7th Annual Field Tour of an Integrated Crop/Forage/Livestock Systems Approach for the Texas High Plains

New Deal Project Summaries and Other Related Research 2006

Funded in part by the Sustainable Agriculture Research and Education (SARE) Southern Regional Program
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7th Annual Integrated Crop/Forage/Livestock Field Tour

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   - Overview of Projects
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   - Tent, tables, and chairs
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2. Industries and Demonstration Project
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   - Cool-season perennial grasses – dryland
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4. Bus Loading Area for Bus Tour
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     Craig Bednarz, Texas Tech University  craig.bednarz@ttu.edu
   - Corn Breeding
     Wenwei Xu, Texas A&M Experiment Station, Texas Tech University  wenwei.xu@ttu.edu
   - Weed management
     Peter Dotray, Texas Tech University, Texas A&M Experiment Station  peter.dotray@ttu.edu
   - Old world bluesem responses to irrigation
     Dirk Phillip, Iowa State University  dphillip@iastate.edu
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USDA-ARS, Lubbock, TX
USDA-NRCS, Lubbock, TX
Rushing Family Foundation, Lubbock, TX
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We are greatly indebted to our sponsors. Without their support, this research would not be possible. Thank you!
Integrated Crop/Forage/Livestock Systems for the Texas High Plains

Vivien Allen/Phil Brown – Texas Tech University

Background:

Texas High Plains agriculture has used irrigation from the Ogallala aquifer at rates that have exceeded recharge for many years. Over 20% of the cotton and about 25% of U.S. beef cattle are found here. Agricultural practices of the past are changing as water for irrigation declines, energy costs escalate, and farm programs are being challenged. Alternative strategies that are less destructive of natural resources including water, soil, and air are essential to continued agricultural production. Such strategies must also maintain a viable level of economic profitability for both individuals and for communities if the Southern High Plains remains viable for agriculture.

Our research, begun in 1997, was based on the hypothesis that integrating crops and livestock would have complementary effects that could diversify income, spread risk over multiple products, improve soil health, and reduce water use for irrigation. This research, made possible by a grant from the USDA Sustainable Agriculture Research and Education (SARE) Southern Regional Program, addresses these issues. Phase 1 (1998-2002), compares a cotton monoculture with an integrated cotton and beef cattle grazing system. Results of these first 5 years are published (Agronomy Journal 97:556-567; Soil Science Society of America Journal 68:1875-1884). In the ongoing Phase II, these systems are continuing and have completed three additional years in which several production strategies were revised to reflect changes in practices on the High Plains. Also, with additional funding received from the USDA-SARE program in 2002, an integrated crop and livestock dryland system and an irrigated all-forage-livestock system were added to the comparisons. Thus, we now have four systems being compared.

The new systems required complete establishment of forages and crops into an area previously in long-term cotton production. Furthermore, installation of a well, construction of the irrigation system, and fencing for the entire project area was required. Additional funding from several sources including the Ogallala Aquifer Initiative was obtained to cover these initial costs. The dryland system was completed and began its first year in 2004. Establishment of the irrigated forage-livestock system was completed during 2004 and was initiated in 2005. All four systems will be tested over the next several years.
Objectives

The overall objective is to develop environmentally sustainable and economically feasible crop/forage/beef cattle systems that will assure the viability of agricultural activities in the Texas High Plains while protecting its natural resources and putting this knowledge into practice.

Specific objectives are:

1. To compare the productivity, profitability, input requirements, and impact on natural resources of an irrigated cotton monoculture, two integrated cotton/forage/livestock systems (one irrigated and one dryland), and an irrigated all forage-livestock system.

2. To disseminate information and provide educational opportunities through graduate student research, workshops, field-days, grazing schools, publications, electronic media, meetings, and student participation.

3. 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.

4. To link this research with systems research in other ecoregions to increase the base of knowledge and understanding of the principles that apply to agricultural systems.

Procedures:

This replicated farm-scale research is conducted at the Texas Tech Field Research Laboratory, New Deal, TX. Each system is replicated three times in a complete randomized block design. Irrigation water is supplied through an underground drip system with tapes on 40” centers buried about 14” deep. Stocking rates are based on the carrying capacity of the system. Target weights for grazing initiation are 450 to 500 lbs and the objective of each system is to produce steers ready to enter the feedlot at about 800 lbs. A primary management objective of each system is to minimize use of water and chemicals and to conserve energy.

Plant nutrients and pesticides are based on recommendations by the Texas Agricultural Experiment Station and Integrated Pest Management Specialists. Within each system, plant and animal production is measured. Inputs of precipitation, irrigation water, fertilizers, pesticides, seed, labor, mechanical, and energy inputs are recorded. Effects of grazing vs. no grazing on soil and plant characteristics are measured. Systems effects on total inputs, product yield and quality, profitability, and impact on natural resources are recorded.
Phase I:

In 1998, field-scale systems research began comparison of 1) a cotton monoculture; and 2) an integrated system that included cotton in alternate rotation with the small grains rye and wheat for grazing by stocker steers. The perennial warm-season grass WW-B. Dahl old world bluestem makes up about half of this system and is used for grazing and seed production. Steers begin grazing dormant bluestem in January along with limited grazing of rye. Rye is grazed out by mid- to late-April. Cotton is no-till planted into rye in May. Cattle move from rye to wheat pasture for grazing and then return to spring growth of the old world bluestem. By mid-July, cattle are sent to the feedyard for finishing. Seed are harvested from the old world bluestem in October.

Phase II:

System 1. This non-irrigated three-paddock system uses a base pasture of buffalograss/bluegrama/sideoats grama. In paddocks 2 and 3, cotton and foxtail millet are rotated annually. Steers graze native grasses and the summer annual grass from May to mid-August. A second set of steers graze the dormant native grasses between January and April.

System 2. This irrigated three-paddock system uses Dahl bluestem in the base pasture with ‘Tifton-85’ bermudagrass in paddocks 2 and 3. Steers graze winter dormant Dahl bluestem and bermudagrass in early spring and are supplemented with hay if needed. As bluestem and bermudagrass begin spring growth, steers sequentially graze these forages. Excess growth of bermudagrass is harvested for hay. Seed is harvested from bluestem in October. Steers graze from late April until mid- to late-September.

RESULTS

The first 5 years of this research had very specific goals and utilized the best selection of forages and crops that were being widely adopted at the time this research began in 1997. During this first 5 years all varieties and management practices were held constant in order to
compare systems and determine long term effects. Over these 5 years, the integrated system used 23% less irrigation water, 40% less N fertilizer, and fewer other chemical inputs than the monoculture cotton. Profitability was 90% greater for the integrated system with a 150 foot pumping depth for irrigation water. Yield of cotton was similar between the two systems.

For sustainable resource management, erosion rates of soil should not exceed 5 ton a\(^{-1}\) yr\(^{-1}\). Predicted wind and water erosion in the continuous cotton system exceeded 8.5 ton a\(^{-1}\) yr\(^{-1}\) but was less than 3.1 ton a\(^{-1}\) yr\(^{-1}\) for cotton in the integrated system and was less than 0.22 ton a\(^{-1}\) yr\(^{-1}\) for the perennial pasture (Collins, 2003). Furthermore, soil (0 to 5 cm) microbial biomass C and N and enzyme activities were enhanced in perennial pastures and in the rotation depending on crop sampled, compared with cotton grown in monoculture (Acosta-Martinez et al., 2004).

At the completion of this first 5 years we began to alter crop varieties and management practices to begin to examine how these changes would affect the systems and their performance through the adoption of newer crop varieties and intensified management schemes. The cotton variety used during the first 5 yr was Paymaster RR2326. In 2003, in 2003 the cotton variety was changed to the picker type Fiber Max 989BR and the chemical weed control was intensified. The irrigation system was upgraded with a grant from the High Plains Underground Water Conservation District No. 1 to allow improved water management of all systems.

In 2003, precipitation was scarce and we experienced the second driest year on record for this area. Rainfall in 2004 exceeded the normal annual rainfall of 18.5 inches/year with a total of over 27 inches, while 2005 returned to a more normal year.

Yields of Paymaster RR2326 cotton from 1999 through 2002 indicated no significant yield differences between the two systems but were well above the average of irrigated cotton (all types of irrigation) for Lubbock County. With the change in management in 2003, there was a significant increase in lint yield for both systems. In 2004, lint yield of the no-till cotton in the integrated system was lower than that of the conventionally tilled cotton, likely due to cooler soil temperatures in this wet year. In 2004 and 2005, yield of dryland cotton, while lower than that of irrigated cotton, has been excellent reflecting the genetic potential of the variety and the outstanding growing conditions of these two years. More years are needed across a range of environmental conditions to reflect dryland cotton production potential in this system.
Cattle weight gains in the initial integrated system have been excellent although gains in the last 3 years have not equaled gains in the first 5 years. Daily gains have averaged about 1.6 lbs over all years of the irrigated, integrated system. During 2004 and 2005, daily gains of steers grazing native grasses in the dryland system have exceeded that of steers grazing irrigated introduced forages. Gain per acre, however, is higher for the irrigated system than the dryland system. The dryland system has also provided fewer total grazing days than that achieved by the irrigated system.

**Economic Analysis:** For Phase I, detailed records of input use and tillage operations were used to develop cost and return budgets for components in both production systems. Cost of the production portion of these budgets was composed of variable costs and fixed costs. Variable costs accounted for the cost of all preharvest and harvest inputs used, and capital costs associated with use of these inputs. Irrigation system-related charges assumed installation of a sub-surface irrigation system for a representative 125 acre irrigated farm in the Texas High Plains. Due to farm to farm variability of pumping-lift in the Texas High Plains, four common pumping lifts were used (150, 200, 250, 300 foot). Actual pumping depth at the research site was 300 feet. Because benefits received by producers vary among farms, net returns do not include any government payments. Year 1 was the establishment year and is not included in the analysis of the next 4 years but is present in Allen et al. (2005).

**Years 2 through 5**

Following the establishment yr, 4 yrs have been completed that include cattle in the system. Prices used do not include any government subsidies and were $0.55/lb for cotton lint, $18/lb for bluestem seed, and $0.87/lb for cattle. Averaged across these yrs, the integrated
system has proven to be more profitable than the conventional cotton system at every pumping depth with difference becoming greater as depth to water increases. Net returns above variable costs of production for these 4 years were $125.61, 110.38, 93.82 and 77.26 for 150, 200, 250, and 300-foot pumping lifts, respectively. For the integrated system, this was $183.46, 171.84, 159.21, and 146.57 for the four respective pumping lifts. Under conditions of this experiment and with prices used, this represented a 90% increase in profitability for the integrated system at the 90-m pumping depth that occurred at the research site. This is important because greater water table depth simulates greater water scarcity. Therefore, the more scarce the water, the greater the justification to adopt the integrated production system. It is important to highlight that of the 4 yrs included in calculations in Table 2, these include one yr in which no bluestem seed were harvested.

**Years 6 and 7.** During years 6 and 7, changes were made in this initial research to include cotton genetics that were not available at the beginning of the project. Several changes in management strategies were also implemented. With these changes, cotton yields in both systems increased. 2003 was the second driest year on record and no-till planted cotton in the integrated system out yielded the monoculture cotton (1,560 and 1,941 lb/a for continuous cotton and cotton grown in rotation with small grains, respectively). In 2004, cooler and much wetter weather reduced yields in both systems but the reduction in cotton yield in the no-till system was greater than in the monoculture (1,391 and 1,161 lb/a for continuous cotton and cotton in the integrated system, respectively). Net returns above variable costs of production for these 2 years were $388 and 376/acre for continuous cotton and $317 and 186 for the integrated system.

The integrated system has continued to use between 25 and 50% less irrigation water and economic value per unit of irrigation water on the integrated system exceeds that of the monoculture system. However, when cotton yields exceeded 3 bales per acre, economic returns over variable costs of production were higher for the cotton monoculture than the integrated system ($388 vs 317/acre, respectively). At 2 bales per acre yields, profitability was greater for the integrated system.

During year 7, the dryland system in Phase II was initiated as a partial year that included the growing of the cotton crop, harvesting of the summer annual as hay, and grazing of the native grasses during late spring until mid-summer. The first full year for this system will occur in 2005. Due primarily to the unusual rainfall during this year, the dryland cotton yields (996 lb/a) were exceptionally high and contributed to the profitability of this system. Without a full year of
the livestock component however, complete economic evaluation of this system will not occur until 2005 but based on the components that were present, net returns were $121/acre for this system in 2004.

Conclusions

Monoculture approaches to agriculture, whether plant or animal, have allowed economies of scale and concentration of assets, skills, and infrastructure that have largely been credited with our global capacity to produce food and fiber. Increasingly, however, this monoculture approach is recognized as coming at a non-sustainable cost to our environment. Clearly, there are multiple benefits to be gained by an integrated approach to agriculture that includes both grazing lands and crop lands. Diversification improves resilience, both on individual farming operations and on a landscape/community scale. Our long-term systems research, is addressing some of the most critical issues in the Texas High Plains today but under research conditions, few such systems can be tested. Answers must come, not only from replicated research but from on-farm producer experience and from a diversity of other information sources. Such information will have implications far beyond the Texas High Plains and will help to provide answers to sustaining agricultural productivity while minimizing negative impacts on our natural resources.

Publications and outreach:

Educational materials

Websites:
http://www.aged.ttu.edu (see link to CATT).
http://www.orgs.ttu.edu/forageresearch/Sustainable.htm

References:


Economic Sustainability of an Integrated Cotton/Livestock Production System

Teresa Duch – Texas Tech University

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%.
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.
Minerals in Forage-Livestock Systems for the Southern Great Plains

Will C. Cradduck – Texas Tech University

With the diversification of agriculture in this area and the integration of more grazing-based animal production comes the demand of specific information on forages and pieces of grazing systems. Among these demands is the need to understand the mineral challenges in grazing systems for the plant and animal.

These experiments produced a record of the mineral content of the forages over their respective growing seasons, as well as the resulting mineral status of steers from the beginning of grazing until the end of grazing, as they were transitioned from one forage to the next. Mineral concentrations in the first stocker system were determined in established WW-B. Dahl, rye, and wheat pastures, and the steers that grazed the pastures. Mineral concentrations in the second stocker system were determined in a mix of established buffalograss, blue grama, sideoats grama, and green sprangletop, and in the steers that grazed the pastures.

These are invaluable data with respect to how forage minerals in forage/livestock systems in the southern Great Plains affect the mineral status of the grazing animals, and will give producers an idea about what to expect in terms of mineral deficiencies and imbalances in these as well as similar forages when planted in this region.

**Materials and Methods**

- Mineral concentrations were determined in WW-B. Dahl, rye, wheat, and blood serum of steers grazing the forage in Trial 1.

- Mineral concentrations were determined in a native grass mixture and blood serum of steers grazing the forage in Trial 2.
Minerals

Mineral concentrations were determined in forage and blood serum:

- Ca, Na
- P, Cu
- Mg, Zn
- K, Mn
- S, Fe
- Al

Copper

Manganese

Zinc

Detection limits were 0.00025 mg dL⁻¹ in serum.
Manganese

Potassium in Forage and Serum

Sulfur in Forage and Serum

Conclusions

• Mineral deficiencies exist in both of these grazing systems for the purposes of ruminant nutrition.

• Differences in forage mineral concentrations correlate with differences in mineral concentrations in steer blood serum.
Grazing a rye cover crop by steers increases soil moisture and yield of rye and no-till cotton

Fujiang Hou, V. G. Allen, C. P. Brown, Changgui Wan, and C. J. Green

Use of small grains as cover crops prior to row crops can reduce soil erosion and improve nutrient cycling. Small grains offer opportunities for grazing by livestock but impacts of grazing on soils and plants are not well understood. Rye was planted each September and was grazed intermittently by steers from January until early April. Rye was then chemically terminated and cotton was no-till planted into residue in May. Permanently located areas in each paddock were caged each year during grazing to prevent animal impact but were otherwise managed as grazed areas. In the 8th yr, a second cage was placed adjacent to the original cage to investigate effects of previous years grazing or zero-grazing on growth of rye and cotton. Soil moisture was higher ($P < 0.01$) in grazed than in non-grazed areas. In areas that were never grazed, plant populations, plant basal cover, tiller numbers, tiller weights, total biomass, and plant heights were less ($P < 0.001$) than where grazing had occurred during the previous 7 yr. At the end of grazing, biomass in non-grazed areas was removed as a hay harvest at a height similar to the grazed height. Height and density of cotton plants, bolls per foot of row were greater ($P < 0.01$) when no-till planted into grazed than non-grazed rye. Grazing the rye increased ($P < 0.01$) cotton yields by about ½ bale per acre. Our
results indicated that grazing increased growth and productivity of rye and the following cotton crop and that this effect persisted through the long-term, 2-paddock rotation of rye-cotton-wheat-a fallow period and back to rye.
Cool-Season Perennial Grasses for the Southern Great Plains$^{1,2}$

Will C. Cradduck – Texas Tech University  
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.

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 were to 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 list of grass species, selections, and cultivars, with scientific names.

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$^{1}$ Sponsored in part by a grant from the Samuel Roberts Noble Foundation, Inc., Ardmore, OK.  
$^{2}$ In conjunction with Ag Research, Ashville, NC.
Cool-season Perennial Grasses

Materials and Methods

• Four replications of eighteen perennial cool-season grasses were planted in plots near New Deal, TX in September 2001, in a randomized block design.

• Each plot was separated into a hay-cut and grazed treatment in April 2003, for a split-plot arrangement of treatments.

Irrigation

• Irrigation was limited to about 320 mm annually.

• Half was applied in spring and half in autumn.

• Water was applied through subsurface drip irrigation.

Cool-Season Grass Species

<table>
<thead>
<tr>
<th>Grasses</th>
<th>Variety</th>
<th>Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardinggrass</td>
<td>Maru</td>
<td>Intermediate wheatgrass</td>
</tr>
<tr>
<td></td>
<td>Maru selection</td>
<td>PI 401166</td>
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<tr>
<td>Tall fescue</td>
<td>Flecha E</td>
<td>Tall wheatgrass</td>
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<tr>
<td></td>
<td>Flecha E+ AR542</td>
<td>Jose</td>
</tr>
<tr>
<td></td>
<td>Jesup E+</td>
<td>PI 401007</td>
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<td></td>
<td>PDF E-</td>
<td>Western wheatgrass</td>
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<td>97TF1 E-</td>
<td>Barton selection</td>
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<tr>
<td>Smooth brome</td>
<td>Achenbach</td>
<td>Barton</td>
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<td></td>
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<td>01WW1</td>
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<tr>
<td></td>
<td>Lincoln selection</td>
<td>97WW5</td>
</tr>
</tbody>
</table>

Persistence

• Persistence was documented using the grid method.

• Weed encroachment was also an indicator of persistence.

Effect of grazing (P < 0.01); mean of 21 dates from April 2003 to Sept. 2004
Biomass

- Biomass production was typical of cool-season grasses in environments with comparable total moisture.

- Fescues often produced more biomass in autumn.

- Wheatgrasses often produced more biomass in spring.

Crude Protein, Spring 2004

TNC, Spring 2004

NDF, Spring 2004
Nutritive Value

• Most measurements of nutritive value were higher in the grazed treatment.

• CP, NDF and ADF tended to be more favorable in spring, but TNC tended to be more favorable in autumn.

Cool-season Grass Minerals

• Most of the 18 grasses will require supplementation of P, Cu, and Zn, and Ca to maintain the Ca/P ratio.

• Na is generally supplemented, but may not be necessary with hardinggrass and tall wheatgrass.

Conclusions

• Persistence was generally good for these grasses under the conditions of this experiment.

• Biomass production and distribution varied among varieties.

• Nutritive value differences existed among varieties and between grazing treatments.

1. Hardinggrass; *Phalaris aquatica*; Maru
2. Hardinggrass; *Phalaris aquatica*; Maru selection
3. Tall fescue; *Festuca arundinacea*; Flecha E-
4. Tall fescue; *Festuca arundinacea*; Flecha E+ AR542
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 selection
11. Intermediate wheatgrass; *Thinopyrum intermedium*; PI 401166
12. Pubescent wheatgrass; *Thinopyrum intermedium*; Luna
13. Tall wheatgrass; *Thinopyrum ponticum*; Jose
14. Tall wheatgrass; *Thinopyrum ponticum*; PI 401007
15. Western wheatgrass; *Pascopyrum smithii*; Barton
16. Western wheatgrass; *Pascopyrum smithii*; Barton selection
17. Western wheatgrass; *Pascopyrum smithii*; 01WW1
18. Western wheatgrass; *Pascopyrum smithii*; 97WW5
Warm Season Perennial Grasses for the Southern Great Plains

Will C. Cradduck – Texas Tech University

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 Ogallala 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.

This study was conducted to determine effects of different species and cultivars on persistence, quality, and biomass production of selected warm season perennial grasses. Please see the end of this summary for a list of grass species and cultivars, with scientific names. 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 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. 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 might 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.
Materials and Methods

- Four replications of ten perennial warm-season grasses were planted in plots near New Deal, TX in spring 2002, in a randomized block design.

- Most plots were reseeded in late spring 2002 and again in spring 2003.

Irrigation

- Irrigation was limited to about 320 mm annually.

- Irrigation was applied during the growing season from May to September.

- Water was applied through subsurface drip irrigation.

Warm-season Grasses

- Sorghum alnum
- Johnsongrass
- Kleingrass
- Switchgrass
- Eastern gamagrass
- Big bluestem
- Little bluestem
- WW-B. Dahl old world bluestem
- Caucasian old world bluestem

Persistence

- Plant stands, %

Biomass Production, 2004

- Mg ha⁻¹
Conclusions

- Persistence was good among most of the warm season grasses, but establishment tended to be slow.
- Biomass production differed among species.
- Nutritive value differed among species.

1. Sorghum almum; *Sorghum almum*
2. Johnsongrass; *Sorghum halipense*, local seed
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. Old world bluestem; *Bothriochloa bladhii*; WW-B. Dahl
10. Old world bluestem, *Bothriochloa caucasia*; Caucasian
Adaptation of Bermudagrass to the Texas High Plains

Summary of Results from Small Plot Trials
Mark A. Marsalis -- New Mexico State 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.

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2 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.
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 75°F (24°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.

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   2002(2003)

<table>
<thead>
<tr>
<th>New Deal</th>
<th>Spraberry:</th>
<th>Posey:</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 9(22)</td>
<td>April 25</td>
<td>May 16(28)</td>
</tr>
<tr>
<td>June 8(19)</td>
<td>May 23(16)</td>
<td>June 13(25)</td>
</tr>
<tr>
<td>July 6(17)</td>
<td>June 20(13)</td>
<td>July 11(24)</td>
</tr>
<tr>
<td>August 1(14)</td>
<td>July 18(11)</td>
<td>August 8(20)</td>
</tr>
<tr>
<td>August 30(Sept. 11)</td>
<td>August 15(8)</td>
<td>September 5(18)</td>
</tr>
<tr>
<td></td>
<td>September 12(5)</td>
<td></td>
</tr>
</tbody>
</table>
Bermudagrass varieties and *Sporobolus virginicus* used in small plot field experiments and sources where plants were obtained.

<table>
<thead>
<tr>
<th>Location</th>
<th>Variety/species</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Deal</td>
<td>Tifton 85</td>
<td>Georgia Coastal Plain Exp. Stn., Tifton, GA, 31794</td>
</tr>
<tr>
<td></td>
<td>Coastal</td>
<td>Georgia Coastal Plain Exp. Stn., Tifton, GA, 31794</td>
</tr>
<tr>
<td></td>
<td>Midland 99</td>
<td>Oklahoma Agric. Exp. Stn., Stillwater, OK, 74078</td>
</tr>
<tr>
<td></td>
<td>Hardie</td>
<td>Oklahoma Agric. Exp. Stn., Stillwater, OK, 74078</td>
</tr>
<tr>
<td></td>
<td>Sahara†</td>
<td>Browning Seed Co., Plainview, TX, 79073</td>
</tr>
<tr>
<td></td>
<td>World Feeder</td>
<td>Agric. Enterprises Corp., Oklahoma City, OK, 73122</td>
</tr>
<tr>
<td></td>
<td>Macho</td>
<td>Agric. Enterprises Corp., Oklahoma City, OK, 73122</td>
</tr>
<tr>
<td></td>
<td>Tifton 44</td>
<td>Georgia Coastal Plain Exp. Stn., Tifton, GA, 31794</td>
</tr>
<tr>
<td></td>
<td>Sumrall 007</td>
<td>Mississippi Agric. For. Exp. Stn., Starkville, MS, 39759</td>
</tr>
<tr>
<td></td>
<td>Giant†</td>
<td>Frontier Hybrids, Inc., Abernathy, TX 79311</td>
</tr>
<tr>
<td></td>
<td>Wrangler†</td>
<td>Richardson Seed Co., Vega, TX, 79092</td>
</tr>
<tr>
<td></td>
<td>Cheyenne†</td>
<td>Browning Seed Co., Plainview, TX, 79073</td>
</tr>
</tbody>
</table>

| Spraberry/ Posey | Tifton 85 | Georgia Coastal Plain Exp. Stn., Tifton, GA, 31794                    |
|                  | Coastal   | Georgia Coastal Plain Exp. Stn., Tifton, GA, 31794                    |
|                  | Midland 99| Oklahoma Agric. Exp. Stn., Stillwater, OK, 74078                     |
|                  | World Feeder| Agric. Enterprises Corp., Oklahoma City, OK, 73122                   |
|                  | Macho     | Agric. Enterprises Corp., Oklahoma City, OK, 73122                   |
|                  | *S. virginicus* | Beeman’s Nursery, Port Orange, FL, 32127                           |

† Indicates seeded varieties.
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:


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).

Total seasonal yields of bermudagrasses and *Sporobolus virginicus* grown at Posey, 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.
Water Use and Forage Nutritive Value of three Old World Bluestems in the Texas High Plains

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dphilipp@iastate.edu

Summary

Agricultural operations in the Texas High Plains are challenged by rapid depletion of ground water. Warm-season grasses offer opportunities for grazing but information is needed on comparative water use efficiencies (WUE). Three old world bluestems (Bothriochloa caucasica, ‘Caucasian’; B. ischaemum, ‘Spar’; and B. bladhii, ‘Dahl’) were grown under dryland and low, medium, and high irrigation levels to determine water use efficiency, yield, and nutritive value during 2001 to 2003. Amount of water applied in the high treatment was 100% replacement of grass reference evapotranspiration (ET₀) minus precipitation. Medium and low treatments were calculated as 66 and 33% of the high treatment; the dryland treatment received no irrigation (0%). Caucasian had higher WUE than Spar under all water treatments in 2001 and under all irrigation levels in 2003, including Dahl. Additionally, Caucasian and Dahl consistently outyielded Spar by about 30%. Maximum yields resulted from a high irrigation level but forage nutritive value was higher under low irrigation. Dahl was higher in crude protein (0.09 lbs/lbs DM) than Spar (0.08 lbs/lbs DM) and Caucasian (0.08 lbs/lbs DM). Dry matter digestibility of all species was higher at a low irrigation level (0.58 lbs/lbs DM) than any other level.

Introduction

Water use efficiency (WUE) of forage grasses is crucial in determining species suitable for implementation into forage/livestock systems in semi-arid environments. Researchers have defined WUE as dry matter (DM) yield (lbs) per acre divided by the amount of water added (inches) to achieve that yield. Old world bluestem species are widely grown in the semi-arid Texas High Plains but information is lacking concerning their water use – yield relationships under semi-arid conditions when compared at one location.
Previous research has suggested a 10 to 20% higher productivity of Caucasian bluestem compared with \textit{B. ischaemum} types. The more recently released old world bluestem WW-B. Dahl showed higher DM yields under dryland conditions than a variety of warm-season grasses in central Texas. With rising concerns regarding sustainability of agricultural systems dominating the Texas High Plains due to a declining supply of irrigation water, introduced warm-season grasses such as \textit{Bothriochloa} species may offer alternatives for designing viable crop/forage/livestock systems. A variety of old world bluestem species, primarily \textit{B. ischaemum} types, were grown widely on Conservation Reserve Program land to minimize soil erosion and degradation. Previous research showed that Dahl can serve as a key component in functioning crop/forage/livestock systems while reducing water and fertilizer needs. This species has been shown to support higher animal gains than \textit{B. ischaemum} types (unpublished data, Texas Tech University). Also, Caucasian is perhaps more cold tolerant given its origin and could be an alternative for areas further north in the Southern High Plains.

Declining water reserves in the Ogallala Aquifer require research efforts to find solutions for alternative agricultural systems. The Southern High Plains of Texas may be environmentally well suited to establish forage-based systems while reducing overall water use. However, little is known regarding the water use of old world bluestems grown under conditions of the Texas High Plains. Thus, our objective was to test Caucasian, Spar, and Dahl regarding their WUE, DM yield, and nutritive value.

Results

Data are shown comprehensively in graphs that follow immediately this report, and findings will be discussed only briefly here.

Results suggested that WUE of all species, water treatments, and years varied between 570 lbs/acre/inch and 142 lbs/acre/inch. Except in year 1 where irrigation treatments started in late June, WUE appeared to be higher under low and medium irrigation than under dryland and high irrigation level. Moreover, maximum WUE were measured in 2002 with above-average precipitation, and minimum WUE were observed in 2003 that was the second driest year on record. Differences may have been due to increased evaporation of irrigation water when applied with surface drip irrigation.
Maximum DM production in 2001 was observed in Caucasian bluestem under a high irrigation level (100% replacement of ET₀) with 13,000 lbs/acre, followed by Dahl with 12,656 lbs/acre, and Spar with 8,800 lbs/acre at the same irrigation levels. Observed yields under dryland conditions averaged 3,600 lbs/acre, 2,700 lbs/acre, and 1,700 lbs/acre for Caucasian, Spar, and Dahl, respectively. In 2002, maximum DM production was again observed in Caucasian bluestem with 25,000 lbs/acre, followed by Dahl (24,000 lbs/acre) and Spar (20,700 lbs/acre) under the high irrigation. Dry matter yields obtained from dryland sites were 5,150 lbs/acre, 3,400 lbs/acre, and 4,700 lbs/acre for Caucasian, Spar, and Dahl, respectively. In the last year of our research, Caucasian averaged 22,200 lbs/acre in dry matter yield under a high irrigation level; Spar generated 12,600 lbs/acre and Dahl 14,200 lbs/acre. Under dryland conditions, Caucasian averaged 4,600 lbs/acre, while Spar generated 4,500 lbs/acre, and Dahl averaged 1,900 lbs/acre.

Concentration of crude protein was higher in Dahl bluestem (0.09 lbs/lbs DM) compared with the other old world bluestems tested averaged over all irrigation levels and dryland. Fiber concentrations in investigated species were affected by irrigation levels. Neutral detergent fiber increased with increasing amounts of irrigation during all three years of research. Similar observations were made regarding ADF. Dry matter digestibility was higher under low irrigation compared with all other irrigation levels and dryland. Total digestible dry matter was higher under a high irrigation level compared to all other water treatments.
Figure: Monthly forage mass of *Bothriochloa caucasica*, *B. ischaemum*, and *B. bladhii* as influenced by dryland and irrigation levels of low, medium, and high. Data were averaged across yr 1 (2001), 2 (2002), and 3 (2003). Above-ground biomass was removed during last wk of July at an 8-cm cutting height. Means within a month and species followed by the same letter are not different ($P > 0.05$).
Figure: Digestible dry matter (A) and dry matter digestibility (B), during the growing season, as influenced by dryland and irrigation levels of low, medium, and high. Data were averaged across Bothriochloa caucasica, B. ischaemum, and B. bladhii, and also averaged across yr 2002 and 2003. Means with the same letter within either (A) or (B) are not different \( (P > 0.05) \).
Effect of Cultivar Type and Seed Size on Stability of Yield and Fiber Properties

Project 04-565

Craig Bednarz, Texas Tech University

Future markets for U. S. grown lint will depend on our capacity to supply high quality fiber. Fiber quality depends on the properties of the lint as expressed by the cultivars and on the effects of the environment on cotton growth. Georgia’s climate is plagued by periodic droughts, coupled with periods of high temperatures. Our previous research has shown that cultivar seed size has decreased, and that small seed size tends to maximize the total surface area per acre available for fiber initiation. We hypothesized that a possible negative consequence of growing cultivars with many small seeds would be an increase in overall demand and inter-seed competition for photosynthetic products. During periods of less than optimal environmental conditions, increased competition among seeds might decrease fiber quality. Thus yield and yield stability may be inversely related in contemporary cultivars.

Experiments with several types of transgenic cultivars were planted in 2004 at Tifton, Camilla, and Plains with and without irrigation. Unfortunately, the experiments at Tifton and Camilla were lost due to damage from hurricanes. Experiments were again planted in 2005 at Tifton, Midville, and Camilla with and without irrigation. The lint yield and coefficient of variation for lint yield across the four environments and two years for each cultivar is illustrated in Table 1. Interestingly, the lowest standard deviation and coefficient of variation values were observed in some of the largest seeded cultivars available. It must be emphasized these are preliminary findings.

(see Table 1 following page)
Table 1. Lint yield and coefficient of variation for lint yield in stability studies conducted in four environments in GA in 04-05.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Midville 2005</th>
<th>Camilla 05</th>
<th>Gibbs 05</th>
<th>Plains 2004</th>
<th>Overall</th>
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<tr>
<td></td>
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<td>lbs lint/a</td>
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<td>lbs lint/a</td>
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Additional Reference:

Breeding Multiple Stress-tolerant Corn Hybrids

Wenwei Xu
Corn Breeder, TEAS/TTU

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

Methodology: The Texas Tech New Deal Research Farm field is one of our primary test sites for field evaluation of drought tolerance, heat tolerance, insect resistance, yield and other agronomic traits. In 2005, a total of 500 experimental hybrids and 200 lines were grown under 100% ET, 50% ET and V-12 drought stress conditions. The plants under 100% ET and 50% ET were watered throughout the growing season. The drought intensity in 50% ET was 40% yield reduction as compared to 100% ET. The V-12 drought stress was primarily for evaluating inbred lines. For V-12 drought stress, irrigation was withheld from V-10 to flowering. In addition, this field was used to evaluate the drought tolerant transgenic corn hybrids in collaboration with Monsanto Company.

Results: The average yield in 100% and 50% ET irrigation was 123 and 68 bu/acre (Table 1). The yield was much lower due to heavy hail damage on June 15 when plants were at V-10 stage.

Several experiment hybrids yield equally or higher than commercial checks. For example, in a test involving 21 TAES hybrids and four commercial hybrids, the average yield of C3A654-1-1 x B100, S2B73BC x NC300, LH200 x SPG3 was 137 to 146 bu/acre in six environments at Halfway, Lubbock, Etter, and College Station, in comparison to 133 to 159 bu/acre of commercial checks.

The aflatoxin level at the Halfway was low, highly variable among replications, and insignificant among genotypes. However, the aflatoxin in S2B72BC x NC300, S1WC3, and WQ22W x S1W was significantly lower at Corpus Christi, Beeville, and Mississippi State under inoculated condition. The aflatoxin in these three hybrids was only 13.2, 27.9, and 33.7% of the average aflatoxin in commercial hybrids, respectively (Table 1). S1WC3 and WQ22W x S1W are white hybrids. Usually white hybrids have lower yield than yellow hybrids.

The results at Helms farm help to released two inbred lines Tx204 and Tx205. We signed material transfer agreement with eight seed companies in 2005. The results in 2005 will help us to released new lines and develop new hybrids.

Expectations: Adoption of new corn germplasm and accompanied strategies for irrigation and crop management can save 5-10% of the irrigation water requirements, reduce aflatoxin by 50%.

(see Table 1 following page)
Table 1. Yield and agronomic traits of selected TAES hybrids and check hybrids in 2005.

<table>
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<tr>
<th>Hybrid Description</th>
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<td>S2B73BC x NC300</td>
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<td>LH200 x SGP3</td>
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<tr>
<td>S1W x CML343</td>
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<td>Garst 8285 (CK2)</td>
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<td>DKC66-80 (CK4)</td>
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<tr>
<td>Mean</td>
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<td>LSD 0.05</td>
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<table>
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<tr>
<th>Species</th>
<th>Days to Pollen Shedding</th>
<th>Plant Height (cm)</th>
<th>Corn Earworm Damages (cm)</th>
<th>Halwafy 100% ET</th>
<th>Halfway 50% ET</th>
<th>Lubbock 100% ET</th>
<th>Lubbock 50% ET</th>
<th>College Station</th>
<th>Percentage of Check Means</th>
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DTP = days to pollen shedding, PHT = plant height in cm, CEW = corn earworm damages to ears in cm. HFFI = Halwafy way 100 % ET, HF50 = Halfway 50% ET, LBFI = Lubbock 100% ET, LB50 = Lubbock 50% ET, CS = College Station. % CK = percentage of four check means. Aflatoxin is the mean at Corpus Christi and Beeville in TX and Mississippi State, MS.

Acknowledgement: We appreciate the financial support from the Texas Corn Produces Board, the High Plains Underground Water Conservation District No. 1, Texas Water Development Board, Texas Department of Agriculture, USDA GEM project, and USDA pre-harvest aflatoxin elimination program.
‘WW-B. Dahl’ Old World Bluestem

*Bothriochloa bladhii* (Retz) S.T. Blake

‘WW-B. Dahl’ Old World Bluestem is a warm-season, perennial ‘tufted’ bunch grass. This grass was collected originally near Manali, India and tested at the Oklahoma Agricultural Experiment Station at Stillwater, OK beginning about 1960. In the mid-1960's, plants were sent to the Southern Regional Plant Introduction Station, Experiment, GA and from there seed were sent to the Southern Plains Range Research Station, Woodward, OK where the grass was tested in the program under the direction of Chet DeWald. Bill Dahl, a professor in Range Science at Texas Tech University, conducted tests with this grass under dryland conditions at the TTU Range Research Ranch at Justiceburg, TX. In 1994, WW-B. Dahl, named for Dr. Bill Dahl, was released jointly by the USDA-ARS, USDA-SCS, Texas Tech University, and the Texas Agricultural Experiment Station.

**Plant Characteristics**

Dahl is a warm-season perennial ‘tufted’ bunchgrass with an upright growth habit. A single plant, when mature, can cover as much as a square yard. Stand longevity appears excellent with 10-year old stands now documented with no indication of stand losses. It has dark green leaves and plants reach a mature height of 2.3 to 3 feet with stems and flowers reaching heights of over 5 feet. In trials at Texas Tech, dry matter yields of Dahl were similar to those of ‘Caucasian’ Old World Bluestem (*B. caucasica* (Trin.) C.E. Hubbard ‘Caucasian’) but were higher than yields from several varieties of *B. ischaemum* [[(L.) Keng. var. ischaemum ] including ‘Plains’, ‘Spar’ and ‘Iron Master.’ Unlike the other old world bluestems, Dahl remains leafy and vegetative throughout much of the growing season and only begins to reach a flowering stage in September with seed maturity and seed shedding in October. Observations suggest that various stresses including drought maturity and seed shedding in October. Observations suggest that various stresses including drought stress can result in earlier flowering, however.

Peak growth of Dahl can be expected to occur by mid- to late-July but is influenced by timing and amount of available moisture and fertilizer applications. Total seasonal dry matter production under dry land conditions in a single seasonal harvest ranged from 1 to 2 tons/acre at
Woodward, OK (http://www.sprrs.usda.gov/owbmanage.htm). At New Deal, TX, total dry matter yields under dryland conditions averaged about 1.5 tons/acre when harvested twice (late July and September) while with irrigation to replace 100% of ET, yields averaged about 8 tons/acre.

Dahl is rich in essential oils that gives it its distinctive odor generally described as a pleasant smell. There is evidence that *Bothriochloa* species, characterized by containing these oils, have insect deterrent properties including resistance to the fall army worm (*Spodoptera frugiperda*) and other insects (see Insect Deterrent Properties below).

**Forage Quality**

Research at TTU has consistently shown that concentrations of crude protein in Dahl forage are about 1 to 2% higher than in the other old world bluestems listed above. Concentrations of crude protein have averaged between 3.5 to 4% during December and January in dormant forage while concentrations range from 9 to 12% during the active growing period from May to July. Crude protein concentrations begin to drop rapidly by July, however, and supplementation of crude protein to grazing animals may be needed in the later part of the growing season as well as to livestock grazing winter dormant forage. Mineral concentrations in Dahl indicate that grazing animals may need supplementation with phosphorus, copper, and zinc. Plant concentrations of sulphur suggest that both the plant and the grazing animal could benefit from sulphur fertilization.

**Fertilization**

Applications of about 60 to 90 lbs of nitrogen/acre annually has generally been sufficient to optimize yields. Based on research with other old world bluestems and limited water resources, higher nitrogen fertilization rates appear unwarranted in most cases. Phosphorus is needed for a healthy root system and should be applied per soil test recommendations. Phosphorus may also be important for seed production of this grass and for seed germination and early seedling growth at establishment. Other nutrients should be applied as the soil tests indicate. In calcareous soils, some iron deficiencies have been observed which result in a yellowing of the leaf material. Zinc deficiency may also occur and should be monitored. Recommendations for sulphur fertilization are best based on plant tissue analysis. Concentrations of sulphur in plant tissue should generally be at least 0.2% for plant and animal nutrition and both plant and animal responses in growth and live weight gains have been observed in response to applications of about 30 to 60 lbs of sulphur/acre annually, when leaf tissue samples are much below 0.2% sulphur.

**Establishment of Dahl Old World Bluestem**

WW-B. Dahl should be planted in late April or early May at a rate of 2 lbs pure live seed (PLS)/acre. Establishment can be by broadcast or drilling into a prepared seedbed or can be no-till established. Seed should be planted NO deeper than 1/4 inch with 1/8 inch the ideal depth. Seeds are more often planted too deep than too shallow. A firm seedbed is essential for
establishment and cultipacking the soil is usually necessary. If a pickup truck driven across the area leaves noticeable wheel track depressions, then more packing of the soil is likely necessary.

Broadcasting seeds onto a granular surface of a well-prepared seedbed and cultipacking is adequate to get good establishment. If using a drill, it must be equipped to handle ‘fluffy’ seeds. These drills usually have paddles or fingers that push the seed down into the drill box openings. Drilling seeds will generally have a higher success rate and has the advantage of being able to identify seeds germinating in rows as opposed to random placement from broadcasting. Young seedlings are very small, are hairy at the leaf collar, and generally lie prostrate on the ground often being overlooked at this stage of development. It is easy to not recognize plants until the fall when this grass goes through stem elongation and flowering.

For no-till planting, surface residue should be minimized. Too much trash prevents good seed to soil contact. The trash is often pushed down in front of the coulter and seed are placed in the fold preventing them from germinating. At least 50% bare ground should be present if no-till planting is attempted. Be sure that existing vegetation is killed 6 to 8 weeks before planting. No-till planting can conserve moisture and soil, fuel, require less time, and reduce weed competition but requires excellent conditions of the soil and surface cover to insure success.

For any method of planting, the seedbed should be free of weeds. Weed control prior to planting is very important. This seedling is very slow to establish and growth is slow throughout the first several months after planting. Competition from weeds during this period can be severe. If weeds are present after plants begin to emerge, shredding frequently is helpful to reduce competition. Herbicides can be used. Consult your local herbicide specialist for recommendations. Precipitation in optimum amounts and times or the ability to surface irrigate newly planted stands are crucial to seed germination and establishment success.

Grazing Management

Growth of forage begins generally in early May with grazing available by mid-May. The response of this forage to water and fertility inputs is greater during the first part of the growing season than by August through September. Quality of the forage is also higher during the first half of the growing season than in later months. Thus, it is more efficient to optimize the use of the grass during May through July than in August and September.

Stocking rates should be high enough to maintain a canopy height of about 5 inches. Understocking leads to patch grazing and undergrazed areas become overmature and of low quality. This grass appears tolerant of close grazing but prolonged defoliation to canopy heights of less than 3 inches is not recommended. Likewise, gains of grazing animals will be
lower when there is too little forage for grazing. An intensive rotational stocking method does not appear to be needed or beneficial to either the plant or the animal. In fact, seed production later in the season may be reduced if defoliation is lax during the growing season. It appears to be more important to manage stocking rates to target a consistent defoliation height with an alternative complementary paddock to supplement grazing if forage becomes limiting. If undergrazing is occurring, consider confining livestock to a smaller area of the paddock and harvesting the remainder for hay. Grazing should be terminated at least by September 1 to allow plants to regrow and regain energy stores to survive through the winter.

Dahl old world bluestem can be accumulated (stockpiled) during August and September for grazing during winter as standing hay. Additional fertilizer may be applied in August along with supplemental irrigation to increase fall growth. Crude protein will be low (3.5 to 4%) by December and a crude protein and energy supplement will be needed for animals grazing the stockpiled forages during winter.

**Animal Performance**

Research at Texas Tech has shown daily gains of grazing steers of about 2.5 lbs/day during the early part of the grazing season (May and June). As the season progresses, daily gains will decrease without supplementation of crude protein. Daily gains of steers grazing the stockpiled forage during January and February have been low (0.4 lbs/day) even with supplementation but grazing this forage avoids the need to burn excess forage in spring and can provide a good source of roughage to compliment grazing of winter rye or wheat pastures and may lower the chance of bloat in animals grazing small grain pastures. In grazing trials at TTU, lambs grazing Dahl old world bluestem had higher daily gains and gains per acre than those grazing Plains, Spar, and Iron Master and were similar to lambs grazing Caucasian.

**Hay Production**

Dahl old world bluestem makes excellent hay that is palatable to livestock. Total seasonal yields can be expected to be between 1 to 8 tons/acre depending on rainfall and the ability to provide supplemental water through irrigation. Limited data from Texas Tech suggests that harvesting in mid-July is the optimum time for hay cutting. Harvesting either earlier or later appears to reduce total seasonal yields. After a seed harvest in October, the residual biomass can also be harvested as hay but quality will be lower at this point.

**Seed Harvest**

Managing Dahl for a seed harvest can provide additional income. Seed are mature and ready to harvest in October and can reach 50 lb PLS/acre. Stockpiling the forage for winter grazing allows for a seed harvest to occur with little effect on the winter forage supply. Seed yields and quality have been variable and more information is needed on management strategies to optimize seed production. Seed prices have ranged from less than $14 to more than $20/PLS lb making this component a valuable commodity. The seed mature at different rates making multiple harvests necessary to maximize yields. Once approximately 50% of the seed is
‘slipping’ (seed strip off in response to light pressure when the flower slides through your hand), the initial harvest can be made. Once the seed is at this point of development, it is very vulnerable to wind and rain as the seed are easily shattered. If adverse weather occurs for an extended period, the potential for losing the seed harvest exists. If a freeze occurs, the seed must be harvested within 24 hours. Harvesting of this grass requires special harvest equipment and can be commercially harvested.

Insect Deterrent Properties

Dahl fields appear to have some resistance to the Red Imported Fire Ant (RIFA; Solenopsis invicta Buren; Hymenoptera; Formicidae) and livestock grazing Dahl may have fewer pestiferous flies. Recent observations suggest almost complete absence of red imported fire ant mounds in Dahl bluestem fields (Britton et al., 2002). Conversely, RIFA mound population densities in nearby bermudagrass and other forage fields were very high on central Texas ranches. Additionally, observations suggest suppression of fly populations on cattle grazing Dahl bluestem pastures. Reduced fly populations would improve cattle performance and could reduce pesticide requirements. Information is needed to further define the effects of Dahl bluestem on fire ant populations and pestiferous flies. Insect resistance in several grasses of the genus Bothriochloa has been suggested previously (Zalkow et al., 1980; Pinder and Kerr, 1980). Volatile oils that give this grass its distinctive odor have been identified by several authors and may be related to insect deterrent properties. Perhaps these are the reasons why cattle grazing Dahl pastures appear less susceptible to pestiferous flies.

Conclusions

WW-B. Dahl is one of the most promising introduced warm-season perennial grasses in the Texas High Plains. It has excellent longevity and potential for grazing, hay, and seed production, drought tolerance under dryland conditions, and has exhibited excellent yields and weight gains for cattle under irrigation. Its growth pattern of remaining vegetative through most of the growing season while entering the reproductive stage in fall lends itself well to a combination of grazing, stockpiling for winter grazing, and seed production. This grass provides an excellent component of an over all grazing system that includes grazing of winter annual small grains, high in crude protein, as a compliment to stockpiled Dahl (Allen et al., 2005).
References


Project Overview

Agriculture is a vital part of the Texas High Plains economy with a combined annual economic value of crops and livestock that exceeds $5.6 billion ($1.1 crops; $4.5 livestock). However, this agriculture industry is also dependent on water from the Ogallala Aquifer — water that is being used faster than it is being replenished.

Unique to this project is a partnership of area producers, data collection technologies, and collaborating partners that includes industries, universities, and government agencies. The project uses on-farm demonstrations of cropping and livestock systems to compare the production practices, technologies, and systems that can maintain individual farm profitability while improving water use efficiency with a goal of extending the life of the Ogallala Aquifer while maintaining the viability of local farms and communities.

Producers

All production-related decisions are made by the more than 20 producers involved in the project. The project field sites involve more than 4,000 acres. These sites represent the range of agricultural practices including monoculture cropping systems, crop rotations, no-till and conventional tillage practices, land application of dairy manure, and fully integrated crop and livestock systems (Figure 1). These sites will also demonstrate key comparisons of many of the production systems currently found in the Texas High Plains. Current or soon to be implemented experimental field work includes tests of (a) sorghum/sudan varieties, (b) triticale and wheat for hay and silage, and (c) the forage production/quality of seven different perennial grasses on dryland, limited irrigation, and moderate irrigation.
Data Collection Technologies

The project sites are being intensely monitored for water use, soil moisture depletion, crop productivity, and economic return. Each site is equipped with instruments to determine total water applied from the aquifer, solar radiation, temperature, rainfall, timing, and amount of irrigation events, and soil moisture. Integrated central processing controller equipment is being utilized to record, store, and transmit these data to a single database that will be accessible to the project participants.

Collaborating Partners

The roles of the collaborating partners include installing and monitoring the data collection technologies, documenting the production-related activities used, developing economic models that evaluate the various systems, and conducting educational and communication projects designed to share the activities and outcomes of this project with others.

The economic component of this project is multidimensional. First, the Farm Assistance program is working with producer field cooperators to assess the financial impact of demonstrations on individual farm/ranch profitability and viability. Second, producer field records will also aide in the development of crop simulation models for each site. These models will be used to look at yield variability, which translates to net income variability. Thus, the simulation model results allow the evaluation of risk under a variety of farming systems. Additionally, the modeling work allows the systems to be evaluated over a wide range of landscapes.

With the ability to evaluate different management strategies within delivery systems and tillage types found in the region, a regional model will be developed to evaluate the regional economic impacts and water use efficiency. Over the 8-year period of the TAWC project, these systems will be intensely monitored and compared for total irrigation water use and water use efficiency, crop and livestock productivity and profitability, total input requirements, and impact on natural resources including soil quality and erosion potential and wildlife habitat.

Figure 1: 2005 TAWC Crops, Tillage and Delivery Systems

<table>
<thead>
<tr>
<th>Crop</th>
<th>Acres</th>
<th>Tillage Methods Being Used</th>
<th>Irrigation Delivery Systems Being Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>2,120.8</td>
<td>Conventional tillage</td>
<td>Center pivot</td>
</tr>
<tr>
<td>Corn</td>
<td>370.1</td>
<td>Limit till</td>
<td>Subsurface drip</td>
</tr>
<tr>
<td>Wheat</td>
<td>203.6</td>
<td>No till</td>
<td>Flood</td>
</tr>
<tr>
<td>Perennial Forage</td>
<td>993.5</td>
<td></td>
<td>Dryland</td>
</tr>
<tr>
<td>Grain Sorghum</td>
<td>221.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>119.0</td>
<td>Irrigation</td>
<td></td>
</tr>
<tr>
<td>Sunflowers</td>
<td>51.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed Millet</td>
<td>45.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grass for Seed</td>
<td>190.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alfalfa</td>
<td>13.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Acres</strong></td>
<td>4,327.8</td>
<td>Several sites will integrate livestock at various times throughout the year for varying lengths of time</td>
<td></td>
</tr>
</tbody>
</table>

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