6th Annual Field Tour of an Integrated Crop/Forage/Livestock Systems Approach for the Texas High Plains

Project Summaries and Other Related Research Studies
2004

Funded in part by the Sustainable Agriculture Research and Education (SARE) Southern Regional Program
Summary Index

Field Tour Organization and Participants.................................................. 2
Station Map of Locations to Visit................................................................. 3
Advisory Council Members........................................................................ 4
Acknowledgements.................................................................................... 5
Integrated Crop/Forage/Livestock Systems Introduction and Summary......... 6
Overall Plot Diagram of New Deal Farm Research Areas........................ 10
Integrated Crop/Forage/Livestock Bus Tour Information
  Phase I.................................................................................................. 11
  Phase II.................................................................................................. 14
System Economics..................................................................................... 16
Impacts of Integrated Crop/Livestock Production Systems on Soil Properties.. 19
Plant Diseases............................................................................................ 20
Adaptation of Bermudagrass to the Texas High Plains.............................. 22
  Plot Map..................................................................................................... 27
Warm Season Perennial Grasses for the Southern Great Plains............. 31
  Plot Map..................................................................................................... 34
Cool-Season Perennial Grasses for the Southern Great Plains............. 35
  Plot Map..................................................................................................... 41
Tables of Herbicides for Pasture Weeds, Alfalfa, and Small Grains........ 42
Annual Summer Forages for West Texas.................................................. 46
Corn Breeding Program............................................................................ 49
Personal Notes.......................................................................................... 50
6th Annual Integrated Crop/Forage/Livestock Field Tour

5:00 - 5:30 Welcome and introductions (Location A)
5:30 - Bus tour No 1 loads and departs  (Location B)
5:45 - Bus tour No. 2 departs
Tours No 3 and up will depart as announced.

Rolling tour to see and hear about
1. Phase I and Phase II of Integrated Systems Research
2. Corn Hybrid Research, Arden Davis (TAMU)
3. Weed Control in Crops Peter Dotray (TTU)

Stations: Visit these for information on specific topics below.

1. Old world bluestems and economics
   Rick Kellison (Silver Creek Farm), Carlos Villalobos (TTU, Dept. Range Wildlife Fisheries), Teresa Duch (TTU, Dept. Plant and Soil Science), and Eduardo Segarra (TTU, Dept. Agricultural and Applied Economics & TAM)
   Vernon Lansford (TTU)

2. Cool-season perennial grasses
   Will Craduck (TTU, Dept. Plant and Soil Science) and Andy Hopkins (Noble Foundation)

3. Bemudagrass grasses and weed control in forages
   Mark Marsalis (TTU, Dept. Plant and Soil Science) and Twain Butler (TAMU)

4. Soil Fertility and fertilization
   Cary Green (TTU), Rick Zartman (TTU, Dept. Plant and Soil Science), and Monty Dollar (USDA-NRCS)

5. Soil microbes, carbon sequestration, and soil-born diseases
   Veronica Acosta-Martinez (USDA), Ted Zobeck (USDA) and Terry Wheeler (TAMU)

6. Warm-season annual grasses and Climate-based decisions
   Calvin Trostle (TAMU) and Steve Mauget (USDA)

7. Fencing options demonstration
   Nelson Martin, Bekaert Fence

8. Beef cattle management
   Jay Johnson, (TTU, Dept. Animal Science)

***Chuck wagon will start serving between 7:30 and 8pm***
Texas Tech University and its Partners
New Deal Agricultural Field Laboratory

A. Overview of Projects and dinner

B. 1. Old world bluestems and economics
   2. Cool Season Grasses
   3. Bermudagrasses and Weed control
   4. Soil microbes, Carbon sequestration, and soil-born diseases
   5. Warm-season grasses and Climate-based decisions
   6. Bekaert Fence Demonstration
   7. Beef Cattle Management
Advisory Council
for Research, Education and Outreach
Integrated Crop/Forage/Livestock Systems for Sustainable High Plains Agriculture

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Silver Creek Farm
Lockney, TX

Jim Conkwright
High Plains Underground Water
Conservation District, Lubbock, TX

Curtis Griffith
City Bank
Lubbock, TX

Harry Hamilton
Harry Hamilton and Associates
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Pitchfork Ranch
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Mike Orr
Tahoka, TX

Tom Sell
Lubbock, TX

Dewayne Thevnick
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This Research is Funded in Part by Grants and Contributions from the following:

USDA-Sustainable Agriculture Research and Education (SARE) Southern Region
High Plains Underground Water Conservation District No. 1, Lubbock, TX
Texas State Support Committee/Cotton Incorporated, Lubbock, TX
USDA-Ogallala Aquifer Initiative
USDA-ARS, Lubbock, TX
USDA-NRCS, Lubbock, TX
Rushing Family Foundation, Lubbock, TX
Samuel Roberts Noble Foundation, Ardmore, OK
Agricultural Enterprises Corporation, Oklahoma City, OK
South West Public Service, Lubbock, TX
City of Midland, Midland, TX
Bayer Crop Science, Lubbock, TX
Seed Resources, Tulia, TX
Frontier Hybrid Seeds, Abernathy, TX
Watley Seed, Spearman, TX
Wilbur Ellis, Lockney, TX
AGCO of Lockney, Texas
Miraco Livestock Water Systems, Grinnell, IA
Poole Chemical, Slaton, TX
Diversified Subsurface Irrigation, Lubbock, TX
Cycle Stop Valves, Lubbock, TX
Water Master, Lubbock, TX
Justin Moore Irrigation, Lubbock, TX
Top Notch Fence, Scurry, TX
Rain Master Irrigation Systems, Inc., Simi Valley, CA
Rieken Electric, Lubbock, TX
Barenbrug, USA, Tangent OR
Cold Water Creek Cattle Co., Stratford, TX
EuroDrip, USA, San Diego, CA
Netafim, USA, Fresno, CA

Texas Tech University
Office of Research Services
Office of the Dean, College of Agriculture and Natural Resources
Department of Plant and Soil Science
Department of Animal and Food Sciences
Department of Agricultural Education and Communications
Thornton Endowment, Department of Agricultural Economics

We are greatly indebted to our sponsors. Without their support, this research would not be possible. Thank you!
Integrated Crop/Forage/Livestock Systems in the Texas High Plains

Phase I
The First Four Years 1999-2002

INTRODUCTION
Texas High Plains crop production has used precipitation and supplemental irrigation with water pumped from the Ogallala aquifer at rates that have far exceeded recharge for many years. Over 20% of the U.S. cotton \((Gossypium hirsutum)\) crop is produced in this once vast grassland. Most of this cotton is produced in monoculture systems that are economically risky and contribute to wind induced erosion and depletion of ground water resources. Although large numbers of cattle are found in this region, little integration of livestock and crop production exists. Integrated crop-livestock systems could improve nutrient cycling, reduce soil erosion, improve water management, interrupt pest cycles, and reduce economic risk through diversification. Cotton yields per acre may be increased through complementary effects of forages and livestock.

Thus, an interdisciplinary research and education Crop/Forage/Livestock Systems Research Project was initiated in 1997 to compare two systems: 1) an irrigated Cotton Monoculture System using best management practices; and 2) an alternative irrigated Integrated Crop/Livestock System for production of both cotton and feedlot ready stocker steers. The Integrated System grows cotton in rotation with forages for grazing by steers. Criteria for evaluating these systems include plant and animal product quantity and quality, net profits, water use, soil conservation and fertility, and input requirements including pesticides, fertilizers, and mechanical operations. Producer cooperators provide on-farm testing of both the livestock and cotton systems, help to identify researchable needs and provide outlets for information to producers and industry. Two cotton experiment stations provide background data and ongoing information for the Cotton Monoculture System. The Texas Tech Agricultural Field Laboratory near New Deal, is the site for the replicated comparison of the Monoculture Cotton System with the Integrated crop/livestock system. Information is dispersed through educational opportunities, publications, field days, involvement of producers and industry as full partners, and linkage with other research sites.
OBJECTIVES

The overall objective is to develop environmentally sustainable and economically feasible crop and livestock systems that will assure the viability of agricultural activities in the Texas High Plains.

Specific Objectives include:

1) To compare productivity, profitability, and impact on natural resources of continuous cotton systems, all forage-livestock systems, and an integrated cotton/forage/livestock system.

2) To involve local producers and industry in identifying researchable needs, in developing and testing systems of production, in the development of more effective dissemination of information to end users, and enhanced adoption of new technologies.

3) To link this research with sustainable systems research in other ecoregions to increase the base of knowledge and understanding of the principles that apply to integrated systems.

Experimental Area

An underground drip irrigation system was installed and each individual paddock and field replication was equipped with a turbine water meter to measure total water applied and rate in gallons. Drip tapes are located on 40-inch centers and are buried approximately 14 inches deep. The tape used was a Netafim 10-mil Python polyethylene seamless extruded tube with injection molded emitters on 24-inch centers. The emitters have a flow rate of 0.39 gallons per hour at an inlet pressure of 12.80 psi. The filter system consists of a Netafim Arkal Model expanding disc dual filter capable of 140-mesh filtration. In addition, a Netafim hydrocyclone and sedimentation tank are used on the system to remove the heavy sand particles prior to disc filtration. The complete filtration assembly is automated with a 4-station controller to flush on a time and a pressure differential basis. The system is also equipped with a chemigation check valve and an Agri-Inject hydraulically actuated teflon diaphragm fertilizer/chemical injection system. The injector has an injection rate of 5.6 GPH at 100% capacity to 0.56 GPH at 10% of capacity. The pump is regulated by a pressure actuated flow control Cycle Stop Valve. This allows continual operation of the pump on a pressure regulated system while irrigating. Construction of the drip irrigation system was begun in July 1997 and was completed in January of 1998.

Each system includes three replications in a complete randomized block design. For the Cotton Monoculture System, wheat is planted in furrow bottoms each autumn to reduce soil erosion. In early May, wheat is terminated with Roundup and Roundup Ready cotton is planted into the raised beds. Cotton is stripped in November and wheat is replanted for the following crop. For the Integrated System, seven Angus-cross steers graze within each rep each year for a total of 21 steers per year. Steers purchased from feeder-calf sales at an initial weight of about 500 lbs, begin grazing in early January on the stockpiled old world bluestem pastures. Steers are supplemented by grazing small grains; first rye until mid-April, then wheat as these pastures are available. Rye is terminated in late April for no-till establishment of cotton, planted into the rye in early May. Wheat is grazed out and the land is fallowed until rye is planted the following September. Steers then graze spring growth of bluestem until moved to the feedlot in mid-July. In late summer, nitrogen (60 lbs/acre) and irrigation water are applied to bluestem to stockpile forage for the following group of steers. Bluestem seed are harvested in mid- to late-October. Following cotton harvest in November, wheat is no-till drilled into cotton stubble. For both systems, all applications of herbicides and pesticides are by currently recommended practices.
RESULTS

At the end of the first 4 years, there was no difference in yield of cotton lint/acre between the two systems. However, the Integrated System required about 38% less nitrogen fertilizer and used about 23% less irrigation water than the Cotton Monoculture System. Cotton in the Monoculture System used 16.5”/acre of water. Most of the water demand in the Integrated System has been for the cotton component (20”/acre) while the forages required between 8 to 12”/acre, annually. Bluestem provided more days of grazing per inch of water applied than rye but was similar to wheat. On a per system acre basis, the Alternative System required fewer inputs of herbicides and pesticides. Daily gains of steers averaged 1.8 lb/d during the pasture phase and 3.5 lb/d during finishing. After the establishment year, no supplementation with stored forage has been required. Likewise, after establishment, profitability has been greater for the Integrated System in net returns to variable costs (calculated returns do not include any government payments for either system). The Integrated System is more sensitive to changes in the price of cattle than to either cotton or seed from Dahl Bluestem.

After 4 years, the Integrated Crop/Livestock System appears more profitable and requires less inputs of irrigation water and energy-expensive chemicals, particularly nitrogen fertilizer. However, further improvements and research are needed to design and implement systems that are economically profitable and that will adequately conserve natural resources, particularly water. Results of this research points the way to development of such systems that can be more sustainable for the Southern High Plains Region.
New Crop/Forage/Livestock Systems Research

In April of 2002, we were fortunate to receive a new grant from the USDA-SARE Southern Region Program to expand this systems research project. During the past 4 years of research with the original project, we have not only identified ways to improve conservation of resources and improve profitability, but the research has also identified ways to make further improvements. Thus, this next generation of research is built on the findings of the original research. The original systems will be continued as the bench-mark for comparison with the new systems as follows:

1. Dry-land integrated cotton/forage/livestock system. This system is based on native grasses and is complemented with a forage sorghum/cotton rotation. Both the native grasses and the forage sorghum will be grazed by stocker steers as forage is available in early spring to late summer. This systems research was initiated in May of this year.

2. A 3-paddock grazing system that uses WW-B. Dahl for the base pasture and bermudagrass for the two supplemental pastures. Steers graze from April to the end of the grazing season. Forages are irrigated by a drip system. Seed will be harvested from the Dahl in October.

3. A single-paddock system that uses WW-B. Dahl for grazing from late winter to late July. Seed will be harvested in October. Steers will be supplemented with gin trash if forage becomes limiting for grazing.
**Phase I**

**Integrated Crop/Forage/Livestock System (irrigated)**

- **Rye**
- **Cotton**
- **Wheat**

**Rotation**

- **OWB**
- **Pasture**

**Monoculture Cotton (irrigated)**

- **Cotton**
- **Terminated**
- **Wheat**

**Steer Performance (4 yr avg)**

<table>
<thead>
<tr>
<th>Month</th>
<th>Weight, lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Feb</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Mar</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Apr</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>May</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Jun</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Jul</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
<tr>
<td>Nov</td>
<td>Pasture: 600, Feedlot: 1400</td>
</tr>
</tbody>
</table>

**Steers:** Angus X  
Purchased: 550 lb avg.  
Graze: Jan to Mid-July  
Feedlot: Cold Water Creek  
Stratford, TX

**Daily Gains:**
- Pasture: 1.8 lbs  
- Feedlot: 3.5 lbs  

**Grazing Sequence:**
- Stockpiled dormant OWB → Rye → Wheat → Spring growth OWB

**Days grazing for each forage by month**

- **OWB**
- **Rye**
- **Wheat**
Stocking rate:
System: 0.7 Steers/acre
OWB: 1.35 Steers/acre
Small grains: 3 Steers/acre

Actual days grazed by 7 steers

Steer grazing days per acre

Steer grazing days per acre per inch irrigation water

Crude protein in forage 2004

Crude protein supplementation:
Total: 75 lbs/steer of 41% Cotton-seed cake (Purina Mills)
Supplemented while majority of grazing was on dormant OWB.

Forage inputs

Grass seed

Seed yield, PLS lbs/acre

Forage crop
Cotton lint yields

Variety:
1998-2002: Paymaster 2326RR
2003: FiberMax 989 RR BR

Fertilizer:
1998-2002: 112 lb N/acre
2003:
Monoculture Cotton – 80 lbs/acre N
       60 lbs/acre P₂O₅
Integrated Cotton – 100 lbs/acre N
       60 lbs/acre P₂O₅

Economics
Prices used for calculations:

<table>
<thead>
<tr>
<th>Crop</th>
<th>$ price</th>
<th>unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>0.55</td>
<td>lb</td>
</tr>
<tr>
<td>Cotton seed</td>
<td>110.00</td>
<td>ton</td>
</tr>
<tr>
<td>OWB seed</td>
<td>18.00</td>
<td>lb</td>
</tr>
<tr>
<td>Cattle buy</td>
<td>93.00</td>
<td>cwt</td>
</tr>
<tr>
<td>Cattle sell</td>
<td>87.00</td>
<td>cwt</td>
</tr>
</tbody>
</table>

*Calculated returns do not include any government payments for either system.
Phase II

Dryland System

Sorghum X Sudangrass hybrid:
Brown Mid-rib type
Variety: SS200
(Seed donated by Seed Resources, Tulia)
Seeding rate: 10 lb/ac ; 7 inch rows
Fertilizer:
50 lb N/ac; 25 lb P$_2$O$_5$/ac; & .5 lb/ac S

Lab lab bean:
(Seed donated by Barenbrug USA)
Seeding rate: 20 lb/ac

Cotton:
Variety: FiberMax 960 RR
Fertilizer:
30 lb N/ac; 15 lb P$_2$O$_5$/ac

Native Pasture
(Seed donated by Frontier Hybrids, Abernathy)

<table>
<thead>
<tr>
<th>Species</th>
<th>Seeding rate, lb/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffalograss</td>
<td>2.0</td>
</tr>
<tr>
<td>Bluegrama</td>
<td>1.0</td>
</tr>
<tr>
<td>Side Oats grama</td>
<td>2.0</td>
</tr>
<tr>
<td>Green Sprangletop</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Fertilizer:
30 lb N/ac; 15 lb P$_2$O$_5$/ac

Cattle:
Angus X
Began grazing May 4, 2004
Initial Weight: 500 lbs

Stocking rate:
System: 3.1 acres/steer
Native pasture: 2.25 acres/steer
Sorghum sudangrass hybrid: 0.9 acres/steer
**Irrigated Pasture System**  
(Drip irrigation – 40” centers)

**Bermudagrass**

**Dahl bluestem**

**Single Paddock Irrigated System**

**Hay vs Grazing**

**Grazing:**  
Steers graze stockpiled forage and spring growth til July. Steers will be supplemented as needed with cotton seed/gin trash.

**Seed harvest:**  
October

**Hay:**  
Total hay harvest system – no grazing  
No seed.

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**Tifton -85**

**Sprigged by Watley Seeds, Spearman, TX**

**Sprigging rate:** 50 bu/ac +

**Fertilizer:**  
100 lb N/ac; 50 lb P₂O₅/ac; &.15 lb/ac S

To be grazed by stocker steers

**Typical cost to producer (Tifton-85):**  
$4.50/bu + $40 /ac

**Typical sprigging rate:**  
25-30 bu/ac
Detailed records on input use and tillage operations were utilized to develop per acre cost and returns budgets for the components of both production systems. The cost of production portion of these budgets were composed of variable and fixed costs. Variable costs accounted for the cost of all pre-harvest and harvest inputs used, and capital expenditures associated with the use of those inputs. Fixed costs accounted for the costs associated with the ownership of machinery and equipment, irrigation system related costs, and land charges. Irrigation system costs assumed the use of a sub-surface drip irrigation system for a representative 120 acre irrigated farm in the Texas High Plains. Due to variability of pumping-lifts in the region, four commonly found pumping-lifts (150, 200, 250, and 300 feet) were analyzed in the development of the budgets.

In the first four years of the project the alternative system outperformed the conventional system in terms of both expected net revenues above variable costs and fixed costs. It was found, also, that as pumping lift increased, the relative difference between the performance of the alternative system over the conventional system became more significant. This implies that the scarcer groundwater is (as revealed/simulated by a higher pumping-lift), the greater the level of justification would be to adopt the alternative system (Figure 1 presents the four year average levels of expected net revenues above variable costs across pumping-lifts). It is important to highlight that over the first four years of the experiment, the alternative system resulted in a net irrigation water savings of slightly over 22 percent when compared to the conventional system. The first four year average irrigation water use for the conventional system was 19 acre inches per year and 14.70 acre inches per year for the alternative system.

Given the results obtained in the first four years of the experiment and based on the advise of cotton production experts, it was felt that the productivity of the cotton production component in both production systems could be improved upon by switching cotton variety from Paymaster 2326 to Fibermax 989. Additionally, it was felt that further overall productivity improvements could be made to both production systems by modifying the management and scheduling of irrigation.

The results of the fifth year of the experiment in terms of expected net revenues above variable costs across pumping-lifts are depicted in Figure 2. The first issue to note in those results is the significant increases experienced in expected revenues above variable costs across for both production systems when compared to the first four years of the experiment. For the alternative system, the level of expected revenues above variable costs almost doubled across pumping-lift scenarios. However, for the conventional system, the level of expected revenues above variable costs more than tripled across pumping-lift scenarios. These improvements in the overall economic performance of both systems, and especially those in the conventional production system, were as expected due to the fact that the improvements induced from the increased productivity in the cotton component would have a relatively larger impact on the conventional as compared to the alternative production system. Also, it is important to note that total irrigation water utilization in both systems was reduced in the fifth year of the experiment when compared to the first four years of the experiment, from 19 to 16.2 acre inches for the conventional system and from 14.7 to 12.9 acre inches for the alternative system.

It is also important to note, that in the fifth year of the experiment the level of expected net revenues above variable costs on a per unit of irrigation water used ranged from $23.04 (for the 300 feet lift scenario) to $25.58 (for the 150 feet lift scenario) per acre inch for the conventional system, and
from $24.12 (for the 300 feet lift scenario) to $26.61 (for the 150 feet lift scenario) per acre inch for the alternative system. Specifically, if the findings presented above for the fifth year are normalized with respect to irrigation water use we find: for the 150 feet pumping-lift scenario, that the expected level of net returns above variable costs of production for the alternative production system represents an increase of slightly over 4 percent when compared to the level of revenues from the conventional system. It is important to highlight, however, that in order to realize these increases in net revenue above variable costs of production, approximately 28 percent more acreage would have to be devoted to the alternative production system than the conventional system, and no water would be saved as compared to the conventional production system. Thus, from an economic perspective, when both production systems are evaluated by considering their respective irrigation water utilization, the fifth year of the experiment shows that their overall performance is quite similar.

Figure 1. Four year average levels of expected net revenues above variable costs across pumping-lifts for 1999-2002.

Figure 2. Results from the fifth year of expected net revenues above variable costs across pumping-lifts for 2003.

Economic Sustainability of an Integrated Cotton/Livestock Production System
Teresa Duch (graduate student) TTU, Dept of Plant & Soil Science

Sustainability of Texas High Plains agriculture is challenged among other factors, by a decline in the Ogallala Aquifer, reduced water for irrigation, increased pumping depth and the high economic risk that cotton as a monoculture imposes on farmers. Therefore, it is necessary to find alternative integral production systems for the region in order to regain sustainability. In order to find a sustainable production system there are many factors to consider. In general, sustainability must be defined in terms of ecology and economy. Ecology involves natural aspects of production including crops and animal species to be produced and environmental characteristics such as type of soil, climate, water availability, nutrient cycle, among others; ecology also includes negative or positive effects caused by productive activities on the environment. Economy addresses the purpose of the production, the profitability of the system, and the farmer’s willingness to change the traditional productive system into a “new” sustainable productive system. To fully address sustainability, it is necessary to develop relationships between ecology and economics. Thus, forage-livestock systems defined as “… the integrated combination of animal, plant, soil and other environmental components managed to achieve a
productive agro ecosystem” (FGTC, 1991), if managed correctly, are an alternative in areas where traditional systems are no longer efficient. Initially, it is important to know all the aspects involved in the system individually and deeply, although to define the system these factors must be playing together. This research took a first step on evaluating one of such alternative systems: a crop-forage- livestock system for the Texas South Plains, using ‘WW-B. Dahl’ (Bothriochloa bladhii, OWB) for grazing by stocker steers and seed production because of its recognized value as forage and for its extremely important seed commercialization; Wheat and rye, grown in alternate year rotation with cotton, provided additional forage. Figure 1 shows the profitability of the forage-crop-system when compared with that of cotton monoculture under various (45, 60, 75 and 90 m) water pumping depths scenarios. Figures 2 and 3 show the results of a sensitivity analysis calculated changing either the variable costs of production or the prices of commodities (cotton lint -$1.21/kg- cotton seed -$242.00/ton-, OWB seed -$39.60/kg- and stocker steers -1.92/kg-) by 2, 5 and10%.

**Fig 1.** Changes in net revenue above variable costs at different water pumping depths.

**Fig 2.** Changes in net revenue above variable costs with prices of commodities unchanged.

**Fig 3.** Changes in net revenue above variable costs with variable costs unchanged.

**Fig 4.** Changes in net revenue above variable costs when variable cost and commodity prices change simultaneously.

From the figures it can be concluded that the net revenues above variable costs for the alternative system are greater than those for cotton monoculture without regard of the water pumping depth. In general, the alternative system uses 25% less water than cotton monoculture. In both systems net revenue above variable costs decreases when water pumping depth increases.

However, the alternative system’s net revenues above variable costs are higher, and this system is more sensitive to changes, in both variable costs and commodities prices, than cotton monoculture.
Evaluation of Soil Properties

Among the evaluation of the sustainability of integrated crop cropping and livestock production systems, it is needed to understand its impacts on the soil functioning.

Generally, conventional monoculture agricultural systems can reduce the quality of soils by loss of organic matter and structure because of low levels of organic inputs and regular disturbance from tillage practices.

Our research have compared selected chemical, physical, and microbiological attributes under the integrated crop-livestock system and the conventional continuous cotton system without the confounding effects of the livestock activities.

Results of our research will be published this year at the Soil Science Society of America Journal.

The study of soil properties as affected by the integrated crop-livestock system will continue. In addition, Drs. Acosta-Martínez, Junping Chen, and John Zak will conduct a microbial ecology research project this year to investigate the impacts of the livestock activities on the soil microbial populations, activities, and diversity.

Importance of Microbes in Soil

Microorganisms are key to soil functioning because they play an important role in the conservation and restoration of agroecosystems (i.e., degradation of pesticides) (Kennedy 1999).

In addition, microorganisms control soil processes such as nitrogen fixation, nutrient cycling, organic matter decomposition, humus synthesis, and soil aggregation.

Microbes control all known soil biochemical processes because they are the main source of enzymes in soils (Tabatabai 1994).

Some enzymes called hydrolyses are critical in the transformation of organic nutrients into forms that are taken up more easily by plants.

Some of our Findings

- We conducted soil samplings from 0-5, 5-10, and 10-15 cm depths in 2002 and 2003 after 5 years of the establishment of the integrated crop-livestock and continuous cotton systems.
- Our study showed higher soil aggregate stability in perennial pasture (0-5 cm depth), which indicated changes in the quantity and quality of soil organic matter. There were no differences in soil total N among systems. However, the soil organic C was higher at 0-5 cm depth in perennial pasture compared to continuous cotton.
- Soil microbial biomas C (Cmic) and N (Nmic), which provide indications of the number of microorganisms in soil, were higher in the perennial pasture and wheat-fallow-rye-cotton rotation compared to continuous cotton at 0-5 cm depth. Soil Cmic was also greater in perennial pasture and wheat-fallow-rye-cotton rotation compared to continuous cotton at 5-10 cm depth.
- Enzyme activities involved in the degradation of chitin, cellulose, and sulfur mineralization were increased in perennial pasture and wheat-fallow-rye-cotton rotation compared to continuous cotton at 0-5 cm depth.
- Fatty acid extraction from soil microorganisms indicated that the types of microbes of perennial pasture differed from rye-cotton-wheat-fallow, wheat-fallow-rye-cotton, and continuous cotton for all depths evaluated.
- We have found clear and consistent differences in several soil properties between continuous cotton and perennial pasture.
- However, differences between continuous cotton and the crop rotation depended on which crop was sampled in the crop rotation and the soil parameter investigated.

For more information...

- Also remember to look for our publication in the Soil Science Society of America Journal this year: "Soil microbial, chemical, and physical properties in continuous cotton and integrated crop-livestock systems".

The nitrogen cycle is the most complex nutrient cycle in soils. Microbes play a key role in the conversion of nitrogen from the soil by the degradation of plant materials or organic amendments (i.e., manure) in soil. In addition, the protection of some bacteria with nitrogen acids is responsible for the biotrophic process.
Emerged plants are healthy in both the continuous cotton and cotton/rye rotation for the irrigated area in 2004. However, the stands for the continuous cotton averaged 5.1 plants/foot of row and the cotton/rye rotation averaged 1.5 plants/foot of row. The cotton in the rotation not only has a poor stand, but the roots are smaller overall than for the continuous cotton. It appears that soil compaction may be playing a role in reducing root development. Stand problems in the cotton/rye rotation are due in part to a very thick rye cover. Earthworms are plentiful in both cotton areas.

Dryland cotton stands were excellent in averaging 2.1 plants/foot row. In one replication, there was a little bit of sore shank on the hypocotyl region of cotton, however, it was not severe enough to cause plant death or yield loss.

Aerial imagery:

Aerial images were taken on June 23, July 9, July 24, and Sept. 2 in 2003. The spectral pattern of cotton and weeds was examined for the first two sets of images (Fig. 1 is for June 23).

Weed control was improved in 2003, so that the reflectance pattern of most weeds was at least partially affected by the multiple Roundup applications. The most prevalent weed in the cotton was bindweed, though there were patches of other perennials including silverleaf nightshade, lakeweed and Texas blueweed. Those weed patches that were least affected by Roundup reflected light more strongly than cotton, while those patches that were most strongly burned down reflected light more weakly than cotton.

In the cotton/rye rotation (Fig. 2), silverleaf nightshade consistently had higher reflectance (or intensity of reflected light) than the cotton did. Lakeweed on the other hand, reflected light less strongly from bands 21 to 31 than did cotton, but reflected light more strongly from about band 35 to band 55, which corresponds to the near-infrared spectrum of light. Texas blueweed reflected light similar to cotton until the near-infrared spectrum, then reflected light more strongly than cotton. Bindweed was all across the board compared with cotton, which probably was a function of how well Roundup had killed the weed in that spot.
In the continuous cotton area, there were more patches of pure cotton to examine, and a larger range in spectral patterns for the cotton. Lakeweed had a spectral pattern similar to cotton in this area as did bindweed, however most of the silverleaf nightshade patches had higher reflectance of light than cotton, particularly in the near-infrared region (Fig. 3). In summary, spectral signatures as a method of identifying weed patches was inconsistent after weeds were sprayed with Roundup. The easiest weeds to separate from cotton were Texas blueweed and silverleaf nightshade.

Figure 3. Spectral patterns of cotton and weeds in the continuous cotton area on June 23, 2003.
Adaptation of Bermudagrass to the Texas High Plains¹
Summary of Results from Small Plot Trials
Mark A. Marsalis (graduate student), Texas Tech University

Justification

The focuses of this research are the issues of water use and quality, forages suited for limited water situations and their relationship with sustainable agriculture on the Southern High Plains of Texas. We are nearing a time when significant changes in resources will affect greatly the present agricultural practices and productivity of this region of the U.S. As human populations increase rapidly and water quality and quantity continue to diminish, the importance of sustainable cropping systems weighs heavier on producers than ever before. Likewise, research in this area is critical and necessary in order to understand better and manage the natural resources that are threatened. Cotton (*Gossypium hirsutum*), by far, is the most extensively grown crop on the Texas High Plains. The greater than 3.5 million acres of cotton grown annually account for 20 to 25 percent of total U.S. cotton (USDA, 1989). Unfortunately, about half of the water applied to cotton through traditional irrigation systems is wasted through runoff and evaporation. More efficient, water conserving irrigation system technology has reduced evaporative losses but has resulted in expanded irrigated cropland acres, ultimately increasing total water withdrawal from the Ogallala aquifer. In addition, traditional cropping systems promote wind-induced soil erosion and reduced soil fertility. With cotton being the largest cash crop on the Southern High Plains and the major user of water, current methods of irrigation are hastening the depletion of ground water sources and will ultimately hinder the productivity of this land.

Grazing systems are potentially viable, sustainable complements to the cotton monoculture. There is no doubt that the cattle industry is an important component of Texas agriculture and economy. Eight of the ten counties in Texas that contribute to its leading all other states in numbers of beef cattle are located in the High Plains, which has also the highest concentration of feedlot cattle in the U.S. (Texas Agricultural Statistics Service, 1994). As cattle numbers increase, improved grazing systems must be developed in order to complement the conservative water use systems necessary in the future.

As good quality water for irrigation is being limited increasingly to municipal use, more poor quality water is allocated toward crop production (e.g. wastewater, saline aquifers). This raises the question of potential salinization within soils, particularly in the extreme southwestern region of Texas, where ground water sources are most limiting and leaching precipitation is very low. Therefore, it is essential to test salt and drought tolerant forages that could be incorporated into these potentially challenging systems. Bermudagrass (*Cynodon dactylon* (L.) Pers.), because of its tolerance to drought and relatively saline conditions, may qualify as a strong candidate for such situations. Bermudagrass is a warm-season perennial grass that appears to have originated in southeast Africa. Introduced in the U.S. as early as 1751, it quickly became one of the most important pasture grasses in the South. It is best adapted where mean daily temperatures are above 75º F (24º C). Little is known about the adaptation of bermudagrass to West Texas and therefore, should be tested to determine its suitability to the unique environmental conditions of the region. Recently, increasing numbers of producers have requested information on bermudagrasses. Because it is lacking, we have sought to obtain this information through research and through an organized effort to survey producers about their experiences with bermudagrass in the region.

¹ This research is funded in part and conducted in cooperation with Agricultural Enterprises Corp., Oklahoma City, OK; Southwest Public Service, Lubbock, TX; and the City of Midland, Midland, TX.
Specific Objectives

- Determine adaptation and nutritive value of bermudagrass varieties and hybrids to the High Plains of Texas.
- Estimate the survival and growth of the bermudagrasses under limited and saline irrigation conditions.
- Evaluate the role of bermudagrass for use in wastewater disposal applications.
- Determine forage quality of several varieties harvested at 28-day intervals.

These are the current establishment and production phase results from all locations of bermudagrass small plot research conducted by Mark Marsalis, Dr. Vivien Allen, and other faculty at Texas Tech University as well as various professionals associated with each site of planting. Measurements to be taken will include forage mass samples taken every 28 days to estimate production during the growing season. In addition, grasses will be analyzed for forage quality and will include analysis of fiber, crude protein, carbohydrate (TNC), and mineral content. Following every 28-day harvest, all plots are fertilized with nitrogen at a rate of 60 lb. per acre. All plots were planted in spring 2001 and research will be continued through summer 2004.

Results obtained from the planting year often times differ greatly from subsequent years of production. In addition, these data should not be interpreted to mean that bermudagrass would perform the same under all conditions or at any location. Our findings are site specific and results will vary with differing management practices (e.g. irrigation method, fertilizer inputs, planting rate, etc.).

Research was initiated in spring 2001 at three locations: Texas Tech Field Research Laboratory, New Deal, TX; Southwest Public Service (SPS) agricultural land, Posey, TX; and City of Midland effluent water application farms, Spraberry, TX.

Production of the plots is presented as total seasonal forage yield and seasonal growth distribution of the grasses at New Deal is included also. Plots at all locations were harvested every 28 days to simulate hay cutting conditions. A list of bermudagrass varieties and other plant species used is included.

Planting

At the Texas Tech Field Laboratory all bermudagrass varieties were planted on May 11, 2001 in 20-ft.² plots. Sprigged types were planted in a 3-row arrangement within each plot. Sprigs were placed in the rows, covered with soil to about 2 inches, and then rolled to compact the soil. Seeded varieties were broadcast within their respective plots at a high rate to ensure good establishment. Seeds were then raked into the newly disturbed soil and compacted. Twelve bermudagrass varieties are being studied at this location (See attached map).

Bermudagrasses (five varieties) at the Spraberry site near Midland were planted on May 10, 2001 via sprigs and in the same manner as those described previously at the Texas Tech Field Laboratory. In addition to bermudagrass, [Sporobolus virginicus (L.) Kunth], a salt tolerant marsh grass, is being studied. This grass is a warm-season perennial with high drought and salt tolerance and may have potential for use as a forage under saline conditions. The S. virginicus plugs were obtained from Beeman’s Nursery, Port Orange, FL and planted in a 3X4 arrangement within the 20-ft.² plots by placing them in relatively shallow holes and covering them with soil.

Due to extra time needed to eliminate existing stands of ‘Jose’ tall wheatgrass [Thinopyrum ponticum (Podp.) Barkw. & D.R. Dewey] in the planting area and time required to negotiate cooperation agreements, the site at the Southwestern Public Service farm near Posey was planted somewhat later than the other two sites, on June 14, 2001. Planting methods were identical to those of the Midland site.
Irrigation

At the site near New Deal, plots are irrigated with good quality Ogallala Aquifer water via a Netafilm® subsurface drip irrigation system. The rate of irrigation is 2.54 mm (0.10 inch) per day throughout the months of May, June, July, and August to supplement precipitation in order to supply at least 76.2 mm (3 inches) per month. A maximum of 312 mm (12 inches) of irrigation water per year is applied. This amount gives a theoretical total of 762 mm (~30 inches) per year when considering mean rainfall contributions for this region.

The Spraberry location receives irrigation from City of Midland wastewater holding ponds near the plot site. Total dissolved solids of the wastewater are about 1700 mg L⁻¹ (ppm). This water is applied through a side roll linear irrigation system used to irrigate adjacent alfalfa (Medicago sativa L.) fields. Timing of watering coincides with that designated for alfalfa production at the site.

Plots at the Posey location are irrigated with industrial cooling tower water from the nearby Jones Station of Xcel Energy (Southwestern Public Service). This water is high in total dissolved solids (TDS), about 7000 mg L⁻¹, and contains appreciable amounts of sulfate and sodium. Water comes from holding ponds through a center pivot irrigation system. Amount of water applied is dependent upon availability and allotment to surrounding crops at the site.

Production Phase Harvest Dates


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<tr>
<th>Location</th>
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<td>New Deal</td>
<td>Tifton 85</td>
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<tr>
<td></td>
<td>Sumrall 007</td>
<td>Mississippi Agric. For. Exp. Stn., Starkville, MS, 39759</td>
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Bermudagrass varieties and *Sporobolus virginicus* used in small plot field experiments and sources where plants were obtained.
Results and Conclusions

Several consistencies were observed in field small plot trials over three years of experimentation and at all locations. Regardless of location or irrigation type and method, Tifton 85 bermudagrass yielded the most forage (> 17,850 lbs/acre average at New Deal) over both growing seasons of the bermudagrasses tested. It is likely that greater genetic production potential of this variety allowed it to produce more forage than other grasses when exposed to varying stressful, climatic and management conditions. Ability to produce well under limited, sporadic, or saline irrigation conditions suggests broad adaptability of Tifton 85. Also, Tifton 85, despite relatively high acid detergent fiber (ADF) levels, exhibited higher in vitro dry matter disappearance (IVDMD; a predictor of digestibility) than other bermudagrasses at all locations. This supports previously reported results (Hill et al., 1993; Taliaferro et al., 1996) regarding superiority of the variety with respect to forage nutritive value. A potential disadvantage of Tifton 85 is lack of cold tolerance or necessity of warmer spring temperatures (than other bermudagrasses) for growth that was evident in our experiments. As a result, producers using this variety may find that adequate production and utilization of Tifton 85 for haying or grazing may be delayed in spring. Although seeded varieties tended to have better nutritive value than sprigged when analyzed by laboratory procedures and NIR, seeded bermudagrasses exhibited lower IVDMD. High relative IVDMD of Tifton 85 likely is the reason for differences between seeded and sprigged methods concerning dry matter disappearance. No differences between the two establishment methods were observed in mean forage mass and total seasonal yields. Yields of Giant, Sahara, Wrangler, and Cheyenne were all above 13,395 lbs/acre/yr and were considered good with the limited resources with which they were grown. It is difficult to speculate whether or not initial cost savings associated with seeding bermudagrasses rather than sprigging will carry over into subsequent years or if savings would outweigh profits sustained from selected sprigged varieties.

World Feeder bermudagrass consistently was one of the lowest producers of forage at all locations, except in spring when emergence and ground coverage of the variety were among the earliest observed. Nutritive value of World Feeder was good relatively, but little dry matter production caused digestible biomass to be low. Contrasts between Tifton 85 and World Feeder were the most notable extreme differences in many cases although various differences existed among other varieties at more specific instances and locations. Macho and Tifton 85, for example, were high in crude protein (CP) at...
all locations and low in total nonstructural carbohydrates (TNC), indicating a possible antagonist relationship between these two nutritive value parameters. Also, CP of grasses at Posey tended to be higher than New Deal and Spraberry and perhaps was due to additional nitrogen delivered in the irrigation water. Interestingly, at the two wastewater locations, Coastal and Midland 99 performed similarly regarding productivity and nutritive value and appear to be adapted to a broad range of growing conditions. Bermudagrass performance at New Deal, particularly Coastal, was comparable to results reported by Burton and Hanna (1995) for Coastal grown at Tifton, GA, but with less water and higher evapotranspiration rates common to the Texas High Plains. Tifton 44 performed well and seasonal yields (15,717 lbs/ac) were greater than those reported by Baker (2002) and Thom et al. (1990) in higher rainfall areas of the US. Sumrall 007 establishment (ground cover) was more rapid (P < 0.05) than other sprigged varieties and mean seasonal yields (15,450 lbs/ac) were greater than those reported by Lang et al. (2002) in Mississippi. Early establishment is important to producers attempting to utilize pastures within the first growing season of planting. Other than Tifton 85, Sumrall 007 and Hardie were the only two varieties with IVDMD above 60%.

Concerning Sporobolus virginicus, performance of the salt tolerant species was better at the municipal effluent water location near Midland, TX than at the industrial wastewater site farther to the north. Reasons for loss of stands at Posey are uncertain, but likely were a result of limited cold tolerance and dry winter conditions, combined with defoliation of dormant biomass in late autumn of 2002. It is unlikely that high salinity in irrigation water used was the cause of stand loss. Lab analysis and IVDMD estimates indicate that S. virginicus nutritive value is similar to that of improved bermudagrasses when grown under similar conditions. Results suggest that under saline conditions where forage options are limited, S. virginicus may be useful in regions where mean temperatures are warmer than those encountered at Posey and warrants further testing.

Results of this research indicate that improved forage bermudagrasses are, at least for the initial three years of establishment, adapted to the unique environmental conditions of the Texas High Plains and are productive when grown as hay using various types and amounts of irrigation and limited amounts of fertilizer. High salinity tolerance of bermudagrass was verified with experimentation in both greenhouse and field small plot trials that utilized slight to high levels of total dissolved solids in irrigation water but ranges of salinity tolerance were close to those reported previously for bermudagrasses. Forage nutritive value [IVDMD, ADF, neutral detergent fiber (NDF), ash] was similar to values reported by Hill et al. (1997) for bermudagrasses grown to four weeks of maturity. Generally, seeded varieties performed similarly to sprigged and no clear advantage was noticed between the two types, with the exception of Tifton 85. The fact that seeded varieties did not differ from sprigged with respect to total seasonal yield and mean forage mass, even with Tifton 85 considered, suggests that seeded bermudagrasses may be a viable option in this region without high costs associated with sprigging; however, long term studies are needed to evaluate persistence. Based on small plot tests, World Feeder bermudagrass performance is comparable to that reported by other researchers (Taliaferro et al., 1996; Evers et al., 1994; Lang et al., 2002) as mediocre at best in amounts of forage produced. Grazing trials are needed to evaluate further the nutritive value and forage productivity of World Feeder under grazing conditions if this variety continues to be of interest. Tifton 85 bermudagrass demonstrated the best overall performance of the grasses tested in the first three years of study. Field small plot studies are precursors to larger scale grazing experiments, and based on initial productivity and nutritive value findings, Tifton 85 is the clear choice for use in future grazing trials. Further research is needed to determine long term persistence and productivity of forage bermudagrasses in the region. Animal grazing and feeding trials are needed to obtain the most reliable and accurate estimates of forage quality of bermudagrasses produced in the area. Bermudagrasses, grown as hay, exhibit potential for use in limited or moderately saline challenged water situations and may contribute to agricultural sustainability on the Texas High Plains as water resources and water quality continue to diminish.
References:


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**Bermudagrass Study- Small Plots**

**Texas Tech Field Research Laboratory, New Deal, TX**

Planted May 11, 2001

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1-Tifton 85 (sp) 7-Macho (sp)
2-Coastal (sp) 8-Tifton 44 (sp)
3-Midland 99 (sp) 9-Sumrall 007 (sp)
4-Hardie (sp) 10-Giant (s)
5-Sahara (s) 11-Wrangler (s)
6-World Feeder (sp) 12-Chevenne (s)

a = 5 ft.
b = 4 ft.
s = seeded
sp = sprigged

195 ft.
Total seasonal yields of bermudagrasses grown at New Deal, TX averaged over two years, 2002 and 2003. n = 8 for each mean. Means not designated with the same superscript are different (P < 0.05).

Seasonal distribution of production of bermudagrasses grown at New Deal, TX, averaged over 2002 and 2003.
Total seasonal yields of bermudagrasses and *Sporobolus virginicus* grown at Spraberry, TX averaged over two years, 2002 and 2003. \( n = 8 \) for each mean. Means not designated with the same superscript are different (\( P < 0.05 \)).

‡ Indicates *S. virginicus* total for 2002 only; stands were lost after 2002. For 2002, *S. virginicus* was less than each variety of bermudagrass (\( P < 0.05 \)).
In vitro dry matter disappearance (IVDMD) of bermudagrasses and *S. virginicus* harvested in July 2002 and 2003 at all locations. At New Deal, blue bars represent sprigged varieties and red bars represent seeded varieties; a Tifton 85 is greater than mean of all other varieties. ‡ Indicates that IVDMD for *S. virginicus* at Posey is for July 2002 only. Grasses with the same letter are not significantly different. Tifton 85 represented by green bars.
Warm Season Perennial Grasses for the Southern Great Plains

Will C. Cradduck (graduate student) – Texas Tech University

**Introduction**

Grasses that are productive, well adapted, and tested on the southern Great Plains will be in greater demand in the near future. The decreasing availability of water from the Ogalalla aquifer will require producers to look for options that are not as dependent on irrigation. Forage-based livestock production could be an important option to traditional row crops. Forages other than native grasses will be needed to expand forage availability throughout the year and to allow increased forage production with increased inputs. Identifying such grasses would allow producers more flexibility when designing grazing systems, and would allow animals to graze a greater percentage of the year, thus, reducing dependence on supplemental feed.

**Rationale**

This study will determine effects of different species and cultivars on persistence, quality, mineral concentration, and biomass production of selected warm season perennial grasses. Please see the end of this summary for a plot map and list of grass species. Knowledge of warm season perennial grasses that can reliably produce forage in the summer months on the southern Great Plains with limited irrigation will be important to livestock producers. Quality and mineral content of these forages will also be important information so that producers can identify possible deficiencies, and supplement the forage or the animal to prevent loss of production in the grazing animal.

Grasses included in this study are, for the most part, known to exist on the southern Great Plains but were a minor part of the historic vegetation. Historically, the southern Great Plains was primarily buffalograss and blue grama, with taller grasses like the ones included in this study occurring in lower areas along creeks, draws, and other waterways. They are large plants, with very deep rooting systems. Rooting depth on the southern Great Plains is often limited by the presence of a petrocalcic (caliche) horizon in the lower part of the soil profile, usually below 100 cm. An important part of this study is to see if these generally deep-rooted grasses are limited in production or persistence by this limited rooting depth. If these grasses can be successfully grown on the southern High Plains under limited irrigation, they may have increased potential for biomass production over the native grasses. The deep rooting habit of these grasses may be important during periods of drought. Producers could sacrifice some production and allow these grasses to survive the drought on moisture deep in the soil profile, and then maximize production with supplemental irrigation during periods of normal rainfall.

**Methods**

Ten warm season perennial grass species were planted near Lubbock, TX in spring 2002, and reseeded in spring 2003. Plots are fertilized in spring and mid-summer with 60 lbs N/acre at each application. Irrigation is limited to 12 inches annually, applied from late spring to late summer through sub-surface drip. Plots will be harvested as for hay through the summer according to growth stage and individual cutting height and frequency recommendations. Persistence and biomass production will be monitored from hay cutting. Forage mineral concentration and forage quality indicators will also be determined from each hay cutting.

**Results**

This study took two years to establish, and we have learned valuable lessons about the establishment of these warm season perennial grasses. Probably the most important lesson learned is that these grasses are slow and difficult to establish. Two notable exceptions are sorghum almund and
These two grasses established easily and completely in 2002. Both did extremely well in 2003, but sorghum almum has not come back well in the spring of 2004. Kleingrass established fairly well in 2002, as did switchgrass, though not as well as kleingrass. Caucasian bluestem and big bluestem had some establishment in 2002, but were below 50%. Caucasian bluestem was slower in 2002, but surpassed big bluestem in 2003. WW-B. Dahl bluestem did not establish well in 2002, but has surpassed big bluestem and was similar to Caucasian bluestem for 2003. Eastern gamagrass established very little in 2002 and required reseeding for 2003, but I would now consider it well established for 2004. Little bluestem has not established well so far, and might only be viable as a portion of a grass mix rather than a monoculture. For 2004, the plots have good stands, with the exception of little bluestem and sorghum almum.

Persistence of these grasses is an important aspect of this experiment. The preliminary data below shows that sorghum almum is not persisting, and we have also lost a few little bluestem plants. The % stand counts for eastern gamagrass show there to be few plants per plot, but based on the large size of mature plants, this is not a problem. Also, the graph shows increases in stand counts of eastern gamagrass from last summer to this spring. This is not due to more seeds sprouting, but instead an increase in crown size due to tillering. This is also true for big bluestem.

![Warm season grass persistence chart](image)

There are a few noticeable differences in when these grasses break dormancy in the spring, as well as when they reach a first haycut stage (50% panicle emergence). Kleingrass and eastern gamagrass were the first to break dormancy, and also first to reach a haycut stage. The kleingrass and eastern gamagrass reached haycut stage on May 25, 2004. The canopy height graph below demonstrates the difference in spring productivity for these grasses.
This is our first year to get any biomass production and stand count data, and we are just beginning to get that information. Plots are harvested for biomass as they reach 50% panicle emergence. For the first haycut on May 25, 2004, kleingrass yielded 3234 lbs/acre, Iuka eastern gamagrass yielded 5186 lbs/acre, and Pete eastern gamagrass yielded 6208 lbs/acre.

**Conclusion**

Even though establishment may be somewhat prolonged, these grasses show promise as viable forage species on the southern Great Plains. Several of these grasses show promise of exceptionally high biomass production per acre. More data is needed on these grasses, as well as work on easier establishment.
Warm Season Perennial Grasses Plot Map

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1. Sorghum almum; *Sorghum almum*
2. Johnsongrass; *Sorghum halipense*
3. Kleingrass; *Panicum coloratum*; Selection 75
4. Switchgrass; *Panicum virgatum*; Blackwell
5. Eastern gamagrass; *Tripsacum dactyloides*; Iuka
6. Eastern gamagrass; *Tripsacum dactyloides*; Pete
7. Big Bluestem; *Andropogon gerardii*; Kaw
8. Little bluestem; *Shizachyrium scoparium*; Cimmaron
9. WW-B. Dahl old world bluestem; *Bothriochloa bladhii*
10. Caucasian old world bluestem, *Bothriochloa caucasia*
Cool-Season Perennial Grasses for the Southern Great Plains

Will C. Cradduck (graduate student) – Texas Tech University  
Dr. Andy Hopkins – Noble Foundation, Inc.

Grasses that are productive, well adapted, and tested on the southern Great Plains will be in greater demand in the near future. Decreasing availability of water from the Ogallala Aquifer, and increasing costs of pumping water from greater depths necessitate alternatives that require less water than currently used in irrigated agriculture. Forage-based livestock production could be an important option. Annual grains such as wheat (Triticum aestivum) that are planted for forage production are common in this area, but perennial cool season grasses could expand forage availability in autumn and spring and reduce operating costs associated with annual forages. Identifying such grasses would allow producers to incorporate them into their own systems for greater forage flexibility throughout the year, and reduce dependence on supplemental feed. Improved forages may also produce higher yields than native species in a high rainfall year, possibly allowing the producer to capitalize on periods of increased rainfall.

Rationale

Grasses included in this study are for the most part not native grasses to the southern Great Plains. These cool season grasses are generally regarded as needing more water than the annual average precipitation in this area can provide. However, adaptation of these cool season grasses to an area that was historically almost entirely warm season grasses may be possible. These genotypes were selected from the breeding program of Dr. Andy Hopkins (Noble Foundation, Ardmore, OK), as well as two cultivars from AgResearch (Ashville, NC). With supplemental irrigation and correct management, these grasses could become important for grazing systems in the southern Great Plains, providing high quality grazing during times in the spring and autumn that have historically been lacking in reliable forage.

Thus, objectives of study are to will determine effects of spring and autumn grazing vs. a non-grazed, hay harvested treatment of different cool-season perennial grass species and cultivars on persistence, quality, mineral concentration, and biomass production. Please see the end of this summary for a plot map and list of grass species and cultivars.

Methods

Eighteen cultivars and advanced breeding lines were planted near Lubbock, TX in September, 2001. Plots are fertilized in early spring and late summer with 60 lbs N/acre at each application. Irrigation is limited to 6 inches in spring and 6 inches in autumn, applied through subsurface drip. Steers graze plots for 60 days in spring and a shorter period in autumn, sufficient to graze plots down to about 8-10 cm. Steers are moved on and off plots during the grazing period based on forage mass in the plots. Non-grazed areas in each plot are cut as for hay at about the panicle emergence growth stage in spring, and about the end of grazing in autumn.

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2 Sponsored in part by a grant from the Samuel Roberts Noble Foundation, Inc., Ardmore, OK.  
2 In conjunction with Ag Research, Ashville, NC.
Results

Persistence

For stand counts, 100% stand represents at least 1 live plant for every 8 inch x 8 inch area of the plot (Hopkins, 1993). Stand counts began in July 2002. Separate grazed and ungrazed stand counts did not begin until April 2003. Stand counts have changed very little to date, even with relatively heavy spring grazing and the unusually dry summer of 2003.

Although it is unlikely for the stand counts to increase once the stands are established, these graphs occasionally show an increase. This is probably due to increases in size of the individual plants as they mature, and some error in sampling. Increases in stand counts in the western wheatgrass plots are due to prolific rhizomes filling in any empty spaces.

The extensive rhizome production of all four western wheatgrasses included in this study have eliminated any recognition of the original seeded rows. These grasses are spreading to adjacent plots, and are beginning to be a problem. This rhizome production may lend itself to tolerance of high grazing pressures, as it may allow the plant many points of regrowth protected beneath the soil surface. They also show little drip tape effect as is evident in the other plots, possibly also due to extensive rhizomes and transport of water and nutrients. The western wheatgrasses also maintained a green color through the dry summer of 2003 when the other grasses were basically dormant.

Some of the tall fescue stand counts and all of the smooth brome stand counts appear to be slightly less in the grazed than non-grazed areas. However, all stand counts are still above 95%, and the difference in grazed and ungrazed is probably not biologically significant. It may only be an artifact of reduced crown and/or overall plant size due to grazing, and not a difference in persistence. Thus far, all grasses have demonstrated excellent persistence under both grazing and hay cutting management.

![Cool season persistence chart](image-url)
Forage Quality
Determination of forage quality indicators are in progress.

Forage Minerals
Determination of forage mineral concentrations are in progress.

Canopy Height
Canopy height was measured by the disk meter method. Canopy heights are a good indicator of animal grazing patterns, as well as seasonal growth patterns.

In spring 2003, steers grazed plots fairly uniformly with the exception of the tall and western wheatgrasses. The steers appeared to find them relatively unpalatable, and we could not force them to graze these plots without overgrazing the other plots. During the autumn grazing period from November 4 to 11 (last canopy height graph), the steers greatly preferred the fescues to anything else, possibly due to a buildup of sugars in the plant. This could occur with cooler temperatures causing reduced plant growth, while photosynthesis continues to produce nonstructural carbohydrates in the plant. The hardinggrasses and bromegrasses were eaten relatively quickly and the intermediate and pubescent wheatgrasses were preferred less. In Spring 2004, canopy height measurements showed that the steers preferred smooth brome and fescues initially, and left the western wheatgrass and tall wheatgrass for last. They did eventually graze all the plots down to a fairly uniform height.

Growth patterns over the year were similar for these grasses, although actual amounts differed. Following is a graph of forage productivity of these cool season grasses over one year, based on growth documented by canopy height measurement. This graph is based on the haycut portion of the plots.
Biomass Production

Haycut yields were calculated by clipping a sample of the forage at a 2-inch cutting height. Each species and variety is harvested in spring based on growth stage rather than a common harvest date. Forages are harvested when 50% of the tillers reach the panicle emergence stage. In autumn, all grasses are harvested at a common date. Grazed areas are only harvested by spring and fall grazing with the exception of an occasional sample to document biomass. Ungrazed areas are harvested as for hay.

The spring 2003 haycut shows noticeably higher yields for the tall wheatgrasses, and noticeably smaller yields for the fescues. This is probably primarily due to the different harvest dates, as noted in the graph. Currently, it appears that these grasses are producing a larger percentage of their biomass in the autumn growth period, despite higher rainfall in the spring and less summer precipitation for the last few years. This year, that may have been affected by the fact that a lot of biomass was left on the plots over the summer and then harvested with the new growth in the autumn, possibly artificially increasing the fall hay harvest.
Fall haycut 2002, November 8

Spring haycut 2003

1 Haycut stage defined as 50% panicle emergence
Early establishment

Visual ratings were used to document the early establishment phase. Smooth bromes and wheatgrasses were slower to establish, especially the western wheatgrasses, but all of the plots were initially well established, by the following autumn. Establishment time may be an important factor to many producers, so the quicker establishing grasses such as hardinggrass and fescue may be a better option assuming they measure up in other respects.

Based on these plots, if these grasses were planted in early autumn, producers might expect very limited forage production from the fescues and hardinggrass the following spring. The wheatgrasses and bromes would only supply limited forage the following autumn. By spring of the second year, plants are mature enough to produce near their full capacity.

Conclusion

Although this research is still in progress, results to date suggest that many of these grasses show promise as viable forage species on the southern Great Plains. There is one possible exception. My only variety of pubescent wheatgrass, PI 401166, has shown low biomass for autumn 2003. Although it still has a normal number of live plants, its canopy cover of the ground is greatly reduced to the point that weeds have invaded those plots to a great extent. I expect its stand count to start dropping significantly, as well as biomass production to continue to be low. Most of the other grasses are still showing promise for this area, although there may be significant differences in their biomass production, palatability, and growth habits and production patterns over the year. Hardinggrass appears to be a top biomass producer as well as being palatable. The tall and western wheatgrasses appear to have good drought tolerance as well as biomass production. The fescues are doing quite well in persistence and biomass production, especially AGRFA 102. The smooth bromes are more average in biomass production, but cannot be discounted until quality has been assessed.

These grasses could fill gaps in available forage in both spring and autumn, where producers have generally relied on hand feeding and annual cereal crops. These grasses may allow livestock producers valuable options and flexibility when designing their grazing systems.
1. Hardinggrass; *Phalaris aquatica*; Maru
2. Hardinggrass; *Phalaris aquatica*; Maru IP Surv. C2
3. Tall fescue; *Festuca arundinacea*; AGRFA 102
4. Tall fescue; *Festuca arundinacea*; AGRFA 103
5. Tall fescue; *Festuca arundinacea*; Jesup E+
6. Tall fescue; *Festuca arundinacea*; PDF E-
7. Tall fescue; *Festuca arundinacea*; 97TF1 E-
8. Smooth bromegrass; *Bromus inermis*; Achenbach
9. Smooth bromegrass; *Bromus inermis*; Lincoln
10. Smooth bromegrass; *Bromus inermis*; Lincoln IP Surv. C2
11. Intermediate wheatgrass; *Thinopyrum intermedium*; PI 401166
12. Pubescent wheatgrass; *Thinopyrum intermedium* spp. barbulatum; Luna
13. Tall wheatgrass; *Thinopyrum ponticum*; Jose
14. Tall wheatgrass; *Thinopyrum ponticum*; PI401007
15. Western wheatgrass; *Pascopyrium smithii*; Barton
16. Western wheatgrass; *Pascopyrium smithii*; Barton H.S. Vig. C1 Syn 1
17. Western wheatgrass; *Pascopyrium smithii*; 01WW1
18. Western wheatgrass; *Pascopyrium smithii*; 97WW5
**Table 1. Herbicides Labeled for Pasture Weed Control**

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Common Name</th>
<th>Restricted</th>
<th>Grazing Restriction No. of days</th>
<th>Use Rate product/A</th>
<th>Cost S/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ally/Cimarron</td>
<td>60% metsulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.10-0.50 oz</td>
<td>2.30-11.50</td>
</tr>
<tr>
<td>Amber</td>
<td>75% triasulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.28-0.56 oz</td>
<td>2.39-4.76</td>
</tr>
<tr>
<td>Banvel/Clarity</td>
<td>4 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>0.5-2.0 pt</td>
<td>6.03-24.13</td>
</tr>
<tr>
<td>Cimarron Max</td>
<td>60% metsulfuron methyl + 2.87 lb 2,4-D + 1 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1 container/20 A</td>
<td>6.48</td>
</tr>
<tr>
<td>Cyclone Max</td>
<td>2.5 lb/gal paraquat</td>
<td>Y</td>
<td></td>
<td>2.0-3.0 qt</td>
<td>22.48-34.12</td>
</tr>
<tr>
<td>Crossbow</td>
<td>1 lb triclopyr + 2 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 14 Dairy</td>
<td>2.0-4.0 qt</td>
<td>27.00-54.00</td>
</tr>
<tr>
<td>Curtail</td>
<td>2 lb 2,4-D + 0.38 lb/gal clopyralid</td>
<td>Y</td>
<td></td>
<td>2.0-4.0 qt</td>
<td>N/A</td>
</tr>
<tr>
<td>Direx Supplemental*</td>
<td>4 lb/gal diuron</td>
<td>N</td>
<td>70 days</td>
<td>1.0-2.0 qt</td>
<td></td>
</tr>
<tr>
<td>Fuego</td>
<td>75% triasulfuron + 4 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1 container/8-10 A</td>
<td>6.83-8.50</td>
</tr>
<tr>
<td>Grazon P+D</td>
<td>0.54 lb picloram + 2 lb/gal 2,4-D</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1-4 pt/A</td>
<td>4.12-16.50</td>
</tr>
<tr>
<td>Outlaw*</td>
<td>1.45 lb 2,4-D ester + 1.05 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1-4 pt/A</td>
<td>3.56-14.25</td>
</tr>
<tr>
<td>Pasturegard</td>
<td>1.5 lb triclopyr + 0.5 lb/gal fluroxypyr</td>
<td>N</td>
<td>0 Beef; 14 Dairy</td>
<td>1.0-4.0 qt</td>
<td>N/A</td>
</tr>
<tr>
<td>Plateau</td>
<td>2 lb/gal imazapic</td>
<td>N</td>
<td></td>
<td>4.0-12.0 oz</td>
<td>10.00-30.00</td>
</tr>
<tr>
<td>Range Star</td>
<td>1 lb/gal dicamba + 2.87 lb/gal 2,4-D</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1.0-4.0 pt</td>
<td>3.63-14.50</td>
</tr>
<tr>
<td>Reclaim</td>
<td>3 lb/gal clopyralid</td>
<td>N</td>
<td>0 day</td>
<td>1.5 pt</td>
<td>38.81</td>
</tr>
<tr>
<td>Redeem</td>
<td>2.25 lb triclopyr + 0.75 lb/gal clopyralid</td>
<td>N</td>
<td>0 Beef; 14 Dairy</td>
<td>1-3 pt/A</td>
<td>9.37-28.13</td>
</tr>
<tr>
<td>Remedy</td>
<td>4.0 lb/gal triclopy</td>
<td>N</td>
<td>0 Beef; 14 Dairy</td>
<td>1.0-4.0 pt</td>
<td>11.69-46.77</td>
</tr>
</tbody>
</table>
### Table 1. Herbicides labeled for Bermudagrass

<table>
<thead>
<tr>
<th>Product</th>
<th>a.i.</th>
<th>Rate/A</th>
<th>Alfalfa Timing</th>
<th>Harvest Interval</th>
<th>Notes:</th>
<th>Cost/Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roundup Weather Max Supplemental Label</td>
<td>5.5 lb glyphosate</td>
<td>N</td>
<td>28 days</td>
<td>11 fl oz.</td>
<td>6.00</td>
<td></td>
</tr>
<tr>
<td>Spike 20 P</td>
<td>20% tebuthiuron</td>
<td>Y</td>
<td>365 days</td>
<td>10-15 lb</td>
<td>76.00-1114.0</td>
<td></td>
</tr>
<tr>
<td>Starane</td>
<td>1.5 lb/gal fluroxypyr</td>
<td>N</td>
<td>0 Beef; 14 Dairy</td>
<td>1.0-2.0 pt</td>
<td>11.75-23.50</td>
<td></td>
</tr>
<tr>
<td>Surmount</td>
<td>0.67 lb picloram + 0.67 lb/gal fluroxypyr</td>
<td>Y</td>
<td>0 Beef; 14 Dairy</td>
<td>1.0-4.0 pt</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Tordon 22K</td>
<td>2.0 lb/gal picloram</td>
<td>Y</td>
<td>0 Beef; 14 Dairy</td>
<td>1.0-2.0 pt</td>
<td>12.63-25.25</td>
<td></td>
</tr>
<tr>
<td>Velpar L</td>
<td>2.0 lb/gal hexazinone</td>
<td>Y</td>
<td>30 days</td>
<td>treat individual plants</td>
<td>12.63-25.25</td>
<td></td>
</tr>
<tr>
<td>Weedmaster*</td>
<td>1 lb dicamba + 2.87 lb/gal 2,4-D amine</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1.0-4.0 pt</td>
<td>3.63-14.50</td>
<td></td>
</tr>
<tr>
<td>2,4-D Amine</td>
<td>3.8 lb/gal 2,4-D amine</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1.5-4.0 pt</td>
<td>2.81-7.50</td>
<td></td>
</tr>
<tr>
<td>2,4-D Ester*</td>
<td>5.5 lb/gal 2,4-D ester</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>1.5-4.0 pt</td>
<td>4.17-11.12</td>
<td></td>
</tr>
</tbody>
</table>

*Denotes Herbicide is labeled immediately after sprigging bermudagrass.

Table 1 website and additional information may be accessed at: [http://stephenville.tamu.edu/~butler/foragesoftexas/pasture/pasturelabels.htm](http://stephenville.tamu.edu/~butler/foragesoftexas/pasture/pasturelabels.htm)

### Table 2. Herbicides labeled for Alfalfa

<table>
<thead>
<tr>
<th>Products</th>
<th>a.i.</th>
<th>Rate/A</th>
<th>Alfalfa Timing</th>
<th>Harvest Interval</th>
<th>Notes:</th>
<th>Cost/Ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balan*</td>
<td>Benefin</td>
<td>2 lb</td>
<td>PPI</td>
<td>-</td>
<td></td>
<td>29.10</td>
</tr>
<tr>
<td>Eptam*</td>
<td>EPTC</td>
<td>3 qt</td>
<td>PPI</td>
<td>-</td>
<td>Stunting may occur</td>
<td>25.80</td>
</tr>
<tr>
<td>Treflan</td>
<td>Trifluralin</td>
<td>1 pt</td>
<td>PPI</td>
<td>21 days</td>
<td>Stunting may occur</td>
<td>3.56</td>
</tr>
<tr>
<td>Seedling Stage</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buctril 4E</td>
<td>Bromoxynil</td>
<td>1.5</td>
<td>&gt;4 leaf</td>
<td>30 days</td>
<td>When broadleaf weeds &lt;4&quot; tall</td>
<td>20.86</td>
</tr>
<tr>
<td>Butyrac*</td>
<td>2,4-DB</td>
<td>2 qt</td>
<td>2-4 leaf</td>
<td>60 days</td>
<td>When broadleaf weeds &lt;3&quot; tall</td>
<td>16.90</td>
</tr>
<tr>
<td>Kerb*</td>
<td>Pronamide</td>
<td>1.5 lb</td>
<td>&gt;1 leaf</td>
<td>25 days</td>
<td>Early poe to grasses and pre to broadleaf</td>
<td>49.00</td>
</tr>
<tr>
<td>Pursuit</td>
<td>Imazethapyr</td>
<td>1.44 oz</td>
<td>&gt;2 leaf</td>
<td>30 days</td>
<td>When weeds &lt;3” tall</td>
<td>16.56</td>
</tr>
<tr>
<td>PoastPlus*</td>
<td>Sethoxydim</td>
<td>2 pt(A) 3.75 pt(P)</td>
<td>Early post</td>
<td>14 days</td>
<td>When grassy weeds are &lt;6” tall</td>
<td>13.68-25.60</td>
</tr>
<tr>
<td>Raptor</td>
<td>Imazamox</td>
<td>4 oz</td>
<td>&gt; 2 leaf</td>
<td>20 days</td>
<td>When grass and broadleaf weeds &lt;3” tall</td>
<td>16.56</td>
</tr>
<tr>
<td>Select*</td>
<td>Clethodim</td>
<td>8 oz(A) 16 oz(P)</td>
<td>Early post</td>
<td>15 days</td>
<td>When grassy weeds are &lt;6” tall</td>
<td>12.18-24.38</td>
</tr>
<tr>
<td>Trade Name</td>
<td>Common Name</td>
<td>Restricted Use</td>
<td>Grazing Restriction No. of days</td>
<td>Use Rate product/A</td>
<td>Crops Barley=B Oat=O Wheat=W</td>
<td>Primary Weeds</td>
</tr>
<tr>
<td>------------</td>
<td>-------------</td>
<td>----------------</td>
<td>-------------------------------</td>
<td>-------------------</td>
<td>-------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Aim</td>
<td>2 lb/gal carfentrazone</td>
<td>N</td>
<td>7 days</td>
<td>0.33-1.24 oz</td>
<td>B, W, O</td>
<td>select broadleaves</td>
</tr>
<tr>
<td>Ally</td>
<td>60% metsulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.1 oz</td>
<td>B, W</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Amber</td>
<td>75% triasulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.28-0.47 oz</td>
<td>B, W</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Banvel</td>
<td>4 lb/gal dicamba</td>
<td>Y</td>
<td>0 Beef; 7 Dairy</td>
<td>4 oz</td>
<td>B, W, O</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Buctril</td>
<td>4 lb/gal bromoxynil</td>
<td>N</td>
<td>30 days</td>
<td>1.0 pt</td>
<td>B, W, O</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Finesse</td>
<td>62.5% chlorsulfuron + 12.5% metsulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.25-0.33 oz</td>
<td>B, W, O</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Glean</td>
<td>75% chlorosulfuron</td>
<td>N</td>
<td>0 day</td>
<td>0.25-0.33 oz</td>
<td>B, W, O</td>
<td>broadleaf weeds</td>
</tr>
<tr>
<td>Maverick</td>
<td>75% sulfosate</td>
<td>N</td>
<td>0 day</td>
<td>0.67 oz</td>
<td>W</td>
<td>bromes</td>
</tr>
<tr>
<td>MCPA</td>
<td>3.7 lb/gal MCPA</td>
<td>Y</td>
<td>0 day</td>
<td>1 pt</td>
<td>B, W, O</td>
<td>mustards</td>
</tr>
<tr>
<td>Outlaw</td>
<td>1.45 lb 2,4-D ester +</td>
<td>Y</td>
<td>0 Beef; 7</td>
<td>1.0-2.0 pt</td>
<td>W</td>
<td>broadleaf weeds</td>
</tr>
</tbody>
</table>

- Also labeled for clovers

Table 2 website and additional information may be accessed at: [http://stephenville.tamu.edu/~butler/foragesoftexas/pasture/alfalfalabels.htm](http://stephenville.tamu.edu/~butler/foragesoftexas/pasture/alfalfalabels.htm)
| **Peak** | 1.05 lb/gal dicamba | Dairy | 57% prosulfuron | N | 30 days | 0.38-0.5 oz | B, W, O | broadleaf weed | 4.80-6.00 |
| **Puma** | 0.67 lb/gal fenoxyprop | Y | 0 day | 1 pt | B, W | wild oats | N/A |
| **Rave** | 8.8% triasulfuron | Y | 0 Beef; 7 Dairy | 4 oz | B, W | broadleaf weed | 5.8 |
| **Starane** | 1.5 lb/gal fluroxypyr | N | 7 days | 1.3 pt | B, W, O | broadleaf weed | 19.50 |
| **Stinger** | 3 lb/gal clopyralid | N | 7 days | 1.5 pt | B, W, O | broadleaf weed | 6.46-8.53 |
| **Weedmaster** | 1 lb/gal dicamba + 2.87 lb/gal 2,4-D amine | Y | 0 Beef; 7 Dairy | 1.0-4.0 | B, W, O | broadleaf weed | 3.63-7.27 |
| **2,4-D amine** | 3.8 lb/gal 2,4-D amine | Y | 0 Beef; 7 Dairy | 1.5-2.0 pt | B, W, O | broadleaf weed | 2.81-3.75 |
| **2,4-D Ester** | 5.5 lb/gal 2,4-D ester | Y | 0 Beef; 7 Dairy | 1.5-2.0 pt | B, W, O | broadleaf weed | 4.17-5.56 |

Table 3 website with additional information may be accessed at the following site:

http://stephenville.tamu.edu/~butler/foragesoftexas/pasture/sm grainlabels.htm
General Principles for High Quality Forage: For any forage, quality and energy level of the forage declines with maturity. This decline is rapid once the forage matures past boot stage. The decision about quality forage vs. tonnage depends on what you will use the forage for. If you seek quality forage for grazing or haying (vs. tonnage) do not allow forage to head out. Maximum tonnage for most forages occurs in the soft dough stage though quality is lower. As a rule of thumb the optimum time to harvest forage sorghum for silage is at the soft dough stage in the grain. For best regrowth after haying or grazing leave a minimum of 6” of stubble. Remember that seed size will differ among forage types. Seeding rates on irrigated land are roughly 1.5 to 2.0 times higher than dryland; grazing seeding rates are slightly higher than rates for hay or silage. For long-term grazing consider plugging your drill to have ~20-22” spacing between rows. Livestock tend to walk between the rows thus regrowth is better. If seed placement and stand establishment is an issue, especially for dryland, growers may be better off using a planter instead of a drill to increase the likelihood of achieving a stand.

Conventional sorghum/sudan. Haygrazer. Adequate for numerous uses and highly productive, but slightly more than 50% of yield comes from stem. Often the best all-round producer for hay or grazing. Better vigor, regrowth, and drought tolerance than forage sorghum. Depending on the hybrid it may be sweet or not, or have coarse or fine stems. These are normally about 16,000 seed/lb. Grazing may be initiated when the plants are 24-30” tall.

Sorgo-sorghum/sudan. Commonly referred to as ‘three-way cross.’ This class of forage is supposedly sweeter than sorghum/sudan, which is believed to increase consumption and palatability for livestock. Seed size (20,000-24,000 seed/lb.) is smaller than conventional sorghum/sudans thus seeding rates should be 20% less. Sorgo-sorghum/sudan has the good regrowth and drought tolerance of conventional sorghum/sudan. Forage tends to be finer stemmed due to increased presence of sorgo and sudan.

Brown mid-rib (BMR) sorghum/sudan. The feature of BMR forages is lower lignin content. The management of BMR sorghum/sudan (~16,000 seed/lb.) is similar to conventional sorghum/sudan for seeding, planting date, and harvesting. The brown mid-rib trait is just that, a brown midrib in the leaves. More importantly, BMRs have lower lignin concentration in the leaves and stalk. This can result in 20 to 50% less lignin than conventional sorghum/sudan when harvested at comparable maturities. High lignin lowers the digestibility (i.e., the negatives of higher Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF)) of the forage. Thus BMR forage has higher feed value and forage palatability for livestock (grazed or baled). 1999 and 2000 results from Texas A&M-Amarillo determined a 12% increase in average daily gain for stockers in a replicated rotational grazing system when grazing BMR vs. the exact same hybrid without the BMR trait (Table 1). In addition, grazing preference for BMR forage vs. other sorghum/sudans has been observed in the field. Don’t be deterred by somewhat higher seed costs with BMR forages. At modest seeding rates many of the regional Texas High Plains
companies’ hybrids will cost $3-4 more per acre to plant (and these companies have been at the forefront of developing BMR), but you may pay an additional $3-4 per acre for the hybrids of large national seed companies.

One concern with BMR may be standability (lodging). This is generally only a concern if the forage heads out. Higher seeding rates increase lodging potential. Lower seeding rates than conventional sorghum/sudans and lower applied N may be appropriate for BMRs if the forage will head out. Also, BMR forage sorghum is available, and forage quality results demonstrate that BMR forage sorghums as a class are very near corn silage quality (Table 2), but require less water to obtain equal tonnage.

**Do BMR forages yield as well as conventional forages?** Few comparisons exist, but the Texas A&M—Amarillo forage sorghum trials do suggest a yield drag with the BMR trait when all BMR forage sorghums are compared as a class to the average of all conventional forage sorghums. Many of the BMR forages represent first-generation BMR forages (as well as experimentals that will not be released). As second generation BMR materials come on the market I anticipate that yield differences will be less. Individual BMRs today do yield more than many conventional forages whether forage sorghum or sorghum/sudan.

**Photoperiod-sensitive sorghum/sudan and forage sorghum.** Current photoperiod sensitive forages remain in the vegetative stage until daylength is less than ~12 h, 20 min (about September 20th for West Texas) at which time it will initiate the reproductive stage (and head out about 4 weeks later). Thus forage potential (grazed, baled, ensiled) is higher due to long-season growth, especially if planted early. While producers run the risk of conventional forages heading out due to delayed harvest (rainy weather, no time to harvest) photoperiod sensitive forage simply continue adding more leaves. This puts the producer in control and reduces the risk of losing forage quality due to heading. The general management of photoperiod sensitive forages (~16,000 seed/lb. for forage sorghum or sorghum/sudan) is the same as conventional hybrids for planting date, seeding rate, regrowth, etc. Photoperiod sensitive traits are now available in forage sorghum from several companies as well as hybrid pearl millet. Some research suggests that photoperiod-sensitive hybrids may have lower quality than conventional forages, but this appears to often be due in part to the higher tonnage. Several companies are marketing photosensitive hybrids that in fact might be very long maturity, but not PS.

**Forage sorghum.** Old names such as ‘Red Top Kandy’, ‘Cane’, ‘Sweet sorghum’. Many forage sorghums are multi-purpose, but are most often planted for silage rather than hay or grazing because of their limited regrowth (retillering) potential. These materials are often very tall and coarse stemmed in part due to their strong daylength sensitivity. Forage sorghums have sweet, juicy stems, relatively small grain heads, and may mature late. Traditionally, some grain production was expected from forage sorghums produced for silage, but the widespread availability of feed supplements has made this less important. Prussic acid potential tends to be higher than sorghum/sudans. Seed size varies, but averages near 16,000 seed/lb. Forage sorghum is the best choice for after frost grazing, especially the “male sterile types” which will head out but not set grain unless pollinated by another hybrid.

Somewhat similar is ‘Red Top Cane,’ an old ‘early sumac’ forage sorghum cross, which has higher seeding rates than conventional forage sorghum. Also, ‘Hegari,’ or ‘Hy-Gere’ is popular with some growers. It produces chalky or starchy-white seeds, and is sweet. Some have suggested that hegari is suitable for shallow soils or chlorotic soils. It is an older ‘workhorse type’ forage with good drought tolerance, but low disease resistance. Over time, Hegari has evolved to a lower-class forage placed on less productive soils. A downside of full maturity in both Red Top Cane and Hegari forages is tannin in the grain which when consumed by livestock inhibits nutrient uptake.

**Hybrid pearl millet.** This leafy forage is similar to conventional sorghum/sudans, but with some key differences. Seed size is much smaller (75,000-90,000 seed/lb.) than sorghum/sudan thus seeding rates must decrease. Due to small seed size, a shallow seeding depth of 0.75 to 1.5” is recommended, which often limits establishment under dry conditions. Relative to sorghum/sudans (60-65 F) warm soils at planting are critical for success for hybrid pearl millet (65-70 F). Yields are somewhat lower than sorghum/sudans but this leafy forage tends to have higher quality (more than 50% leaf). In West Texas hybrid pearl millet is much more tolerant than sorghum/sudan of iron (Fe) deficiency induced by chalky or caliche soils. Thus millets may produce comparable or even higher yields on these soil types relative to conventional sorghum/sudans. Hybrid pearl millet is drought tolerant, can be grazed by horses, and does not develop prussic acid problems (a good forage choice for fall grazing when light
frosts are possible). This material may be grazed sooner (18-24") than sorghum/sudan. It should be harvested in boot stage for maximum total digestible nutrients per acre, or in pre-boot if higher quality is desired. Regrowth potential is somewhat less than sorghum/sudan so if haying leave 8” of stubble or if grazing do not allow livestock to trample the stalks.


<table>
<thead>
<tr>
<th>Evaluation Criteria</th>
<th>Non-BMR</th>
<th>BMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily gain (ADG), lbs. per head</td>
<td>2.62</td>
<td>2.94</td>
</tr>
<tr>
<td>Average gain per acre, total lbs.</td>
<td>300</td>
<td>337</td>
</tr>
</tbody>
</table>

Initial weight, 531 lbs. per head
Grazing cycle, 41 days in '99, 59 days in '00.
Note: The non-BMR is the same genetic hybrid without the BMR gene. Field observations indicated steers more readily grazed the stalks of the midrib plants.

Table 2. Comparative data for non-brown midrib and brown midrib sorghums and sorghum/sudans as well as corn harvested for silage, Texas A&M-Amarillo, 2001.

<table>
<thead>
<tr>
<th>Forage Type</th>
<th>Crude Protein, CP, %</th>
<th>Acid Detergent ADF, %</th>
<th>Neutral Detergent NDF, %</th>
<th>Lignin, %</th>
<th>In Vitro True IVTD, %</th>
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</thead>
<tbody>
<tr>
<td>Corn (Avg. of 4)</td>
<td>9.0</td>
<td>23.9</td>
<td>41.2</td>
<td>3.5</td>
<td>82.7</td>
</tr>
<tr>
<td>Corn (Range)</td>
<td>8.4-9.7</td>
<td>18.2-27.4</td>
<td>33.7-45.8</td>
<td>2.7-4.2</td>
<td>78.3-88.1</td>
</tr>
<tr>
<td>BMR forage sorghum (Avg. of 21)</td>
<td>9.2</td>
<td>27.6</td>
<td>45.69</td>
<td>3.6</td>
<td>81.3</td>
</tr>
<tr>
<td>BMR forage sorghum (Range)</td>
<td>6.9-10.5</td>
<td>24.3-35.0</td>
<td>40.7-60.1</td>
<td>2.8-4.5</td>
<td>75.1-84.2</td>
</tr>
<tr>
<td>Non-BMR forage sorghum (Avg. of 28)</td>
<td>8.3</td>
<td>29.9</td>
<td>49.1</td>
<td>4.4</td>
<td>75.5</td>
</tr>
<tr>
<td>BMR forage sorghum (Range)</td>
<td>6.3-10.8</td>
<td>21.3-41.7</td>
<td>33.9-67.5</td>
<td>2.7-6.4</td>
<td>60.9-83.6</td>
</tr>
</tbody>
</table>

Corn Breeding

Wenwei Xu, Corn Breeder, Agricultural research and Extension Center, TAES and Texas Tech University

Objective: To develop multiple stress tolerant corn germplasm (lines and hybrids) by transferring desirable genes from tropical corn into temperate lines and to determine the genetic and physiological mechanisms of stress tolerance.

Methodology: The New Deal Tech Farm is one of our primary test sites for field evaluation of drought tolerance, heat tolerance, insect resistance, yield and other agronomic traits. With the subsurface drip irrigation system, we can create uniform soil moisture across the field and control the timing, intensity, and duration of drought stress and are important factors. In 2003, a total of 380 experimental hybrids and 324 breeding lines were grown at this location under three water treatments (100% ET, 50% ET and post-tassel drought stress conditions). Each of the water treatments received 16.0, 12.3 and 7.0 acre-inch water respectively.

Results: The experiments at New Deal Tech Farm and other locations lead to the following major findings:

- Three inbred lines have improved drought and heat tolerance, corn earworm resistance, and grain mold resistance. We are preparing to release these lines.
- Three yellow hybrids and two white hybrids with equivalent or higher grain yields but significantly lower aflatoxin contamination in comparison to commercial checks.
- The hybrids made with these three lines as parent produced 10 to 14% higher than the average yield of four commercial check hybrids. These hybrids have improved resistance to drought, heat, insect, and molds.
- One white hybrid S1WC3, as shown in the picture, produced 228 bu/a under 100% ET and 125 bu/a 50% ET on the Helms Farm. S1WC3 is a non-transgenic hybrid with a relative maturity of 119 days. It is resistant to corn earworm and gain mold. Under inoculated field at Corpus Christi, it had significantly lower aflatoxin than the commercial check.

Expectations: Corn breeding is a continuous process that involves hybridization of selected germplasm, evaluation and selection. We will continue to use this field facility as one of our primary test sites. The multiple stress tolerant lines and hybrids developed from our program can be used for commercial production and for further breeding by the seed industry. They are well to Texas and can help corn producers to save water and reduce the risk of mycotoxin contamination.

Financial support: This research is funded by the Texas Corn Producers Board, High Plains Underground Water District #1, Texas Department of Agriculture and USDA.
Notes: