



Integrating Legumes with Grass to Improve Forage-Livestock Systems

One can't talk about agriculture in the Texas High Plains without including "water" in the same sentence. The Ogallala Aquifer, which has kept ag production humming for nearly a century, is running low. Agriculture in the Texas Panhandle and Southern Plains is adapting to decreased water availability.

For over two decades, researchers and producers across the Texas High Plains have been developing integrated crop/livestock production systems that address the growing need for water conservation, while keeping soils fertile, crop yields profitable, cattle production thriving, and surrounding communities viable.

Funded through nearly \$1.5 million in Southern SARE Research & Education, Large Systems, and Graduate Student grants, the results showcase long-term alternative production systems, and how those results are being translated into practical field production practices and sustainable agriculture applications.

This model of sustainable agroecosystems in the Texas High Plains is changing the face of agriculture in the region and helping to conserve water, improve soil health, boost ag profits and keep the High Plains region thriving for generations to come.

This bulletin looks at integrating legumes with grasses to improve the profitability of forage-livestock systems while minimizing irrigation usage to preserve water.



Cattle grazing on OMB. Photo credit: Texas Tech University

Over the past century, agriculture on the Texas High Plains has evolved into a \$20 billion-plus industry centered largely on cotton and finishing beef cattle in feedlots.

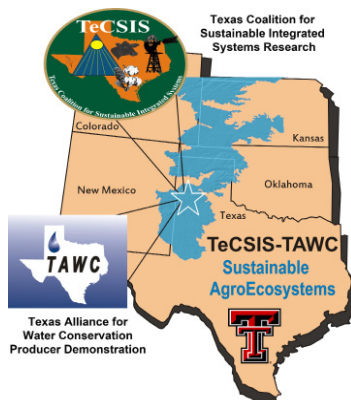
Agriculture was made possible with fertile soils, cheap energy and fertilizers, and irrigation water from the Ogallala Aquifer – a crucial, but finite resource deep below the soil surface stretching from South Dakota to the Texas Panhandle.

With energy and other resource costs rising, and water declining in the Ogallala Aquifer, farmers are at a crossroads: Continue current unsustainable practices, or make cropping choices that conserve energy, improve soil and prolong the use of water remaining in the Ogallala.

Taking a "systems research" approach, Texas Tech University researchers – backed by over a decade of producer-driven field studies -- have compared cotton monoculture to diversified crop/livestock systems. What they have found is that systems based on or inclusive of forages and livestock require less water for irrigation and livestock use than systems based entirely on row crops.

Research continues at the Texas Tech New Deal Research Station with field trials pertaining to the integration of forages and livestock into a predominant row-crop region as a means of reducing water extraction from the Ogallala Aquifer, building soil organic matter, stabilizing soil from wind erosion, and diversifying income.

Following severe drought in the Texas High Plains in 2011 and 2012 and pasture recovery in 2013, grazing trials were restarted in 2014. A basic steer grazing



trial was conducted from 2014-2016 comparing a grass-only system of Old World Bluestem (OWB) receiving nitrogen fertilizer to an alternative (and hypothetically more sustainable) grass-legume system for animal productivity and water use efficiency.

The study also included grazing some native and teff pastures, but were used in minor amounts and didn't have an overall impact on the results.

Research Summary

Research results showed that steers gained more weight, and gained it more quickly, grazing a grass-legume system of OWB, alfalfa, and yellow sweetclover, compared to the OWB alone. In addition, the grass-legume system demonstrated a lower water footprint. The trials satisfied the hypothesis that including legumes with drought-tolerant grasses can improve animal productivity at low water input.

Research Objectives

The three-year grazing trial (2014-2016) was the basis for graduate student research on water use efficiency of cattle production and legume composition and forage availability. As the Ogallala Aquifer decline further limits irrigation, the goal is to identify water-efficient forage systems while keeping



Alfalfa in bloom. Photo credit: Texas Tech University

cattle production in the Texas High Plains region profitable.

Researchers employed two innovations to test their hypothesis: Introducing alfalfa and yellow sweetclover into OWB; and creating a limited-acreage "protein bank", consisting mostly of alfalfa, which was rotationally grazed on a limited basis.

The novel aspects of the research challenged the notion that alfalfa is a high water use crop. "That is true when managed as a hay crop when pushed to its high-yield potential," said forage systems researcher Chuck West. "The other face of alfalfa is that it is a very deep-rooted, drought-resilient plant which can lay dormant during dry summers and recover after periodic rains. The soils of the Texas High Plains favor such a crop."

The research also targeted legumes for their low water needs as high-protein forages that can be integrated into grasses to boost the liveweight gain in cattle with little to no increase in irrigation for the entire grazing system.

Research Results

Researchers limited the irrigation supply to the test pastures over the three years: 8 inches to the grass system, and 7 inches to the grass-legume, averaged over the whole system. They then measured the water footprint (groundwater used per pound of weight gain in the cattle) and found that it took around 30 percent less water to produce a pound of beef liveweight gain when adding legumes to the pasture system. With only pumped groundwater, the comparison was 287 gallons of water per pound of gain in the legume-grass system vs. 395 gallons of water per pound of gain in the grass-only system.

Researchers determined that 9 to 12 inches of irrigation were reasonable



Cattle grazing on a legume/grass mix. Photo credit: Texas Tech University

targets if grazing-season rainfall is less than average or above average but unevenly distributed across the season. By comparison, the amount of irrigation applied annually to cotton averages around 12 inches and for corn, around 18 inches.

“Our realization of 7-8 inches of irrigation indicates progress in providing a viable land-use option for cropland whose irrigation systems can no longer provide irrigation at high-yield levels,” said West.

Over the three-year trial, average weight gain for steers was 2.06 pounds per day in the grass-legume system, compared to only 1.74 pounds per day in the grass-alone system. The season-long weight gain per area was 188 pounds per acre and 118 pounds per acre, respectively.

In addition, forage quality averaged 14.4 percent crude protein content in the grass-legume system compared to 7 percent for the grass-alone system. This, say the researchers, explains the greater productivity of cattle on the grass-legume system.

Final Outcomes

The take-home message is that boosting forage quality by adding legumes to drought-tolerant grasses while keeping

water inputs low boosts the sustainability of water use in a beef grazing system.

Researchers are currently conducting an economic analysis of the grazing trial data to round out the picture of sustainability of water use for beef cattle grazing in legume-enhanced pastures.

Studies at Texas Tech University have emphasized the transition to low-irrigation management systems that address trends that are shaping the future of Southern High Plains agriculture: Fewer overall irrigated acres and increased acres of limited-acreage, high-value crops; improvements in water use efficiency of major row crops; partial replacement of irrigated row crops with drought-tolerant grasses and legumes or dryland crops; increased use of water management technologies; and warmer temperatures leading to greater evaporative demand and more droughts.

Details of the study are outlined in the SSARE Research & Education Grant LS14-261, “Long-term Agroecosystems Research and Adoption in the Texas Southern High Plains – Phase III.”

High Plains Water Conservation Resources

General Information

Texas Coalition for Sustainable Integrated Systems (TeCSIS)
<http://www.orgs.ttu.edu/forageresearch/>

Texas Alliance for Water Conservation
<http://www.depts.ttu.edu/tawc/>

TAWC Solutions
<http://www.tawcsolutions.org/>

Texas Water Development Board
<http://www.twdb.texas.gov/groundwater/aquifer/majors/ogallala.asp>

Texas High Plains Water District
<http://www.hpwd.org/>

Ogallala Aquifer Program
<http://ogallala.tamu.edu>

Ogallala Water Coordinated Agriculture Project (USDA-NIFA)
<http://www.ogallalawater.org>

Publications

High Plains Water Conservation Bulletin No. 1: Water Conservation in the Texas High Plains

High Plains Water Conservation Bulletin No. 2 : Sustainable Crop/Livestock Systems in the Texas High Plains Phase I

High Plains Water Conservation Bulletin No. 3: Sustainable Crop/Livestock Systems in the Texas High Plains Phase II

High Plains Water Conservation Bulletin No. 4: Sustainable Crop/Livestock Systems in the Texas High Plains Phase III

High Plains Water Conservation Bulletin No. 5: Diversifying in the Texas High Plains

High Plains Water Conservation Bulletin No. 6: Agroecosystems Economics in the Texas High Plains

High Plains Water Conservation Bulletin No. 7: Soil Quality of Integrated Crop/Livestock Systems

High Plains Water Conservation Bulletin No. 8: Texas Alliance for Water Conservation

High Plains Water Conservation Bulletin No. 9: Water Use of Old World Bluestems in the Texas High Plains

High Plains Water Conservation Bulletin No. 10: Cover Crops and Cotton in the Texas High Plains

High Plains Water Conservation Bulletin No. 11: Agroecosystems Research in the Texas High Plains: Graduate Student Studies

High Plains Water Conservation Bulletin No. 12: The Performance of Cover Crops in Minimally Tilled Forage-based Grazing Systems

Grant Projects

LS17-286 Long-term Agroecosystems Research and Adoption in the Texas Southern High Plains: Phase III

LS14-261 Long-term Agroecosystems Research and Adoption in the Texas Southern High Plains: Phase II

LS11-238 Long-term Agroecosystems Research and Adoption in the Texas Southern High Plains: Phase I

LS10-229 Integrated Crop and Livestock Systems for Enhanced Soil Carbon Sequestration and Microbial Diversity in the Semiarid Texas High Plains

LS08-202 Crop-livestock Systems for Sustainable High Plains Agriculture

LS02-131 Forage and Livestock Systems for Sustainable High Plains Agriculture

LS97-082 Sustainable Crop/Livestock Systems in the Texas High Plains

GS18-196 Effects of Cumulative Cattle Trampling on Soil Bulk Density and Infiltration of Rain Water on an Annual Forage Crop Pasture

GS15-152 Evaluation of Winter Annual Cover Crops Under Multiple Residue Managements: Impacts on Land Management, Soil Water Depletion, and Cash Crop Productivity

GS07-056 Allelopathic effects of small grain cover crops on cotton plant growth and yields

GS02-012 Optimizing Water Use for Three Old World Bluestems in the Texas High Plains

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