EXHIBIT C
Cover Sheet

Final Report
for
Texas Grain Sorghum Board (TGSB)

Project Title:	Demonstrating Grain Sorghum Potential in Texas: Using Best Management Practices to Maximize Yield and Economic Return
Institution or Organization:	Texas A&M AgriLife Extension
Principal Investigator(s):	Ronnie Schnell
Other Investigator(s):	T. Provin, J. Mowrer
Cooperator(s):	San Patricio County, Williamson County, Burleson County

<u>List of All Project Expenditures:</u>

Student Labor:	$5,000
Travel:	$3,500
Seed, fertilizer etc:	$2,000
Rental/other:	$3,750
Soil analysis:	$750
Total:	$15,000

Table of Contents

List of Figures

Executive Summary

Grain sorghum yields overall in Texas have not increased much since the 1970's. Yet, statewide data does not accurately describe sorghum potential in Texas. Using actual yield measurements from AgriLife trials, yield trends have increased in some regions but has not been equal across the state. Large yield increases (1.6 bu/acre/yr) have been observed in the High Plains region under irrigation while other regions have had little if any increase in yield. National Sorghum Yield Contest and other yield reports from regions with lower yield trends suggest that much greater yield potential does exist. Greater than 200 bu/acre was obtained in central Texas during 2014 while many growers are content with less than 100 bu/acre. Research/demonstration plots were established within three major sorghum production regions of Texas to compare production systems with varying yield goals and inputs. Best management practices were used to ensure adequate weed, insect and disease control. Increasing nitrogen fertilizer rates were used to determine optimum yield potential. Environmental conditions were a major constraint for grain yield during 2016 across all three regions. Excessive rainfall reduced tiller production and limited grain yield. Furthermore, residual soil nitrogen (N) at all sites reduced N fertilizer response and lowered economic return for added N fertilizer. Ultimately, unusual weather conditions limited yield potential precluding the demonstration of true sorghum yield potential.

Technical Objectives

1. Demonstrate grain sorghum yield potential across three environments in Texas.
2. Disseminate information to grain producers on low and high input grain production.

Background

Historical yield estimates (NASS) for Texas do not show significant yield increases since 1970's. Yet, NASS data does not accurately reflect yield potential in Texas. Limited irrigation systems, low input systems, dry land production all contribute to lower state-wide yield averages. Yet, regional data obtained through the Texas A&M AgriLife Research Crop Testing program indicates that yield increases have not been equal across all regions of Texas. The High Plains region of Texas has a trend line yield increase of 1.6 bu/acre/yr while the Gulf Coast region has 0.6 bu/acre/yr and the Blacklands region in central Texas has no detectible change in yield over time. Yet, yield trends in central and coastal areas of Texas may not reflect the true potential for grain sorghum production in these regions. To increase yields in these regions, producers must simultaneously adopt top performing hybrids and make appropriate adjustments to crop inputs to realize full yield potential.

Grain sorghum hybrid trials conducted across Texas by the Crop Testing Program continues to identify superior corn hybrids with good yield potential (http://varietytesting.tamu.edu/sorghum/index.htm). Sorghum grain yields often vary by 20-40 bu/acre comparing trial average yields to the best performing hybrids. Despite genetic gains for new hybrids available to producers, yield goals (evident by N fertilizer rates used at many trial locations) have not changed much in some regions of Texas over the last decade or more. Producers making minimal adjustments to yields goals over time may largely explain the lack of yield increase over time for some regions of Texas. In fact, where yields have increased dramatically in Texas (High Plains), we have observed significant increases in N fertilizer rates, as well as other inputs. The potential for higher grain yields will not be accomplished through adjustment to N fertilizer rates alone. Higher yields also require higher levels of management. Optimum tillage practices (compaction management), weed control and pest/disease control must be employed to achieve higher yields.

Dryland farming in Texas is exposed to large variation in weather patterns year to year. Moisture and heat stress are the most devastating to grain yields in Texas. Increased yield goals and associated inputs are coupled to greater economic risks. Therefore, weather conditions before and during the production season should be considered when identifying optimum yield goals. Some years, environmental conditions may preclude higher yield goals. In addition, grain prices and input costs should be considered when identifying optimum yield goals.

Research Methods:

Replicated field studies were installed at three locations in Texas (Coastal Bend, Brazos River Bottom, Blacklands) in cooperation with County Extension Agents and growers. Treatments included yield goals of 100, 150, 200, 250 and 300 bushels per acre. Plots were 4 rows wide with 30 inch spacing and100 to 500 ft in length (smaller plots in Williamson county due to excessive rainfall). The same hybrid was used at all locations, Dekalb DKS 51-01 at 65,000 seeds per acre. Soils were sampled and analyzed. Other crop inputs (including herbicides, pest and disease control) were applied to maintain plots free of weeds, insects and disease. Yield was measured by hand and/or combine. Economic response to variable crop inputs were calculated.

Outreach:

Demonstration sites served as a component of crop tours held during June or July in each county. State and County AgriLife Extension personal provided current information on sorghum production (including sugarcane aphid management) in addition to discussion of grain sorghum yield potential. In addition to in-person meetings, Extension publications and presentation at professional meeting were used to deliver results to growers and professionals in the region.

Results

All field sites had good plant stands, free of major pest, weeds or diseases. Increasing nitrogen rates were imposed to determine optimum grain yield and economic return. Several factors limited grain yield and affected economic return for fertilizer inputs. Weather conditions affected sorghum growth and development. Most notably, excessive soil moisture reduced tillering at all three locations. Planting rates were 65,000 seeds per acre at all locations. Heads per acre at harvest was between 53,000 and 54,000, suggesting little if any tillering occurred. Reduced or delayed tillering is well documents for grain sorghum under prolonged flooding or saturated conditions (Howell et al., 1976; Orchard and Jessop, 1984). Yield reductions of 30% or more have been reported for sorghum under prolonged waterlogged conditions.

Waterlogging and the effect on tillering and grain yield diminished crop response to added nitrogen fertilizer. Moreover, significant residual soil nitrogen further reduced crop response to added nitrogen fertilizer. In Burleson county, where crop nitrogen uptake was measured, greater than 100 lb N/acre was found in grain and above ground biomass in plots that received no N fertilizer. As a result, modest grain yields were obtained with low rates of added N fertilizer. Yields of 4,356 to 5,325 lb/acre were achieved with less than 100 lbs N/acre at all locations. Maximum grain yield with added N fertilizer was 257 to 905 lb/acre greater than minimum N rates. The agronomic optimum N fertilizer rate (AONR) was near 180 lb N/acre across all three sites (Figure 1). The lack of significant grain yield response to added N fertilizer results in a much lower economic optimum N fertilizer rate (EONR) of 11 lb/acre (Figure 1). The low EONR across all sites further supports the presence of residual soil N and reduced yield potential. Economic optimum N fertilizer rates would likely be much greater in fields with low amounts of residual soil N and during years with conditions favoring greater yield potential.

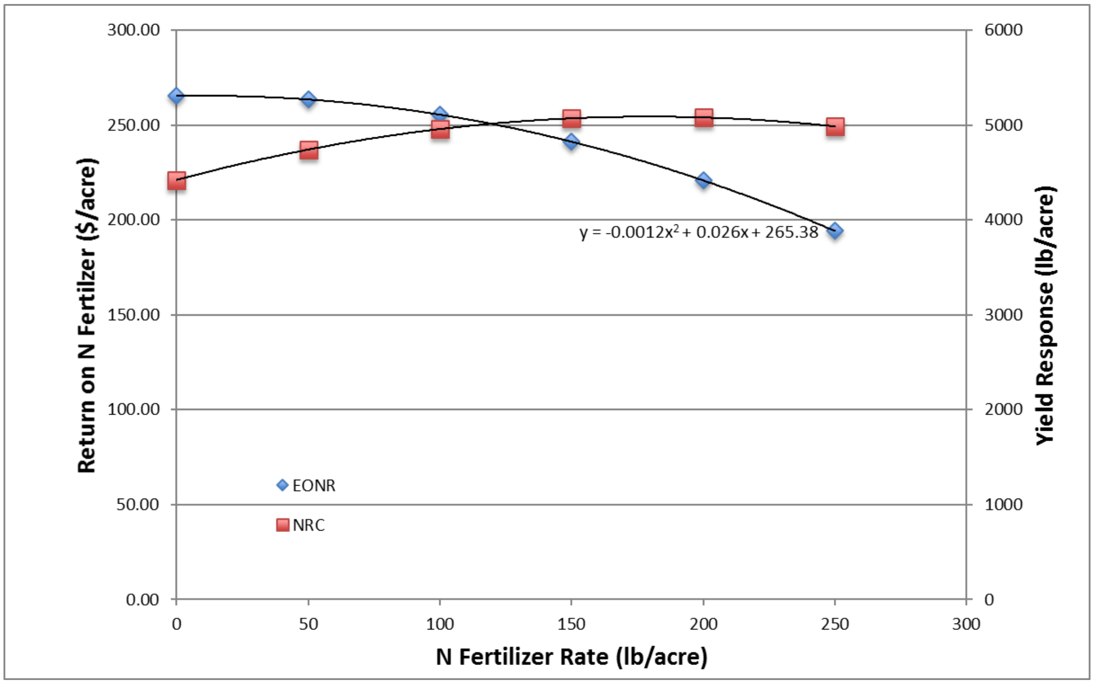

Figure 1. Economic return on nitrogen fertilizer applied given nitrogen response at three locations during 2016. Grain price at $6.00 cwt, Nitrogen fertilizer $0.42 per lb of N.

Conclusions

The second straight year of excessive spring rainfall limited yield potential in all three regions. Excessive residual soil N from previous crops diminished sorghum response to added inputs. The combination of events precluded the demonstration of true sorghum yield potential. It is expected that under normal weather conditions, sorghum yield potential and response to crop inputs would increase. Additional studies will be imposed during 2017 and beyond to demonstrate sorghum yield potential.

Impact

Economic Impact

- **Industry**
- **Producer** Environmental conditions and residual soil N during 2016 created a scenario where crediting of N in the soil profile could reduce N fertilizer rates, with potential savings for producers estimated at $20 per acre.

Economic Feasibility

Return on Investment

Next Steps

Grain sorghum yield potential for low and high input systems will be demonstrated in 2017. Trials will be initiated that will provide side-by-side comparison of low and high input systems. Low input will be characterized as minimal herbicide, insecticide and nutrient inputs with lower yield goals (100 bu/acre). High input will provide complete crop nutrition, as prescribed by soil testing, and utilize available herbicide programs, insecticides and fungicides as needed to obtain higher yields (200 bu/acre minimum). Economic return for contrasting management systems will be compared. The goal is to maintain these plots over time (long-term) and incorporate new technology as it becomes available.

In addition, yield response to added N fertilizer will be measured during 2017. Replicated field trials will be imposed to determine optimum rate and timing of N with and without starter fertilizer practices. Information on economic optimum N rates for contrasting production systems will be determined.

Appendices

Church, S., R. Schnell, J. Mowrer, T. Provin. 2016. Impact of Starter Fertilizers on Optimum Rate and Timing of Nitrogen Fertilizer in Grain Sorghum. 2016 ASA.CSSA.SSSA Intl. Annual Meetings, Nov. 6-9, Phoenix, AZ.

Church, S., R. Schnell, J. Mowrer, T. Provin, N. Rajan and S. Shafian. 2016. Monitoring Nitrogen Status in Grain Sorghum Under Contrasting Fertilizer Management. 2016 Plant Protection Conference, December 6-7, College Station, TX.

List of Abbreviations

References

Howell T.A., Hiler E.A., Zolezzi O., Ravelo C. (1976) Grain Sorghum Response to Inundation at Three Growth Stages. 19. DOI: 10.13031/2013.36138.

Orchard P., Jessop R. (1984) The response of sorghum and sunflower to short-term waterlogging. Plant Soil. 81:119-132.