AC 263,222	0.063							
Endothall	0.5	EPOST	33	97	81	88	20	1526
+imazethapyr	0.063							
Endothall	0.5	LPOST	28	91	84	56	30	874
+imazethapyr	0.063							
Endothall	0.5	EPOST	25	83	20	40	20	560
+2,4-DB	0.25							

Table 2 continued.

Treatment	Rate	Application time[†]	Peanut injury (5 DAT)[‡]	Weed control[§]				Peanut yield
				3 WAT[¶]		10 WAT		
				Grass	Nutsedge	Grass	Nutsedge	
	lb ai acre^{-1}			%				lb acre^{-1}
Endothall +2,4-DB	0.5 0.25	LPOST	21	75	55	10	20	1200
LSD (0.05)								
Treatment			9	9	20	17	31	303
Appl. Time			NS	7	NS	NS	NS	NS
Treatment X Appl. Time			NS	NS	NS	NS	14	382

†Application timing: EPOST=early postemergence, LPOST=late postemergence.

‡DAT=days after treatment

§Grass=Annual grasses, a mixed stand of 70% southern crabgrass and 30% Texas panicum.

¶WAT=weeks after LPOST treatment.

resulted in delayed maturity and lower yields. Endothall + AC 263,222 applied LPOST, endothall + imazethapyr applied EPOST, and pendimethalin + imazethapyr resulted in a yield increase over the untreated check. In neither year did endothall result in a decreased yield from the untreated check.

Johnson et al. (1994) reported that peanut yields were not affected by endothall at 0.5 to 1.0 lb ai acre^{-1}, applied from vegetative emergence through four weeks after emergence.

CONCLUSION

This study demonstrates that early season control of annual grasses (Texas panicum and southern crabgrass), pitted morningglory, and yellow nutsedge with endothall was comparable with bentazon + paraquat. However, when endothall was tank-mixed with AC 263,222 season long control of annual grasses and pitted morningglory were possible. Early season yellow nutsedge control was excellent with endothall + AC 263,222; however, late season control was inconsistent.

Since early season peanut injury with endothall is comparable to paraquat, the use of endothall for peanut weed control will probably be limited to the southeastern U.S. where growers are comfortable with some burning of peanut leaves by paraquat.

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Coleoptile Length and Emergence of Amigo 1AL.1RS Semidwarf Wheats

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ABSTRACT

This study compared growth chamber coleoptile length and field emergence of wheat backcross lines, that have the Amigo 1AL.1RS wheat-rye translocation, to those of their recurrent semidwarf cultivar parents. Field emergence from 4, 6 and 8 cm was determined in 1989, 1990 and 1991. Fourteen of 22 backcross lines had significantly longer coleoptiles than their recurrent parent, but those of only one were more than 10% longer. None had shorter coleoptiles. Differences in emergence among genotypes were substantial only in 1990, significant among planting depths in all experiments, but the genotype x planting depth interaction was not significant in all experiments. Differences in coleoptile lengths accounted for no more than 10% of the variation in emergence percentage across all treatments, but in 1990 variation in coleoptile length accounted for 36% of the variation in emergence percentage from the 8 cm depth, 81% of the variation in emergence among genotypes, and 98% of the variation among seed source emergence means. Although generally unrelated, seed weight in 1991 accounted for 64% of the variation in emergence of genotypes from the 8 cm depth. The Amigo 1RS rye segment had a small positive effect or no effect on coleoptile length and seedling emergence.

The coleoptiles of wheat (*Triticum aestivum* L.), as in other grasses, protect the plumule of the emerging seedling. Semidwarf cultivars generally have shorter coleoptiles than standard height cultivars (Allan et al., 1961). Nevertheless, semidwarfs of essentially the same height can differ substantially in coleoptile length (Peterson, 1989). Allan et al. (1962) found the emergence rate increase (ERI), a weighted average emergence that gives additional value to early emerging seedlings, was related positively to plant height and coleoptile length. However, they found coleoptile length only partially effective in predicting ERI of semidwarf wheats of comparable heights. Burleigh et al. (1965) found average coleoptile length positively correlated with ERI in all cases, but with emergence percentage only from the 4-inch (10.2 cm) and 5-inch (12.7 cm) planting depths. Allan et al. (1962) and Burleigh et al. (1965) also found coleoptile length negatively related to temperature, as did Sunderman (1964) who obtained significant correlations between emergence

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percentages and coleoptile lengths in field tests from all but 2-inch (5.1 cm) and 3-inch (7.6 cm) planting depths. He obtained the highest correlations from cultivars planted four inches (10.2 cm) deep. Sunderman (1964) and Sharma (1990) showed coleoptile length positively related to planting depth. Berg and Martin (1988) found large seed produced longer and heavier coleoptiles, heavier shoot weight and greater emergence percentage than small seed. They also found that shoot weight and emergence were positively related to thousand kernel weight, but coleoptile length and weight were unrelated to thousand kernel weight. They found that high protein content of the seed enhanced coleoptile length and weight, but shoot weight and emergence were unrelated to seed protein. Guedira (1993) found coleoptiles extremely sensitive to drought, that they became more sensitive as they elongated, and that advanced coleoptiles were unable to recover from very low water potentials.

Coleoptile length became a more critical consideration with widespread production of semidwarf cultivars. Nevertheless, by 1984, semidwarfs were grown on 59% of the wheat acreage of the United States (Dalrymple, 1988). Coleoptile length may be critical for emergence where it is necessary to plant deep to reach adequate moisture or when crusting or other soil conditions restrict emergence. Increasing the coleoptile length of semidwarf wheats is a desirable and feasible breeding objective.

The breeding material used in this study was chosen because it has been used extensively to provide resistance to greenbug biotypes B, C, and E, as well as other desirable characteristics.

The 1AL.1RS translocation in the germplasm line Amigo, Sebesta and Wood (1978), provided both insect and disease resistance as well as enhanced yield potential. Genes carried on the 1AL.1RS translocation in Amigo confer resistance to biotypes B and C of the greenbug, *Schizaphis graminum* (Rondani), powdery mildew, *Erysiphe graminis* DC. f. sp. *tritici* E. Marchal, stem rust, caused by *Puccinia graminis* Pers. f. sp. *tritici* Eriks. and E. Henn, and wheat curl mite, *Eriophyes tulipae*, vector of wheat streak mosaic virus. The coloeptiles of TAM 107 (TAM 105*4/Amigo), a greenbug biotype B and C resistant cultivar, were found to be 12% longer than those of TAM 105 (T.J. Martin, personal communication, 1987). Coleoptiles of TAM 105, 'Insave rye', the donor of the 1RS rye segment in Amigo, Amigo, and Largo, a greenbug biotype C and E resistant germplasm amphiploid of 'Langdon' (T. *turgidum* L. *durum* group 2n=28) and PI 268210, (T. *tauschii* (Coss.) Schmal (2n=14), Joppa et al. 1980, were found in replicated tests, to average 86, 91, 110, and 116 mm in length, respectively (K.B. Porter, unpublished data, 1988).

The purpose of this study was to determine the effect of the 1AL.1RS wheat-rye translocation from the germplasm line Amigo on coleoptile length and percent emergence of semidwarf backcross lines of different genetic gackgrounds and to determine the relationships among emergence, coleoptile length, and seed weight.

MATERIAL AND METHODS

Plant Material

Two groups of plant materials were used in this study. Group I included 22 entries. There were three backcross lines with the pedigree 'TAM W-101'*4/Amigo, seven lines with the pedigree 'TAM 108'*4/Amigo, eight lines, including the cultivar TAM 107, with the pedigree 'TAM 105'*4/Amigo, the three recurrent semidwarf cultivar parents (recurrent parents), and the tall check cultivar 'Scout 66'. The seed source of Group I was a rainfed breeding nursery at Chillicothe, TX. Group II included four seed sources of eight entries. The entries were TAM 107, one backcross line each with the pedigrees TAM W-101*4/Amigo*4//Largo, TAM 108*4/Amigo*4//Largo, and TAM 105*4/Amigo*4//Largo, the three recurrent parents, and Scout 66. The four seed sources of Group II were the 1988 irrigated and rainfed wheat breeding nurseries at Bushland, TX and rainfed nurseries at Stinnett and Dallas, TX. The presence of the 1AL.1RS translocation in backcross lines was verified cytologically or by the manifestation of homozygous resistance to biotype C greenbug or powdery mildew.

Coleoptile Measurements

Coleoptile lengths of entries in both Group I and Group II were determined on seedlings from Captan treated seed planted in growth pouches (Pfahler et al., 1991) and/or in screen bottom flats of water-moistened vermiculite (Livers, 1958). Polyethylene growth pouches measuring 16 x 17 cm, inserted with an absorbent unbleached paper wick with an upper trough for seed, were filled with 35 ml of either tap water or one half strength Hoagland's solution. The growth pouches were hung on 16 x 17 x 40 cm racks. The gross weight of sixteen seeds of a single entry was determined and the seeds were placed about 5 mm apart along the seed trough. Each pouch was a treatment.

The screen bottoms of wooden flats were covered with 3 cm of vermiculite. Twenty five seed of a single entry were weighed, spaced uniformly in a 30 cm row, and covered with six cm of vermiculite. There were eight rows per flat, a replication. Flats were then placed in shallow pans of water where the vermiculite and seeds imbibed water for 24 hours. The drained flats and racks of growth pouches were placed in a dark growth chamber where the temperature was maintained at 18°C and approximately 100% relative humidity. Growth periods ranged from 13 to 15 days. Coleoptiles were measured from the base of the embryo to the point of plumule emergence. Coleoptiles of seeds that germinated slowly or from which the plumule had not emerged were not measured. Nevertheless, coleoptiles were measured on more than 95% of seedlings from viable seed.

Coleoptile measurements of entries in Group I were made of seedlings grown in pouches of water and pouches of Hoagland's solution. The experimental design was a randomized split-plot replicated four times with growth mediums as whole-plots and genotypes as sub-plots. Seedlings from each seed source in Group II were grown in separate randomized block experiments in vermiculite flats and in a single split-plot water-pouch experiment in which seed sources were whole-plots and genotypes were sub-plots. Measurements were made of seedlings from the Bushland rainfed source in two vermiculite tests and the one growth pouch experiment, but seedlings of the other three seed sources were grown only once in each of the two types of experiments. Thus nine evaluations were made of the eight genotypes in Group II. Group II experiments were replicated three times.

Analyses of variance were made of coleoptile length and seed weight for each experiment, and a combined analysis was made of the means of the nine evaluations. Correlation coefficients were calculated between mean coleoptile length and seed weight of each treatment.

Emergence

Emergence was studied only of the genotypes in Group II, which were planted at three depths on a Pullman clay loam (fine, mixed, thermic Torrertic Paleustoll). The Dallas seed source was not included in the study. Experiments were conducted during 10 to 26 Apr 1989; 2 to 18 Apr 1990; and 19 Feb to 4 Mar 1991. Plots were planted with a 4-row nursery plot drill. The experimental design was a randomized split-split-plot with three replications. Depths of planting, 4, 6 and 8 cm, were whole plots, seed sources were sub-plots, and genotypes were sub-sub-plots. In 1989, each sub-sub-plot was a single 0.5 m row of 50 seeds. In 1990, each sub-sub-plot was 75 seeds planted in a 3-m row and, in 1991, sub-sub plots were four 1-m rows of 25 seeds each.

Percent germination of each genotype within seed sources was determined in unbleached paper towel rag dolls of 200 seed each in Jul 1989 and again in Jan 1991. Mean percent germination in Jul 1989 was 96%, ranging from 94 to 98% among seed sources and 89 to 96% among seed lots. Mean percent germination in Jan 1991 was 92%, ranging from 91 to 93% among sources and 82 to 96% among seed lots. Emerged plants were counted in each sub-sub-plot and mean percent emergence from viable seed was determined. Germination percentages determined in Jul 1989 were used to convert emergence counts to percent emergence from viable seed in the 1989 and 1990 trials while germination percentages determined in Jan 1991 were used for converting 1991 emergence data.

Analyses of variance were made of seed weight and percent emergence. Correlation coefficients were calculated between percent emergence and growth chamber mean coleoptile length, plot seed weight, and planting depth.

RESULTS AND DISCUSSION

Coleoptile Length

Mean coleoptile lengths of TAM W-101 and TAM 108 in Group I were essentially the same, but significantly ($P<0.01$) less than those of TAM 105 and TAM 107, while the mean coleoptile length of Scout 66, the tall cultivar check, was significantly ($P<0.01$) greater than that of all other genotypes (Table 1). Most backcross lines had longer coleoptiles than their recurrent parent, and ten of the 18 had significantly longer ($P<0.05$) coleoptiles than their recurrent parent. In addition, the mean coleoptile length of backcross lines with the pedigree TAM 108*4/Amigo was significantly greater ($P<0.01$) than the mean coleoptile length of the recurrent parent TAM 108 and the mean coleoptile length of lines with a TAM 105 genetic background was significantly greater ($P<0.05$) than the mean coleoptile length of TAM 105. Although the mean coleoptile length of some backcross lines in TAM 105 and TAM 108 genetic backgrounds were greater, none exceeded the mean coleoptile length of their recurrent parent by more than 9%. No backcross line had shorter coleoptiles than its recurrent parent.

The mean coleoptile length of seedlings grown in pouches of Hoagland's solution was not significantly greater than that of seedlings grown in pouches of water, but the genotype x growth medium interaction was significant ($P<0.01$). This significant interaction primarily was due to the result of three genotypes, TAM 105*4/Amigo

Table 1. Mean coleoptile length of wheat seedlings of the recurrent parents TAM W-101, TAM 105, TAM 108, their backcross lines to Amigo, and Scout 66 of Group I grown in growth pouches of water and growth pouches of one half strength Hoagland's solution.

		Mean Coleoptile Lengths			
		Growth Medium		Across Mediums	
Genotype	No. of lines	H_2O	Hoagland's	Range of Means	Mean
		mm			
TAM W-101	†	66	66	66	66
TAM W-101*4/Amigo	3	68	69	67-70	68
TAM 105	†	75	79	77	77
TAM 105*4/Amigo	8	78	84[‡]	79-83	81[*]
TAM 108	†	62	66	64	64
TAM 108*4/Amigo	7	70	73[‡]	69-73	71[**]
SCOUT 66	†	96	105[‡]	100	100
Mean		73	77		75
LSD (0.05)				4.2	
C.V.%				5.2	

†Bulk seed from plots of certified seed.

‡Significantly (<0.01) greater than the corresponding H_20 mean.

*Significantly ($P<0.05$) greater than the mean coleoptile length of the recurrent parent.

**Significantly ($P<0.01$) greater than the mean coleoptile length of the recurrent parent.

lines, TAM 108*4/Amigo lines and Scout 66 having significantly longer coleoptiles when grown in Hoagland's solution than when grown in pouches of water. This differential response of genotypes to Hoagland's solution suggests the kind and quantity of nutrients in the seed affects coleoptile length, an hypothesis that is supported by results obtained by Berg and Martin (1988), who found coleoptile length was related positively to protein content of the seed.

The mean coleoptile length of Group II seedlings grown in vermiculite was 85 mm, and the mean of those grown in growth pouches of water was 79 mm. This difference was significant ($P<0.01$). Differences in mean coleoptile length among the eight genotypes were significant ($P<0.01$) in all tests, but the genotype x test interaction was not significant. The 36 correlation coefficients of mean genotype coleoptile lengths between any two of the nine evaluations, $N=8$, averaged 0.96, and ranged from 0.92 to 0.99. Thus only the nine-evaluation means for each of the eight genotypes are presented (Figure 1). All differences in coleoptile length among cultivars TAM W-101, TAM 105, TAM 108, and Scout 66 were significant ($P<0.01$). Coleoptiles of genotypes with the 1AL.1RS translocation were significantly longer ($P<0.05$) than those of their recurrent parent. Coleoptiles of progeny with TAM W-101 or TAM 105 as their recurrent parent were less than 10% longer than coleoptiles of the recurrent parent, but coleoptiles of the line with the translocation in a TAM 108 genetic background were 25% longer than those of

TAM 108.

No backcross line had more than three backcrosses. On the average, a line with three backcrosses will carry 6.25% of the genes of the non-recurrent parent that are not selected. These genes that are not selected of the non-recurrent parents may partially account for the small increase in coleoptile length of backcross lines over the recurrent parents in this study. Also, seed derived from the individual plants of cultivars used in the backcrosses were not available, and some differences might be attributed to differences between the individual parent plants and the bulk seed of the recurrent parent used in this study.

Overall the Amigo 1AL.1RS translocation had no effect, or a small positive effect, on coleoptile length; however, the increase in length attributable to the presence of the translocation was more than twice as great in TAM 108 backcross lines than in either TAM W-101 or TAM 105 backcross lines. This suggests genetic background may influence the effect of 1AL.1RS on coleoptile length.

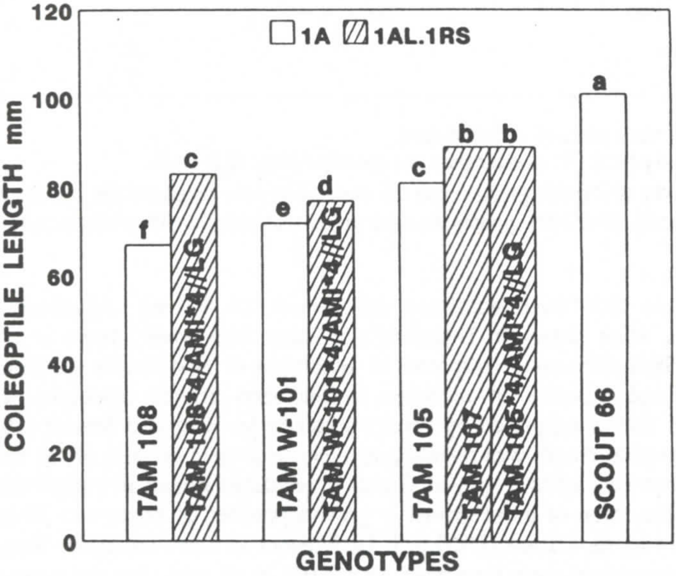


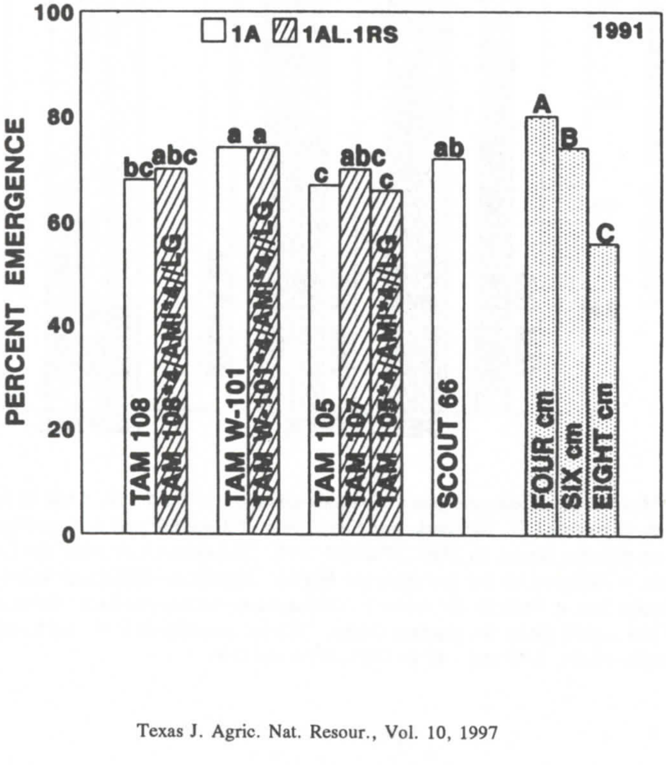
Figure 1. Nine-evaluation mean growth chamber coleoptile length of the standard height cultivar Scout 66; semidwarf recurrent parents, TAM 108, TAM W-101, and TAM 105, and their 1AL.1RS backcross line(s). The presence of either the 1A or 1AL.1RS translocation chromosome is indicated by the appropriate bar legend. Significant differences based on Duncan's Multiple Range Test at $P \leq 0.05$ are shown by different letters above the bars (SE=0.85).

Genotypes were ranked similarly for coleoptile length when grown in flats of vermiculite, pouches of water, or pouches of Hoagland's solution. Some genotypes, however, did respond positively to the Hoagland's solution. Different seed sources also had similar coleoptile length rankings of the genotypes tested.

Emergence

Mean emergence percentages in 1989, 1990, and 1991 were 89%, 63%, and 70%, respectively, differences among which were significant ($P<0.01$). Moist, mellow soil contributed to the high percent emergence in 1989. In 1990 and 1991, seed were germinated in moist soil but were covered with soil considered less favorable for emergence than in 1989. Differences in emergence among 3-year planting depth and 3-year genotype means were significant ($P<0.01$) as were the 3-year seed source means ($P<0.05$). All first order interactions among genotypes, seed sources, planting depths, and years were not significant except for year x planting depth and genotype x year ($P<0.01$). Mean emergence of the eight genotypes and of the three planting depths are presented for each year (Figure 2).

In 1989, differences in mean emergence among genotypes were small and not significant and differences among planting depths, although significant ($P<0.01$), were small. Neither the first order interactions nor the second order interaction among genotypes, planting depths, and seed sources were significant.



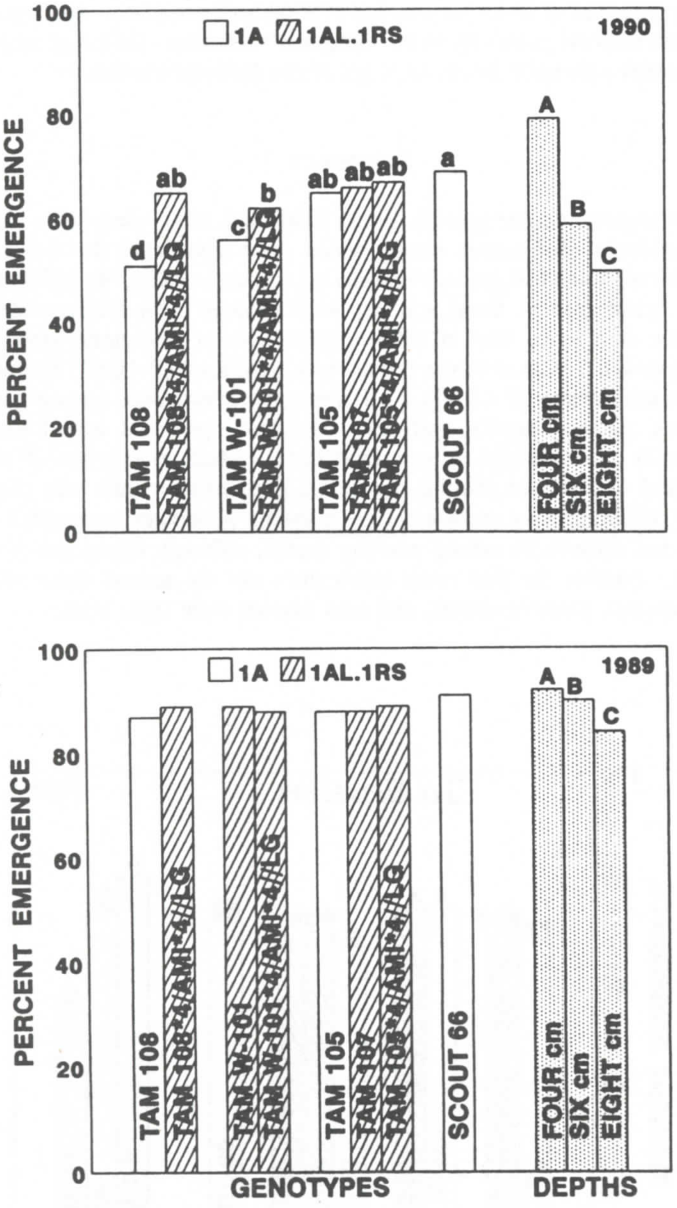


Figure 2. Mean percent field emergence of semidwarf cultivars TAM 108, TAM W-101, and TAM 105, of their respective 1AL.1RS backcross line(s), and of Scout 66; and mean emergence from 4-, 6-, and 8-cm planting depths, in 1989, 1990 and 1991. The presence of either the 1A or 1AL.1RS chromosome is indicated by the genotype bar legend. Significant differences based on Duncan's Multiple Range Test at $P \leq 0.05$ are shown by different letters above the bars: lower case letters for genotypes and capital letters for planting depths. SEs for genotypes=1.10, 1.63 and 1.62 and for planting depths=0.49, 1.78 and 1.87 in 1989, 1990 and 1991.

In 1990, differences in emergence among genotypes and among planting depths were significant ($P<0.01$), but as in 1989, neither the first order interactions nor the second order interaction among the three variables were significant. In 1990, mean emergence of the tall cultivar Scout 66, having substantially longer coleoptiles than the semidwarf genotypes, was significantly greater than that of three genotypes but substantially greater than that of only TAM W-101 and TAM 108. Emergence percentages for TAM W-101 and TAM 108 were only 39% and 37% for the 8-cm planting depth, compared to 59% for Scout 66. All backcross lines having the Amigo translocation exceeded the emergence of their recurrent parent but differences were significant ($P<0.01$) only for lines in which the 1RS segment was in either TAM W-101 or TAM 108 genetic background.

In 1991, the small emergence differences among genotypes were significant ($P<0.05$) as were the greater differences among planting depths ($P<0.01$). Mean emergence of backcross lines with the 1RS segment did not differ significantly from their recurrent parent. Unlike in previous years, differences among seed sources were significant ($P<0.01$) as was the genotype x seed source interaction ($P<0.01$). Planting depth x seed source, genotype x planting depth, and the second order interaction among these variables were not significant. Mean emergence of the Bushland irrigated, Bushland rainfed, and Stinnett rainfed seed sources was 74%, 64%, and 77%, respectively. The genotype x seed source interaction was primarily a result of genotypes TAM W-101 and TAM W-101*4/Amigo*4//Largo from Bushland irrigated and Stinnett sources exceeding the emergence of all other genotypes but being among the lower emerging genotypes from the Bushland rainfed source.

Relationships Among Percent Emergence, Growth Chamber Coleoptile Length, Seed Weight and Depth of Planting

Mean coleoptile lengths of the 22 genotypes of Group I plant material (Table 1) varied from 64 to 100 mm but mean coleoptile length of seedlings of individual pouches (data not given) ranged from 44 to 113 mm, reflecting sampling deviations and differences among genotypes, seed sources, replications and in response to growth mediums. Mean pouch seed weight was 56 mg but gross seed weight of individual pouches ranged from 34 to 75 mg. Differences in coleoptile length and pouch seed weight were substantial but the correlation coefficient between mean coleoptile length and gross seed weight across all pouches, $N=176$, was only 0.11 ($P<0.14$). Correlation coefficients between coleoptile length and seed weight, within growth mediums, $N=8$, were insignificant values of 0.14 and 0.06 and these values within each of the 22 genotypes, $N=88$, were significant for only two genotypes, one of which was a negative value. The same correlations calculated within groups of genotypes with the same genetic background were not significant, and the correlation coefficient between coleoptile length and seed weight among the means of 22 genotypes was only 0.14 ($P<0.53$). Coleoptile length and seed weight of Group I plant material were unrelated.

Correlation coefficients among coleoptile length, seed weight and seedling emergence for genotypes in Group II plant material are given in Table 2. Differences in mean coleoptile lengths among genotypes, shown in Figure 1, were substantial as were differences among genotypes in seed weight (data not shown). Nevertheless, only three of the r values given were significant ($P<0.05$) and all

Table 2. Correlation coefficients (r) between growth chamber coleoptile lengths and seed weights in nine coleoptile evaluations and correlation coefficients of growth chamber mean coleoptile length and plot seed weight with percentage emergence in 1990 and 1991 depth of planting experiments.

	Between growth chamber coleoptile length and seed weight		Correlation coefficient with seedling emergence				
				Coleoptile length		Plot seed weight	
				1990	1991	1990	1991
	N	r	N	r	r	r	r
ACROSS ALL PLOTS	216	0.04	216	0.34*	0.08	0.07	0.12
WITHIN GENOTYPES							
TAM 105	27	-0.16	27	0.27	0.35	-0.30	-0.11
TAM 107(TAM 105*4/AMIGO)	27	0.11	27	0.14	0.24	-0.03	0.06
TAM 105*4/AMIGO*4//LARGO	27	-0.09	27	0.30	0.17	-0.04	-0.04
TAM W-101	27	0.09	27	0.25	0.52**	0.10	0.22
TAM W-101*4/AMIGO*4//LARGO	27	0.22	27	0.13	0.49**	-0.03	0.13
TAM 108	27	-0.05*	27	0.07	0.26	0.05	-0.03
TAM 108*4/AMIGO*4//LARGO	27	-0.39*	27	-0.03	0.04	0.16	-0.21
SCOUT 66	27	0.15	27	-0.17	0.28	0.03	-0.07
AMONG GENOTYPE MEANS	8	0.07	8	0.90**	-0.02	0.23	0.69*
WITHIN SEED SOURCES							
BUSHLAND IRRIGATED	48	0.05	72	0.22	-0.08	0.01	0.24
BUSHLAND DRYLAND	72	0.09	72	0.39*			
STINNETT	48	0.12	72	0.36*	-0.09	0.12	0.14
DALLAS	48	0.18					
AMONG SEED SOURCE MEANS	4	-0.89*	3	0.99**	0.99**	-0.75	0.47
WITHIN PLANTING DEPTHS							
4 cm depth			72	0.45**	0.02	0.11	0.03
6 cm depth			72	0.47**	0.22	0.16	0.20
8 cm depth			72	0.61**	0.06	0.13	0.24
AMONG GENOTYPE MEANS WITHIN							
4 cm depth			8	0.87**	-0.29	0.17	0.04
6 cm depth			8	0.77**	0.22	0.25	0.65
8 cm depth			8	0.88**	-0.04	0.21	0.80**

*Significant at 0.05 level of probability.
**Significant at 0.01 level of probability.

were negative. Coleoptile length of Group II genotypes, as with Group I genotypes, was not meaningfully related to seed weight.

The lack of differences in emergence percentages among genotypes, seed sources, small differences among planting depths and insignificant first order interactions among these variables precluded the possibility of meaningful associations of emergence with seed weight or with coleoptile length in 1989.

The correlation coefficient between percent emergence and coleoptile length, across all plots, although significant ($P<0.05$), in 1990, indicated no more than 12% of the variation in percent emergence could be attributed to variation in coleoptile lengths. Variation in percent emergence within genotypes in 1990 was unrelated to variation in coleoptile lengths, but 81% of the variation in mean emergence among genotypes could be attributed to variation in mean coleoptile lengths. The positive relationship between emergence percentage and coleoptile length among genotypes was about the same magnitude among genotype means within each of the three depths of plantings. In 1991, 25% of the variation in emergence within two genotypes could be attributed to variation in coleoptile length but variation in mean emergence among genotypes was unrelated to variation in coleoptile lengths. In 1990, 16% of the variation in emergence within two seed sources could be attributed to variation in coleoptile lengths, but compelling is the fact that in both 1990 and 1991, 98% of the variation in seed source emergence means could be attributed to variation in coleoptile length. Nevertheless, the small number of seed sources used in this study precludes the conclusion that this relationship would be true among other seed sources. In 1990, coleoptile length had a significant effect on emergence percentages within all depths of plantings. It is notable that 36% of variation in emergence from the 8 cm depth could be attributed to variation in coleoptile length, but no more than 22% of the variation in emergence from either 4 or 6 cm could be attributed to variation in coleoptile lengths. Seed weight had no effect on seedling emergence in 1990, but in 1991 48% of the variation among genotype means could be attributed to variation in mean seed weights. Variation among genotype emergence means was not related to variation among seed weight means when seed was planted 4 cm deep, but when seed was planted 8 cm deep 64% of the variation among genotype emergence means could be positively related to variation in seed weight. Overall 50% of the variation in emergence was attributable to variation in depth of planting.

SUMMARY AND CONCLUSIONS

Coleoptiles of fourteen of 22 Amigo 1AL.1RS backcross lines, in Groups I and II, were significantly longer than coleoptiles of their recurrent parent, but those of only one were more than 10% longer. No translocation line had shorter coleoptiles than its recurrent parent. Coleoptile length rankings of genotypes grown in flats of vermiculite, pouches of water, or in pouches of Hoagland's solution, were comparable, but some genotypes responded positively to the exogenous source of nutrients. Coleoptile length differences among genotypes were unrelated to differences in seed weight.

Differences in field emergence among eight genotypes, which differed significantly in coleoptile length and seed weight, were negligible in 1989, significant ($P<0.01$) and large in 1990, and significant ($P<0.05$) but small in 1991.

Differences in emergence among 4-, 6- and 8-cm planting depths were significant ($P<0.01$) in all years and substantial in 1990 and 1991. In 1990, Scout 66, with the longest coleoptiles, exceeded significantly ($P<0.01$) the emergence of three of the seven semidwarf genotypes, including TAM W-101 and TAM 108 with the shortest coleoptiles. Though differences in emergence among planting depths were significant, the genotype x planting depth interaction was in no year significant. However, in 1990, the emergence percentages of TAM W-101 and TAM 108 from 8 cm were only 39% and 37%, compared to 59% for Scout 66. Emergence of 1AL.1RS lines were significantly greater ($P<0.01$) than that of the recurrent parent only in 1990 in lines in which the 1AL.1RS chromosome was in either a TAM W-101 or TAM 108 genetic background. Across all treatments, differences in coleoptile length in no year accounted for more than 10% of the variation in seedling emergence. However, in 1990, 34% of the variation in seedling emergence from the 8-cm planting depth could be attributed to differences in coleoptile length. In general, emergence and seed weight were unrelated, but in 1991, 64% of the variation in mean emergence among genotypes from the 8-cm planting depths was attributable to variations in seed weight. Overall, fifty percent of variation in emergence was related to differences in planting depth.

It is concluded that the presence or absence of the Amigo 1AL.1RS had little effect on emergence of the genotypes tested. However, no precipitation was received on the three depth-of-planting tests prior to emergence, and results of this study are not necessarily applicable to plantings made under different environments, particularly where precipitation after planting but prior to emergence could cause soil crusting or an increase in soil density.

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First Sight Records of a White-nosed Coati in Texas in Nearly Thirty Years

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ABSTRACT

A white-nosed coati (*Nasua narica*) was seen on two occasions in Victoria County, Texas, while conducting a study on biodiversity of the area. The first sighting occurred on 27 Jul 1994, in riparian habitat approximately 1.0 mi SW of the Guadalupe River and 2.7 mi E of Highway 77 (28° 39' 59" N, 96° 59' 37" W). The second sighting of a coati occurred on 29 Apr 1995; a coati was seen crossing State Road 175 approximately 2.0 mi N of the intersection of Highway 77 and State Road 175 (28° 44' 30" N, 97° 01' 00" W). This represents the first sightings of a coati in Texas in nearly 30 years and the northernmost observation of a coati in the Gulf Prairies region of Texas.

KEYWORDS: *Nasua narica*, range expansion, Victoria County

The white-nosed coati (*Nasua narica*) is considered a native species of the southwestern United States (Kauffman et al., 1976). However, coatis are rarely seen in Texas and can be found only sporadically. Presence of coatis has been documented in the southernmost portion of the state along the Rio Grande (Tabor, 1940; Davis and Schmidly, 1994). The first recorded account of a coati in Texas was from the Brownsville region, Cameron County, Texas, in 1877 (Bailey, 1905). The next three sightings occurred in Maverick, Brewster, and Uvalde counties in 1938, 1939, and 1943, respectively (Davis, 1943; Kauffman et al., 1976). Davis and Schmidly (1994) reported coatis from Aransas and Kerr Counties, Texas. The last three known sightings occurred in the Trans-Pecos region near Big Bend in 1959 (i.e., twice) and 1966 (Kauffman et al., 1976). A road-killed coati was found near Abilene, Texas, in 1975; however, it was considered an escaped pet and not a range expansion of the species due to the surrounding suboptimal habitat (Kauffman et al., 1976). To our knowledge, there have been no other records of free-ranging coatis in Texas.

OBSERVATIONS

As part of a larger study comparing biodiversity of different habitat types in Victoria County, the second author and an associate observed a lone coati on 27 Jul 1994 approximately 10.5 mi S of Victoria, Texas. It was found approximately 1.0 mi SW of the Guadalupe River and 2.7 mi E of Highway 77 (28° 39' 59" N, 96° 59'

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37" W). This is the first known sighting of a coati in Victoria County and the first sighting of a coati in Texas in nearly 30 years.

The coati was observed for about 10 seconds from a distance of approximately 50 yards on a clear day at 1130 hours. It was observed crossing an unimproved road within the riparian area of the Guadalupe River. Both observers noted a raccoon-sized (*Procyon lotor*) animal with an elongated snout, reddish brown in color, and a slendor tail as long as its head-body length, which was held vertically erect. Soils of this area consist of deep, moderately-permeable clay which are subjected to frequent floods (USDA, 1982). On this day, the soil was dry with a hard crust that precluded identifiable tracks.

A second sighting of a coati in Victoria County occurred on 29 Apr 1995. The first author observed a coati at 1530 hours crossing State Road 175, approximately 2.0 mi N of the intersection of HWY 77 and State Road 175 (28° 44' 30" N, 97° 01' 00" W). The coati was travelling in an eastwardly direction, moving toward the northern shore of Stubbs Lake, located approximately 1.0 mi W of the Guadalupe River. Once across the highway, the coati appeared to forage with its tail in an upward position and curved forward over its back. The coati was followed for about 1 minute; the first author approached as close as 10 yards before the coati disappeared in the brush. Due to the moist clay soil, tracks were left by the animal. Front and hind tracks consisted of five toes with deep claw marks approximately 0.3 inches in front of each toe. Front tracks were slightly smaller than the hind tracks. Front tracks, on average, measured 1.5 inches long by 1.6 inches wide, while hind tracks, on average, measured 1.8 inches long by 1.6 inches wide. The heel pad of the hind feet registered a longer extension on the outside portion of the track than on the inside portion of the heel pad. Overall, the tracks resembled those of a ringtail (*Bassariscus astutus*), only much larger.

Woody plants identified on both areas of coati sightings included hackberry (*Celtis* sp.), pecan (*Carya illinoensis*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), and black willow (*Salix nigra*). Dominant understory included eastern gamagrass (*Tripsacum dactyloides*), common bermudagrass (*Cynodon dactylon*), rustyseed paspalum (*Paspalum langei*), cocklebur (*Xanthium chinense*), mustang grape (*Vitis mustangensis*), palmetto (*Sabal minor*), and sedges (*Carex* sp.). Victoria County is characterized as having a humid subtropical climate, receiving 38 inches of annual precipitation (USDA, 1982). This habitat description is consistent with known coati habitat preference for tropical woodlands (Kauffman et al., 1976).

DISCUSSION

Because coatis are listed as endangered by the State of Texas, collection of a specimen for deposition in a museum to document its occurrence was undesirable. Even though a voucher specimen does not exist, we believe it highly unlikely to have misidentified the animal. No other comparable species exhibits the "tail-up" posture like the coati (Russell, 1984), and the tracks left by the animal were consistent with those described for coatis (Murie, 1954). These sightings constitute the northernmost occurrence of a coati in the Gulf Prairies and Marshes Vegetational Area of Texas.

Attempts were made at both sighting locations to capture a coati in Havahart single door cage traps. However after 2400 trap-hours, only six raccoons and two opossums (*Didelphis virginiana*) were captured. Area residents (n = 15) were questioned and shown a photograph of a coati; no one remembered seeing such an animal. However, several responded that they do not frequently travel roads along the Guadalupe River, therefore, limiting their chances of observing a coati.

The lone specimen could have been a wandering adult male. Adult males are documented as being largely solitary (Russell, 1981; Davis and Schmidly, 1994) and can live up to seven years in the wild (Russell, 1984). Coatis also are known to be mobile and adaptable, capable of crossing deserts and grasslands in order to reach optimal habitat (Kauffman et al., 1976). It is possible that the same animal was seen on both occasions. The two sighting locations were only 5 miles apart; the second sighting was 9 months after the first.

We believe it unlikely that the observed coatis were escaped pets or zoo specimens. The only zoo in South Texas that has coatis is the Texas Zoo, which is located in Victoria, Texas. They reported no missing specimens. Regional game officials were not aware of individuals keeping or breeding coatis locally. Coatis are not a common animal in the pet trade industry within the United States (L. Shotts, TPWD biologist, pers. comm.). Because they are endangered, coatis only can be sold legally as pets if they were born in captivity and documentation exists to substantiate their captive status (Texas Parks and Wildlife, 1989).

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Control of Hophornbeam Copperleaf (*Acalypha ostryifolia* Riddell) and Ivyleaf Morningglory (*Ipomoea hederacea* L. Jacq.) in Peanut (*Arachis hypogaea* L.)

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ABSTRACT

Copperleaf control in peanut was difficult to obtain with either soil-applied or postemergence herbicides. Control was most consistent with RH-1658 or Dual plus Cobra applied at peanut emergence and followed by Cobra postemergence. Cobra applied postemergence controlled ≥98% copperleaf while Cadre control was inconsistent. The lack of consistent control with Cadre may be due to the size of copperleaf (4 to 6 inches tall) at the time of herbicide application. Ivyleaf morningglory control with soil-applied herbicides was most consistent with Sonalan plus Pursuit applied preplant incorporated. Butyrac and Cadre applied postemergence controlled ≥90% ivyleaf morningglory while Blazer, Pursuit, and Storm controlled >80% ivyleaf morningglory. Tough control of morningglory was inconsistent.

Some broadleaf weeds such as Hophornbeam copperleaf (*Acalypha ostryifolia* Riddell) and ivyleaf morningglory [*Ipomoea hederacea* (L.) Jacq.] are a continuing problem in certain areas of the state. Dowler (1995) ranks hophornbeam copperleaf and morningglory spp. among the ten most troublesome weeds and morningglory spp. among the ten most common weeds in Texas peanuts. Copperleaf is a problem in peanuts along the Red River area of Texas as well as in certain areas of central Texas (author's personal observation). It can be found in Texas from Cooke and Grayson Counties west to Nolan County and south to Medina, San Patricio, and Harris Counties (Correll and Johnston, 1979).

Ivyleaf morningglory is found in peanut fields mostly in south and central Texas (author's personal observation). It is commonly found from east Texas west to the west Cross Timbers area of the state, south to the Rio Grande (Correll and Johnston, 1979).

In the past, most research has focused on the control of annual morningglories encompassing many species. Only in recent years have researchers evaluated the competitiveness and control of individual morningglory species and determined that they vary in competitiveness (Cordes et al., 1984; Higgins et al., 1988) and response to herbicides (Barker et al., 1984; Wilcut et al., 1991a,b; Wilcut et al., 1994b).

The herbicide, 2,4-DB, is used for controlling *Ipomoea* morningglory species (Buchanan et al., 1982). Smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.] is more tolerant of 2,4-DB than *Ipomoea* morningglory species (Wilcut et al., 1994c). Pitted morningglory (*Ipomoea lacunosa* L.) is the most 2,4-DB-tolerant

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Ipomoea morningglory species (Barker et al., 1984).

Pursuit provides excellent full-season control (greater than 90%) of *Ipomoea* morningglory species (Wilcut et al., 1991a,b; Wilcut et al., 1994b). Research in the southeast noted that the greatest control of *Ipomoea* spp. was obtained with systems that used two applications of Cobra either with or without Lasso, or with a single late postemergence (LPOST) application of either Blazer + Basagran or Cobra (Jordan et al., 1993). However, in one year of the study, Blazer + Basagran LPOST controlled the *Ipomoea* spp. better than one application of Cobra POST (Jordan et al., 1993). Blazer is considered to be a better POST herbicide for *Ipomoea* spp. control than Cobra (Higgins et al., 1988).

Cadre was cleared for use in peanuts during the spring of 1996. Cadre in soybeans (*Glycine max* L.) controlled sicklepod (*Cassia obtusifolia* L.) and *Ipomoea* morningglory species (Griffin et al., 1993; Wixson et al., 1991). Wilcut et al. (1994b) reported that Cadre controlled the *Ipomoea* morningglories which included ivyleaf morningglory at least 91%. Cadre was more effective than Pursuit applied preplant incorporated (PPI), preemergence (PRE), or early postemergence (EPOST). Although Pursuit controls *Ipomoea* morningglories applied either PPI, PRE, EPOST, or POST (Wilcut et al., 1991a,b), maximum control is obtained with EPOST applications on small *Ipomoea* morningglories (Klingman et al., 1992). Cobra and Tough also are effective against small *Ipomoea* morningglories (Jordan et al., 1993; Wilcut, 1991; Wilcut et al., 1994c).

Soil-applied herbicides provide little or no *Ipomoea* morningglory control (Richburg et al., 1995). Dual does not control the *Ipomoea* morningglories (Richburg et al., 1995). Pursuit applied PPI alone has partially controlled the *Ipomoea* morningglories (Richburg et al., 1995).

Little information is available on the control of hophornbeam copperleaf and ivyleaf morningglory in peanut in the southwestern U.S. This research was undertaken to identify herbicides which have efficacy against copperleaf and ivyleaf morningglory when soil-applied or POST applied.

MATERIALS AND METHODS

Two separate studies were conducted in 1993 and 1994 in a producer's field in Comanche County near Comyn, Texas, to determine the most effective control of hophornbeam copperleaf and ivyleaf morningglory with soil-applied and postemergence herbicides. These fields had naturally high populations of copperleaf and ivyleaf morningglory.

The experimental design was a randomized complete block with three replications. Plots consisted of two 15 to 20 feet long rows with a row spacing of 36 inches. Copperleaf and morningglory populations were moderate to heavy (3 to 4 plants ft^{-2}). To prevent annual grasses from interfering with the copperleaf and morningglory growth and development, Poast (sethoxydim) was used to control Texas panicum (*Panicum texanum* Buckl.) and southern crabgrass [*Digitaria ciliaris* (Retz.) Koel].

Soil-applied study

Herbicide treatments included Dual (metolachlor) alone at 1.5 lb ai $acre^{-1}$ applied PRE, Frontier (dimethenamid) alone at 1.0 lb ai $acre^{-1}$ applied PRE or 1.25

lb ai acre^{-1} applied PPI or PRE, Prowl (pendimethalin) alone at 0.75 lb ai acre^{-1} applied PPI, RH-1658 at 0.067 lb ai acre^{-1} applied PRE, Sonalan (ethalfluralin) alone at 1.12 lb ai acre^{-1} applied preplant incorporated (PPI), Pursuit (imazethapyr) alone at 0.063 lb ai acre^{-1} applied PRE, Dual at 1.5 lb ai acre^{-1} in combination with Cobra (lactofen) at 0.25 lb ai acre^{-1} applied at peanut emergence (EMERGENCE) followed by Cobra at 0.20 lb ai acre^{-1} applied postemergence (POST), Dual at 1.5 lb ai acre^{-1} in combination with Cobra applied at EMERGENCE followed by Cobra at 0.2 lb ai acre^{-1} in combination with Butyrac at 0.25 lb ai acre^{-1} applied POST, Dual at 1.5 lb ai acre^{-1} in combination with Pursuit at 0.063 lb ai acre^{-1} applied PRE, Prowl at 1.0 lb ai acre^{-1} in combination with Dual at 1.5 lb ai acre^{-1} applied PPI, Prowl at 0.75 lb ai acre^{-1} applied PPI followed by Dual at 1.5 lb ai acre^{-1} applied PRE, Prowl at 0.75 or 1.0 lb ai acre^{-1} in combination with Pursuit at 0.063 lb ai acre^{-1} applied PPI, and Sonalan at 0.75 or 1.12 lb ai acre^{-1} in combination with Pursuit at 0.063 lb ai acre^{-1} applied PPI.

Postemergence study

Treatments included Blazer (acifluorfen) at 0.5 lb ai acre^{-1}, Butyrac (2,4-DB) at 0.3 lb ai acre^{-1}, Cadre (imazameth) at 0.032, 0.048, 0.055 and 0.063 lb ai acre^{-1}, Cobra at 0.25 lb ai acre^{-1}, Pursuit at 0.063 lb ai acre^{-1}, Storm (bentazon + acifluorfen) at 0.75 lb ai acre^{-1}, Tough (pyridate) at 0.9 lb ai acre^{-1}, Blazer at 0.375 lb ai acre^{-1} in combination with Butyrac at 0.25 lb ai acre^{-1}, Cadre at 0.063 lb ai acre^{-1} in combination with Butyrac at 0.25 lb ai acre^{-1}, Cadre at 0.063 lb ai acre^{-1} in combination with Blazer at 0.5 lb ai acre^{-1}, Cadre at 0.063 lb ai acre^{-1} in combination with Tough at 0.45 lb ai acre^{-1}, Tough at 0.9 lb ai acre^{-1} in combination with Butyrac at 0.25 lb ai acre^{-1}, and Tough at 0.75 lb ai acre^{-1} in combination with Butyrac at 0.25 lb ai acre^{-1}.

Herbicides were applied with a compressed-air bicycle sprayer using Teejet 11002 flat fan nozzles (Spraying Systems Co., Wheaton, IL 60188) which delivered a spray volume of 20 gal acre^{-1} at 26 psi. Preplant incorporated herbicides were applied and immediately incorporated to a 2 inch depth with a tractor-driven power tiller. PRE herbicides were applied immediately after peanuts were planted. EMERGENCE herbicide treatments were applied approximately 7 days after planting when the peanut cotyledon was emerging from the ground. Sprinkler irrigation was applied as needed throughout the growing season.

'Florunner' peanuts were planted both years of the study at 90 lb acre^{-1}. Visual ratings of weed control were recorded at various intervals throughout the growing season. However, only ratings taken prior to peanut digging are presented. In both years of the study, the peanuts were dug, but not harvested because of rain for 2 to 3 continuous weeks. In the weedy plots, soil remained attached to the roots and the peanut pods never were able to dry and fell off, therefore many of the pods could not be harvested which prevented an accurate assessment of yield.

Weed control ratings were subjected to an analysis of variance and differences among means were determined by Fisher's Protected LSD Test at the 5% probability level. Copperleaf and ivyleaf morningglory size varied at the time of POST herbicide application. Most of the copperleaf was approximately 4 inches tall but plant height ranged from less than 2 inches up to 6 inches. Pursuit and Cadre treatments included X-77, a nonionic surfactant (Valent USA, San Francisco, CA) at 0.25% v/v while Tough, Butyrac, Blazer, and Storm included Agridex (Helena

Chemical Co.), a nonphytotoxic petroleum oil based adjuvant at 1 qt acre^{-1}. Cobra included Agridex at 1 pt acre^{-1}.

RESULTS AND DISCUSSION

Soil-applied herbicides

Ivyleaf morningglory control was most consistent (≥95%) with Sonalan at 1.12 lb ai acre^{-1} plus Pursuit at 0.063 lb ai acre^{-1} applied PPI (Table 1). Sonalan alone at 1.12 lb ai acre^{-1} controlled at least 82% ivyleaf morningglory while Pursuit alone controlled ≥70% ivyleaf morningglory (Table 1). Wilcut et al. (1994c) reported that the *Ipomoea* species did not exhibit a differential response to Pursuit. Although Pursuit controls *Ipomoea* morningglories applied either PPI, PRE, EPOST or POST (Wilcut et al., 1991a,b), maximum control is obtained with EPOST applications on small *Ipomoea* morningglories (Klingman et al., 1992).

Overall, ivyleaf morningglory control was much better in 1993 than 1994. This may be due in part to a reduction in the overall copperleaf populations in 1994 which reduced competition. In 1993, only one herbicide treatment controlled less than 80% morningglory while in 1994 only two treatments controlled >95% morningglory (Table 1).

Copperleaf control was most consistent with RH-1658 or Dual plus Cobra applied at peanut emergence and followed by Cobra POST (Table 1). Little is known about the chemistry of RH-1658, but it does have good activity against Palmer amaranth (*Amaranthus palmeri* S. Wats) and eclipta (*Eclipta prostrata* L.) as well as yellow nutsedge (*Cyperus esculentus* L.) (author's personal observation). Jordan et al. (1993), reported that a herbicide system which included sequential applications of Cobra at EMERGENCE followed by EPOST was the most effective herbicide system for control of broadleaf weeds. They stated that this system provided superior control of prickly sida (*Sida spinosa* L.) and common lambsquarters (*Chenopodium album* L.) than the standard of Blazer + Basagran. This system was the only system to yield as high as the weed-free checks. Frontier, which has shown to have excellent eclipta activity (Grichar and Colburn, 1996; Blum et al., 1996) provided poor copperleaf control in 1993 (<65%) but excellent control in 1994 (≥87%).

Sonalan plus Pursuit controlled 63 to 87% copperleaf while Prowl plus Pursuit controlled 65 to 100% copperleaf. Sonalan or pendimethalin alone does not have appreciable activity on large seeded broadleaf weed species (Wilcut et al., 1994c).

Postemergence herbicides

Cadre alone or in combination with Tough, Blazer, or Butyrac and Butyrac alone controlled ≥89% ivyleaf morningglory in both years (Table 2). Peanut is tolerant of Butyrac applied POST for broadleaf weed control (Buchanan et al., 1982). Smallflower morningglory is more tolerant of Butyrac than *Ipomoea* morningglory species (Wilcut et al, 1994c). Pitted morningglory is the most 2,4-DB-tolerant *Ipomoea* morningglory species (Barker et al., 1984).

Blazer, Pursuit, and Storm controlled >80% morningglory. Blazer applied POST is widely used in the Virginia-North Carolina and southwestern peanut regions of the U.S. (Wilcut et al., 1995). Blazer controls *Amaranthus* species, common

Table 1. Ivyleaf morningglory and copperleaf control with soil-applied herbicides.

			Control			
			1993		1994	
Treatment	Rate	Application Timing†	Ivyleaf	Copperleaf	Ivyleaf	Copperleaf
	(lb ai acre^{-1})		%			
Check	-	-	0	0	0	0
Dual	1.5	PRE	80	60	60	77
Frontier	1.0	PRE	75	23	23	87
Frontier	1.25	PPI	97	53	7	100
Frontier	1.25	PRE	87	62	37	87
Prowl	0.75	PPI	80	72	53	63
RH-1658	0.07	PRE	90	92	60	87
Sonalan	1.12	PPI	82	63	100	100
Pursuit	1.5	PRE	97	40	73	53
Dual	1.5	EMERGENCE/	88	88	17	100
+Cobra/	0.25	POST/				
Cobra	0.2	POST				
Dual	1.5	EMERGENCE/	90	98	47	77
+Cobra/	+0.25					
Cobra	0.20	POST				
+Butyrac	+0.25					
Dual	1.5	PRE	96	58	63	100
+Pursuit	+0.063					
Prowl	1.0	PPI	83	72	73	100
+Dual	+1.5					
Prowl	0.75	PPI	99	79	73	100
+Pursuit	+0.063					
Prowl	1.0	PPI	97	65	73	100
+Pursuit	+0.063					
Sonalan	0.75	PPI	93	63	77	87
+Pursuit	+0.063					
Sonalan	1.12	PPI	95	73	100	77
+Pursuit	+0.063					
LSD (0.05)			16	29	48	33

†PPI=preplant incorporated; PRE=preemergence; EMERGENCE=peanut emergence; POST=postemergence.

Table 2. Ivyleaf morningglory and copperleaf control with postemergence herbicides.

Treatment	Rate	Control			
		1993		1994	
		Ivyleaf	Copperleaf	Ivyleaf	Copperleaf
	(lb ai $acre^{-1}$)	%			
Check					
Blazer	0.5	90	95	82	77
Butyrac	0.3	95	70	94	43
Cadre	0.032	89	67	92	62
Cadre	0.048	93	65	96	80
Cadre	0.055	92	83	99	69
Cadre	0.063	95	67	99	77
Cobra	0.25	80	100	70	98
Pursuit	0.063	85	55	88	67
Storm	0.75	82	89	87	57
Tough	0.9	73	80	83	83
Blazer+Butyrac	0.375 + 0.25	93	88	88	60
Cadre+Blazer	0.063 + 0.5	92	95	96	88
Cadre+Butyrac	0.063 + 0.25	97	95	93	75
Tough+Cadre	0.45 + 0.063	92	93	97	83
Tough + Butyrac	0.75 + 0.25	80	98	85	63
Tough + Butyrac	0.9 + 0.25	77	88	73	88
LSD (0.05)		16	23	18	23

lambsquarters, common ragweed (*Ambrosia artemisiifolia* L.), eclipta, horse purslane (*Trianthema portulacastrum* L.), jimsonweed (*Datura stramonium* L.), smartweed (*Polygonum pensylvanicum* L.), and tropic croton (*Croton glandulosus* Muell. Arg.) (Buchanan et al., 1982; Wilcut et al., 1990; Wilcut, 1991; Grichar et al., 1993; Wilcut et al., 1994c).

The addition of Butyrac to Tough, Cadre, or Blazer did not improve ivyleaf morningglory control over any of those herbicides alone (Table 2). Many POST broadleaf herbicides are applied in mixture with Butyrac which helps improve control of many broadleaf species, particularly if the weeds are larger than recommended size for treatment (Wilcut et al., 1995). In the southeast, Butyrac is commonly applied with foliar fungicides to reduce the expense of making two separate applications (Wilcut et al., 1995).

Cobra POST provided ≥98% copperleaf control in both years. Cobra has shown promise for control of eclipta (*Eclipta prostrata* L.) in Texas peanuts (Grichar and Colburn, 1996). Cobra is not as efficacious as Blazer on *Ipomoea* morningglory species (Higgins et al., 1988) but provides better control of common ragweed, prickly sida (*Sida spinosa* L.), and spurred anoda [*Anoda cristata* (L.) Schlecht.] (Wilcut et al., 1990). Jordan et al., (1993) reported that POST systems which included a minimum of one application of Cobra provided ≥99% eclipta control.

Cadre control of copperleaf was inconsistent with control ranging from 62 to 83% (Table 2). The erratic control of copperleaf may be due to the size of the copperleaf at the time of Cadre application (4 to 6 inches tall). Copperleaf treated with Cadre in an adjacent field when the copperleaf plants were no larger than 2 inches in height provided better than 90% control (author's personal observations).

Tough and Blazer controlled 77 to 95% copperleaf (Table 2). The addition of Butyrac to Tough or Blazer did not improve copperleaf control over Tough or Blazer alone while the addition of Butyrac to Cadre at 0.063 lb ai acre^{-1} resulted in a 28% increase in control in 1993 and a 2% reduction in control in 1994 over Cadre alone at 0.063 lb ai acre^{-1}.

CONCLUSION

Effective control of copperleaf and ivyleaf morningglory is possible; however, a single application of a herbicide may not be enough in most instances to provide season-long control. The use of a dinitroaniline herbicide in combination with Pursuit followed by Blazer or Cobra should provide control. Cadre may be an option if applied to copperleaf ≤2 inches in height.

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Economics of Yield and Returns Variability with Dryland Cotton Cropping Systems

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ABSTRACT

Cotton production in the Texas High Plains region accounts for 15 to 18% of the total cotton production in the United States. About half of the cotton in this region is grown under dryland conditions. Although much of the cotton in the region is produced using a conventional tillage cropping system, several alternative cropping systems are becoming increasingly accepted. The objective of this study was to evaluate the relative economic performance of the conventional tillage dryland cotton production system and several conservation tillage dryland cotton production systems on the Texas High Plains. The net economic returns to six feasible dryland cropping systems were ranked using stochastic dominance with respect to a function. Four conservation cropping systems (reduced tillage continuous cotton, wheat-cotton reduced tillage, sorghum-cotton reduced tillage, and no-till continuous cotton) are confirmed to be superior to the widely accepted conventional cotton cropping system. These four conservation systems increased stability and profitability over the conventional tillage system. Hence these alternatives are options that producers should consider as conservational tillage systems in dryland cotton production and may be better suited to producer risk preferences than conventional practices.

KEYWORDS: wheat, sorghum, stochastic dominance

The Texas High Plains (THP) is a 25-county semi-arid region in northwest Texas with annual average rainfall of 471 mm and a frost-free growing season of 153 days. Cotton is the most economically important agricultural product originating in the area. Around 7.5 million hectares of cotton are planted each year in the Texas High Plains (Texas Agricultural Statistics Service, 1994). Approximately half the cotton area is farmed dryland without irrigation. Average economic returns have historically been greater from cotton than from other agronomic crops, inducing a gradual shift of most of the agricultural resources toward a conventional tillage cotton monoculture.

Conventional tillage production generally follows the order of operations listed in Table 1. Following harvest, cotton stalks are destroyed, followed by a deep tillage operation. Before planting in the spring, herbicide and fertilizer are

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incorporated and beds are formed. Planting and cultivation begin in May. The growing season extends throughout the summer and fall, and cotton is typically harvested in October or November. Prior to harvest, about ten field operations are performed.

Fewer operations are included in the alternative tillage systems. The operations in a representative crop season are listed in Table 1. The crop is planted into the residue of the previous crop, and additional herbicides are used for weed control, eliminating some of the tillage practices. Through the elimination of many of these operations, production costs such as labor, fuel, and machinery costs are lowered.

Conservation tillage systems generally provide benefits such as conservation of soil moisture and reduction of soil erosion from wind and water. Several studies have substantiated these benefits. A study by Unger et al. (1991) found that although no-tillage changed the distribution of organic matter and some plant nutrients in the soil, changes were relatively small and no-tillage appeared to be a viable cropping practice for conserving soil and water and maintaining crop productivity on dryland in the southern Great Plains. Likewise, a study by Eck and Jones (1992) found that conservation tillage practices reduced soil erosion and increased precipitation storage efficiency. Additionally, Wagger and Denton (1989) found that corn and soybean yield increases were attributed primarily to greater soil moisture availability as a result of reduced runoff using no-tillage.

Resulting from emphasis on conservation in government agricultural policy, conservation tillage systems have received increased attention from producers in the THP. However, like all aspects of agricultural production, widespread acceptance of conservation tillage practices for cotton in the region depends on the relative long-term profitability of each system as compared to feasible alternatives. Harman et al. (1989) found support for conservation's profitability when it was determined that although herbicide costs were greater than with no-tillage, long-term annual profit of cotton on the southern High Plains with no-tillage increased \$82 ha^{-1} over conventional tillage because of increased yield and lower machinery depreciation costs. Further, in a study of no-tillage versus conventional tillage, Bordovsky et al. (1994) found that no-tillage significantly increased total revenue by increasing lint yields of cotton 6.9 and 5.5% for dryland and irrigated, respectively. Likewise, Morrison et al. (1990) found that, under no-tillage practices, soil is protected, resource use is lowered, and crop yields are maintained. All these studies indicated that profitability is attainable with conservation techniques, thus providing a viable alternative for producers. The objective of this study was to evaluate the relative economic performance of the conventional tillage dryland cotton production system and several conservation tillage dryland cotton production systems on the THP.

MATERIALS AND METHODS

In 1987, long-term dryland cropping systems experiments were established at the Texas Agricultural Experiment Station at Lubbock, TX. The soil type at the experimental site is an Acuff loam (fine-loamy, mixed, thermic Aridic Paleustolls) with 50% sand, 21% silt, and 29% clay with a pH of 7.8. Experiments were conducted on 7.9 m by 15.2 m randomly arranged plots. Treatments (cropping systems) included conventional tillage system in continuous cotton and five

Table 1. Cropping system practices at the Texas Agricultural Experiment Station, Lubbock, TX.

Conventional	Reduced	No till	Terminated Wheat/Cotton	Sorghum/ Cotton	Wheat/ Cotton
Shred stalks	Shred stalks	Apply 2,4-D & diuron	Plant wheat	Apply 2,4-D & diuron	Apply 2,4-D & diuron
Disc					
Disc in trifluralin & fert.	List in trifluralin & fert.			Apply glyphosate & diruon	
Plant	Plant & apply caparol	Plant & apply prometryn, glyphosate, metolachlor, & caparol	Plant & apply prometryn, glyphosate, metolachlor, & caparol	Plant & apply caparol, glyphosate, & Dual	Plant & apply caparol, glyphosate, & Dual
Rotary hoe	Rotary hoe	Rotary hoe			
Cultivate 3 times	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time	Cultivate 1 time
Harvest	Harvest	Harvest	Harvest	Harvest	Harvest

alternative tillage cropping systems: reduced tillage system in continuous cotton, no-tillage system in continuous cotton, reduced tillage cotton system with terminated wheat cover crop, a reduced tillage cotton rotation with sorghum, and a reduced tillage cotton rotation with wheat. Cropping and tillage systems were initiated in 1987, and data used in this study were collected for the crop years 1988-1994. Prior to the establishment of these cropping system plots, the area had been in continuous cotton production for five years.

In conventional-tillage continuous cotton, standard land preparation, herbicide, and tillage practices were used (Table 1). In the reduced till continuous cotton, deep tillage was eliminated and trifluralin was incorporated in the bedding operation. In no-till continuous cotton, the crop was planted into the old stalks without any tillage. Winter weeds were controlled with an early preplant application of 2,4-D + diuron. Glyphosate was applied at planting as a burn-down to emerged weeds and metolachlor + prometryn was applied pre-emergence. Similar herbicide treatments were used on the wheat-cotton, and sorghum-cotton rotations. In the terminated wheat-cotton system, wheat was drilled into the cotton stalks after harvest as a winter cover crop. The wheat was terminated with glyphosate at 0.43 kg ha^{-1} in April.

Fertilizer applications were based on yearly soil tests of each plot. Fertilizer applications were 22 to 33 kg N ha^{-1} and 22 kg P ha^{-1} for dryland cotton. Cotton lint yield was determined by harvesting and ginning 4.0 m of two rows from each plot. Gross returns per hectare were calculated as lint yield times the market price and did not reflect government deficiency payments. Total costs of production were separated into two components: preharvest and harvest costs. Because harvesting costs are a function of actual cotton yields, they varied across cropping systems. Cost of mechanical operations were based on the Texas crop enterprise budgets (TAES, 1994). Variable input costs were based on local prices for seed, fertilizer, herbicide, and irrigation.

Behavior and patterns of average yields and returns provide the producer with useful tools for production planning; however, only the variability of yields and returns allows the producer to examine the relative risk associated with particular cropping practices. To accommodate the need for a valuation of relative risk, the stochastic dominance with respect to a function (SDRF) technique was used, King and Robison (1981). The SDRF is a valuative criterion that orders variable alternatives for a defined set of decision makers who have an absolute risk aversion coefficient that falls between specified upper and lower bounds. The absolute risk aversion coefficient (ARAC), defined as the negative ratio of the second derivative of a von Neumann-Morgenstern utility function to the first derivative of the same function, is a measure of the degree of convexity or concavity of the decision maker's utility function. Since the slope of a utility function is accepted to be positive, a positive ARAC suggests the second derivative is negative, indicating a concave utility function. Accordingly, the absolute risk aversion coefficient serves as a suggestion of the risk preference for the decision maker. Because the absolute risk aversion coefficient is a unique measure that holds across preferences and the utility function is unique only to a positive linear transformation, the former provides a less restrictive measure of risk preference. A major advantage of SDRF as a valuation criterion is that it imposes no limitations on the upper or lower bounds of the absolute risk aversion interval. The interval can be specified as small or large as necessary to account for the uncertainty in the approximation of the coefficient.

Formally, the SDRF method designates a necessary condition that ensures the domination of one distribution over another for a given range of absolute risk aversion. Given two distributions, ***A*** and ***B***, the necessary condition for the dominance of distribution ***A*** over distribution ***B*** is that the area in the limit, as the X variable approaches $+\infty$, above the cumulative distribution function of distribution ***A*** be greater than the same for the cumulative distribution function of distribution ***B***.

Yield data points were taken from three plots of each cropping system for each of the six sample years. Therefore, eighteen yield data points were used along with costs of production and revenues specified in 1993 values to find eighteen net revenue calculations for each cropping system. Following King and Robison, (1981), the SDRF technique was used to compare the net revenues given alternative absolute risk aversion intervals. Three risk aversion intervals were specified. The intervals span the range of the absolute risk aversion coefficient from -.0003 to .0006. SDRF was performed for each interval.

RESULTS AND DISCUSSION

Dryland cotton lint yields exhibit wide fluctuation relative to rain patterns during the growing season. Table 2 summarizes the overall average and standard deviation of cotton yields for each of the six cropping systems.

Monthly rain for each year is found in Table 3. Rain in four of the six years is below the 75-yr. average, with three of those years enduring a below average measure of at least 76 millimeters. In spite of low rain in 1988, yields were above average for all systems except the sorghum-cotton rotation, resulting from acutely dry conditions throughout most of the rest of the sample period reducing the overall average.

Severely dry conditions in 1988 and 1989 lead to below average yields in 1989 for all systems except for the wheat-cotton rotation. Rain for 1990 was below average; however, timely rains in April and through the last part of the summer lead to above average yields for all systems except reduced tillage in that year.

Annual rain in 1991 exceeded the long-run average by over 75 mm due to heavy rains in September. The September rainfall was over 76 mm above the 75-year average, leading to extremely wet conditions late in the growing season when excessively wet conditions are detrimental to yield. As a result, the yields for all systems in 1991 were below the sample average. However, average yields for all the cropping systems were well above the sample average, resulting from significant and timely rain throughout the growing season in 1992.

Cotton yields in 1993 for the continuous cotton systems were significantly below sample averages, while yields for the two cotton rotations were higher than average. Above average precipitation during the last two months of 1992, resulting in good residual moisture on the rotation systems accounted for the yield differential.

Average net revenues for each system for the six year sample are found in Table 4. Revenues in Table 4 do not reflect government deficiency payments. Slight variations in the price of cotton existed across systems resulting from differences in fiber quality. The values in Table 4 are presented in 1994 dollars.

The reduced tillage continuous cropping system outperformed the other systems on the basis of mean net revenue above total costs. However, the wheat-cotton

Table 2. Average cotton yields on dryland cropping systems at Lubbock, TX, 1988-1994.

Cropping System	1988	1989	1990	1991	1992	1993	1994	Mean	Std. Dev.
					----kg ha^{-1}----				
Conventual tillage	263	175	274	178	464	170	110	233	116
Reduced tillage	413	243	271	235	503	221	197	298	115
No-till	343	222	302	177	459	212	110	261	116
Terminated wheat-cotton	298	174	0	183	473	91	81	186	158
Sorghum-cotton reduced	317	263	353	357	512	412	169	340	109
Wheat-cotton reduced	542	637	428	372	576	558	342	494	112

Table 3. Monthly rainfall at Lubbock, Texas, 1988-1994.

	1988	1989	1990	1991	1992	1993	1994	75 year average
	mm							
Jan	8	11	12	30	34	26	9	13
Feb	11	26	44	11	51	10	4	17
Mar	6	17	15	2	35	9	5	22
Apr	36	7	34	0	32	29	79	31
May	58	10	21	45	133	52	97	68
Jun	40	125	5	103	112	96	7	67
Jul	85	8	148	59	43	21	53	56
Aug	11	86	38	53	40	45	2	52
Sep	63	89	27	147	18	6	30	63
Oct	3	0	53	9	0	12	18	50
Nov	6	0	32	29	37	8	19	16
Dec	13	6	10	65	35	8	4	17
Total	340	385	439	552	569	324	327	471
Percent of 75 yr. Mean	72	82	93	117	121	69	69	

National Weather Service, Lubbock, TX.

Table 4. Net revenues above total costs in 1994 prices for dryland cotton systems at Lubbock, TX.

Cropping System	1988	1989	1990	1991	1992	1993	1994	Mean	Std. Dev.
	-------------------------------				$\$ \text{ ha}^{-1}$				-------------------------------
Conventional tillage	40.88	38.14	63.30	-36.37	251.72	-48.51	-68.32	40.21	104.03
Reduced tillage	202.82	157.13	133.96	34.92	281.38	26.72	69.98	123.61	106.45
No-till	101.81	106.79	103.05	-25.46	180.11	1.41	-50.22	63.91	77.57
Terminated wheat-cotton	72.15	32.80	-161.20	-38.56	192.41	-114.61	-114.44	-9.05	116.25
Sorghum-cotton reduced	78.16	45.00	64.40	56.38	249.55	61.17	-74.10	74.95	80.13
Wheat-cotton reduced	171.55	245.24	77.65	43.65	92.95	142.38	83.98	115.35	75.98

rotation showed a comparable value. The net revenue of these two systems far exceeded those of the remaining four. The systems ranked according to net revenue above total cost in the following order: (1) Reduced tillage continuous cotton; (2) Wheat-cotton reduced tillage; (3) Sorghum-cotton reduced tillage; (4) No-till continuous cotton; (5) Conventional tillage continuous cotton; and (6) Terminated wheat-cotton.

The cropping systems were next ranked using SDRF to determine if the order would change from that found using average net revenues when the standard deviations of those net revenues are considered. Likewise, the SDRF provides insight in determining if the ordered systems might change given alternative levels of producer risk preference represented by the absolute risk aversion coefficient.

The results from the SDRF are found in Table 5. A "1" to the right of any pair of cropping systems indicates that the first cropping system dominated the second. A "-1" to the right of any pair indicates that the second system dominated the first. For example, a "-1" is found to the right of the first pair of systems, CONVTILL-REDTILL, indicating that REDTILL distribution of net revenues dominated CONVTILL distribution of net revenues. Complete examination of the results in

Table 5. Results from SDRF applied to dryland cropping systems.

Dryland cropping systems[†]			
CONVTILL-REDTILL	-1[‡]	TWC-CONVTILL	-1
CONVTILL-NOTILL	-1	TWC-REDTILL	-1
CONVTILL-TWC	1[§]	TWC-NOTILL	-1
CONVTILL-SORGCOT	-1	TWC-SORGCOT	-1
CONVTILL-WHEATCOT	-1	TWC-WHEATCOT	-1
REDTILL-CONVTILL	1	SORGCOT-CONVTILL	1
REDTILL-NOTILL	1	SORGCOT-REDTILL	-1
REDTILL-TWC	1	SORGCOT-NOTILL	1
REDTILL-SORGCOT	1	SORGCOT-TWC	1
REDTILL-WHEATCOT	1	SORGCOT-WHEATCOT	-1
NOTILL-CONVTILL	1	WHEATCOT-CONVTILL	1
NOTILL-REDTILL	-1	WHEATCOT-REDTILL	-1
NOTILL-TWC	1	WHEATCOT-NOTILL	1
NOTILL-SORGCOT	-1	WHEATCOT-TWC	1
NOTILL-WHEATCOT	-1	WHEATCOT-SORGCOT	1

[†] CONVTILL-Conventional tillage cotton; REDTILL-Reduced tillage cotton; NOTILL- No-till cotton; TWC-Terminated wheat-cotton; SORGCOT-Conservation tillage sorghum-cotton; and WHEATCOT-Conservation tillage wheat-cotton.

[‡] Second cropping sytem dominated the first.

[§] First cropping system dominated the second.

Table 5 indicate that reduced tillage dominated all other systems. The overall ranking implied by the results in the table are: (1) Reduced tillage continuous cotton; (2) Wheat-cotton reduced tillage; (3) Sorghum-cotton reduced tillage; (4) No-till continuous cotton; (5) Conventional tillage continuous cotton; and (6) Terminated wheat-cotton.

Upon comparison of the ranking of systems using SDRF to the ranking using average net revenues, the two techniques concluded the same order of systems. However, when the distributions under consideration are more similar, the two techniques often confirm different rankings. In this case, the results from the SDRF are preferred to the results from the average net revenue ranking because the SDRF accounts not only for the average net revenues of the systems, but also for the variability of the net revenues. The cumulative distribution functions for the distributions of returns relative to each cropping system are shown in Fig. 1.

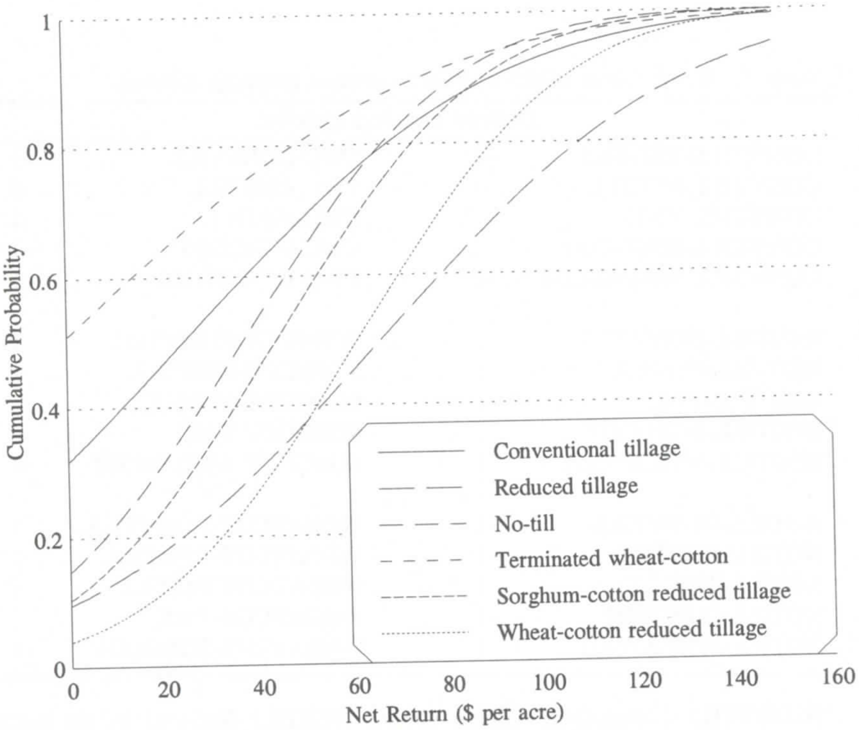

Figure 1. Cumulative distribution functions of cropping system returns.

CONCLUSION

The stochastic dominance with respect to a function analysis of six dryland cotton cropping systems revealed that four of the five conservation tillage systems are superior to the conventional tillage system for all likely producer risk preference levels. These four conservation systems displayed increased stability and profitability over the conventional tillage system, and, hence, are workable options that producers should consider. Conservation tillage systems in dryland cotton production may be better suited to producer risk preferences than conventional practices. Although conservation systems are being used by increasing numbers of farmers, many producers are reluctant to change from conventional practices.

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Wheat Cultivar Response to Grazed and Ungrazed Production Systems

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ABSTRACT

Wheat grown on the Southern Great Plains is frequently utilized for both grazing and grain. The effects of grazing on grain yield are controversial. Semidwarf and tall cultivars were compared in grazed and ungrazed production systems where the major variables were wheat planting date and grazing duration. Semidwarf cultivars outyielded tall cultivars regardless of wheat planting date or duration of grazing. The grain yield advantage of semidwarf cultivars was greatest (up to 58%) in the most productive environment (late planted ungrazed) and least (5%) in the early planted wheat with longer grazing duration. Lodging resistance and grain yield potential were important cultivar attributes correlated with response to production system. Grazing induced reduction in height and lodging potential is more likely to benefit tall cultivars than semidwarf, lodging-resistant cultivars.

Wheat grown on the Southern Great Plains is frequently utilized for grazing prior to floral initiation and, after cattle removal, for grain production. The effects of grazing on wheat grain yield are poorly defined and have been the subject of controversy for many years. Both positive and negative effects of grazing on wheat grain yield have been summarized in two major reviews on the subject (Holliday, 1956; Redmon et al., 1995).

Grazing generally reduces plant height and lodging (Winter and Thompson, 1987). Thus, in productive environments with cultivars prone to lodge, grazing may increase grain yield by reducing lodging (Holliday, 1956; Redmon et al., 1995; Winter and Thompson, 1987; Winter and Thompson, 1990). Semidwarf lodging-resistant cultivars may offer higher grain yield potential than tall cultivars in productive environments (Winter et al., 1990; Winter and Musick, 1991). However, semidwarf cultivars may be more sensitive to the negative aspects (reduced height and leaf area) of excessive grazing (Pumphrey, 1970; Redmon et al., 1995; Winter and Musick, 1991).

The objective of this research was to compare tall and semidwarf wheat cultivar responses to a range of grazed and ungrazed wheat production systems. A wide range of treatments was considered essential to delineate the full range of responses and interactions that can occur.

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MATERIALS AND METHODS

Wheat grazing systems research was conducted on Pullman clay loam soil (fine, mixed, thermic Torrertic Paleustoll) with furrow irrigation at Bushland, Texas for the 1989-90 and 1990-91 wheat growing seasons. The independent variables evaluated were: date of planting, date of grazing, grazing management, and cultivar.

Planting date was the main plot, or whole pasture, variable with each pasture 5.5 acres in size (200 x 1200 ft). Each year there were four planting dates plus a duplicate of the earliest planting date with intensive, early-season grazing. This provided five main effect variables referred to as production systems 1 to 5 (Table 1).

The main effect treatments are systems as contrasted to single variable treatments. Each system was managed individually to maximize net return using best management practices. Thus, multiple variable effects may be confounded in main plots (systems) and results must be interpreted accordingly. The confounding of planting date, irrigation, grazing dates, etc. is appropriate for systems research where it is needed to optimize management of each system.

The grazing treatments (subplots) within each pasture were an ungrazed check plot plus cattle removal dates of 1 February, 1 March, and 21 March. Subplot areas were 50 ft x 70 ft blocks near the south end of each pasture. Each block consisted of seven cultivars as sub-subplots each 10 ft x 50 ft in size. Cattle water tanks and mineral supplement were on the north end of each pasture to avoid excessive trampling in the plot area and to maintain suitable beds and furrows in the critical water input area (south end). This method provided representative grazing pressure in the plot area without destroying beds and furrows.

The seven cultivars were randomized as strips each 10 ft wide (four 30-inch beds) that ran the entire 1200 ft length of each pasture. The remaining 130 ft width of each pasture was planted to TAM 107. Drill rows were spaced 6 inches apart (five rows per bed) in the cultivar strips and 10 inches in the bulk area of TAM 107. Seeding rate was 90 to 100 lbs acre^{-1} on all areas.

The cultivars used included four modern semidwarf cultivars: TAM 107, Quantum 588 (Q588, a hybrid), TAM 200, and Mesa. The taller cultivars were Quantum 554 (Q554, a beardless hybrid), Siouxland, and Triumph 64. Cultivar plots were harvested with a small plot combine. Total harvest area of each cultivar plot within each pull-off date was 5 ft by 40 ft. Grain yields were adjusted to 13% moisture.

The pastures of systems 2 to 5 were initially stocked with 450 to 500 lb stocker cattle at the rate estimated to fully consume available forage prior to rapid spring growth without over or undergrazing. Adjustments in stocking rates were made when it became apparent that a pasture was over or understocked. No more than one or two adjustments were needed in each pasture each year. Initial stocking rates varied from 300 to 900 lbs live weight acre^{-1} depending on available forage and length of grazing season remaining. This process reduced forage height to approximately 3 inches in late winter as growth resumed. After rapid spring growth began in mid to late February, green leaf area generally increased because growth rate exceeded consumption. Stocking rates from late February until 21 March were usually 500 to 1200 lbs acre^{-1} because the cattle had grown and forage availability was high. System 1 was managed somewhat differently than systems 2 to 5 in that a high initial stocking rate (2.7 to 4.0 head acre^{-1}) was used in October to rapidly remove most of the available forage. After irrigation, a lower stocking rate (1.0 head acre^{-1}) was used to utilize regrowth.

Planting dates and irrigation amounts are listed in Table 1. All grazing treatments within a production system were irrigated the same including the ungrazed check plots. All pastures were fertilized the same. The only fertilizer needed according to soil testing was nitrogen. Each year the total of nitrate nitrogen in the 0-4 ft soil profile plus preplant applied nitrogen from anhydrous ammonia equaled at least 250 lbs acre^{-1}. No fertilizer was applied during the growing season. These fertilization practices equal or exceed standard recommendations for Pullman soil (Pennington et al., 1981).

Table 1. Planting dates and irrigation amounts for 2 years at Bushland, Texas.

Production system	Planting date		Irrigation			
			1989-1990		1990-1991	
	1989	1990	Fall	Spring	Fall	Spring
			- - - - - - - - - inches - - - - - - - - -			
1	24 Aug	21 Aug	4.6	8.0	7.5	12.0
2	24 Aug	21 Aug	7.4	8.0	7.3	12.0
3	5 Sep	10 Sep	3.8	8.0	6.9	12.0
4	18 Sep	21 Sep	3.9	8.0	3.4	12.0
5	5 Oct	7 Oct	4.1	8.0	0.0	12.0

Lodging was rated visually during grain filling as the percentage of the plot area that was leaning significantly (usually 45° or greater from vertical). In some cases, plants that lodged soon after heading later partially recovered. An attempt was made to rate lodging at its maximum occurrence.

Data were analyzed as a split-split plot with three replications the first year and four the second. Production systems were main plots, grazing pull-off date treatments were subplots, and cultivars were sub-sub plots.

RESULTS AND DISCUSSION

System, grazing treatment, and cultivar mean effects averaged over all levels of the other factors are given in Table 2. Wheat in the later planted systems had higher grain yield. This is in agreement with previously reported results (Petr and Doughtrey, 1978; Winter and Musick, 1993). The early October (system 5) planting date was intended to be the optimum for grain yield. One must, however, remember that the results for systems presented in Table 2 could be affected by much more than planting date. Water, fertility, weather patterns, or other factors could contribute to yield differences. The higher yield and greater height of system 2 wheat compared to system 1 (same planting date) in 1990 illustrates the effect that factors other than planting date can have on system performance. System 2 wheat received more fall irrigation in 1989 than system 1, which probably accounts for much of the yield and height difference.

Moderate grazing until early spring increased grain yield compared to the same planting date (system) that was ungrazed (Table 2). However, grazing past 1 March 1990, or 1 February 1991, tended to reverse that effect such that grazing until 21 March provided a similar or only slightly greater grain yield than ungrazed. The effects of late grazing on wheat grain yield are similiar to earlier results when one takes into consideration that the earlier studies were more severely grazed (Winter and Thompson, 1987).

Grazing reduced plant height and lodging compared to the ungrazed check (Table 2). Lodging may be reduced as much by the soil firming attributable to grazing as to the slight height reduction. None of the cultivars lodged significantly when grazed. Lodging was severe only in the ungrazed wheat of system 5 in 1990.

The cultivars could be divided into two groups based on height. TAM 107, TAM 200, Q588, and Mesa averaged about 8 inches shorter than Q554, Siouxland, and Triumph 64 (Table 2). The four shorter cultivars averaged about 80% as tall as the three taller cultivars.

On average, TAM 107 was the highest yielding cultivar both years (Table 2). TAM 200 and Q588 were next highest yielding. Triumph 64 was consistently low in yield and lodged the most.

Detailed results of cultivar grain yield by system and treatment are presented in Tables 3 and 4. The positive response of early planted wheat to moderate grazing appears to hold true for all cultivars. Significant interactions of cultivars with system or treatment occurred in some cases (eg., system x cultivar was significant for yield and lodging in 1990 and 1991) but otherwise was not consistently obtained. The interactions that occurred are not easily explained. One interaction occurred in 1990 when Q588 yielded relatively much better compared to TAM 107 in system 5, where yield potential was high, than in systems 1 to 3 where yields were lower (Table 3).

A significant interaction of cultivar with system and treatment in 1989-90 is illustrated in Figure 1 where the data are presented by height class. The four semidwarf cultivars yielded significantly more in system 5 ungrazed than the three tall cultivars. Reference to Table 3 indicates that this outperformance was attributable almost exclusively to TAM 107, Q588, and Mesa with yields of 82.6, 86.8, and 72.0 bu acre^{-1}, respectively. TAM 200 yielded only 61.4 bu acre^{-1} in system 5 while the three tall cultivars averaged only 50.8 bu acre^{-1}. These results are partially attributable to lodging which was 57, 43, 32, 13, 10, 7, and 6% for Triumph 64, TAM 200, TAM 107, Siouxland, Q554, Q588, and Mesa, respectively. The poor yield of Triumph 64 and the under performance of TAM 200 relative to the other semidwarf cultivars may be partially explained by lodging. TAM 200 has relatively weak straw for a semidwarf wheat. The relatively good performance of Q588 compared to TAM 107 in system 5 compared to systems 1 to 3 may be explained by the greater lodging of TAM 107 in system 5. However, lodging does not explain why the semidwarf cultivars outyielded the tall cultivars Q554 and Siouxland that did not lodge severely. In 1991, with even higher yields and no

Table 2. Mean effect for production systems, grazing treatments, and cultivars averaged over all other factors for wheat harvested in 1990 and 1991 at Bushland, TX.

	Grain yield		Height		Lodging		Heading date	
Factor	1990	1991	1990	1991	1990	1991	1990	1991
PRODUCTION SYSTEM	- - bu acre^{-1} - -		- - - inches - - -		- - - - % - - - -		Day of year	
1	38.5 d	66.5 d	28.4 e	33.6 d	0 b	0 c	120	113
2	48.8 c	63.2 e	33.7 b	32.5 e	0 b	2 bc	121	113
3	54.7 b	77.7 c	29.9 d	34.4 c	0 b	3 ab	120	113
4	63.0 a	82.9 b	30.5 c	36.0 b	1 b	4 a	124	115
5	64.0 a	87.9 a	38.3 a	36.6 a	9 a	1 bc	129	118
GRAZING TREATMENT								
Ungrazed	49.2 c	72.8 c	32.9 a	35.5 a	6 a	4 a	122	113
Feb. 1	56.4 a	79.0 a	32.3 b	35.4 a	2 b	2 b	121	113
Mar. 1	57.0 a	77.3 b	32.0 b	34.5 b	1 b	1 b	124	114
Mar. 21	52.6 b	74.1 c	31.4 c	33.6 c	0 b	1 b	125	117
CULTIVAR								
Semidwarf								
TAM 107	66.7 a	84.1 a	30.7 d	32.3 c	2 b	1 cd	119	112
Quantum 588	57.5 b	79.0 b	29.9 e	30.3 e	0 b	0 d	120	113
TAM 200	54.4 c	79.9 b	29.6 e	31.5 d	3 b	1 cd	124	114
Mesa	51.5 d	73.5 d	26.4 f	30.3 e	0 b	0 d	119	112
Tall								
Quantum 554	50.0 d	76.1 c	37.0 a	41.4 a	1 b	2 bc	129	118
Siouxland	49.8 d	73.6 d	35.1 c	39.0 b	2 b	3 b	128	117
Triumph 64	46.7 e	64.1 e	36.2 b	38.6 b	6 a	6 a	121	113

Table 3. Grain yield response of seven wheat cultivars to production systems and grazing treatments in 1989-90.

Production system	Grazing dates		Cultivar						
	Date on	Date off	TAM 107	TAM 200	Q588	Mesa	Siouxland	Triumph 64	Q554
			bu acre^{-1}						
1	Ungrazed	Ungrazed	41.1 a[†]	32.7 ab	22.1 c	18.8 c	27.5 bc	21.5 c	28.4 bc
	4 Oct	1 Feb	58.1 a	42.9 b	41.8 b	32.7 b	35.4 b	34.3 b	43.8 b
	4 Oct	1 Mar	57.2 a	43.3 b	44.0 b	36.8 b	43.8 b	40.4 b	41.7 b
	4 Oct	21 Mar	53.4 a	39.8 bc	40.4 bc	34.8 c	43.4 b	38.7 bc	38.0 bc
2	Ungrazed	Ungrazed	56.3 a	54.3 ab	44.4 bc	40.9 c	42.8 bc	33.9 c	45.4 abc
	27 Oct	1 Feb	67.0 a	55.9 b	53.0 b	53.6 b	46.9 c	45.8 c	53.7 b
	27 Oct	1 Mar	57.3 a	51.6 ab	54.3 ab	52.8 ab	47.5 b	49.1 b	47.0 b
	27 Oct	21 Mar	52.7 a	40.6 b	45.3 ab	45.6 ab	45.2 ab	43.9 ab	40.0 b
3	Ungrazed	Ungrazed	67.4 a	60.6ab	47.3 bc	46.5 c	55.1 abc	44.6 c	48.2 bc
	15 Nov	1 Feb	67.7 a	58.0 ab	56.1 ab	48.3 b	57.7 ab	46.3 c	58.7 ab
	15 Nov	1 Mar	67.3 a	52.6 bc	52.3 bc	54.9 bc	61.3 ab	48.9 c	49.8 c
	15 Nov	21 Mar	65.2 a	52.7 b	51.9 b	48.2 b	62.3 a	49.4 b	51.6 b
4	Ungrazed	Ungrazed	66.5 a	63.1 ab	54.8 bc	52.7 c	54.0 bc	42.6 d	52.2 c
	15 Nov	1 Feb	79.8 a	70.6 ab	73.9 ab	60.1 bc	58.4 bc	52.4 c	61.7 bc
	15 Nov	1 Mar	82.4 a	68.5 bc	74.6 ab	62.7 c	66.1 bc	60.8 c	63.8 bc
	15 Nov	21 Mar	78.7 a	58.1 bc	67.1 b	64.5 bc	61.9 bc	53.2 c	58.7 bc
5	Ungrazed	Ungrazed	82.6 a	61.4 bc	86.8 a	72.0 ab	44.7 c	56.6 bc	51.0 c
	11 Jan	1 Feb	83.8 a	64.4 b	83.0 a	68.8 ab	45.0 c	56.9 bc	55.9 b
	11 Jan	1 Mar	81.5 a	63.9 bc	80.6 a	69.5 ab	51.0 d	55.3 cd	61.2 bcd
	11 Jan	21 Mar	67.3 b	53.0 d	75.6 a	66.6 b	45.4 e	58.9 c	50.2 d

[†] Within a row means are followed by the same letter are not significantly different at $P=0.05$.

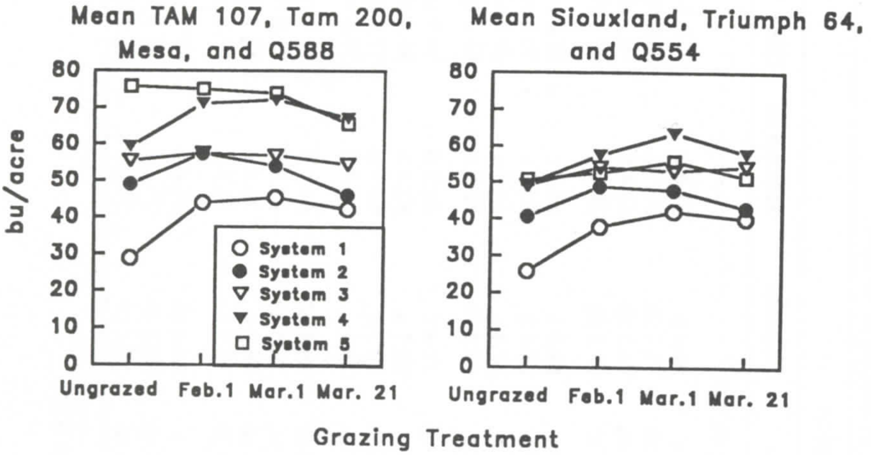

Figure 1. Grain yield response of semidwarf and tall wheat cultivars to five production systems and four grazing treatments for the 1989-90 wheat crop.

significant lodging by any cultivar, the under performance of tall cultivars is about the same in all systems (Table 4 and Figure 2).

Absolute differences in yield between semidwarf cultivars and taller cultivars may not be due to height. Perhaps the difference could be attributed to breeding progress since the shorter cultivars are generally of more recent origin. Relative responses or interactions of cultivars with other factors might be attributable to height differences.

The semidwarf wheats were selected in environments similar to system 5 ungrazed. In such productive environments for grain yield, semidwarf wheats have a significantly higher grain yield potential than the taller cultivars due to higher harvest index and greater seed acre^{-1} (Winter and Musick, 1991). The high potential grain yield of semidwarf wheat cultivars must be considered when comparing the economic potential of various grazed and ungrazed wheat production systems.

Even though most semidwarf wheat cultivars were selected almost exclusively in nongrazed environments, these cultivars equal or exceed the grain yield of taller cultivars in all grazing systems and treatments tested. With early planting and late grazing termination, the grain yield advantage of the semidwarf cultivars was reduced but not eliminated (Figure 1).

The important cultivar attributes for wheat production systems that were identified in this research appear to be lodging resistance and grain yield potential. Tall cultivars never yielded more than the semidwarfs and yielded much less in a high yield environment where lodging became significant and where tall cultivars have reduced ability to convert high biomass to grain. While early planting and heavy grazing may have reduced the grain yield advantage of semidwarf cultivars, they

Table 4. Grain yield response of seven wheat cultivars to production systems and grazing treatments in 1990-91.

Production system	Grazing dates		Cultivar						
	Date on	Date off	TAM 107	TAM 200	Q588	Mesa	Siouxland	Triumph 64	Q544
			- bu acre^{-1} - - - - - - - - - - - - - - - - - -						
1	Ungrazed	Ungrazed	71.4 a[†]	64.1 b	57.3 bc	53.0 c	61.4 b	51.0 c	62.1 b
	10 Oct	1 Feb	79.0 a	73.2 ab	69.1 ab	67.1 ab	71.1 ab	57.7 c	68.0 b
	10 Oct	1 Mar	80.3 a	73.2 ab	71.1 ab	68.6 ab	71.9 ab	63.4 b	70.1 ab
	10 Oct	21 Mar	72.0 a	69.8 ab	66.2 bc	59.8 ab	67.8 ab	54.1 c	69.2 ab
2	Ungrazed	Ungrazed	74.5 a	62.8 b	58.5 bc	53.0 c	63.0 b	54.7 c	62.2 b
	24 Oct	1 Feb	77.7 a	63.8 bc	73.2 a	56.9 c	65.4 b	56.0 c	70.8 ab
	24 Oct	1 Mar	69.5 a	59.8 b	71.4 a	56.4 b	67.5 a	50.9 c	68.6 a
	24 Oct	21 Mar	65.8 ab	61.8 b	69.1 a	55.1 c	63.8 ab	52.9 c	63.8 ab
3	Ungrazed	Ungrazed	92.9 a	83.6 b	82.2 b	76.1 bc	71.4 c	61.8 d	76.9 bc
	15 Nov	1 Feb	90.1 a	85.4 a	87.8 a	83.4 a	82.1 a	67.7 b	83.8 ab
	15 Nov	1 Mar	83.2 a	81.4 a	80.7 a	76.5 ab	80.3 a	67.3 b	77.8 a
	15 Nov	21 Mar	77.1 a	72.8 a	72.1 a	70.7 a	75.1 a	62.3 b	74.5 a
4	Ungrazed	Ungrazed	92.5 a	89.9 a	81.7 b	76.0 bc	68.4 cd	64.4 d	72.4 cd
	26 Nov	1 Feb	99.6 a	93.3 ab	90.0 abc	88.9 bc	76.5 de	68.1 e	81.5 cd
	26 Nov	1 Mar	94.0 ab	90.7 ab	90.8 ab	87.3 ab	76.9 c	70.3 c	85.1 b
	26 Nov	21 Mar	92.6 a	87.5 a	86.4 a	84.2 ab	75.2 bc	71.8 c	84.8 a
5	Ungrazed	Ungrazed	93.5 a	93.3 a	92.5 a	86.1 a	83.1 ab	74.6 b	87.7 a
	20 Feb	1 Mar	93.5 ab	94.2 ab	96.6 a	91.6 ab	88.3 ab	75.2 c	86.1 b
	20 Feb	21 Mar	91.8 a	93.4 a	90.8 ab	90.4 ab	80.1 ab	77.2 b	87.4 ab

†Within a row means are followed by the same letter are not significantly different at $P = 0.05$.

always outperformed tall cultivars. When comparing the economics of various grazed and ungrazed wheat production systems, the high grain yield potential of modern semidwarf cultivars should be considered. Modern, lodging-resistant, wheat cultivars may give a very high grain yield response to productive environments that would have resulted in severe lodging and reduced grain yield with older, taller cultivars. With lodging resistant cultivars, the need for grazing to control lodging is much reduced.

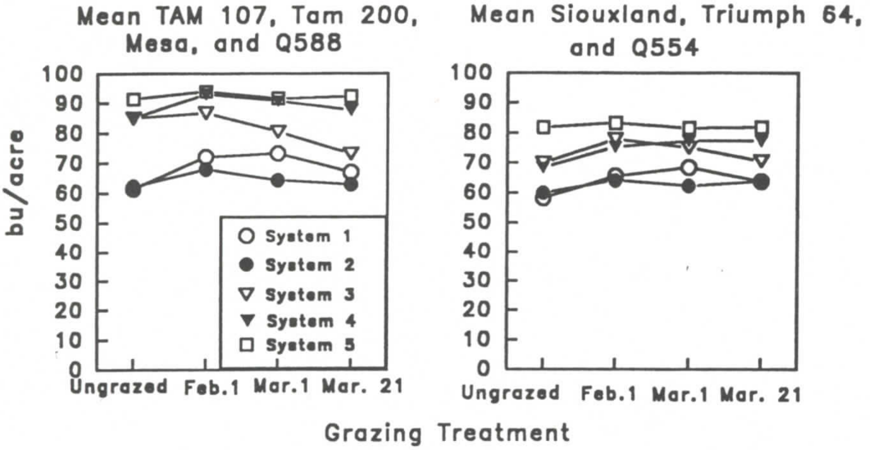

Figure 2. Grain yield response of semidwarf and tall wheat cultivars to five production systems and four grazing treatments for the 1990-91 wheat crop.

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Home Ranges of Pronghorn in the Trans-Pecos Region of Texas

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ABSTRACT

We determined home ranges of pronghorn (*Antilocapra americana*) over a 3-year period in the Trans-Pecos region of Texas. Male pronghorn consistently had smaller ($P<0.05$) home ranges than females; males ($n=8$) and females ($n=28$) averaged 25.1 ± 4.5 (SD) and 42.4 ± 10.1 km^2, respectively. Drought conditions influenced home ranges of females. In 1990, a year of below average precipitation, home ranges of females ($n=36$) during post-fawning (18 Jun to 20 Aug) were larger ($P<0.05$) than female home ranges ($n=36$) during fawning (15 Apr to 17 Jun), averaging 32.5 ± 14.5 and 17.1 ± 8.3 km^2, respectively. During 1991, a year of above average precipitation, female home ranges were similar ($P>0.05$) between fawning and post-fawning periods. Home ranges of females during the fawning season were similar ($P>0.05$) between 1990 and 1991. However, in 1990 females during the post fawning season had larger ($P<0.05$) home ranges than those in 1991, averaging 32.5 ± 14.5 and 20.4 ± 6.2 km^2, respectively. We concluded that pronghorn in the Trans-Pecos require larger home ranges than pronghorn occurring in more optimal habitats of their geographic range, that females require larger home ranges than males, possibly related to greater nutritional demands, and that monthly precipitation, which affects forage quantity and quality, influences home range size for females, particularly during the post-fawning period.

KEYWORDS: *Antilocapra americana*

Limited information is available on home-range sizes of pronghorn. Studies have been conducted in Wyoming (Amstrup, 1978), Montana (Bayless, 1969; Kitchen, 1974), Idaho (Hoskinson and Tester, 1980; Reynolds, 1984), New Mexico (Sanchez, 1993; Clemente et al., 1995), and Arizona (Wright and deVos, 1986). Although these studies make important contributions toward understanding pronghorn home ranges, differences between geographic regions and environmental conditions make specific comparisons between studies ambiguous. Additionally, widespread use of different home range estimators makes direct comparisons difficult (Boulanger

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and White, 1990), further complicating our understanding of why differences occur.

Although the Trans-Pecos region of Texas is important habitat for pronghorn, no home range estimates are available. Thus, we conducted a 3-year study to examine home ranges of pronghorn. Specifically, our objectives were to quantify and compare home range sizes for adult male and female pronghorn in the Trans-Pecos region of Texas.

MATERIALS AND METHODS

The study was conducted in Hudspeth County, Texas, on the Double U Ranch, which is part of the University of Texas Lands System. Topography ranges from gentle to steep hills on the west side bordering the Hueco Mountains to open flats on the east side. Typical rangeland sites include stony hills, clay flats, gypsum flats, and deep uplands (Correll and Johnston, 1970). Annual precipitation of this semi-arid region is about 30 cm, most occurring during late summer. Annual temperatures range from -18 to 38°C. Important vegetation types are yucca (*Yucca elata*) savannahs, grama (*Bouteloua* spp.) grasslands, and creosote bush (*Larrea tridentata*)-tarbush (*Flourensia cernua*) shrublands. Vegetation communities are further characterized by Canon (1993).

On 5 March 1990, we trapped pronghorn with a corral-type trap and applied mortality-sensing, transmitter collars (3-5 year life expectancy) to 50 females and eight males. Females also were marked with numbered ear tags. We used telemetry to obtain general locations of collared individuals, then made visual observations to determine specific locations. We marked each location on U.S. Geological Survey topographic maps. The entire study area was accessible by vehicles; the open terrain easily permitted identification of marked individuals without disturbance. Locations of animals were recorded randomly as other research activities were being conducted during April-August, 1990-92. We obtained additional locations one or two times per month during September-March, 1990-92. Locations only were taken in the day. However, overall home-range estimates are presumed to include night activity areas, based on our knowledge of marked animals.

We converted locations to Universal Transverse Mercator coordinates for computer analyses. No estimates of triangulation error were computed since collared individuals were visually observed and the exact locations were recorded on maps. Location error could only occur by incorrectly plotting or misreading topographic maps. However, less error is likely using our method than using triangulation of unobserved individuals. We used the 90% harmonic mean estimator (Dixon and Chapman, 1980), based on findings presented in Canon (1993), to generate home-range size estimates using the Microcomputer Program for Analysis of Animal Locations software (MCPAAL; Stuwe and Blohowick, 1985).

We combined 1991 and 1992 data for annual home-range size comparisons between male and female pronghorn, due to reduced observations resulting from radio collar failure (up to 90% by the last year of study) and after preliminary analysis (nine animals with ≥25 locations each for 1991 and 1992) indicated annual home-range sizes were similar between years.

We separated the summer into two temporal periods, the fawning season and the post-fawning season. The fawning season extended from two weeks prior to the first known fawn birth date to two weeks following the last known fawn birth date (15

Apr to 17 Jun); the post-fawning season was from the end of the fawning season to the time when fawns readily accompany females at 60-120 days of age (late August). We compared the effects of season on female home-range size for 1990 and 1991 only, since insufficient sample size in 1992 and too few observations negated comparisons between 1991 and 1992 to determine if data from both years could be pooled.

We determined overall (3-year) home-range size estimates using only those pronghorn that survived through the study and had ≥100 locations. Estimates for 1990 and 1991-92 included only those animals with ≥50 locations for each period. Fawning and post-fawning seasonal estimates included only those females with ≥15 locations per season. We used t-tests for comparisons of mean home ranges for sex, season, and year variables.

We estimated monthly precipitation by averaging rainfall records from the two closest weather stations, the El Paso East (8 km west) and Cornudas (30 km north) stations (NOAA, 1990-92). We used X^2 analysis to compare annual precipitation during the study (1990-92) to the long term average (1985-92).

RESULTS AND DISCUSSION

Home range estimates across the 3-year study were determined for eight male and 28 female pronghorn (Table 1). Overall, we found home range sizes in male and female pronghorn averaged 25.1 ± 4.5 (SD) and 42.4 ± 10.1 km^2, respectively. With the understanding that different estimators yield different home-range sizes, pronghorn in our study appeared to have larger home ranges than those found in seemingly more optimal habitats. In southeastern Idaho, Reynolds (1984) reported mean home-range size of 16 pronghorn as 11.9 ± 2.1 (SD) km^2 (minimum area method). Additionally, Hoskinson and Tester (1980) found that pronghorn home-range sizes from different areas in southeastern Idaho and southwestern Montana ranged from 13.4 to 71.4 km^2 (minimum area method), averaging about 20 and 23 km^2 during summer and winter, respectively. However, we report smaller home ranges than that found in Arizona (Wright and deVos, 1986). Wright and deVos (1986) attributed large (41 to 1,213 km^2) home-range sizes of the Sonoran pronghorn (*Antilocapra americana sonoriensis*) to limited forage availability.

For 1990 and 1991-92, six males and 22 females were used for gender comparisons (Table 1). Home range was consistently larger for females than for males. In other studies, males had larger home ranges (Wright and deVos, 1986) or both sexes had similar home ranges (Reynolds, 1984; Clemente et al., 1995). In south-central New Mexico, Sanchez (1993) compared mean home range sizes of two adult male and two adult female pronghorn over a 14-month period (two observations per month). His estimates (minimum convex polygon method) were 16.6 and 11.9 km^2 for males and females, respectively, substantially lower (by 34 and 74%, respectively) than home-range sizes we found. Clemente et al. (1995) found water sources were important in determining home-range locations and likely sizes, in which middle points of home ranges were no farther than 3 km from permanent water. However, permanent livestock water sources on our study area were evenly distributed at about 1 per 2.6 km^2 and inclusion of naturally occurring wetlands would further increase water availability.

In our study, gender differences in home-range size may be related to behavior. Based on the high incidence of fawn predation on the study area (Canon, 1993), predator avoidance and escape strategies may have caused females to move greater distances than males. Additionally, nutritional requirements of females during lactation are presumably greater than at any other time. Although more energy is likely expended as home-range size increases, lactation demands on females may require the expansion of their home ranges to find adequate forage, particularly during periods of below average range conditions.

Table 1. Average home range of adult pronghorn by sex and year variables for 1990-92 on the Double U Study Area, Hudspeth County, Texas.

Year	Sex	*n*[†]	Home Range[‡]	
			$\bar{x}$	SD
			km^2	
1990	Male	6	25.8a[§]	6.3
	Female	22	39.2b[*]	9.5
1991-92[¶]	Male	6	21.9a	2.5
	Female	22	32.9b[*]	7.7
All years	Male	8	25.1a	4.5
	Female	28	42.4b	10.1

[†] Number of pronghorn individuals with ≥ 50 locations were used in yearly comparisons; those with ≥ 100 locations were used in "all years" comparisons.
[‡] Home range estimates were calculated using the 90% harmonic mean estimator.
[§] Values not followed by a common letter for within year comparisons are different ($P<0.05$). Values followed by * are different ($P<0.05$) between years. Data from "all years" were not tested against other years.
[¶] Data for 1991 and 1992 were combined.

For comparisons between fawning and post-fawning seasons, 36 and 11 females were used during 1990 and 1991, respectively (Table 2). In 1990, mean home range of females was larger ($P<0.05$) in the post-fawning period than was found for females during the fawning period. The trend was similar in 1991 but the difference was not significant ($P>0.05$). Mean home range during the fawning period was similar ($P>0.05$) both years.

Annual precipitation during 1990-92 (34.6, 44.9, and 32.9 cm, respectively) was higher ($X^2=9.5$, df=2, $P<0.05$) than the long term average (29.4 cm; years 1985-92), of which precipitation in 1991 was substantially higher (86% of generated X^2 value). However, monthly precipitation patterns appeared to be a factor in influencing home-range sizes. Drought conditions from September 1989 through June 1990 (Fig. 1) resulted in less favorable habitat conditions. Also, mean home range in females averaged 6.2 km^2 larger ($P<0.05$) in 1990 than in 1991-92. In 1990, females during the post-fawning season had significantly ($P<0.05$) larger home ranges than those during 1991 (Table 2). However, females during the fawning season in both years exhibited nearly identical home-range sizes (Table 2).

Table 2. Home range comparisons of adult female pronghorn during fawning and post-fawning seasons, 1990-91, on the Double U Study Area, Hudspeth County, Texas.

Year	Season[†]	n[‡]	Home Range[§]	
			$\bar{x}$	SD
			km²	
1990	Fawning	36	17.1a[¶]	8.3
	Post-fawning	36	32.5b	14.5
1991	Fawning	11	17.2a	9.5
	Post-fawning	11	20.4a*	6.2

[†] Fawning season is from 15 Apr to 17 Jun; Post-fawning season is from 18 Jun to 20 Aug.

[‡] Number of pronghorn with ≥15 locations per season.

[§] Home range estimates were calculated using the 90% harmonic mean estimator.

[¶] Values not followed by a common letter for within year comparisons are different ($P<0.05$). Values followed by * are different ($P<0.05$) between years.

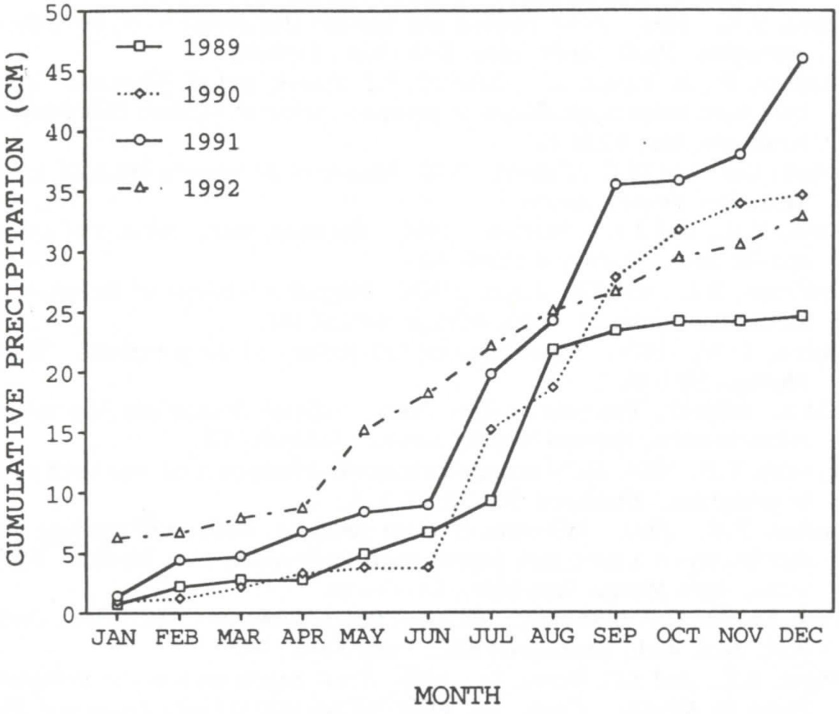

Figure 1. Monthly cumulative precipitation for years 1989-92 on the study area, based on averages from the El Paso East (8 km west) and Cornudas (30 km north) stations.

This suggests that maternal protective instincts may have been the overriding factor affecting sizes of home range during this period, at least until fawns become more mobile. Management strategies must take into account that precipitation rates directly affect forage quantity and quality, which in turn, influences home-range size in pronghorn.

In summary, we found that female pronghorn ranged farther than males. Females during post-fawning had larger home-range sizes than those during fawning, particularly when below average precipitation occurred. Our results suggest that during extended periods of low rainfall, females, particularly during the post-fawning season, must range greater distances to meet their nutritional requirements in the Trans-Pecos region of Texas.

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Effects of Penned vs. Pasture Feeding Techniques on Cortisol Levels in Weaned Angus Bulls

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ABSTRACT

The effects of feeding in open pens versus pasture on blood cortisol levels in response to exogenous administrations of adrenocorticotropic hormone (ACTH) was measured in 30 weaned Angus bulls. Twenty-four bulls were allotted to eight 24.4 X 6.1 m pens, and the remaining six were kept in pastures. Threats, butts or physical combat that resulted in a subordinate yielding space to an aggressor (yields), and feeding location were recorded in 2 wk intervals during feeding periods in order to classify penned bulls as being either dominant or submissive. Adrenal response to ACTH treatment was quantified at the beginning, middle, and end of the study (approximately 56 d apart). During each sampling period, 8 dominant, 8 submissive penned bulls and 6 pasture bulls were haltered and blood was collected via jugular cannula every 20 min for 2 h, followed by injection of 100 IU of ACTH via jugular cannula and then blood samples were taken every 20 min for 4 h. Dominant bulls delivered more butts ($P<0.05$) over the entire period than did submissive bulls. Submissive bulls exhibited more instances of yielding space to an aggressor than did dominant bulls ($P<0.05$). Dominant bulls had lower cortisol levels ($P<0.05$) post-ACTH than pasture bulls for the intermediate bleeding period. Pasture bulls had higher ($P<0.05$) post-ACTH cortisol levels than penned bulls for the intermediate bleeding period. There were no differences ($P>0.05$) in pre-ACTH or post-ACTH cortisol levels among bulls across all treatments for the final bleeding period. Bulls raised in pens of this size were not under stress when compared to pasture raised bulls.

KEYWORDS: stress, ACTH, behavior, bulls, cortisol

Over time, humans have subjected cattle to various management schemes in order to maximize productivity. Recently, there has been a great deal of public concern about the well-being of animals used in agriculture. These concerns have brought about the need for animal scientists to develop techniques that will assess behavioral stress in livestock. Mastering these techniques will make it possible to recommend what management practices are optimum for minimizing the impact that behavioral stress can have on animal production.

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Moberg (1987) stated that a behavioral stressor is an event or stimuli that is acknowledged by the animal as a threat to its well-being. Behavioral stressors for animals include being introduced into strange surroundings, being placed into a new herd, or encounters with an aggressive peer. The consequences of stress, the stress response, and the recognition of a threat to homeostasis are the responses that animals have to a stressful event. The recognition of a threat to homeostasis or well-being takes place in the central nervous system. The degree of stress that an animal undergoes will determine how much the pituitary-adrenal axis responds (Dantzer and Mormede, 1983). Both behavioral and hormonal responses are closely related in stressful situations. Stress enhances pituitary-adrenal reactivity and facilitates the return to homeostasis.

Many researchers have stated that animals having increased plasma corticosteroid concentrations are in a stressful state and the conditions that cause these hormonal changes are stressors. Being able to determine when cattle have experienced stressful situations could be of great importance to the animal industry in evaluating management techniques (Friend et al., 1977). Adrenal response testing (ART) to exogenous adrenocorticotropic hormone (ACTH) is one method to determine if cattle have been exposed to stressful conditions. An injection of a large dose of ACTH reveals maximum amounts of glucocorticoids which an animal can produce (Fraser and Broom, 1990). Increased circulating corticoids (cortisol) sustained for 4 to 6 h after administration of ACTH may indicate the adrenal response to stress (Friend et al., 1979). This study was designed to determine the effects of penned versus pasture feeding on blood cortisol levels in response to exogenous administration of ACTH in weaned Angus bulls.

MATERIALS AND METHODS

This study was conducted at Angelo State University's Management, Instruction and Research (MIR) Center. Thirty weaned Angus bulls averaging 250 kg bodyweight were used for behavioral testing. Twenty-four bulls were allotted to eight 24.4 X 6.1 m pens, and the remaining six were kept in pastures under natural management conditions. Penned bulls were blocked by live weight with three bulls in each pen.

There was a 15-d adjustment feeding period, followed by a 112-d feeding period. Both penned and pasture bulls were observed for dominance and stress during feeding periods at 2 wk intervals (Arave et al., 1975). Bulls were monitored for approximately 2 h and threats, butts, and physical combat that resulted in a subordinate yielding space to an aggressor (yields) were recorded. Feeding location was also observed and recorded because previous studies indicated that dominant animals utilize all sections of a feed trough while submissive animals tended to utilize only a portion of a feed trough. Each trough within a pen measured 4.3 m in length. Troughs were divided into three sections by duct tape which provided 1.43 m per section.

Blood sampling for cortisol determination was taken at the beginning, middle, and end of the study (approximately 56 d apart). Indwelling jugular catheters were inserted approximately 24 h prior to each sampling period to minimize any cortisol response to the catheterization procedure. During each sampling period, blood (10 ml) was collected via jugular cannula into heparinized tubes with animals restrained in a chute every 20 min for 2 h to establish baseline cortisol concentrations (pre-ACTH). Then, 100 IU of ACTH was immediately administered intravenously via the jugular catheter and blood samples were taken every 20 min for 4 h to determine the cortisol response of both the penned and pasture bulls to exogenous ACTH (post-ACTH). All blood samples were immediately placed into an ice bath and the plasma was separated by centrifugation. The samples were then frozen and stored at -20 C until analyzed for glucocorticoid hormones.

Blood cortisol (pre-ACTH and post-ACTH) analysis was determined by methods of Radioimmunoassay (RIA). Blood samples at -40, 0 (pre-ACTH); +40, +80, +120, +160, +200, and +240 (post-ACTH) times were analyzed for cortisol concentrations for eight dominant and eight submissive penned bulls and six bulls in the pasture group for all three bleeding periods.

In the statistical treatment of the data, plasma hormone concentrations were subjected to the general linear models (GLM) procedure of SAS (SAS, 1988). A Duncan's multiple range test was also used to statistically differentiate cortisol concentrations between dominant, submissive, and pasture bulls. Statistical data were further analyzed for differences in cortisol concentrations between penned and pasture bulls. The GLM procedure and Duncan's multiple range test were also used for the analysis of dominance within a pen for penned bulls.

RESULTS AND DISCUSSION

Behavioral Analysis

There were no significant differences ($P>0.05$, Table 1) among dominant and submissive bulls for threats; however, dominant bulls delivered more butts ($P<0.05$, Table 1) over the entire period than did submissive bulls. Dominant bulls gave a total of 105 butts during the trial versus only 13 for submissive bulls. Throughout the study, submissive animals exhibited more instances of yielding space ($P<0.05$) to an aggressor than did dominant animals. The total sum of yields was 2 and 24 for dominant and submissive bulls, respectively. Dominant bulls tended to utilize more sections of the feed trough than did submissive bulls, but there were no significant differences between the two treatment groups.

Table 1. Mean behavioral responses to confinement management for penned bulls for an observed feeding period.

	Treatment	
Items	Dominant	Submissive
Threats	0.25	0.25
Butts	13.12a†	1.62b
Yields	0.25a	3.00b
Location of Intake	0.97	0.94

†Within a row means followed by a different letter are significantly ($P<0.05$) different.

Cortisol Analysis

There were no significant differences ($P > 0.05$, Table 2) in pre-ACTH or post-ACTH cortisol concentrations among dominant, submissive, and pasture bulls for the initial bleeding period. However, pre-ACTH levels were highest for pasture bulls (6.150 ng ml^{-1} ± 1.533) and lowest for submissive bulls (2.865 ng ml^{-1} ± 0.606), with dominant bulls being intermediate (5.981 ng ml^{-1} ± 1.407). These values are similar to those reported by Friend et al. (1977), Friend et al. (1985), and Gwazdauskas et al. (1972). Standard errors were relatively high for both dominant and pasture bulls which accounts for the lack of significant differences among pre-ACTH concentrations. Post-ACTH levels for the initial bleed were 25.000 ng ml^{-1} ± 3.399, 28.751 ng ml^{-1} ± 5.465, and 18.278 ng ml^{-1} ± 5.720 for dominant, submissive, and pasture bulls, respectively. Although not statistically different, bulls that were fed in pastures tended to have the lowest cortisol concentrations of the three groups. Cortisol concentrations were slightly lower for dominant bulls than for submissive bulls. Initial bleeding data was further analyzed by combining cortisol levels from dominant and submissive bulls to form a penned group and was then compared to cortisol levels from pasture bulls (Table 3). Penned bulls post-ACTH levels were higher ($P < 0.05$) than pasture bulls.

Table 2. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the initial bleeding period†.

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	5.98±1.41	2.86±0.61	6.15±1.53
post-ACTH	25.00±3.40	28.75±5.46	18.28±5.72

†Means ± standard errors.

Table 3. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the initial bleeding period†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.42±0.84	6.15±1.53
post-ACTH	27.00a‡±3.24	18.28b±5.72

†Means ± standard errors.

‡Within a row means followed by different letters are significantly ($P < 0.05$) different.

In Table 4, the intermediate bleeding pre-ACTH concentrations were similar for dominant, submissive, and pasture bulls, with dominant bulls having the lowest level. Pre-ACTH values are similar to those reported by Dunlap et al. (1981). Post-ACTH cortisol concentrations for the intermediate bleeding were higher ($P<0.05$) for pasture bulls when compared to dominant bulls. There were no significant differences in post-ACTH concentrations between submissive bulls and dominant bulls, or submissive bulls and pasture bulls. However, submissive bulls had lower post-ACTH cortisol levels than did pasture bulls.

Table 4. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the intermediate bleeding period[†].

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	2.04±0.64	5.10±2.40	5.07±1.92
post-ACTH	7.11b[‡]±0.83	10.40bc±1.33	14.09c±1.20

†Means ± standard errors.

‡Within a row means followed by different letters are significantly ($P<.05$) different.

When dominant and submissive cortisol concentrations were combined to compare penned concentrations to pasture bulls for the intermediate bleeding period, there were no differences ($P>0.05$, Table 5) among pre-ACTH values between the two treatment groups with penned bulls having slightly lower cortisol levels than pasture bulls. Post-ACTH cortisol levels were higher ($P<0.05$) for pasture bulls than for penned bulls.

Table 5. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the intermediate bleeding period[†].

Item	Treatment	
	Penned	Pasture
pre-ACTH	3.57±1.26	5.07±1.92
post-ACTH	8.76a[‡]±0.88	14.09b±1.20

†Means ± standard errors.

‡Within a row means followed by different letters are significantly ($P<0.05$) different.

Table 6 indicates no differences (P>0.05) in pre-ACTH cortisol concentrations among dominant (2.663 ng ml^{-1} ± 0.671), submissive (5.625 ng ml^{-1} ± 2.264), and pasture (4.950 ng ml^{-1} ± 0.902) bulls for the final bleeding period. In addition, there were no differences (P>0.05) in post-ACTH cortisol concentrations between all groups for the final bleeding period. However, pasture bulls exhibited the highest cortisol concentrations (16.667 ng ml^{-1} ± 2.921) when compared to the other two treatment groups and submissive bulls had the lowest cortisol concentrations (11.537 ng ml^{-1} ± 1.208).

Table 6. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for the final bleeding period†.

Item	Treatment		
	Dominant	Submissive	Pasture
pre-ACTH	2.66±0.067	5.62±2.26	4.59±0.90
post-ACTH	12.59±1.93	11.54±1.21	16.67±2.92

†Means ± standard errors.

Table 7 shows that there were no differences (P>0.05) in cortisol concentrations for both pre-ACTH and post-ACTH between treatment groups when cortisol data from dominant and submissive bulls was combined and compared to cortisol concentrations from pasture bulls. Pre-ACTH values were slightly lower for penned bulls (4.144 ng ml^{-1} ± 1.203) than for pasture bulls (4.950 ng ml^{-1} ± 0.902). Post-ACTH cortisol concentrations were lower for penned bulls (12.062 ng ml^{-1} ± 1.107) than for pasture bulls (16.667 ng ml^{-1} ± 2.921), and this difference approached significance (P=0.12).

Table 7. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the final bleeding period†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.14±1.20	4.95±0.90
post-ACTH	12.06±1.11	16.67±2.92

†Means ± standard errors.

When hormonal data from all three bleeding periods was combined, no differences (P>0.05) appeared between penned and pasture bulls (Table 8).

However, both pre-ACTH and post-ACTH cortisol concentrations were slightly lower for penned bulls than for pasture bulls.

Table 8. Cortisol (ng ml^{-1}) response to pre- and post-ACTH challenge for penned and pasture fed bulls for the entire study†.

Item	Treatment	
	Penned	Pasture
pre-ACTH	4.00±0.65	5.40±0.95
post-ACTH	15.34±1.19	16.35±2.60

†Means ± standard errors.

CONCLUSIONS

ACTH was used successfully in eliciting maximum secretion of cortisol from the adrenal glands with post-ACTH levels being similar to other research. Pre-ACTH levels were also similar to levels reported by Friend et al. (1977). It was also stated by Friend et al. (1977) that there is great variability in basal corticosteroid concentrations. This was true with this study as well resulting in standard errors relatively high for both dominant and pasture bulls which accounts for the lack of significant differences among pre-ACTH concentrations. The lack of significant differences in pre-ACTH or post-ACTH cortisol concentrations between dominant and submissive bulls for the initial, intermediate, and final bleeding periods is consistent with the findings of Arave et al. (1975).

Data presented in this study indicate that bulls raised in confinement are not under stress, and acclimate to confinement conditions very rapidly as evidenced by cortisol response to ACTH, when compared to bulls raised in pastures under natural management conditions. However, more study is needed at varying rates of density within a pen to determine the amount of space required for normal cortisol levels.

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Agricultural Science Teachers' Perceptions of Male and Female Agricultural Science Teachers in South Texas

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ABSTRACT

Agricultural science education is a male-intensive field. However, in recent years the role of women has expanded. Only 3.9% of agricultural science teachers in Texas are female, ranking well below the national average of 9.7%. The 357 male and 29 female teachers surveyed from Areas III, VII, and X in South Texas made judgements about teaching and leadership competencies. Males were ranked higher in agricultural mechanics, animal science and SAE programs project supervision. Females ranked higher in horticulture.

Agricultural education in public schools was active in only 30 states before the passage of the National Vocational Education Act (Smith-Hughes) in 1917 (Phipps and Osborne, 1988). This act provided funds to promote vocational education in agriculture for present and prospective farmers.

Female participation was limited in this area from the outset, but more recent legislation has sought to eliminate sexual discrimination. Since the inclusion of female students into Future Farmers of America (FFA) in 1969, the role of women in agricultural education has increased dramatically (Stockton et al., 1988). Data reported in a national study of the supply and demand for agriculture teachers in 1993 (Camp, 1994) indicated that Texas is below the national average in the proportion of female agriculture teachers. Nationwide, 9.7% of agriculture teachers are female compared to only 3.9% females among the 1,450 agriculture teachers in Texas (Camp, 1994a).

Agriculture is expected to employ over 3 million persons in the next 15 years (Leftwich, 1992). In 1992, agricultural education experienced the first decline in 28 years (Camp, 1994b), dropping to less than 10,000 teacher positions nationwide. Leftwich (1992) states, however, that secondary schools are expected to add over 437,000 total positions by the year 2005.

The objective of this research was to determine agriculture teachers' attitudes and perceptions toward male and female agricultural science teachers working in schools designated as members of Areas III, VII and X of the Texas FFA Association.

The specific questions to be addressed were:

1. What are male teachers' perceptions toward male and female teachers with regard to competence in instruction and management in lab, class, FFA and project situations?

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2. What are female teachers' perceptions toward male and female teachers with regard to competence in instruction and management in lab, class, FFA and project situations?

3. How do male teachers perceive male teachers' and female teachers' leadership and involvement in professional organizations?

4. How do female teachers perceive male teachers' and female teachers' leadership and involvement in professional organizations?

5. How do male and female teachers' perceptions compare with regard to male and female teachers competence in instruction and management in lab, class, FFA and project situations?

6. How do male and female teachers' perceptions compare with regard to male and female teachers' competence in leadership and involvement in professional organizations?

METHODS AND PROCEDURES

Instrumentation consisted of a self-developed questionnaire accompanied by a disclaimer cover letter. Questions on the instrument corresponded to the objectives of the study. The instrument consisted of one part each for demographics; professional associations; and leadership/teaching perceptions. The leadership/teaching consisted of the following sections: 1) whether or not the respondent has ever nominated or voted for a female in a leadership role; 2) perceptions of male and female leadership; and 3) perceptions of strength within selected teaching/instruction areas. The questions within the leadership and teaching/instruction areas were to be answered using a 10-point (1=very weak, 10=very strong) Likert-type scale. The instrument, not including the section on demographics, was divided into two sections, one to be answered by males and one to be answered by females. The division covered the event that some of the data would not be analyzed or the scope of the research would have to be modified. The instrument was reviewed for content validity by a group of experts composed of teacher educators. A pilot test of the instrument was administered to five undergraduate Agriculture Science Certification majors at Texas A&M University-Kingsville. The students were asked to comment on the clarity of the directions and the subject matter of questions, following which the instrument went through final revisions.

Participants in this study were male and female agricultural science and technology teachers present at their respective Area association meetings held on 2 August 1994, during the state Professional Improvement Conference in Corpus Christi, Texas. The teachers involved represented schools in Areas III, VII, and X. These teachers represent schools from the three areas in South Texas.

Data were analyzed using SAS Institute (1989) programs. The results were reported as descriptive statistics and inferential statistics. Selected responses of male and female participants were compared using Student's t-tests.

RESULTS

Demographics

A total of 397 surveys was distributed. Completed surveys were returned by 357 male and 29 female teachers. The mean age of male teachers was 38, mean teaching experience was 14 years, and males taught in areas averaging 5,000 - 9,999 population. Female teachers were, on average, working in larger towns with populations from 10,000 - 24,999. The mean age was 30, with 7 years of experience. Male teachers tended to teach in more single-teacher departments than did the females. Of female teachers, 73% reported being married compared to 92% of the males. Education level indicated that the average level of education for both groups was between a bachelor's degree plus hours and a master's degree, with the women averaging a higher level of education.

Professional Associations

Most teachers surveyed were members of VATAT (Vocational Agriculture Teachers Association of Texas) and secondly, NVATA (National Vocational Agriculture Teachers Association). Male respondents reported membership rates of 98.5% with VATAT (340 responding) and 32.8% with NVATA (319 responding). These figures were lower in comparison to the 100% VATAT membership (26 responding) and 46% membership rate with NVATA for females. The teachers were also asked to report whether or not they held membership within the NEA (National Education Association), PAWT (Professional Agricultural Workers of Texas), TCTA (Texas Classroom Teachers Association), and AVA (American Vocational Association), but the membership rates ranked considerably lower than rates for VATAT and NVATA.

Leadership Association

Both men and women indicated that they had voted for more women for association leadership positions than they had nominated. The greatest number of nominations and votes for female candidates occurred at the Area association level. Nearly 40% of the male teachers (n=351) had nominated a female, and 30.7% of female teachers reported that they had nominated a female. Reportedly, 64.9% of males and 61.5% of females had voted for a female for a leadership position.

Using a 10-point (1=very weak, 10=very strong) scale, males assessed male leadership with a mean score of 8.1, whereas females gave males an average of 7.6. In the assessment of female abilities, males responded with 7.8, and females with 8.3 (Table 1).

For classroom performance, males gave males a 8.3 compared to 7.7 for females. Female teachers rated males 8.0 and females 8.4. Leadership competence and willingness to serve are also reported in Table 1.

Table 1. Sample size (n), mean (x̄) and standard deviation (SD) of perceptions of male and female agricultural science teachers leadership abilities.

	By Males			By Females		
	n	x̄	SD	n	x̄	SD
Perceptions of Males' Strengths						
Within professional settings	357	8.1	1.4	29	7.7	1.9
In the classroom	357	8.3	1.5	29	8.0	1.7
Competent to serve in leadership role	356	8.4	1.2	29	8.2	1.5
Willing to serve in leadership role	357	8.0	1.6	29	8.0	1.7
Perceptions of Females' Strengths						
Within professional settings	337	7.8	1.6	28	8.3	1.3
In the classroom	337	7.7	1.7	28	8.4	1.3
Competent to serve in leadership role	337	7.9	1.7	28	8.4	1.3
Willing to serve in leadership role	337	7.9	1.7	28	8.5	1.3

Perceptions of Teaching Competencies

The teachers responding to this survey evaluated teachers in ten selected teaching areas: agricultural mechanics, agribusiness, animal science, animal and plant production, horticulture, leadership, recreational management, pre-employment labs, cooperatives, and supervised agricultural experience (SAE).

In agricultural mechanics, perceptions of males rated much stronger than females (P=0.0001). Females rated males stronger at 8.8 and females 6.4 (Table 2).

In both agribusiness instruction and animal and plant production, males rated males stronger than females, and females rated females stronger than males (Table 2).

In animal science, both males and females ranked males stronger (Table 2). Females rated females nearly equal to males (8.6 vs. 8.4).

In animal and plant production, males rated male teachers as stronger than females, whereas females rated females as stronger (Table 2).

Horticultural instruction has traditionally been an area of instruction dominated by females. Both male and female teachers demonstrated this perception by rating females stronger than males. Females rated females at 9.3, and males rated females 8.5. Males received mean scores of 7.1 and 6.6 from females and males.

The leadership instruction area, as applied to this survey, included leadership, personal development, parliamentary procedure and FFA. Males rated male teachers stronger in leadership while female teachers rated females stronger. Male perceptions of males and females were 8.4 and 8.1, while female perceptions of males and females were 8.0 and 8.9 (Table 2).

For recreational management, both male and female teachers rated males

Table 2. Ranks and average scores[†] of male and female strengths within teaching areas.

	Male Teachers				Female Teachers			
	Judged by Males		Judged by Females		Judged by Males		Judged by Females	
Area	rank	x̄ score	rank	x̄ score	rank	x̄ score	rank	x̄ score
Agricultural mechanics	4	8.5	1	8.8	10	5.7	10	6.4
Agribusiness	8	7.9	8	7.7	4,5[‡]	7.7	8	8.3
Animal science	1	8.6	3	8.6	4,5[‡]	7.7	3	8.4
Animal and plant production	7	8.3	6	8.2	6	7.5	5	8.4
Horticulture	9	7.1	10	6.6	1,2[‡]	8.5	1	9.3
Leadership	6	8.4	7	8.0	3	8.1	2	8.9
Wildlife and recreational management	3	8.6	2	8.6	8	7.1	9	8.0
Pre-employment labs	10	1.7	4	8.4	9	6.9	6,7[‡]	8.3
Cooperatives	5	8.4	5	8.3	7	7.1	6,7[‡]	8.3
SAE Project Supervision	2	8.6	9	7.2	1,2[‡]	8.5	4	8.4

[†] Based on scale 1=very weak, 10=very strong.
[‡] Tie.

as stronger.

Few teachers responded to the section of the survey addressing pre-employment labs. Mean male scores for this section were 1.7 by male teachers and 8.7 by females. Female teachers rated males stronger (Table 2).

For cooperative instruction, males rated males higher than female teachers. Females rated the groups equally strong at 8.3.

In SAE project supervision, male perceptions of male and female strengths averaged 8.5. Females rated males 7.2 and females 8.4 (Table 2).

CONCLUSIONS

As reported by both male and female teachers, nomination rates in professional organizations did not exceed 40%. In comparison, 64% of male and 61% of female agricultural science teachers reported voting for female candidates at the area association level.

Further study should be done to determine the reason for low nomination and voting rates. Perhaps few females express an interest in running. Even though females saw females as somewhat strong to strong (7-8 on the 10 point scale) in these areas, it could be that the effects seen by Knotts and Knotts (1975) such as sexually stereotyped guidance counseling and low self-esteem limit female entrance in leadership positions.

In general, males rated males higher than females, and females rated females higher than males in leadership ability.

In teaching competence, teachers in South Texas did not deviate far from expected social norms and tended to categorize different instruction areas as male and/or female dominated as evidenced by their mean scores much like those reported by Cano (1990), Robbin (1992) and McMillin (1975). Females were perceived in this study as stronger in leadership and horticultural instruction while males were perceived stronger in agricultural mechanics, animal science, and SAE project supervision. Male respondents scored both genders lower than did females.

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