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Sigma Agricultural Risk and Actuarial Services, LLC

Final Report Task Order 2 – Grain Sorghum Evaluation Actuarial Review

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Executive Summary

Grain sorghum is a major crop grown primarily in semi-arid regions of the U.S. Typically, grain sorghum has a lower value per acre than many other field crops grown on the same farm. In the southern plains of the United States, when irrigation water is limited, growers typically apply water first to higher-valued crops. Thus, irrigated grain sorghum is often managed as a residual claimant on irrigation water.

This perfectly understandable behavior creates two problems for crop insurance on irrigated grain sorghum. The first is that growers know much more than the Risk Management Agency (RMA) or Approved Insurance Providers (AIPs) about their access to irrigation water and the likelihood that grain sorghum will receive sufficient irrigation water to reach its full yield potential. This asymmetrically distributed information leads to a situation where those who have less (more) access to irrigation water and/or are less (more) likely to apply available water to grain sorghum are more (less) likely to purchase crop insurance on irrigated grain sorghum. The result has been high levels of loss cost (indemnities/liability) resulting in high premium rates.

A second and related problem is that, due to many growers producing grain sorghum as a residual claimant on irrigation water, T-yields for irrigated grain sorghum are well below the actual yield potential for sufficiently irrigated grain sorghum. With reduced water availability from aquifers in some regions of the southern plains, some growers are recognizing that they should be switching out of corn and/or cotton into grain sorghum because grain sorghum requires less irrigation water. However, with the low T-yields on irrigated grain sorghum, these growers cannot obtain sufficient crop insurance liability to securitize an operating note with their lender. Thus, to obtain financing, the lender requires the grower to instead produce corn or cotton which requires more irrigation water.

There is no one single solution to either of these problems. For the asymmetric information problem, this report makes several recommendations that collectively may help mitigate (but likely not fully alleviate) the problem. These recommendations are based on standard insurance understandings of how to address challenges created by information asymmetry. The recommendations fall into two general categories. The first is to implement underwriting requirements that compel potential insureds to reveal more information about their access to irrigation water and/or the likelihood that available irrigation water will be applied to grain sorghum. The second is to provide potential insureds with a menu of policies or policy options designed such that, by their policy choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum.

To help address the second problem of low T-yields, this report recommends extending the personal T-yield pilot program to irrigated grain sorghum production in the southern plains. This should allow those who intend to provide adequate irrigation water to their grain sorghum to obtain higher T-yields and thus higher levels of liability. However, again, this is not a complete solution because growers must have at least one year of actual yield data for a given combination of crop, county, type, and practice before they are eligible to utilize personal T-yields for that same combination of crop, county, type, and practice.

The task order also asked for an analysis of abandonment in irrigated grain sorghum relative to other irrigated crops. For the southern plains, we found no compelling evidence that abandonment occurs more frequently for irrigated grain sorghum than for irrigated corn or irrigated cotton. This suggests that the impact of insufficient irrigation water on grain sorghum is not manifested primarily in more unharvested acreage (relative to irrigated corn or cotton) but rather in harvested acreage with realized yields that are substantially less than the potential yield with sufficient irrigation.

The recommendations contained in the report, prioritized based on conversations with the National Sorghum Producers (NSP), are:

Highest Priority

- Allow irrigated grain sorghum growers to index grain sorghum indemnities to another irrigated crop.

Secondary Priority

- Create a “sensor-reported irrigated practice” for those who provide soil moisture sensor information.
- Extend personal T-yield pilot to grain sorghum in the southern plains.

Tertiary Priority

- Consider requiring information from aquifer maps to assess water availability.
- Create an irrigated policy option that excludes coverage for “hot, dry” cause of loss.
- Increase the availability of area-based products for grain sorghum.

Contents

Table of Figures

Table of Tables

Grain Sorghum Evaluation Actuarial Review

Situation

The following statements summarize our understanding of the environmental and behavioral conditions that have contributed to the crop insurance challenges identified in the task order:

1. Grain sorghum tends to have lower value per acre than other field crops (e.g., corn or cotton). When irrigation water is limited, growers typically apply water first to higher-valued crops. Thus, irrigated grain sorghum is often managed as a residual claimant on irrigation water.
2. This issue is becoming particularly pronounced in regions that depend upon aquifers for irrigation water and where water availability is decreasing rapidly (e.g., high plains of Texas, southwestern Kansas).
    a. Operationally, this issue may occur in various ways. For example, within an irrigation center pivot circle, a grower may plant half of the circle to corn and half to grain sorghum with the understanding that the grain sorghum will only be irrigated if sufficient water is available.
    b. Another scenario would be that the grower applies irrigation to grain sorghum only once, around 30 days after germination, when the marginal benefit is thought to be highest. Subsequent irrigation would be required to reach the potential yield but will not occur unless water is available that is not needed for higher-valued crop(s).

Geographic Focus

The National Agricultural Statistics Service (NASS) estimates that almost 5.7 million acres of grain sorghum were planted nationally in 2018 (the last year for which data are currently available). The Risk Management Agency (RMA) Summary of Business indicates that almost 4.2 million acres of grain sorghum were insured under Yield Protection (YP), Revenue Protection (RP), or Revenue Protection with Harvest Price Exclusion (RP-HPE) policies in that year. Thus, in the last year for which NASS data are currently available, approximately 74% of grain sorghum acreage nationally was insured.

NASS reports grain sorghum planted acres for Arkansas, Colorado, Georgia, Illinois, Kansas, Louisiana, Mississippi, Missouri, Nebraska, New Mexico, North Carolina, Oklahoma, South Dakota, and Texas. However, of the almost 5.7 million acres of grain sorghum planted in the United States in 2018, Kansas and Texas accounted for 76% (2.8 million acres for Kansas and 1.6 million acres for Texas). Colorado was the next largest with 355,000 acres, Oklahoma had 300,000 acres, and South Dakota had 260,000 acres. No other state had more than 80,000 acres. For this reason, though some of the recommendations contained in this report are likely relevant across other grain sorghum producing areas, the analyses presented here will focus on Kansas and Texas. We will further focus on the NASS agricultural districts in Kansas and Texas that are most dependent on aquifers for irrigating grain sorghum and where water availability is decreasing rapidly. These districts are the Southwest agricultural district of Kansas and the Northern and Southern High Plains agricultural districts of Texas.[1] In these districts, irrigated grain sorghum competes for acreage with irrigated corn and irrigated cotton.

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[1] This geographic focus was agreed upon during conversations between the contractor and the National Sorghum Producers (NSP).

Drought and Heat Tolerance

Grain sorghum is generally considered one of the most heat- and drought-tolerant of all grain crops. This is emphasized in publications available online (see the reference list at the end of this report) from the Kansas State University Department of Agronomy (undated) and the Texas A&M University Department of Soil and Crop Sciences (undated).

Bean (2017) and Carter et al. (1989) highlight that grain sorghum self-pollination reduces the risk of heat-damage compared to the cross-pollination of corn. Carter et al. also discuss the importance of considering available soil moisture when making plant population decisions for corn – something that is less important when producing grain sorghum. Grain sorghum will compensate for low moisture conditions by reducing the size of the grain heads and the number of tillers and in high moisture conditions will increase the size of the grain heads and more tillers will produce heads. Finally, Carter et al. explain that the grain sorghum plant resists drying due to the waxy coating on the leaves, whereas the corn plant loses much more of its water content through the leaves.

Although grain sorghum is one of the most drought-tolerant grain crops, three studies agree that very high temperatures during pollination can affect grain yield and glucose content. Nanjundaswamy et al. (2011), Schnell (2017), and Tack et al. (2017) describe the damage resulting from extreme heat during pollination. The temperature thresholds differ with Schnell reporting a threshold of 97 – 100 degrees Fahrenheit for 5 days before and 5 days after flowering and Tack et al. reporting a threshold of 91 degrees Fahrenheit which compares to thresholds for cotton, rice, and wheat but is 7 degrees Fahrenheit greater than the threshold for corn. In the focus areas for this study, grain sorghum is generally planted about a month later than corn (Shroyer et al., 1996). This implies that grain sorghum can be the residual claimant on irrigation water for both economic and agronomic reasons.

Production Costs

The Department of Agricultural Economics at Kansas State University and the Texas A&M AgriLife Extension Service both generate enterprise budgets for various commodities produced in different regions of their respective states. The Extension regions used for these budgets are generally (though not perfectly) aligned with the NASS agricultural districts that are the focus of this study.

Table 1 presents comparisons of 2020 budget data for irrigated grain sorghum, corn, and cotton production. The budget comparisons include revenue and expenses per acre for each crop in each of the three NASS agricultural districts that are the focus of this study. Where differences exist between the Extension region and the NASS agricultural districts, the table shows the budget for the Extension region that most closely aligns with the agricultural district. The units for yield and price are hundredweight (cwt) for grain sorghum, bushels for corn, and pounds for cotton. Cottonseed revenue was included in the Texas budgets but not in the Kansas budget. Costs for seed, fertilizer, herbicide, insecticide, and irrigation energy are included. Other variable costs include fuel, labor, interest, and custom operations.

The assumed irrigation water use is included in each budget. Noticeably for each region, irrigated corn is assumed to require considerably more irrigation water than irrigated grain sorghum. This is particularly true in Texas where irrigated corn is assumed to require more than twice as much water as irrigated grain sorghum. Irrigated cotton is assumed to require less irrigation water than irrigated corn but more than irrigated grain sorghum.

These budgets also demonstrate the very large difference in expected revenue between irrigated corn and irrigated grain sorghum. In Texas, the expected revenue per acre for irrigated corn is between two and two and half times the expected revenue per acre for irrigated grain sorghum. The expected revenue for irrigated cotton is even higher than that for irrigated corn. In Kansas, the expected revenue per acre for irrigated corn is one and two-thirds times the expected revenue per acre for irrigated grain sorghum. The expected revenue for irrigated cotton is between that of irrigated corn and irrigated grain sorghum. Not surprisingly, production costs are also higher for corn and cotton compared to grain sorghum but, in all three regions, irrigated grain sorghum had the lowest expected net return for 2020.

Table 1. Irrigated Production Budgets for Grain Sorghum, Corn, and Cotton, 2020

	Kansas Southwest			Texas Northern High Plains			Texas Southern High Plains		
	Grain Sorghum	Corn	Cotton	Grain Sorghum	Corn	Cotton	Grain Sorghum	Corn	Cotton
REVENUE									
Yield	89.6	225	1200	60	225	1500	55	210	1250
Price	6.03	4.00	0.61	6.75	4.20	0.66	6.50	4.30	$0.63
Cottonseed						225.00			146.44
Total Revenue per Acre	540.40	900.00	736.80	405.00	945.00	1215.00	357.50	903.00	933.94
VARIABLE EXPENSES									
Seed	12.98	119.43	109.91	8.43	94.50	89.20	10.80	119.00	63.60
Fertilizer	75.63	105.16	51.12	60.41	124.11	80.75	64.70	133.45	79.50
Herbicide	48.30	57.03	32.02	24.77	36.69	45.74	21.12	45.00	42.00
Insecticide	0.00	16.50	1.80	29.77	22.87	11.10	25.00	25.00	12.00
Irrigation (acre-inches)	*12*	*16*	*10*	*10*	*22*	*12*	*9*	*20*	*12*
Irrigation Energy	35.09	46.79	29.24	39.60	87.12	47.52	90.00	200.00	120.00
Other VC	237.28	270.61	349.38	199.96	322.30	568.47	142.25	203.27	384.15
Total VC per Acre	409.28	615.52	573.47	362.94	687.59	842.78	353.87	725.72	701.25
Returns above Total VC per Acre	131.12	284.48	163.33	42.06	257.41	372.22	3.63	177.28	232.69
Fixed Expenses per Acre	256.89	245.89	245.89	190.34	215.81	161.51	210.25	235.25	205.25
Total Expenses per Acre	666.17	861.41	819.36	553.28	903.40	1004.29	564.12	960.97	906.50
Returns above Total Expenses per Acre	**-125.77**	**38.59**	**-82.56**	**-148.28**	**41.60**	**210.71**	**-206.62**	**-57.97**	**27.44**

Units for yield and price - Grain sorghum - cwt; Corn - bushel; Cotton - pound.
Irrigation energy is assumed as: $2.92 per acre-inch in Kansas, $3.96 per acre-inch in Texas Northern High Plains, and $10.00 per acre-inch in Texas Southern High Plains.
Grain sorghum for the Kansas budget was converted from bushels to cwt at 56 pounds per bushel. No cottonseed revenue was available for the Kansas cotton budget.

Sources: Kansas State University Department of Agricultural Economics and Texas A&M University Texas AgriLife Extension.

Acreage of Grain Sorghum and Competing Crops

In the three focal regions for this study, grain sorghum competes for acreage with corn and cotton. More specifically, corn is the primary competing crop in the Southwest agricultural district of Kansas, both corn and cotton compete with grain sorghum for acreage in the Northern High Plains agricultural district of Texas, and cotton is the primary competing crop in the Southern High Plains agricultural district of Texas. This section of the report examines the history of NASS planted acreage for these crops in the focal regions.

Southwest Agricultural District of Kansas

The Southwest agricultural district of Kansas is composed of Clark, Finney, Ford, Grant, Gray, Hamilton, Haskell, Hodgeman, Kearny, Meade, Morton, Seward, Stanton, and Stevens counties (see figure 1). This district accounted for 28% of Kansas grain sorghum acres in 2018 and 27% of Kansas production. Figure 2 presents grain sorghum planted acres in the Southwest district of Kansas from 1972 until 2018. For the past twenty years, the district has planted between 480,000 and 780,000 acres each year. Unfortunately, grain sorghum acreage and production data are not available by irrigation practice in Kansas after 2009 so the graph includes both irrigated and non-irrigated practices.

In the Southwest agricultural district of Kansas, corn is the primary crop that competes with grain sorghum for acres. Figures 3 and 4 present irrigated and non-irrigated corn planted acres in the Southwest agricultural district of Kansas from 1974-2018. Irrigated corn acres have been just under 700,000 in recent years while non-irrigated corn acres reached a maximum of 342,000 in 2017. The second highest planted acreage of non-irrigated corn occurred in 2018 with 213,000 acres. Cotton is also grown in the Southwest district of Kansas but NASS does not consistently report cotton planted acres in the district. The available NASS cotton data have never exceeded 50,000 planted acres.

Figure 1. Southwest Agricultural District of Kansas

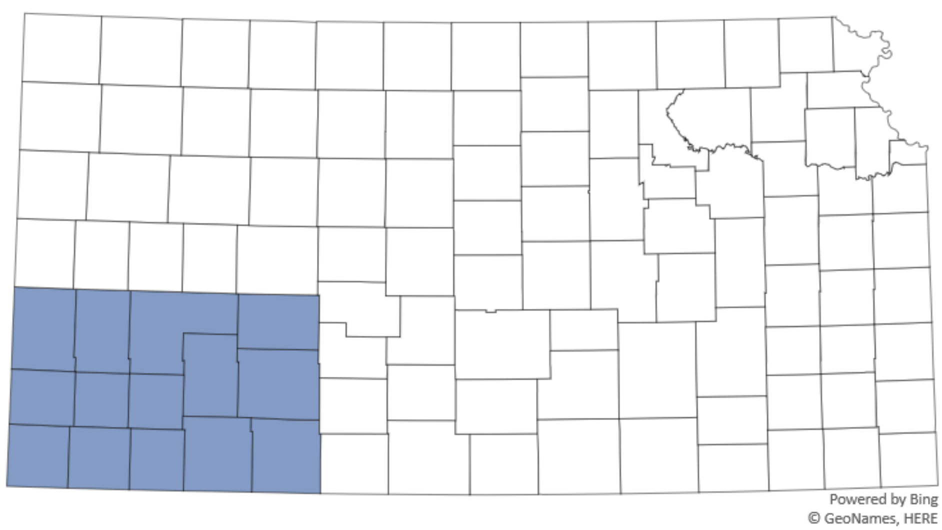


Figure 2. Kansas Southwest Grain Sorghum Planted Acres, 1972-2018

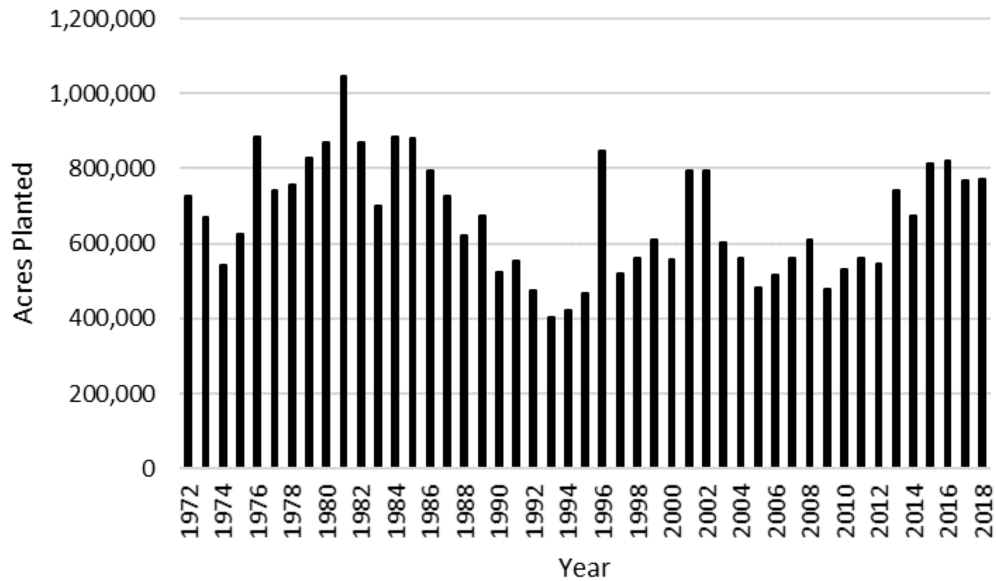


Figure 3. Kansas Southwest Irrigated Corn Planted Acres, 1974-2018

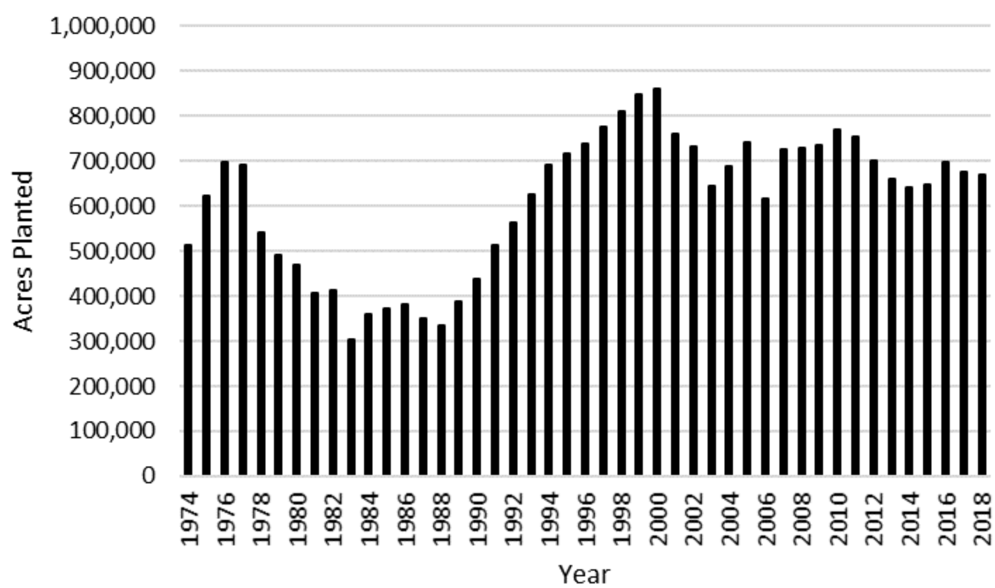
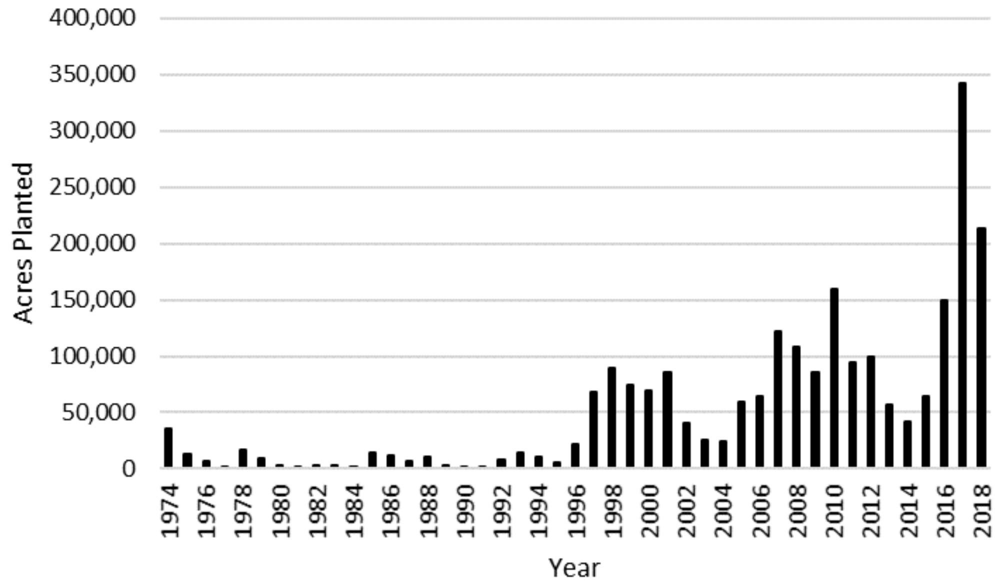


Figure 4. Kansas Southwest Non-irrigated Corn Planted Acres, 1974-2018



Northern High Plains Agricultural District of Texas

The Northern High Plains agricultural district consists of Armstrong, Briscoe, Carson, Castro, Dallam, Deaf Smith, Floyd, Gray, Hale, Hansford, Hartley, Hemphill, Hutchinson, Lipscomb, Moore, Ochiltree, Oldham, Parmer, Potter, Randall, Roberts, Sherman, and Swisher counties (see figure 5). Figures 6 and 7 present irrigated and non-irrigated grain sorghum planted acres in the district.

In the early 1970s, the Northern High Plains raised well over 1 million acres of irrigated grain sorghum compared to less than 400,000 acres of non-irrigated grain sorghum. Since that time, irrigated grain sorghum acres have decreased steadily. In the early 1990s, non-irrigated grain sorghum acreage began exceeding irrigated grain sorghum acreage in the district. In recent years, less than 150,000 acres of irrigated grain sorghum have been planted in the district. While exceeding irrigated acreage, non-irrigated grain sorghum acreage has also decreased relative to the high-price years earlier in the decade.

Both corn and cotton compete with grain sorghum for acreage in the Northern High Plains agricultural district of Texas. Figures 8 and 9 present irrigated and non-irrigated corn planted acres for the Northern High Plains. Irrigated planted acres are available for the period 1981-2018 while non-irrigated planted acres are only available for the period 1998-2018.

Irrigated corn acreage in the Northern High Plains reached record levels during the high-price years earlier in the decade before decreasing in 2017 and 2018. Even with the decrease in recent years, irrigated corn acreage in the district is approximately double what it was through most of the 1980s. Non-irrigated corn acreage in the district has never exceeded 50,000 acres. As with irrigated corn acres, non-irrigated corn planted acres reached a peak in the high-price years earlier in the decade before falling off in 2017 and 2018.

Figure 5. Northern High Plains Agricultural District of Texas

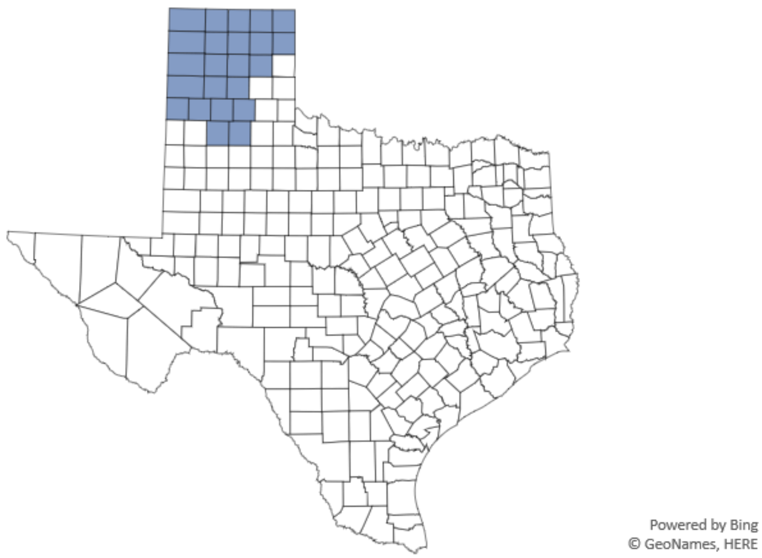


Figure 6. Texas Northern High Plains Irrigated Grain Sorghum Planted Acres, 1972-2018

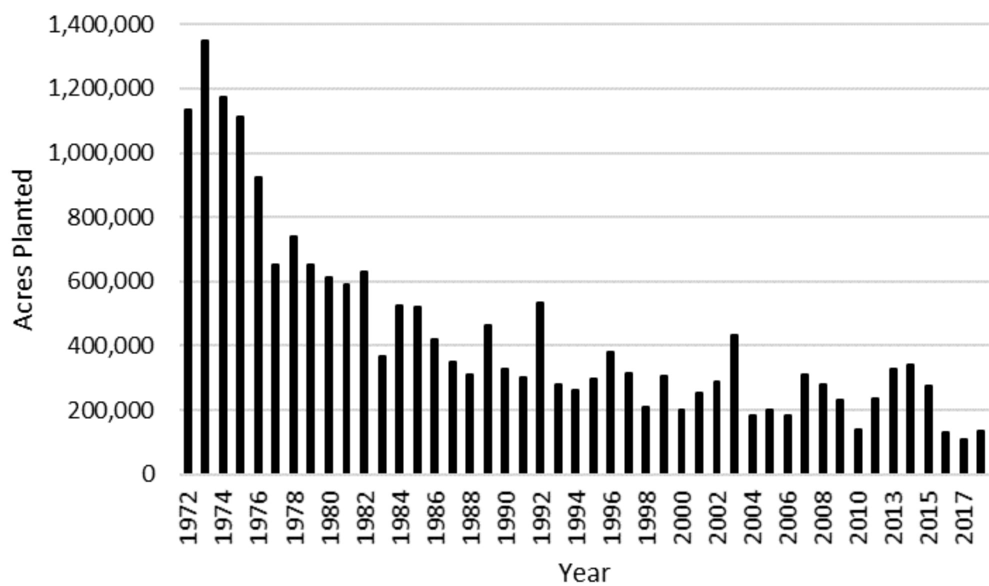


Figure 7. Texas Northern High Plains Non-irrigated Grain Sorghum Planted Acres, 1972-2018

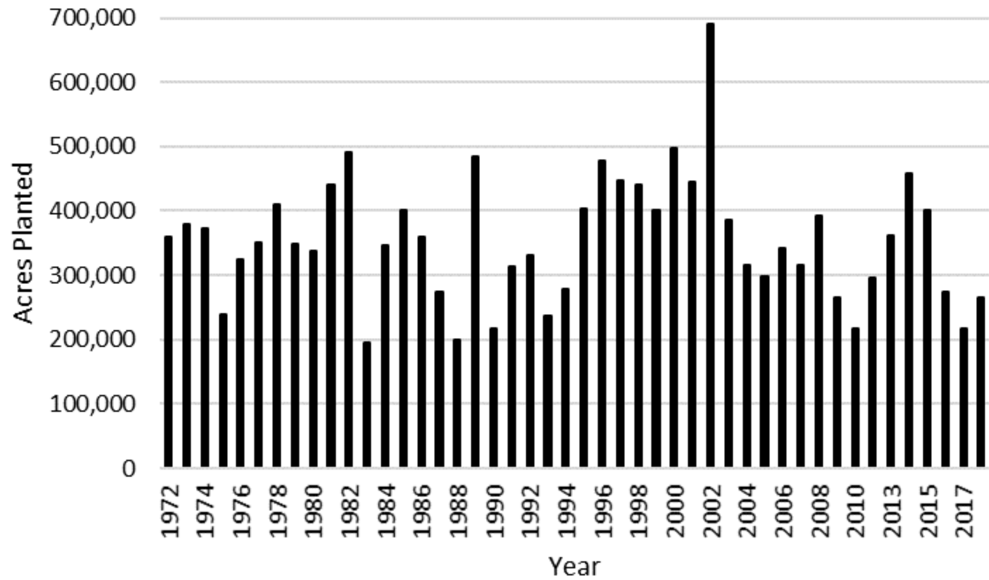


Figure 8. Texas Northern High Plains Irrigated Corn Planted Acres, 1981-2018

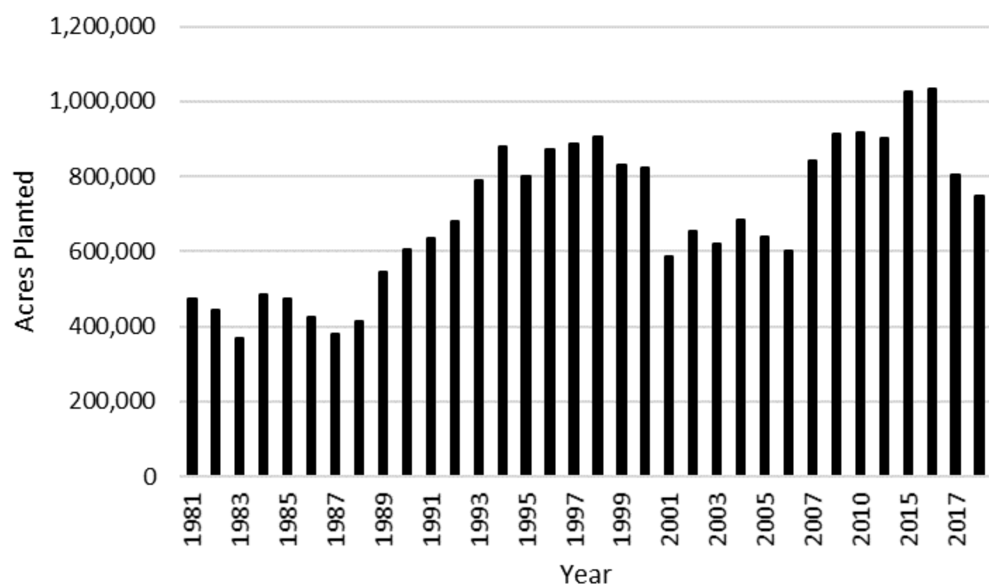
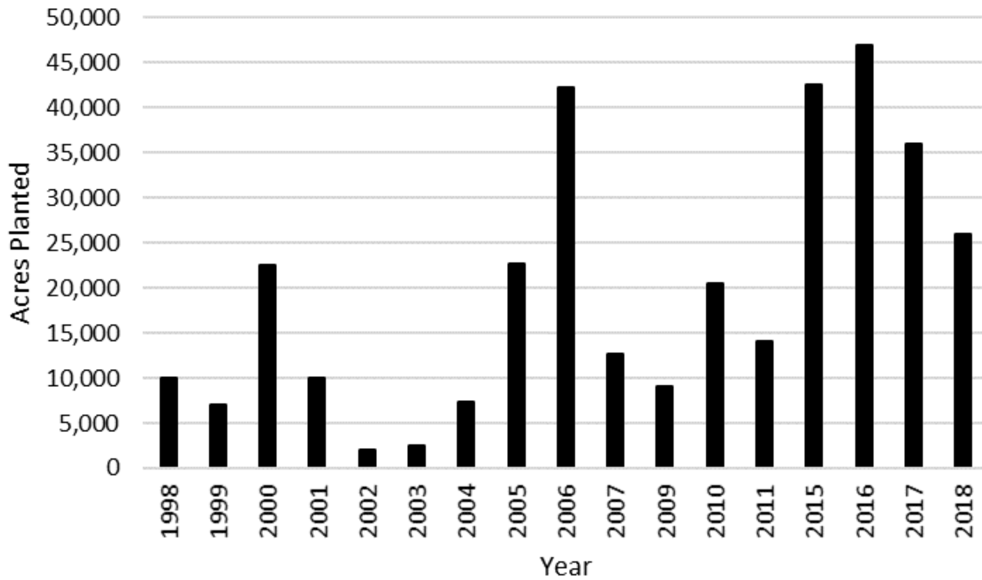


Figure 9. Texas Northern High Plains Non-irrigated Corn Planted Acres, 1998-2018



Figures 10 and 11 present irrigated and non-irrigated cotton planted acres in the Northern High Plains agricultural district of Texas. Over the past decade, irrigated planted acreage reached a low in 2015 (283,000 acres) and a high in 2018 (835,000 acres). Non-irrigated planted acreage has increased steadily since the early 1980s reaching record high levels during the past decade. As with irrigated acreage, the lowest non-irrigated acreage in recent years was in 2015 (183,000 acres) while the highest was in 2018 (686,000 acres).

Figure 10. Texas Northern High Plains Irrigated Cotton Planted Acres, 1972-2018

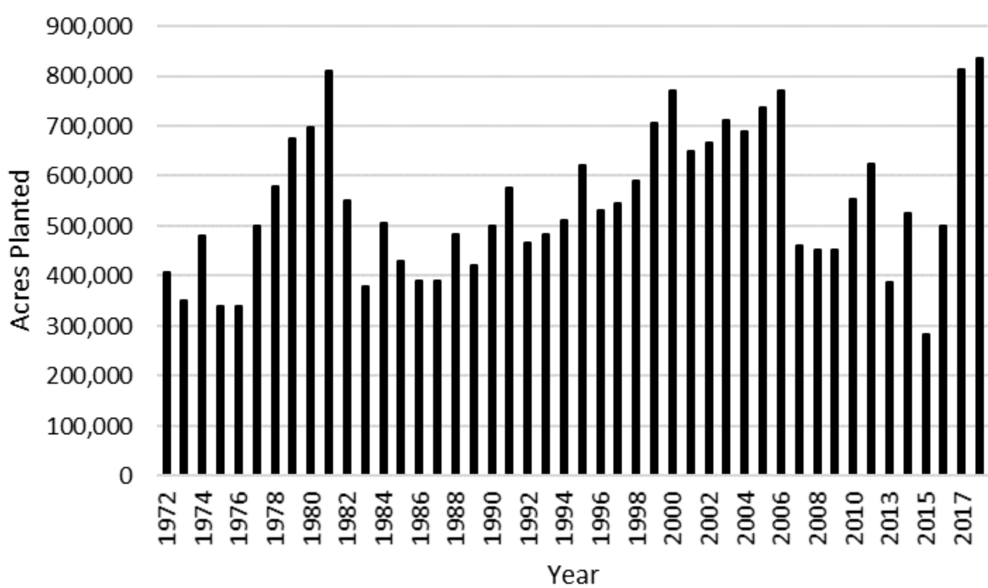
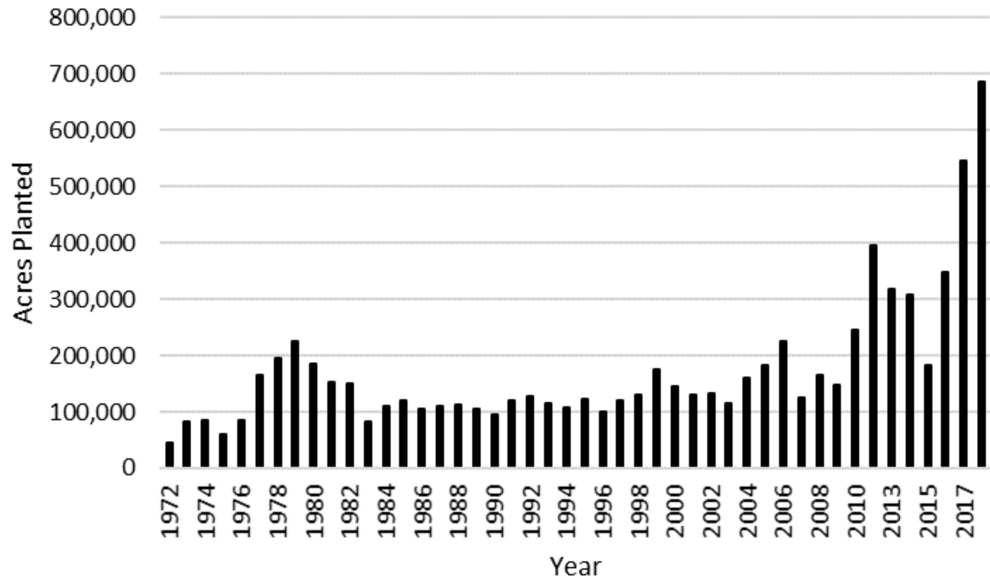


Figure 11. Texas Northern High Plains Non-irrigated Cotton Planted Acres, 1972-2018



By comparing the figures on grain sorghum, corn, and cotton planted acres in the Northern Plains, it is apparent that irrigated grain sorghum has experienced a tremendous decrease in planted acreage since the early 1970s. Over the same period, irrigated corn acreage has generally trended upward. Both grain sorghum and corn gained acres at the expense of cotton (primarily irrigated cotton) during the period of high feed grain prices earlier in the decade. In recent years, both grain sorghum and corn have lost acreage to irrigated and non-irrigated cotton.

Southern High Plains Agricultural District of Texas

The Southern High Plains agricultural district of Texas consists of Andrews, Bailey, Cochran, Crosby, Dawson, Gaines, Glasscock, Hockley, Howard, Lamb, Lubbock, Lynn, Martin, Midland, Terry, and Yoakum counties (see figure 12). Cotton is the primary crop that competes for acreage with grain sorghum in the Southern High Plains.

Figures 13 and 14 present irrigated and non-irrigated grain sorghum planted acres in the Southern High Plains district of Texas for the years 1972-2017. As with the Northern High Plains, the Southern High Plains currently have more acres of non-irrigated grain sorghum than irrigated grain sorghum. Unlike the Northern High Plains, this has consistently been the case in the Southern High Plains. In 2017 (the last year for which data are available), the Southern High Plains had only 250,500 acres of non-irrigated grain sorghum and 63,500 planted acres of irrigated grain sorghum. Perhaps the most noticeable thing about figures 13 and 14 is the extreme year to year variability in both irrigated and non-irrigated grain sorghum acres in the district.

Figures 15 and 16 present irrigated and non-irrigated cotton planted acres for the Southern High Plains agricultural district of Texas. Cotton planted acres do not exhibit the same year to year variability as grain sorghum planted acres in the district. Irrigated cotton acreage peaked in 1980 at 1.5 million acres before decreasing rapidly during the farm financial crisis years to 760,000 acres in 1987. Irrigated cotton acreage remained above 1.2 million acres from the mid-1990s until the mid-2000s. Since then, it has generally remained in the range of 1.0-1.2 million acres. Non-irrigated cotton acreage in the district similarly peaked at 2.2 million acres in the early 1980s before decreasing precipitously in the drought year of 1983. Since then, non-irrigated cotton acreage has gradually increased returning to levels exceeding 2 million acres in recent years.

Figure 12. Southern High Plains Agricultural District of Texas

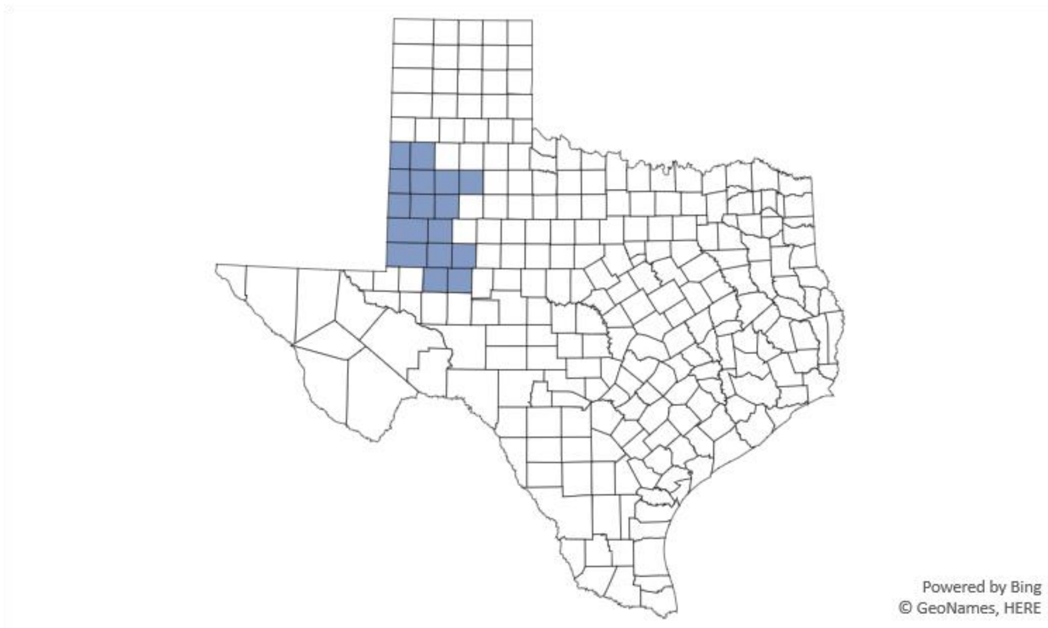


Figure 13. Texas Southern High Plains Irrigated Grain Sorghum Planted Acres, 1972-2017

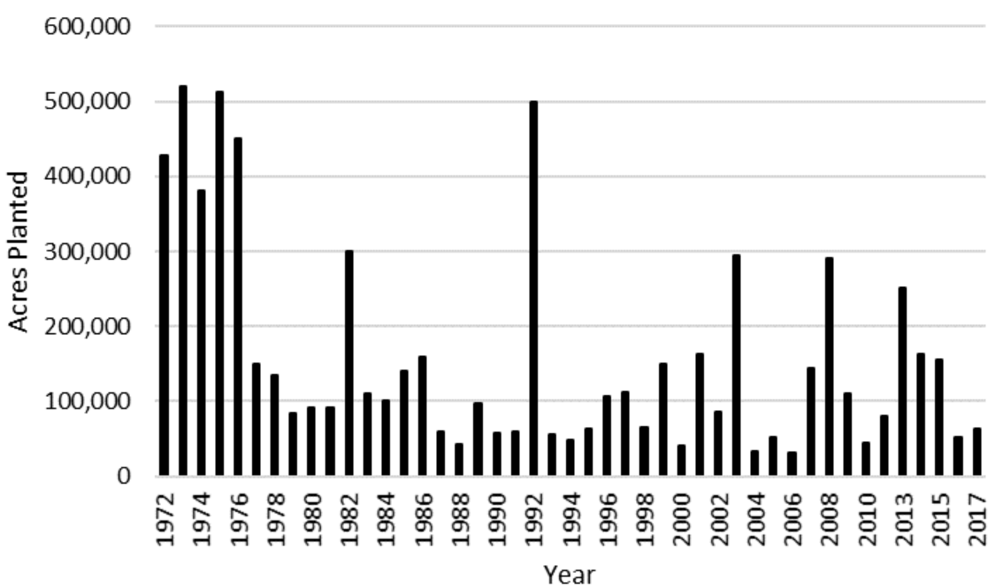


Figure 14. Texas Southern High Plains Non-irrigated Grain Sorghum Planted Acres, 1972-2017

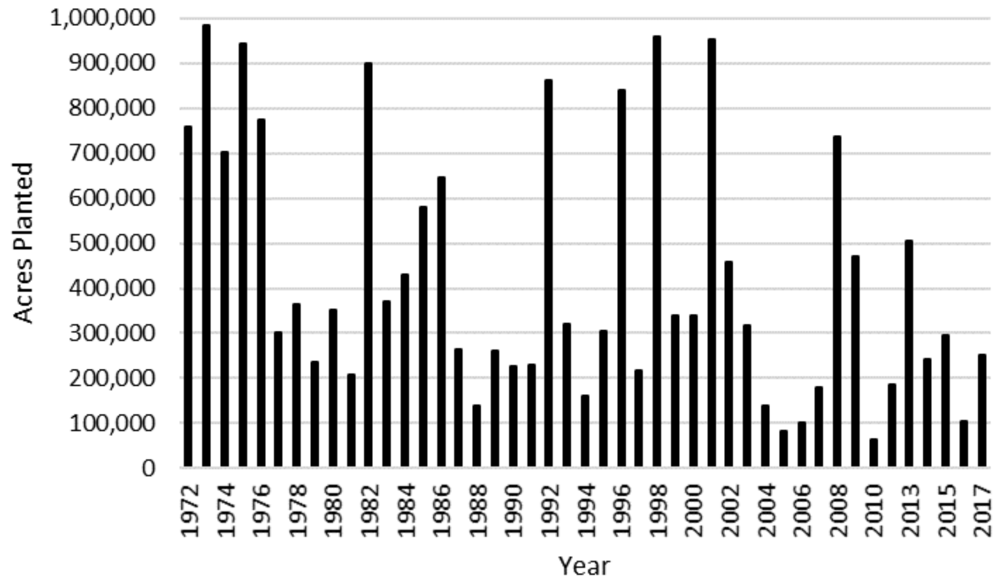


Figure 15. Texas Southern High Plains Irrigated Cotton Planted Acres, 1972-2018

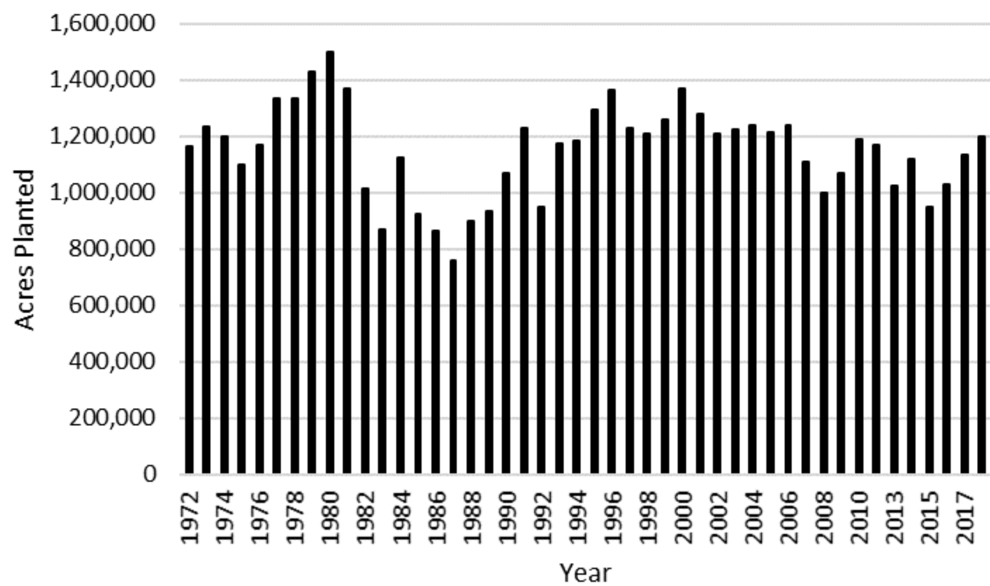
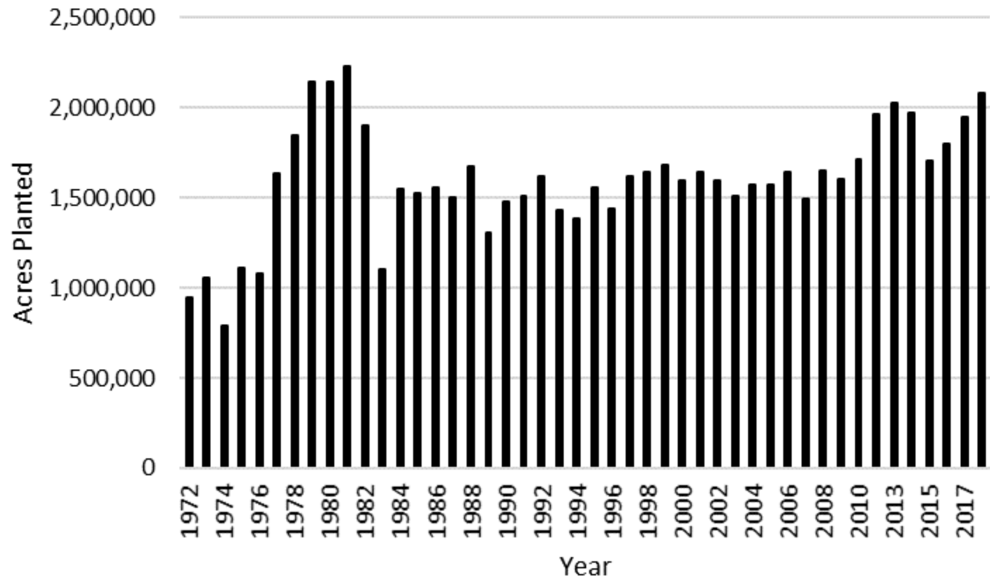


Figure 16. Texas Southern High Plains Non-irrigated Cotton Planted Acres, 1972-2018



Given the extreme year to year variability in both irrigated and non-irrigated grain sorghum acreage in the Southern High Plains, it is difficult to reach any conclusions regarding the extent to which competing crops like cotton have influenced grain sorghum acreage.

Implications for Crop Insurance

This section of the report analyzes how grain sorghum irrigation practices impact crop insurance performance. A key theme is asymmetrically distributed information regarding growers' access to irrigation water and the likelihood that available irrigation water will be applied to higher-valued crops rather than to grain sorghum. Simply put, growers know much more than RMA or Approved Insurance Providers (AIPs) about their access to irrigation water and the likelihood that grain sorghum will be a residual claimant on any available irrigation water. This asymmetrically distributed information leads to a situation where those who have less (more) access to irrigation water and/or are less (more) likely to apply available water to grain sorghum, are more (less) likely to purchase crop insurance on irrigated grain sorghum. As is common with these situations, the result has been high levels of loss cost (indemnities/liability) which has led to high premium rates. These high premium rates were one of the primary concerns raised by the National Sorghum Producers (NSP) in their meetings with Sigma Agricultural Risk and Actuarial Services (hereafter, "the contractor").

Given that grain sorghum is often a residual claimant on irrigation water, a second crop insurance concern raised by the NSP is that T-yields for irrigated grain sorghum are well below the actual yield potential for irrigated grain sorghum. The NSP contends that with reduced water availability from aquifers in many regions of the southern plains, some growers are recognizing that they should be switching out of corn and/or cotton into grain sorghum because grain sorghum requires less irrigation water. However, with the low T-yields on irrigated grain sorghum, these growers cannot obtain sufficient crop insurance liability to securitize an operating note with their lender. Thus, to obtain financing, the lender requires the grower to instead produce corn or cotton.

Loss Costs and Premium Rates

Crop insurance indemnities on irrigated grain sorghum have been extremely high in some years for the Southwest agricultural district of Kansas and the Northern and Southern High Plains agricultural districts of Texas. Figure 17 compares irrigated grain sorghum loss costs to those of irrigated corn in the Southwest agricultural district of Kansas for the period 2002-2019. Despite grain sorghum generally being considered more drought- and heat-tolerant than corn, in every year except for 2017, the loss cost for irrigated grain sorghum exceeded the loss cost for irrigated corn. Over the period 2002-2019, the average loss cost for irrigated corn was 5.0%. The average loss cost for irrigated grain sorghum was 12.7%.

Figure 17. Kansas Southwest Crop Insurance Loss Costs for Irrigated Grain Sorghum and Corn, 2002-2019

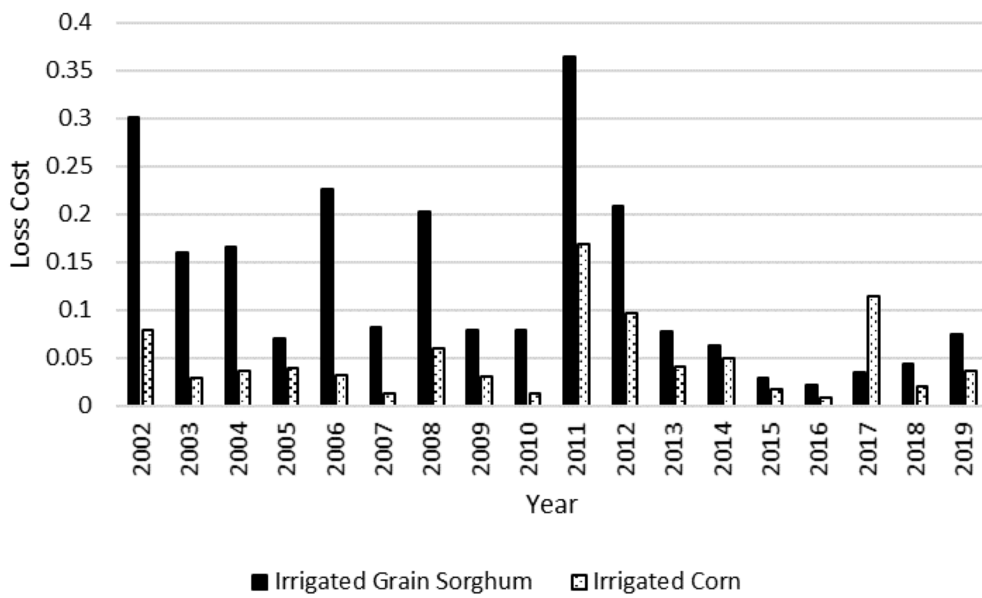


Figure 18 compares irrigated grain sorghum loss costs to those of non-irrigated grain sorghum in the Southwest agricultural district of Kansas. Not surprisingly, non-irrigated grain sorghum loss costs are generally higher than those of irrigated grain sorghum. Over the period 2002-2019, the average loss cost for non-irrigated grain sorghum was 24.2% (compared to 12.7% for irrigated grain sorghum) but over the last five years (when loss costs were unusually low) non-irrigated grain sorghum loss costs have actually been lower than those of irrigated grain sorghum. Perhaps even more interesting is that the Pearson correlation coefficient between irrigated grain sorghum and non-irrigated grain sorghum loss costs is 0.92 (statistically significant at $\alpha=0.01$). The Pearson correlation coefficient between irrigated grain sorghum and irrigated corn loss costs is 0.64 (statistically significant at $\alpha=0.01$).

Though it is not possible to make conclusive inferences about management practices solely based on these loss cost data, the fact that irrigated grain sorghum loss costs are more closely related to non-irrigated grain sorghum loss costs than they are to irrigated corn loss costs is at least consistent with what the contractor was told about grain sorghum being managed as a residual claimant on irrigation water.

Figure 18. Kansas Southwest Crop Insurance Loss Costs for Irrigated and Non-irrigated Grain Sorghum, 2002-2019

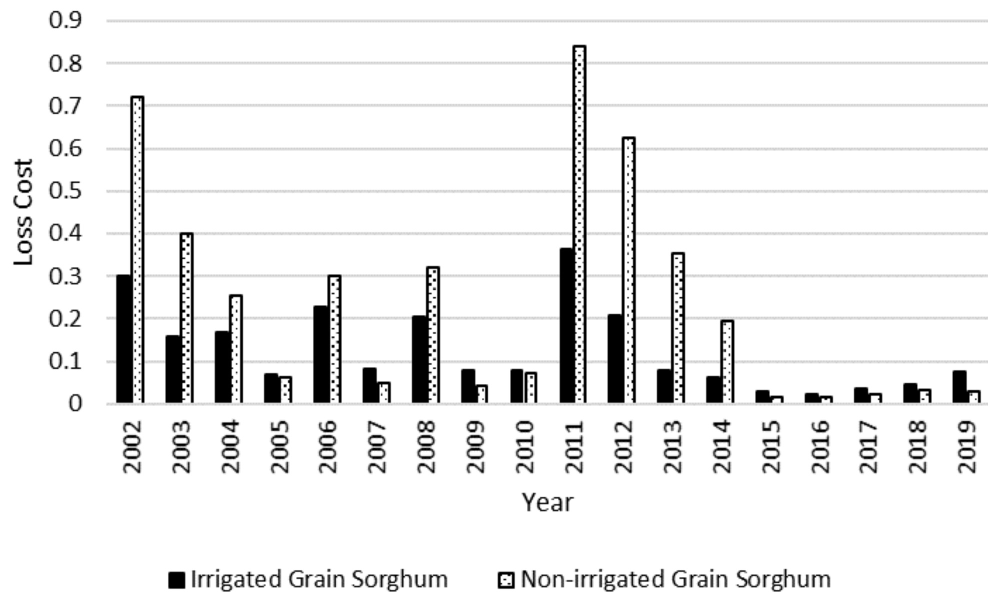


Figure 19 compares Texas Northern High Plains irrigated grain sorghum loss costs to those of irrigated corn and irrigated cotton for the period 2002-2019. Again, the loss cost for irrigated grain sorghum exceeds the loss cost for irrigated corn for every year except 2017. Over the period 2002-2019, the average loss cost for irrigated corn was 6.3%. The average loss cost for irrigated grain sorghum was 16.9%. The average loss cost for irrigated cotton was 21.3%.

Figure 19. Texas Northern High Plains Crop Insurance Loss Costs for Irrigated Grain Sorghum, Corn, and Cotton, 2002-2019

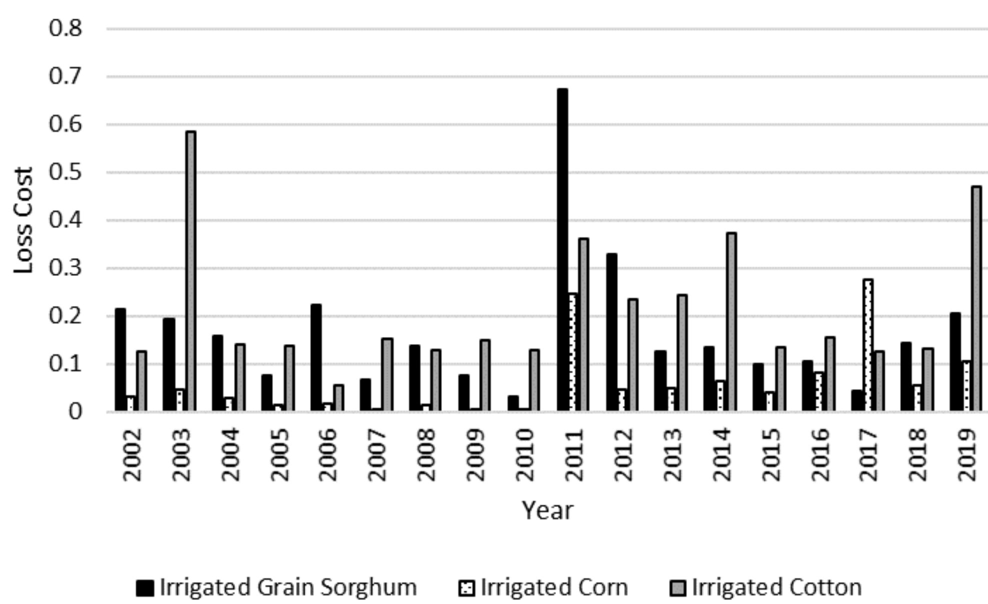
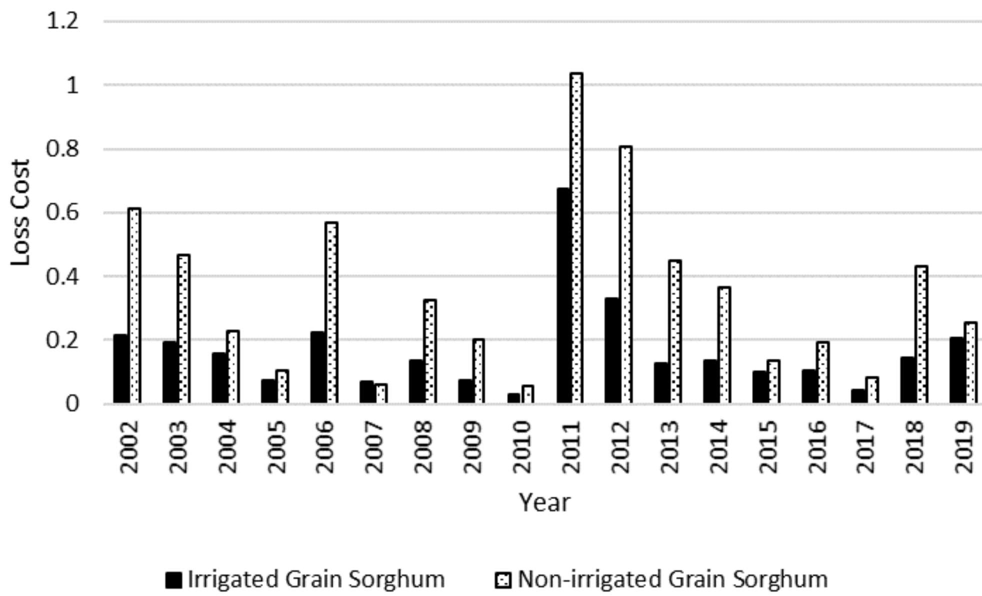


Figure 20 compares irrigated grain sorghum loss costs to those of non-irrigated grain sorghum in the Northern High Plains agricultural district of Texas. In every year except for 2007, the non-irrigated grain sorghum loss cost exceeded the loss cost of irrigated grain sorghum. Over the period 2002-2019, the average loss cost for non-irrigated grain sorghum was 35.5% (compared to 16.9% for irrigated grain sorghum). The Pearson correlation coefficient between irrigated grain sorghum and non-irrigated grain sorghum loss costs is 0.90 (statistically significant at α=0.01). The Pearson correlation coefficient between irrigated grain sorghum and irrigated corn loss costs is 0.45 (statistically significant at α=0.10) The Pearson correlation coefficient between irrigated grain sorghum and irrigated cotton loss costs is not statistically different than zero at α=0.10. Again, the strong correlation between irrigated and non-irrigated grain sorghum loss costs seems to support the contention that much of the grain sorghum insured under an irrigated practice is being produced as a residual claimant on irrigation water.

Figure 20. Texas Northern High Plains Crop Insurance Loss Costs for Irrigated and Non-irrigated Grain Sorghum, 2002-2019



For the Southern High Plains agricultural district of Texas (Figure 21), loss costs for irrigated grain sorghum exceeded those of irrigated corn for every year except for 2017 and 2019. Over the period 2002-2019, the average loss cost for irrigated corn was 8.9%. The average loss cost for irrigated grain sorghum was 20.4% and the average loss cost for irrigated cotton was 19.6%.

Figure 22 compares irrigated grain sorghum loss costs to those of non-irrigated grain sorghum in the Southern High Plains agricultural district of Texas. In every year, the non-irrigated grain sorghum loss cost exceeded the loss cost of irrigated grain sorghum. Over the period 2002-2019, the average loss cost for non-irrigated grain sorghum was 35.2% (compared to 20.4% for irrigated grain sorghum). The Pearson correlation coefficient between irrigated grain sorghum and non-irrigated grain sorghum loss costs is 0.91 (statistically significant at α=0.01). The Pearson correlation coefficient between irrigated grain sorghum and irrigated cotton loss costs is 0.70 (statistically significant at α=0.01). The Pearson correlation coefficient between irrigated grain sorghum and irrigated corn loss costs is 0.51 (statistically significant at α=0.05).

Figure 21. Texas Southern High Plains Crop Insurance Loss Costs for Irrigated Grain Sorghum, Corn, and Cotton 2002-2019

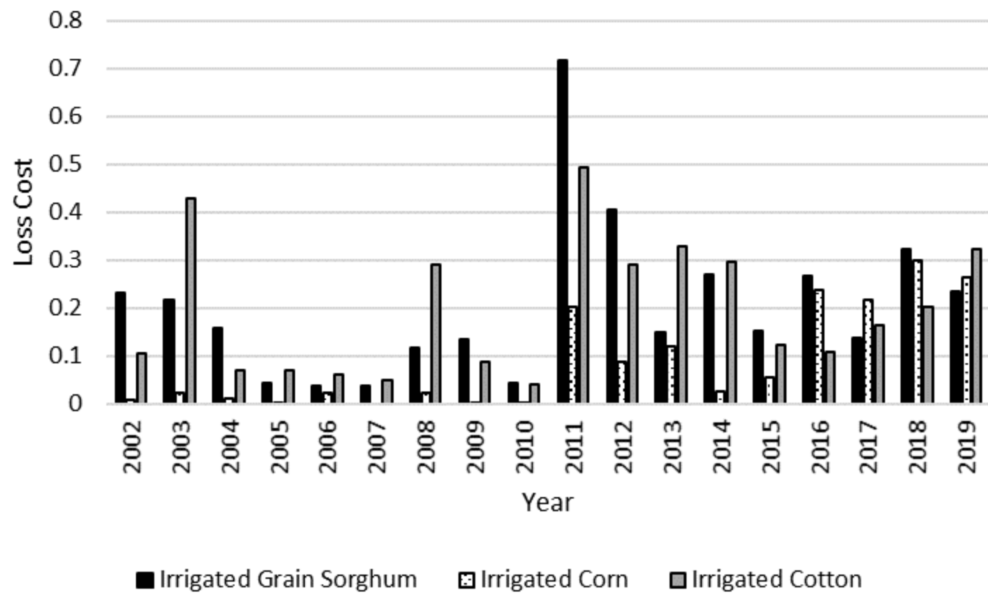
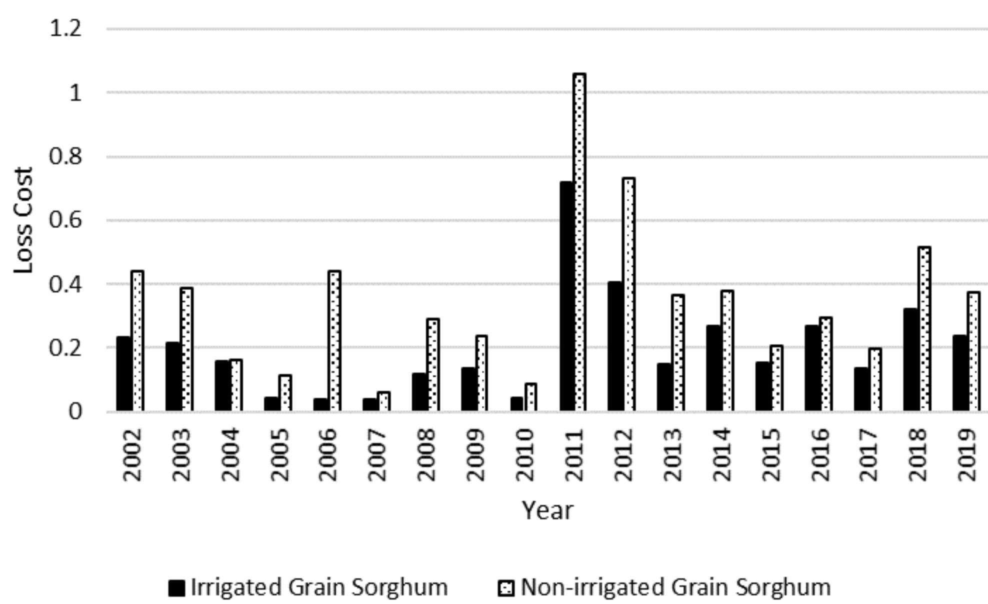


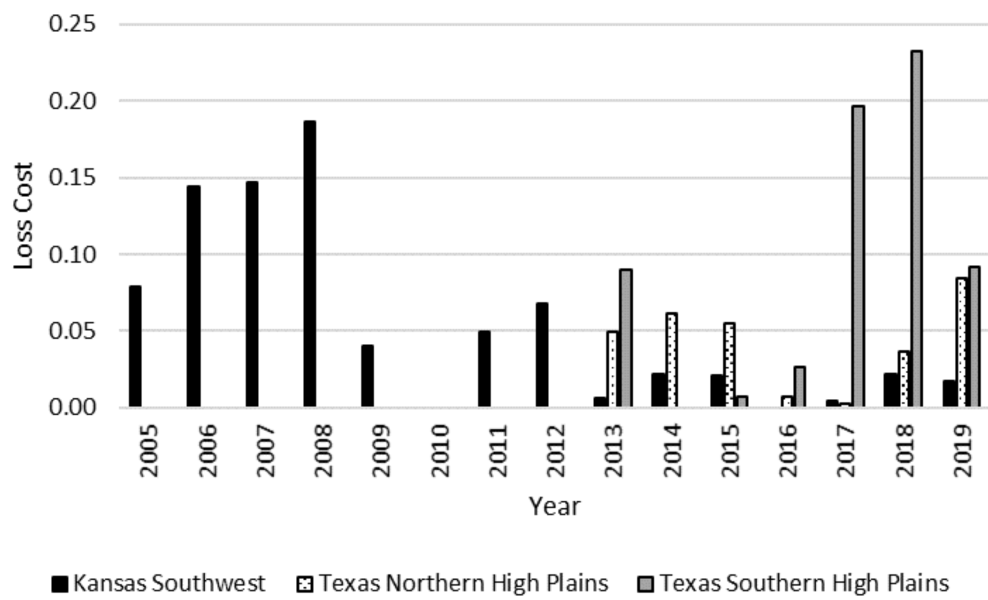
Figure 22. Texas Southern High Plains Crop Insurance Loss Costs for Irrigated and Non-irrigated Grain Sorghum, 2002-2019



Sorghum silage is also insurable under a pilot program in the three agricultural districts that are the focus of this report. The sorghum silage pilot has been available in the Kansas Southwest agricultural district since 2005 and in the Texas Northern and Southern High Plains agricultural districts since 2013. Figure 23 presents the sorghum silage loss cost history for these three districts. Over the life of the program, the average loss cost for the Kansas Southwest agricultural district has been 5.4%. For the

Texas Northern and Southern High Plains, the average loss cost has been 4.2% and 9.2%, respectively. There could be various reasons why loss costs for the sorghum silage program are considerably lower than those for grain sorghum. A thorough examination of the sorghum silage program is beyond the scope of this report however the contractor was told that much of the sorghum silage in this region is sold under contract to large dairies. An interesting question is whether these production contracts cause growers to manage sorghum silage differently than grain sorghum.

Figure 23. Sorghum Silage Loss Costs for Kansas Southwest and Texas Northern and Southern High Plains, 2005-2019



Premium Rates

Given the loss cost experience, it is not surprising that premium rates for irrigated grain sorghum also tend to exceed those for irrigated corn in these agricultural districts. Figure 24 presents 2019 65% coverage YP base county premium rates (assuming that the rate yield is equal to the reference yield) for irrigated grain sorghum and corn in the Southwest agricultural district of Kansas. In every county in the district, the premium rate for irrigated grain sorghum is at least two and a half times the premium rate for irrigated corn. In some counties (e.g., Clark, Meade, and Stevens), the premium rate for irrigated grain sorghum is more than five times that of irrigated corn.

Figure 25 presents 2019 65% coverage YP base county premium rates (assuming that the rate yield is equal to the reference yield) for irrigated grain sorghum, corn, and cotton in the Northern High Plains agricultural district of Texas. In every county, the premium rate for irrigated grain sorghum is at least three and a half times that of irrigated corn. In some counties (e.g., Hutchinson, Moore, and Sherman), the premium rate for irrigated grain sorghum is more than ten times that of irrigated corn. In about one-third of the counties, irrigated grain sorghum premium rates are lower than those of irrigated cotton. However, irrigated grain sorghum premium rates are more than double irrigated cotton premium rates in Hansford, Hutchinson, Lipscomb, Ochiltree, Roberts, and Sherman Counties.

Figure 24. Kansas Southwest 65% Coverage YP Base County Premium Rates (Assuming Rate Yield = Reference Yield) for Irrigated Grain Sorghum and Corn, 2019

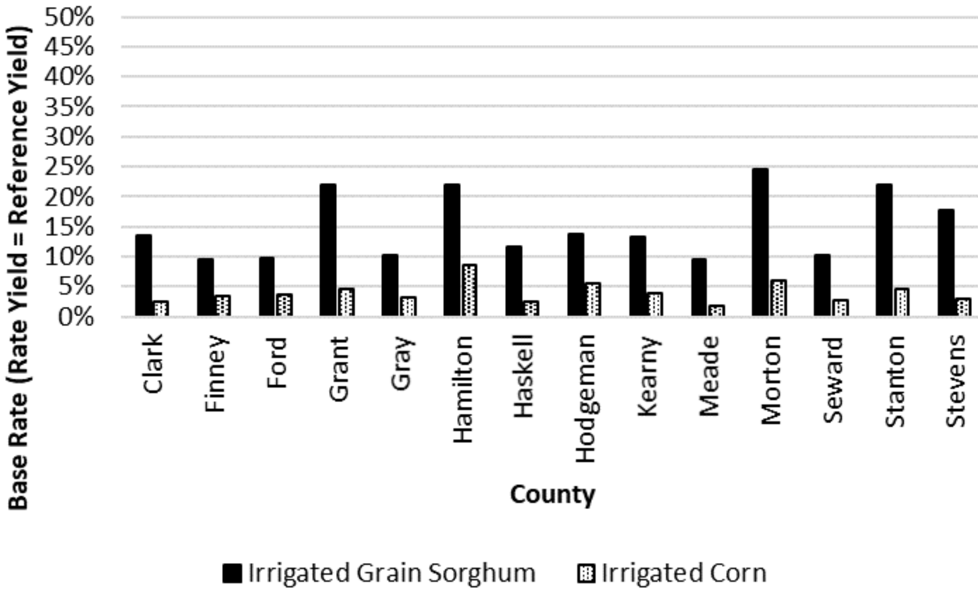
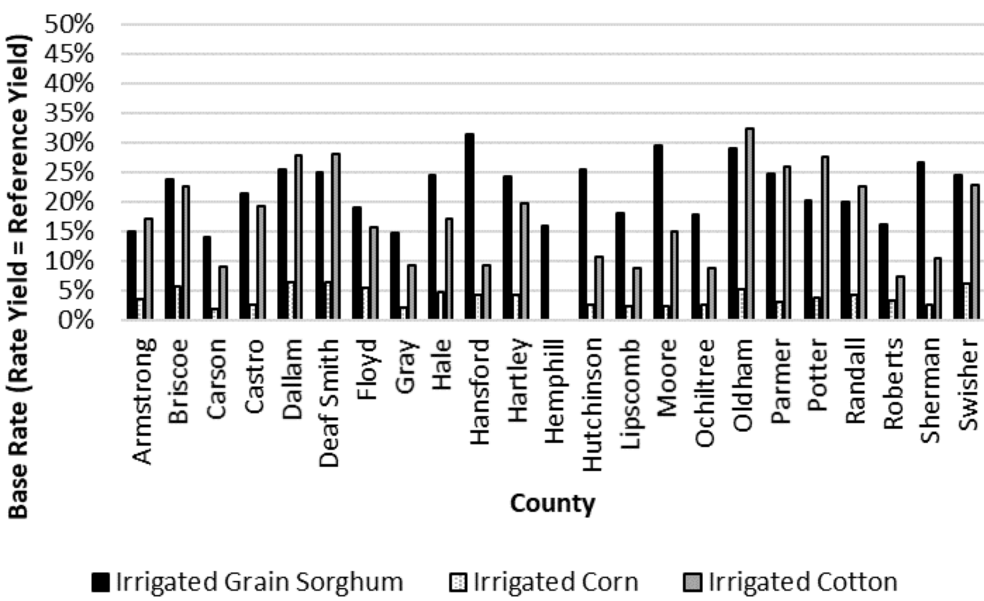


Figure 25. Texas Northern High Plains 65% Coverage YP Base County Premium Rates (Assuming Rate Yield = Reference Yield) for Irrigated Grain Sorghum, Corn, and Cotton, 2019



Crop insurance on irrigated corn is only offered in some counties of the Texas Southern High Plains. Figure 26 presents 2019 65% coverage YP base county premium rates (assuming that the rate yield is equal to the reference yield) for irrigated grain sorghum and corn in the Southern High Plains counties where insurance on irrigated corn is available. In every county, the premium rate for irrigated grain sorghum is at least two and a half times that of irrigated corn. In Lamb County, the irrigated grain sorghum premium rate is five and three-quarters times that of irrigated corn.

Figure 26. Texas Southern High Plains 65% Coverage YP Base County Premium Rates (Assuming Rate Yield = Reference Yield) for Irrigated Grain Sorghum and Corn, 2019

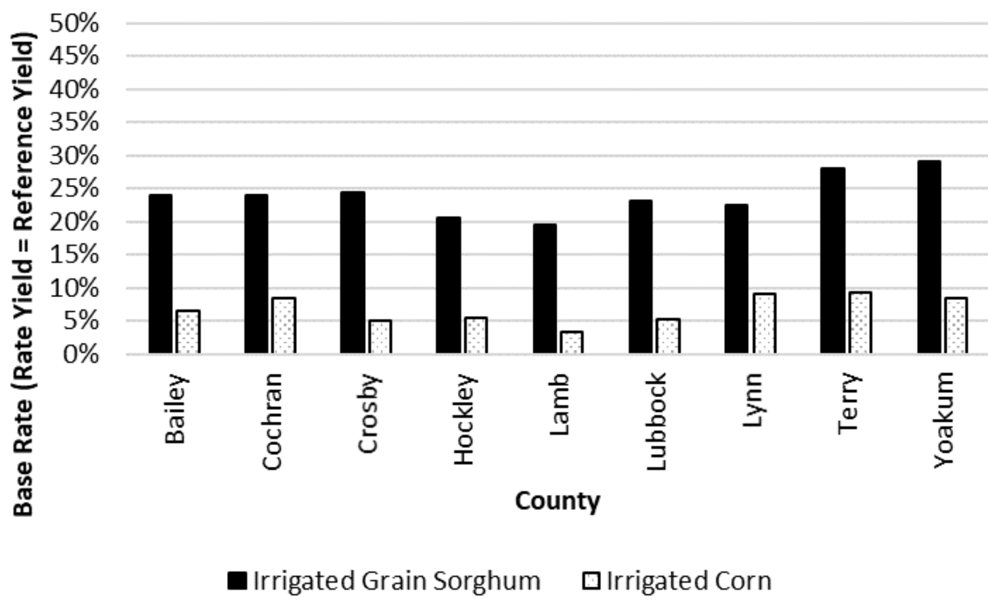
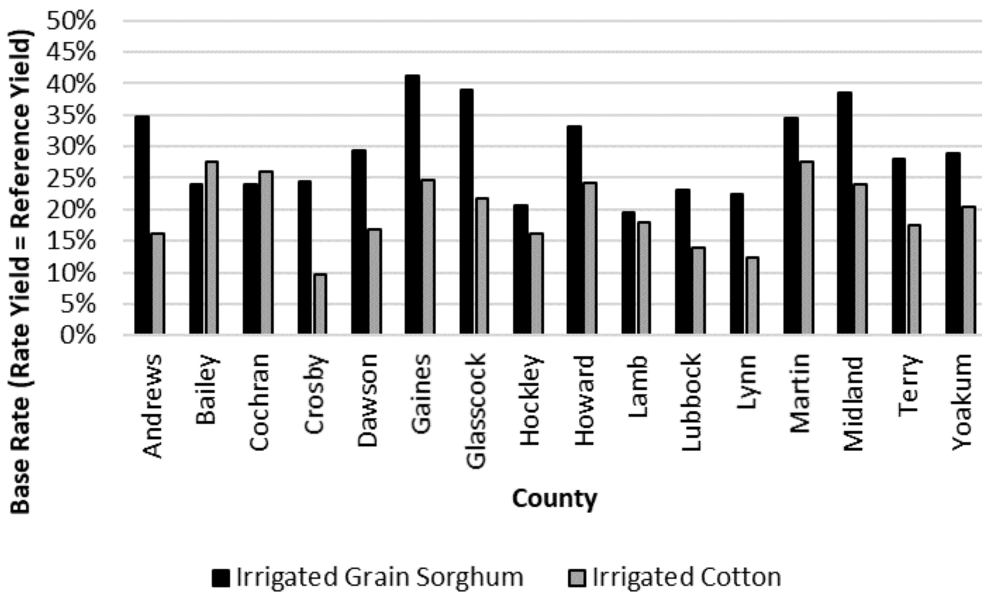


Figure 27 presents 2019 65% coverage YP base county premium rates (assuming that the rate yield is equal to the reference yield) for irrigated grain sorghum and cotton in the Texas Southern High Plains. In two counties (Bailey and Cochran), the irrigated grain sorghum base premium rate is lower than the premium rate for irrigated cotton. In the other counties, irrigated grain sorghum premium rates are higher than those for irrigated cotton. In Andrews and Crosby Counties, the irrigated grain sorghum premium rate is more than double that for irrigated cotton.

These high crop insurance premium rates for irrigated grain sorghum relative to irrigated corn (and relative to irrigated cotton in the Texas Southern High Plains) are the source of much frustration among irrigated grain sorghum growers in these regions of Kansas and Texas. These growers find it hard to understand why grain sorghum which is generally considered more drought- and heat-tolerant than corn should have crop insurance premium rates that are so much higher than those of corn. While the loss cost experience presented in figures 17,19, and 21 provides some empirical justification for irrigated grain sorghum premium rates being higher than those of irrigated corn in these regions, it cannot explain the causal mechanism that creates such a counter-intuitive outcome. One is still left questioning why grain sorghum, a crop that is generally considered to be more drought- and heat-tolerant relative to competing crops such as corn and cotton, should have premium rates that are considerably higher than those of these competing crops.

The explanation that was consistently presented to the contractor is that among irrigated grain sorghum insureds, significant differences exist in access to irrigation water and/or the likelihood that available irrigation water will be applied to higher-valued crops rather than to grain sorghum. If this explanation is correct, the current counter-intuitive situation is the result of information asymmetry. Growers know more than RMA or AIPs about their access to irrigation water and the likelihood that grain sorghum will be a residual claimant on any available irrigation water. The resulting problem can only be solved by addressing the underlying information asymmetry.

Figure 27. Texas Southern High Plains 65% Coverage YP Base County Premium Rates (Assuming Rate Yield = Reference Yield) for Irrigated Grain Sorghum and Cotton, 2019



It is important to note that for growers who are producing multiple irrigated crops (e.g., grain sorghum and corn or grain sorghum and cotton), there are often sound economic reasons for treating the lower-valued grain sorghum crop as a residual claimant on limited irrigation water. Furthermore, if the crops are all insured, it is likely in the insurer's best interest for the grower to use available irrigation water first on the higher-valued corn or cotton crops. The problem is not caused by fraudulent or unreasonable behavior on the part of the grower but rather by the underlying information asymmetry that prevents the insurer from being able to sort potential insured into different rating categories based on their access to irrigation water and/or likelihood of using available irrigation water on grain sorghum.

We will suggest below that there are two approaches that can be used to address this information asymmetry problem. The first is to implement underwriting requirements that compel potential insureds to reveal more information about their access to irrigation water and/or the likelihood that available irrigation water will be applied to grain sorghum. The second is to provide potential insureds with a menu of policies or policy options designed such that, by their policy choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum.

Specific Tasks from the Task Order

This section of the report addresses each of the specific tasks identified in the task order. Our recommendations regarding irrigated grain sorghum crop insurance are embedded in the responses to many of these tasks.

Task 1, Kick-off Meeting and Meetings with NSP

The contractor participated in a kick-off meeting with RMA personnel in Kansas City on January 30, 2020. The contractor met with the NSP on March 5, 2020, in Lubbock, Texas. RMA personnel participated in this meeting with the NSP via telephone conference.

Task 2, Draft Report of the Grain Sorghum Evaluation

The draft report was submitted on July 16, 2020 and formally accepted by RMA on August 27, 2020.

Discussions to Gather Input

The contractor participated in a kick-off meeting with RMA personnel in Kansas City on January 30, 2020. The contractor met with the NSP on March 5, 2020, in Lubbock, Texas. RMA personnel participated in this meeting with the NSP via telephone conference. On March 5, 2020, the contractor also met at Texas Tech University with the representatives of the Texas Alliance for Water Conservation (TAWC) who were identified in the task order. Another meeting was held with the NSP via Zoom on June 19, 2020, to elicit feedback on draft recommendations. The contractor met again with the NSP via Zoom on September 10, 2020 to determine their priorities for the recommendations contained in the final report.

Identify Economic and Insurance Program Incentives and Prevalence of Irrigated Sorghum Abandonment

In general, abandonment occurs when something happens after planting that makes it no longer economically viable to harvest the crop. In other words, something has changed that now makes the costs of continuing to care for and harvest the crop exceed the expected revenue from selling the crop. It may be that there is no longer a buyer for the crop or there has been a dramatic decrease in the price that the grower can expect to receive from selling the crop. It may be that there has been an unexpected increase in one or more yet to be incurred production costs. Perhaps the most common reason for abandonment is that extreme weather events have reduced the expected yield to a point where the cost of harvesting would exceed the expected revenue from the meager production. Any of these factors, individually or in combination, can lead growers to make a rational economic decision to abandon a crop.

Poorly designed crop insurance products can also create incentives for abandonment. This can occur when, as a result of having purchased insurance, a grower who would otherwise harvest the crop now chooses to abandon the crop because the expected net return from losing the crop and collecting an insurance indemnity exceeds the expected net return from continuing to care for and harvest the crop. While this is a theoretical possibility, the contractor was not made aware of any suspicions that crop insurance was stimulating increased abandonment in irrigated grain sorghum.

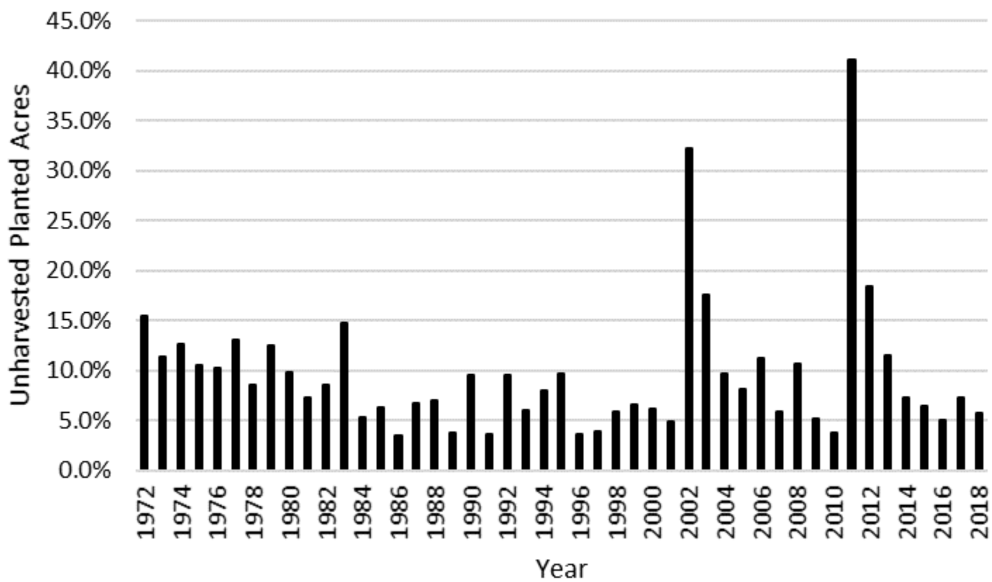
In the focal regions for this report, the frequency of extreme weather conditions likely leads to higher levels of abandonment than in other regions of the United States. The contractor examined both NASS and RMA data to assess the prevalence of abandonment in irrigated grain sorghum relative to abandonment in competing crops for the three NASS agricultural districts that are the focus of this study.

NASS Data

Figure 28 presents, based on NASS data, the percentage of planted grain sorghum acres in the Southwest agricultural district of Kansas that were not harvested (i.e., were abandoned) for the period

1972-2018. Recall that, since 2009, NASS has not provided data separated by irrigation practice for grain sorghum in Kansas. Thus, the data presented in figure 28 are for both irrigated and non-irrigated production.

Figure 28. Percentage of Kansas Southwest Planted Grain Sorghum Acres that were Not Harvested, 1972-2018



On average, over this period, 9.4% of planted acres were abandoned. The years 2011 and 2002 are outliers. In 2011, over 41% of Kansas grain sorghum acres were abandoned. In 2002, over 32% of Kansas grain sorghum acres were abandoned. These data provide no evidence that grain sorghum abandonment has increased in recent years. In fact, over the most recent 5-year period, 2014-2018, abandonment averaged only 6.3%.

To allow for comparison, figures 29 and 30 provide the percentage of Kansas Southwest abandoned corn acres for irrigated and non-irrigated practice, respectively. During the period 1974-2018, the average abandonment for irrigated corn was 6.9%. The 1970s and 1980s had the highest percentage of irrigated corn abandonment, but abandonment has never exceeded 15%. However, in the most recent five-year period (2014-2018), the average abandonment for irrigated corn has actually been higher (7.8%) than that of grain sorghum with no practice specified (6.3%). Not surprisingly, abandonment for non-irrigated corn is considerably higher than that for irrigated corn. It is also higher than abandonment for grain sorghum with no practice specified. Over the period 1974-2018, the average abandonment for non-irrigated corn was 26.8% however, over the most recent 5-year period, the average abandonment for non-irrigated corn is similar to that of irrigated corn and grain sorghum with no practice specified.

Figure 31 presents Texas Northern High Plains irrigated grain sorghum abandonment for the period 1972-2018. These data show that abandonment has increased over the most recent 20 years. NASS data are not available for the year 2011 in this agricultural district of Texas but anecdotal evidence, confirmed by RMA data presented later, indicates that this was a year of unusually high levels of abandonment due to extreme heat and drought conditions.

Figure 29. Percentage of Kansas Southwest Irrigated Planted Corn Acres that were Not Harvested, 1974-2018

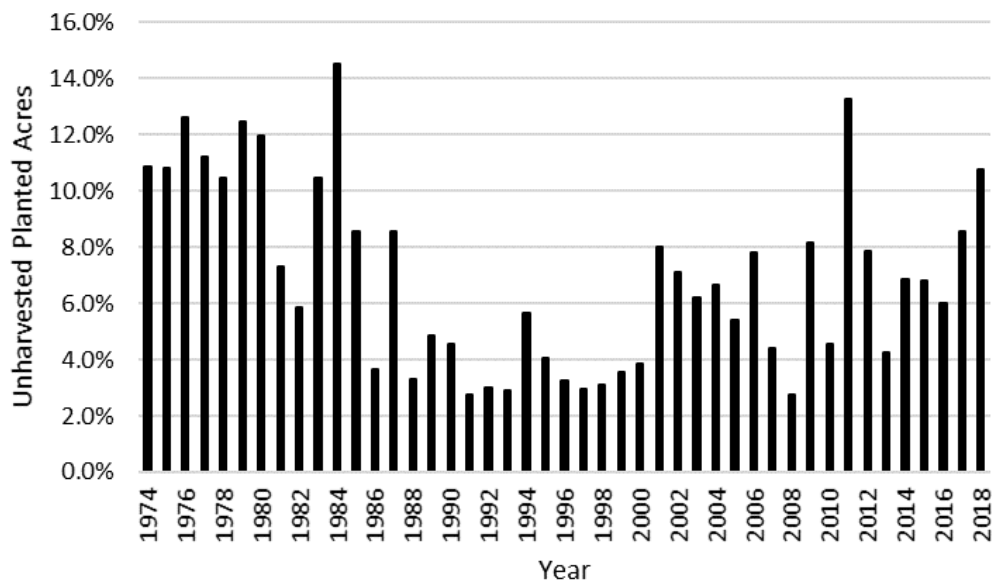


Figure 30. Percentage of Kansas Southwest Non-irrigated Planted Corn Acres that were Not Harvested, 1974-2018

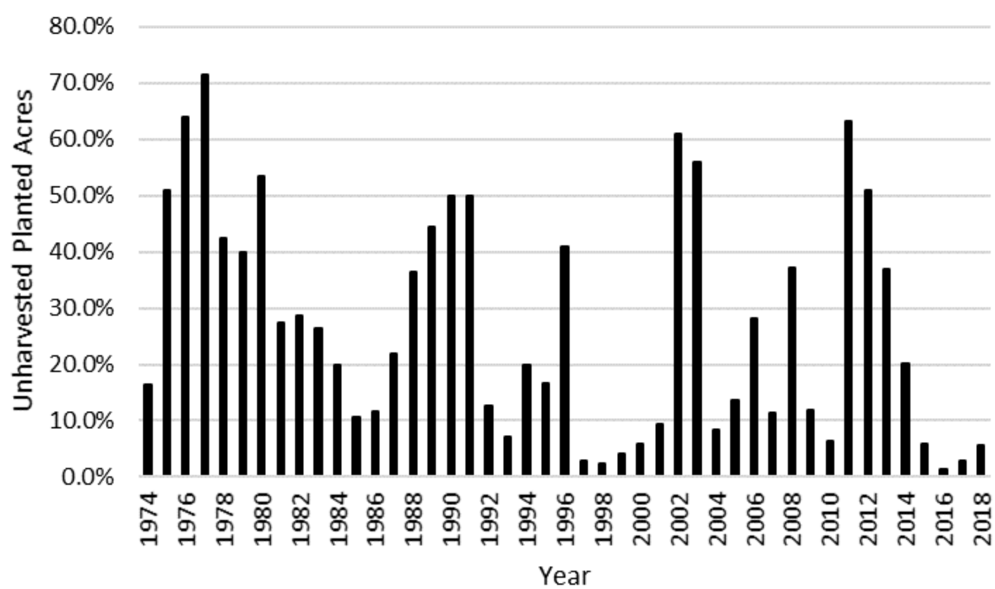


Figure 32 presents Texas Northern High Plains irrigated corn abandonment since 1981 (with some missing years). These data also show an increase in abandonment over the most recent 20 years with the highest levels of abandonment occurring in 2011 and 2018. Nevertheless, on average, abandonment for irrigated grain sorghum is higher than that for irrigated corn. On average, over the past 20 years, abandonment of irrigated cotton in the Texas Northern High Plains has been less than that of either irrigated grain sorghum or irrigated corn (figure 33). However, irrigated cotton has had more volatility in abandonment with three years (1982, 1992, 2003) having more than 50% of planted acres that were unharvested. As with irrigated grain sorghum, no NASS data are available for irrigated cotton in the extreme weather year of 2011.

Figure 31. Percentage of Texas Northern High Plains Irrigated Planted Grain Sorghum Acres that were Not Harvested, 1972-2018

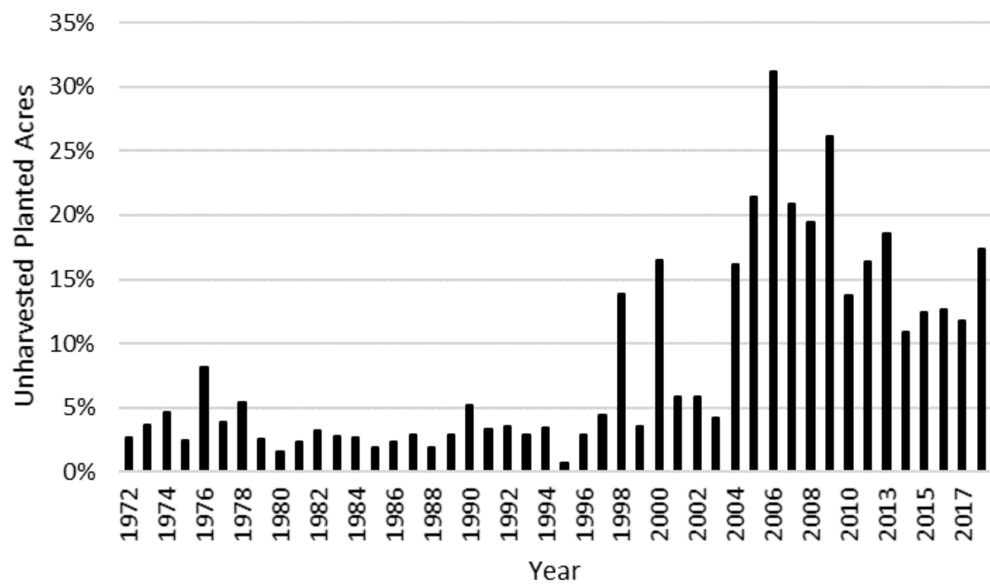


Figure 32. Percentage of Texas Northern High Plains Irrigated Planted Corn Acres that were Not Harvested, 1981-2018

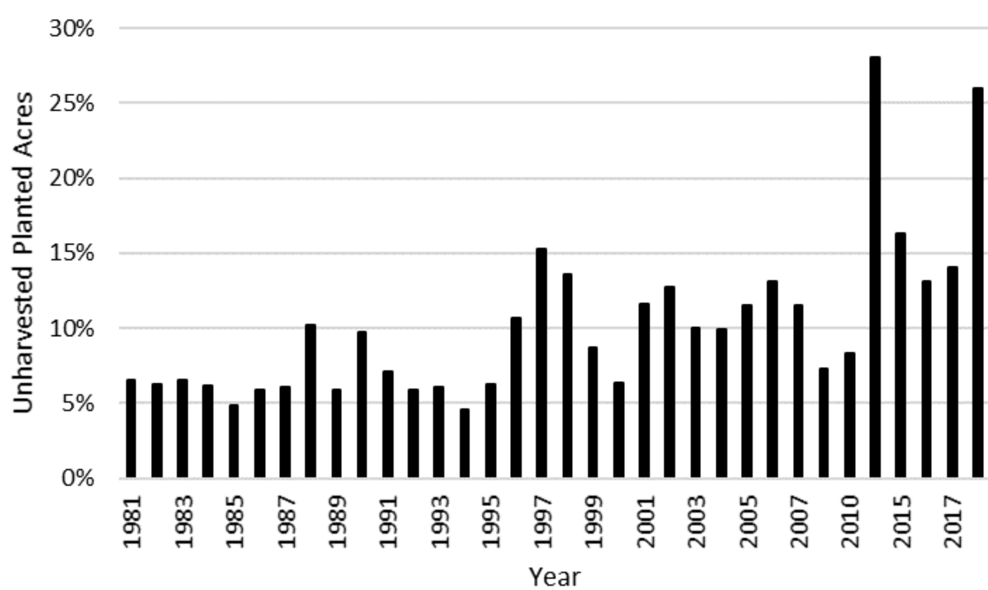
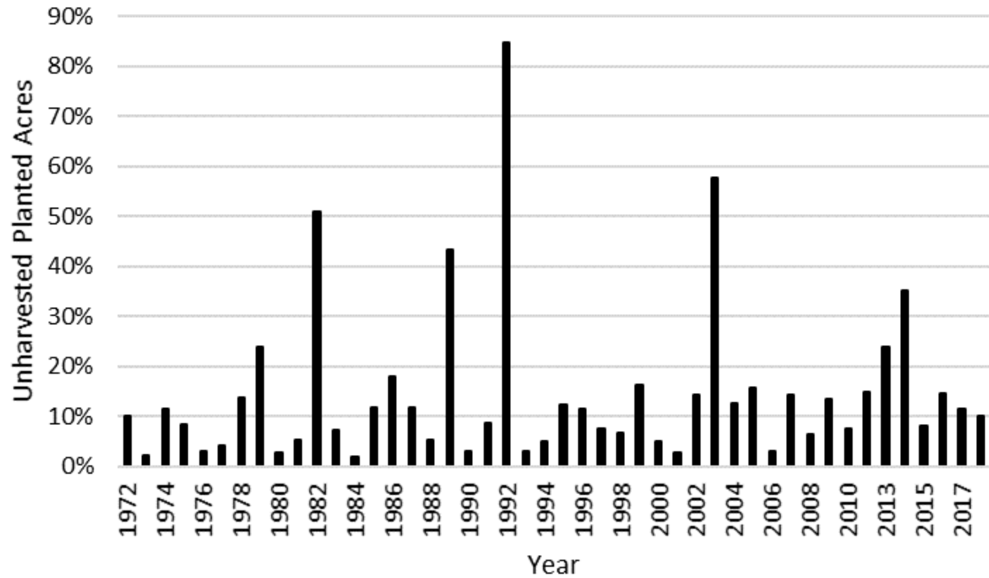


Figure 33. Percentage of Texas Northern High Plains Irrigated Planted Cotton Acres that were Not Harvested, 1972-2018



Figures 34 and 35 present, for the Texas Southern High Plains, the percentage of irrigated grain sorghum and irrigated cotton planted acres, respectively, that have been abandoned since 1972. Though it is not immediately obvious from the figures, on average, the irrigated grain sorghum abandonment is actually less than the irrigated cotton abandonment since 1972. As with the Northern High Plains, data are not available for irrigated grain sorghum and irrigated cotton in 2011.

Figure 34. Percentage of Texas Southern High Plains Irrigated Planted Grain Sorghum Acres that were Not Harvested, 1972-2017

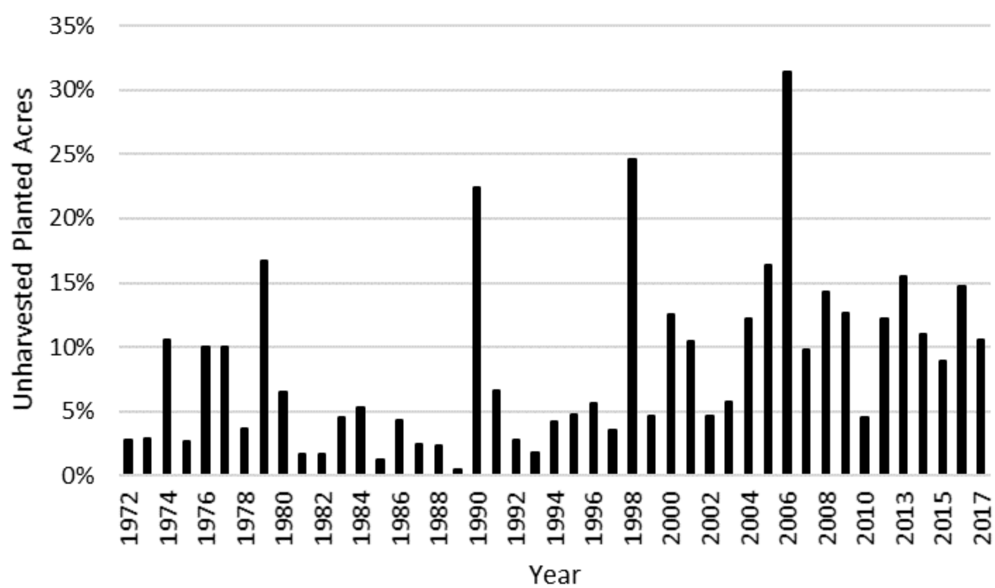
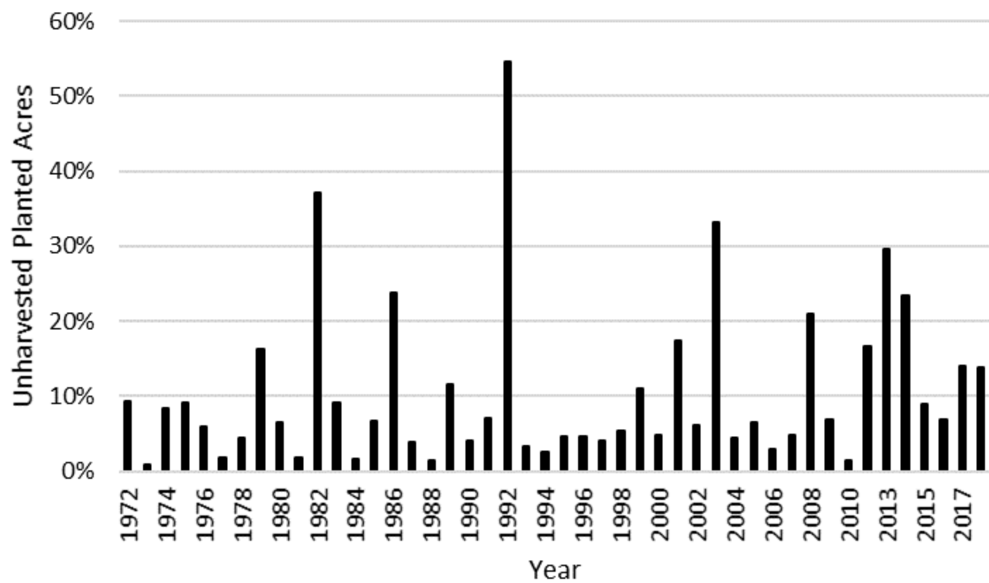


Figure 35. Percentage of Texas Southern High Plains Irrigated Planted Cotton Acres that were Not Harvested, 1972-2018



To summarize, NASS data seem to provide only limited evidence that rates of irrigated grain sorghum abandonment exceed those of irrigated corn in the three agricultural districts that are the focus of this study. Irrigated grain sorghum abandonment has been higher than that of irrigated cotton in the Northern High Plains of Texas, but the opposite is true in the Southern High Plains.

RMA Data

Another source of insight into abandoned acreage is the RMA data on indemnities. On average, over the period 2001-2018, 23% of national irrigated grain sorghum indemnities have been on unharvested acres. In comparison, 27% of national irrigated corn indemnities have been on unharvested acres.

Figure 36 presents the percentage of irrigated grain sorghum and irrigated corn indemnities that were from unharvested acreage in the Southwest agricultural district of Kansas for the period 2001-2018. On average, over this period, more than 17% of irrigated grain sorghum indemnities and more than 37% of irrigated corn indemnities were from unharvested acreage. The year with the highest evidence of grain sorghum abandonment is 2011. In that year, a little more than 31% of the indemnities paid on irrigated grain sorghum in the Southwest agricultural district of Kansas were for unharvested acreage. For irrigated corn, 2009 was the year with the highest evidence of abandonment with 74% of indemnities being on unharvested acreage.

Figure 37 presents the percentage of irrigated grain sorghum and corn indemnities that were from unharvested acreage in the Northern High Plains agricultural district of Texas for the period 2001-2018. On average, over this period, more than 26% of irrigated grain sorghum indemnities and more than 45% of irrigated corn indemnities were from unharvested acreage. As in the Southwest agricultural district of Kansas, 2011 was the year with the highest evidence of irrigated grain sorghum abandonment. In that year, more than 75% of irrigated grain sorghum indemnities were on unharvested acreage. The year 2011 was also the year with the highest level of irrigated corn abandonment with 81% of indemnities occurring on unharvested acreage. In contrast to irrigated grain sorghum, irrigated corn has experienced three additional years during the period 2001-2018 in which at least 75% of indemnities were from unharvested acreage (2003, 2004, 2010).

Figure 36. Percentage of Kansas Southwest Irrigated Grain Sorghum and Corn Indemnities for Unharvested Production, 2001-2018

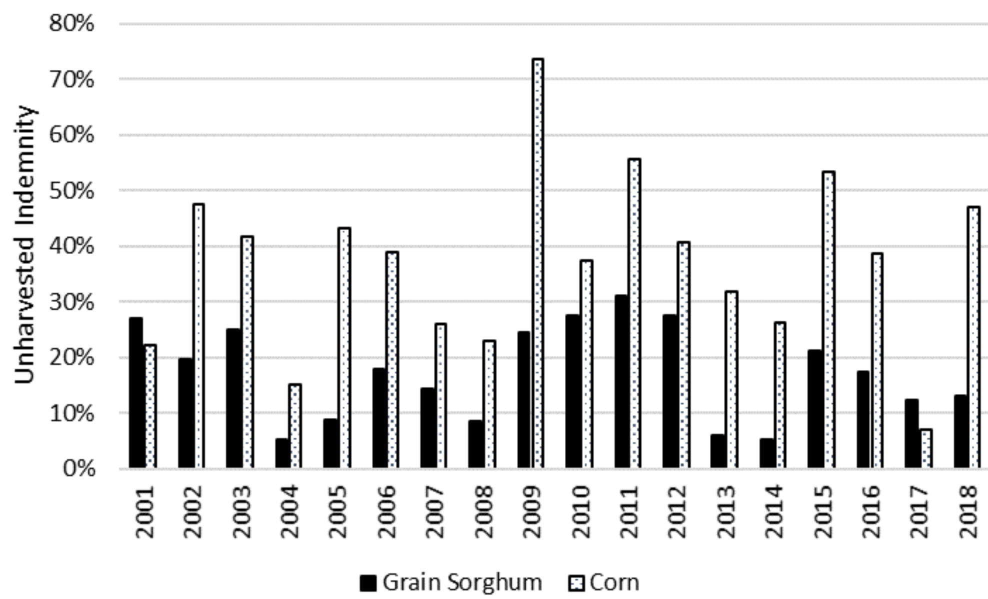


Figure 37. Percentage of Texas Northern High Plains Irrigated Grain Sorghum and Corn Indemnities for Unharvested Production, 2001-2018

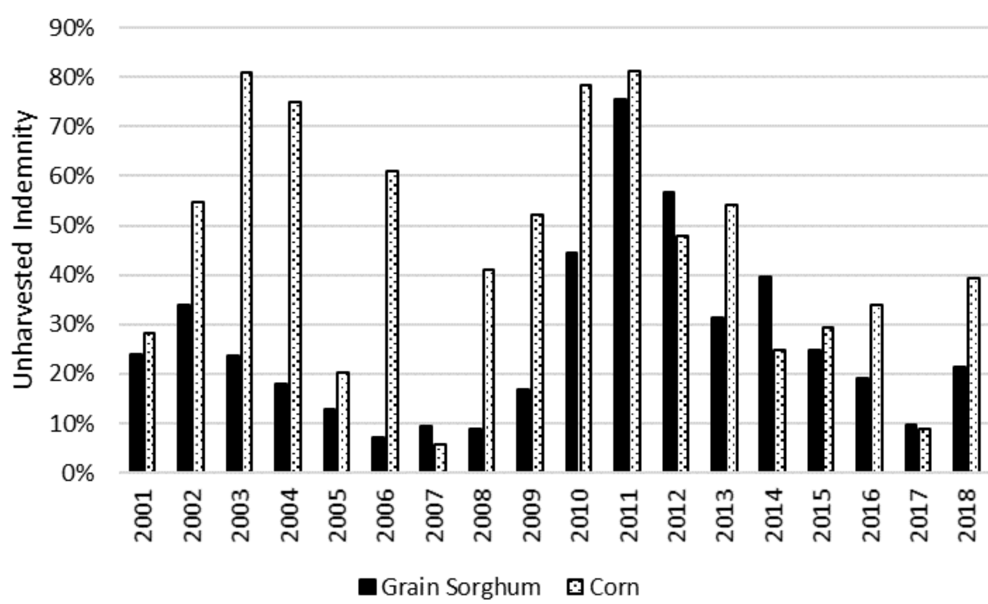
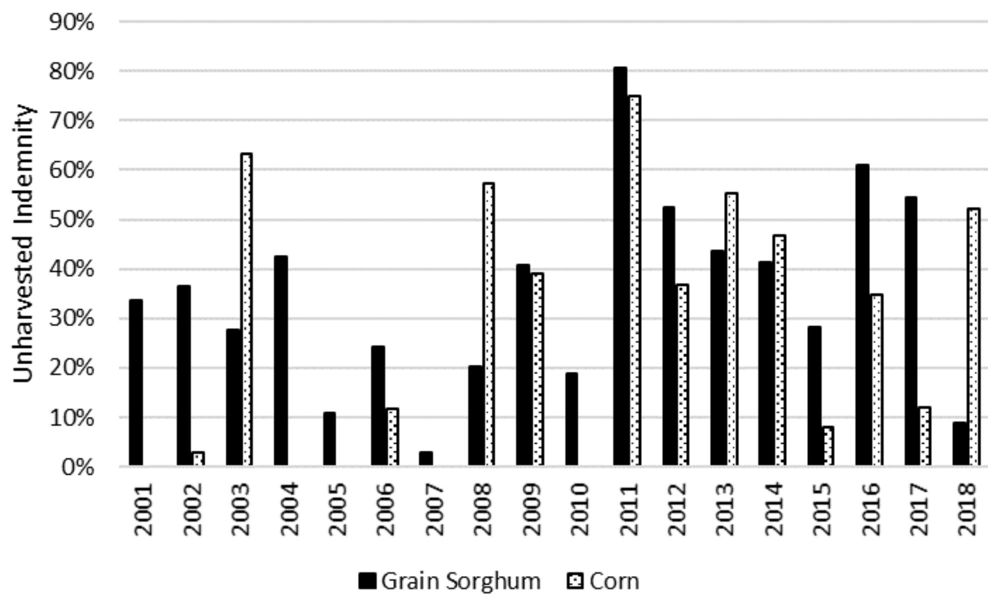


Figure 38 presents the percentage of irrigated grain sorghum and corn indemnities that were from unharvested acreage in the Southern High Plains agricultural district of Texas for the period 2001-2018. On average, over this period, around 35% of irrigated grain sorghum indemnities and 29% of irrigated corn indemnities were from unharvested acreage. Abandonment was highest in 2011 with more than 80% of irrigated grain sorghum indemnities and 75% of irrigated corn indemnities occurring on unharvested acreage.

Figure 38. Percentage of Texas Southern High Plains Irrigated Grain Sorghum and Corn Indemnities for Unharvested Production, 2001-2018



To summarize, the RMA data provide mixed results regarding abandonment in irrigated grain sorghum versus irrigated corn. In the Southwest agricultural district of Kansas and the Northern High Plains agricultural district of Texas, unharvested acres have accounted for a higher percentage of indemnities for irrigated corn than for irrigated grain sorghum while the opposite has been the case in the Southern High Plains agricultural district of Texas.

For these three agricultural districts, the NASS and RMA data do not generally provide compelling evidence that abandonment occurs more frequently for irrigated grain sorghum than for irrigated corn. This finding is a little surprising given what the contractor was told about irrigated grain sorghum being a residual claimant on irrigation water in these agricultural districts. However, it may be that the impact of insufficient irrigation water on grain sorghum is not manifested primarily in more unharvested acreage (relative to irrigated corn) but rather in harvested acreage with realized yields that are substantially less than the potential yield with sufficient irrigation.

Research and Examine Potential Policy Improvements and New Coverage Options for Irrigated Grain Sorghum

As indicated above, the NSP identified two specific concerns with irrigated grain sorghum crop insurance: 1) high premium rates; and 2) low T-yields. We will suggest below that it should be possible to use existing crop insurance mechanisms to at least partially address the concern related to low T-yields. The concern related to high premium rates is more challenging since it is the result of information asymmetry regarding the insured's access to irrigation water and/or the likelihood that available irrigation water will be applied to grain sorghum.

T-yields

Transitional Yields (T-yields) are RMA-determined estimates of expected yield for a given combination of crop, practice, type, variety, and T-yield map area. They are used to calculate approved yields when fewer than four years of actual yield records are available for an insured unit. In meetings with the contractor, the NSP emphasized a concern that, in the focal areas for this study, T-yields for irrigated grain sorghum are well below the actual yield potential. As indicated previously, this is likely the result of grain sorghum frequently being grown as a residual claimant on irrigation water in these areas.

The NSP contends that with reduced water availability from aquifers in some regions of the southern plains, many growers are recognizing that they should be switching out of corn and/or cotton into grain sorghum because grain sorghum requires less irrigation water. When a grower wants to insure acreage on which the grower has not previously produced a specific combination of crop, type, and practice, T-yields are generally applied.[2] However, with the low T-yields on irrigated grain sorghum, growers wishing to switch into irrigated grain sorghum production cannot obtain sufficient crop insurance liability to securitize an operating note with their lender. Thus, to obtain financing, the lender requires the grower to instead produce corn or cotton. This situation also applies to those who qualify as "beginning farmers" or "new producers" since the provisions for calculating approved yields for these individuals are tied to T-yields.

The task order instructed the contractor to consider whether Personal T-yields (PTYs) could be used to address this situation with irrigated grain sorghum. PTYs are calculated based on an insured grower's own actual or assigned yields and are used as an alternative to the typical T-yield provided in the FCI-35 County Actuarial Documents.

A PTY option pilot program was first introduced with the 2007 crop year for all eligible Category B Actual Production History (APH) crops in North Dakota. One motivation behind the development of the PTY option pilot program was the long crop rotations used in some areas of the U.S. northern plains (Watts and Associates, 2010). While these rotations are typically considered to represent good production practices in this region, they often effectively require the use of T-yields to calculate the approved yield on an insured unit. If the T-yield understates the true expected yield, the liability on the insured unit is decreased (Watts and Associates, 2010).

The PTY is calculated using a summary database for the insured grower that consolidates, by crop, practice, type, variety, and T-yield map area, all basic and optional unit acres and production to generate a yield for a given year (RMA, Undated). The PTY is the simple average of these annual yields based on a minimum of four consecutive crop years, one of which must be an actual yield. The PTY may be based

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[2] Exceptions can apply under certain circumstances. For example, it may be possible for the policyholder to receive a yield determined by the regional RMA office, in lieu of the T-yield specified in the actuarial documents, the first time a new practice is used on an insured unit (e.g., when an irrigated practice is used for the first time). Also, under certain circumstances, a grower may qualify to use another producer's production history to establish an approved yield on added land.

on as many as ten consecutive crop years of actual or assigned production values. Units must be insured at a level greater than the catastrophic coverage level to be eligible to use PTYs. A premium surcharge applies to units that utilize PTYs.

It is important to note that PTYs are used in lieu of typical T-yields in all relevant calculations including approved yields, yield substitutions, yield floors, yield cups, beginning farmer and new producer procedures, and perhaps most importantly, rate yields (RMA, Undated). Thus, PTYs have impacts on both the liability and the premium rate for the insured unit.

In 2010 the RMA contracted for an evaluation of the PTY program in North Dakota. The contractor was asked to evaluate three topics: 1) the impact of making the use of PTYs (in lieu of T-yields) mandatory rather than voluntary; 2) the impact of an alternative approach for calculating PTYs; and 3) the feasibility of expanding PTY availability beyond North Dakota. Complete citations of the contractor's reports are contained in the reference list for this report and are designated as Watts and Associates 2010a and 2010b.

In general, the contractor found little impact on loss costs or loss ratios from making PTYs mandatory rather than voluntary but a strong preference among farmers and insurance agents for leaving them as voluntary. The alternative approach for calculating PTYs had little impact on loss costs or loss ratios. In regard to the feasibility of expanding PTY availability, the contractor was explicitly directed to not make recommendations but rather to "lay out all the issues to consider and weigh regarding any decision to make the pilot program part of the program requirements." One relevant finding from the report was that if voluntary PTYs were expanded to other crops, the premium surcharge for using PTYs would likely need to differ by crop, location, and practice.

The 2010 reports on PTYs were based on only three years of experience for a select set of crops in North Dakota. The reports are also now 10 years old. Without updating the reports to reflect experience with PTYs since 2010 – something that is beyond the scope of work for this task order – it is difficult to anticipate all the potential implications of making a PTY option available for irrigated grain sorghum in the southern plains. However, it does seem like PTYs could help to address the problem identified by the NSP. Growers who have a history of providing sufficient irrigation water to their grain sorghum crop would be able to obtain higher approved yields and liability while those who still produce grain sorghum as a residual claimant on irrigation water will likely find PTYs to be less beneficial – since their PTY may not be much different than the assigned T-yield. It is important to remember that growers would need to have at least one year of actual yields to be eligible to use a PTY. Because PTYs impact rate yields (and thus, premium rates) the loss ratio performance of PTYs would need to be monitored closely should they be introduced for irrigated grain sorghum in the southern plains. More specifically, the RMA would need to assess, based on loss experience, whether the premium rate surcharge currently applied for the PTY option on various category B crops in North Dakota is also appropriate for irrigated grain sorghum in the southern plains.

The NSP was generally supportive of this recommendation but emphasized that it will not help a grower who is producing irrigated grain sorghum for the first time.

Premium Rates

Earlier we stated that there are two approaches that can be used to address the underlying information asymmetry problem that has led to extremely high premium rates for irrigated grain sorghum in some regions. The first is to implement underwriting requirements that compel potential insureds to reveal more information about their access to irrigation water and/or the likelihood that available irrigation water will be applied to grain sorghum. The second is to provide potential insureds with a menu of policies or policy options designed such that, by their policy choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum.

We find these two approaches to be a conceptually useful way of thinking about possible methods of addressing this issue. For this reason, the remainder of this report does not discuss the specific tasks in the order in which they were listed in the task order but rather organizes them under headings for these two approaches to addressing information asymmetry.

Underwriting Requirements that Reveal Information

A standard approach to dealing with information asymmetry is to impose underwriting requirements that compel potential insureds to reveal information about their risk exposure. This, for example, is why auto insurers require potential insureds to provide information about driving habits, previous driving violations, and whether there are any teenage drivers covered by the policy. While these requirements can help address asymmetric information problems, they can, at some point, become onerous for potential insureds. Insurers seek to establish underwriting requirements that provide as much information about risk exposure as possible without imposing an unreasonable burden on potential insureds.

Establish Specific Requirements which Must be Met Before Insurance Attaches to the Irrigated Practice

The task order asked us to consider underwriting requirements that must be met before insurance would attach for the irrigated practice. Specifically, we were asked to consider items like minimum seeding rates and water requirements.

It is not clear why minimum seeding rate requirements are relevant to whether insurance would attach for an irrigated practice. Presumably, underwriting requirements already exist to ensure that seeding rates are sufficient to generate the approved yield per acre under normal conditions for the selected practice and type in the production area.

Underwriting requirements related to water availability and application would seem more relevant. The goal of these requirements would be to offset information asymmetry related to the insured's access to irrigation water and/or the likelihood that available irrigation water would be applied to grain sorghum. As we discuss below, while there are some technologies that can assist with offsetting this information asymmetry they are not without implementation challenges and may be onerous for the insured.

The task order specifically asked us to determine whether minimum water requirements could force growers to water the crop even when it is not economically optimal. This is an important question because forcing insured growers to water a crop when it is not economically optimal to do so is not in the best interests of the grower, the environment, or, in many cases, the insurer. The short answer to the question is "yes." For example, consider a situation where the overall value of loss could be minimized if the limited available water were directed to higher-valued crops but instead water is being diverted to grain sorghum just because the grower needs to meet a minimum water requirement for the insurance to attach to the grain sorghum. If the insurer is covering both the higher valued crops and the grain sorghum, both the grower and the insurer would likely be better off if the water were directed to the higher valued crop rather than to the grain sorghum. Thus, the challenge is to develop underwriting requirements that: 1) effectively address the information asymmetry problem related to water availability and usage; 2) are not overly onerous to insureds, and 3) do not create the potential for perverse incentives regarding how available water is utilized. Subsequent sections of this report further discuss these issues in the context of some specific technologies that could be used for underwriting irrigated grain sorghum.

Add Policy Requirements Similar to the Current Special Provision for Organic in Southeast Texas

RMA has used a certification process for organic production that allows growers to prove the viability of their organic production by demonstrating that organic yields meet a minimum level. The essence of this process is that organic growers must: 1) provide evidence of having successfully harvested and marketed the organic crop for a specified period of time; and 2) provide evidence that for at least some subset of that period the organic yield has exceeded a stated percentage of the organic T-yield for the reference county. If the grower cannot meet this threshold, the insured unit will remain in the transitional organic practice.

A specific example taken from the Harris County, Texas grain sorghum special provisions reads:

> To be eligible to insure your acreage under an Organic (Certified) practice written agreement, you must provide evidence that you have planted the requested organic certified crop for a minimum of three years. In one of those three years you must have successfully harvested and marketed the crop as organic and the yield you produced must be at least 50% of the current organic T-Yield in a reference county. If you do not have such documentation, the acreage may only be insured under the Organic (Transitional) practice thru a written agreement.

The organic practice verification is a bit different than the irrigation practice verification that is the focus of this report. For example, the marketing dimension is not relevant for determining whether grain sorghum should be insured under an irrigated or non-irrigated practice. However, in both cases, the goal would be to verify continued, viable, use of the relevant practice. If similar language were to be applied to the grain sorghum special provisions for the irrigated practice, it would presumably read something like:

> To be eligible to insure your acreage under the irrigated practice you must provide evidence that you have successfully planted and harvested the irrigated crop for a minimum of three years. In at least one of those three years, you must have successfully harvested the crop under the irrigated practice and the yield you produced must be at least 50% of the current irrigated T-Yield. If you do not have such documentation, the acreage may only be insured under the non-irrigated practice offered in this county.

An important question is whether such language would help address the asymmetric information problem that occurs with the irrigated practice for grain sorghum. As stated in the task order, would such language help “sift out non-dedicated producers who are insuring under the irrigated practice while limiting the adverse effects this statement would have on dedicated irrigated producers?”

Our response to this question is that language such as this might, at least to some degree, help address the underlying asymmetric information problem. However, it would likely compound the problem described above of new irrigated grain sorghum growers not being able to obtain sufficient crop insurance liability to satisfy lenders.

Another obvious limitation is that the practice of growing irrigated grain sorghum as a residual claimant on irrigation water is likely widespread in many regions of the southern plains. As we have indicated previously, there are sound economic reasons why this would be the case. But, if the practice is widespread, then it is likely reflected in the T-yields that are available for irrigated grain sorghum. As discussed previously, the low T-yields available for irrigated grain sorghum in the southern plains is one of the primary concerns that the NSP expressed to the contractor. Thus, while we are not implicitly opposed to the use of such language in the special provisions for the irrigated practice, we are concerned about the impact on new irrigated growers and believe that there may be other mechanisms that would better address the underlying information asymmetry (though they may prove more onerous for growers).

Aquifer Maps

When an individual wishes to purchase a crop insurance policy for an irrigated practice, a determination must be made regarding whether the individual has access to an adequate supply of water. That determination is made by the AIP in accordance with paragraph 301 C of the Loss Adjustment Manual. The relevant portion of that paragraph reads:

> The adequate quantity of irrigation water will be considered to be adequate only if the insured can demonstrate to the AIP's satisfaction that at the time insurance attached, there was a reasonable expectation of receiving an adequate quantity of water at the times necessary to carry out a good irrigation practice on the acreage insured under the IRR practice.

The Loss Adjustment Manual does not provide any guidance on what types of documentation might be sufficient to demonstrate a "reasonable expectation" of having access to an adequate supply of irrigation water. For the areas that are the focus of this report, we would suggest that RMA could use aquifer maps developed by state and local groundwater authorities to assess the adequacy of the water supply. Table 2 shows the water agencies for Southwest Kansas and the Texas High Plains and the characteristics available from the maps on their individual websites. Depending on the agency, the maps may show depth to water, surface topography, base of aquifer topography, and saturated thickness. Many of the maps are interactive and show individual wells with drillers' well logs describing well characteristics, such as location with latitude and longitude, depth of the pump, and date of drilling. Observation wells which are maintained by the water districts may also show annual water readings taken during the winter non-irrigation season when water levels have stabilized.

Saturated thickness is an indicator of water availability, but not a direct measure. It is the depth of the saturated zone of the aquifer and is measured by the difference between the elevation of the water table and the base of the aquifer. Although it is the best measure available, it is not precise. The contour lines designating the elevation of the water table are typically extrapolated from the annual readings taken from the observation wells. Water availability and well yield measured in gallons pumped per minute are also affected by the composition of the aquifer. The composition, e.g. sand or gravel, affects the rate at which water can flow laterally toward the pumps with larger particles allowing faster lateral flow than smaller particles.

Table 2. Information Available from Aquifer Maps of Southwest Kansas and Texas High Plains Water Agencies

	Kansas Geological Service	Southwest Kansas Groundwater Management District #3	Texas Water Development Board	North Plains Groundwater Conservation District	Panhandle Groundwater Conservation District	High Plains Underground Water Conservation District #1
Interactive map	✓	Note 1	✓	✓		✓
Depth to water	✓		Water level report	✓	✓ Note 2	Water table elevation
Surface topography	✓		✓			✓
Base of aquifer topography						✓
Saturated thickness	✓			✓	✓ Note 2	✓
Information to calculate saturated thickness				✓		✓
Continuous well monitoring network				✓		✓
Driller’s log	✓		✓	✓		✓

NOTES

1. Aquifer information is found on the Kansas Geological Service website.
2. Saturated thickness maps for Panhandle Groundwater Conservation District for 2016 are found at https://www.pgcd.us/mapping. These are updated every 5 years. Depth to water readings in the July newsletter http://online.anyflip.com/npyx/tybn/mobile/index.html

While not a precise absolute measure, the saturated thickness is a reasonably good relative measure of water availability. For example, assuming that the pump is positioned at the base of the aquifer, a grower with a well in an area of saturated thickness between 200 and 250 feet should be able to plan for season-long irrigation, whereas a grower with a well in an area with less than 50 feet of saturated thickness may only be able to irrigate once early in the growing season before water is no longer available for effective irrigation.

The websites for the state agencies and groundwater districts are listed below.

Kansas Geological Survey
Website http://www.kgs.ku.edu/Hydro/hydroIndex.html
Map http://www.kgs.ku.edu/HighPlains/HPA_Atlas/InteractiveAtlas.html

Southwest Kansas Groundwater Management District #3
Website http://www.gmd3.org/
Map Interactive map not available. Use Kansas Geological Survey map.

Texas Water Development Board
Website http://www.twdb.texas.gov/index.asp
Map https://www3.twdb.texas.gov/apps/WaterDataInteractive/GroundwaterDataViewer/?map=gwdb

North Plains Groundwater Conservation District
Website http://northplainsgcd.org/
Map http://map.northplainsgcd.org/
Annual Report http://northplainsgcd.org/wp-content/uploads/2019-Hydrology-and-GW-Resources-Double-Side-1.pdf

Panhandle Groundwater Conservation District
Website https://www.pgcd.us/
Map Interactive map not available. Use Texas Water Development Board map.

High Plains Underground Water Conservation District #1
Website http://www.hpwd.org/
Map http://www.hpwd.org/interactive-maps

As indicated above, the Loss Adjustment Manual clearly indicates that an irrigated practice policy should only attach if the insured can demonstrate to the satisfaction of the AIP that there is a "reasonable expectation" of having an adequate supply of water at the times necessary to carry out a good irrigation practice. To be clear, we are not hydrologists, and a thorough examination of the underwriting potential of aquifer maps is beyond the scope of this project. However, based on what we have learned to date, it does seem like information from aquifer maps could assist in determining whether there is a reasonable expectation of having an adequate supply of water for the insured unit. In other words, we believe that it may be at least part of the solution for addressing the ongoing information asymmetry problem with irrigated grain sorghum crop insurance. At the very least, aquifer maps may serve as a screening tool that helps segregate areas where the water supply is almost certainly adequate from areas where further investigation of water adequacy is warranted.

Clearly, aquifer maps are not a complete solution to the information asymmetry problem because they only provide evidence of water availability. They do not provide any information on the likelihood that the available water will be applied to insured grain sorghum. However, it seems reasonable to expect that, at a minimum, evidence of irrigation water availability from aquifer maps should be considered before providing insurance coverage based on an irrigated practice.

When this idea was presented to the NSP, they indicated that, in principle, they were not opposed to the idea. They did say that the aquifer maps would likely be better at indicating locations that would be expected to have sufficient irrigation water than they would be at indicating water adequacy in areas with more marginal access to water. Due to competition among AIPs for insureds, they also questioned whether AIPs would refuse irrigated practice coverage based on information from an aquifer map.

Policy or Policy Option Choices that Reveal Information

As indicated above, a second approach for dealing with asymmetric information in irrigated grain sorghum policies is to provide potential insureds with a menu of policies or policy options designed such that, by their choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum. The ideas described below are based on this approach.

Meters or Sensors

The discussion of aquifer maps focused on a possible mechanism for addressing information asymmetry regarding a potential insured's access to irrigation water. This section focuses on potential mechanisms for addressing information asymmetry regarding the application of irrigation water to the insured crop.

The task order asked us to determine if tools such as water meters could be used to track water requirements, the level of difficulty monitoring whether growers are meeting certain requirements, and the burden the requirements and enforcement of them may have on growers. Based on conversations with NSP and TAWC personnel, we have concluded that while water meters would provide information about the amount of water pumped from a particular well, there are important limitations to the usefulness of this information for insurance underwriting purposes. Perhaps the most significant of these limitations is just the scarcity of water meters. While some irrigation wells in the southern plains have water meters, it is not common. Even if a meter is in place, growers might be reluctant to share the information with an insurer. Another limitation is that water meters only report the amount of water pumped from the aquifer. They do not provide any information about where the water was applied and, depending on the meter, may not provide information about when it was applied. Given limited access to water, it is not uncommon in the southern plains for part of the area under a center pivot to be planted to a higher-valued crop such as corn or cotton and the rest to grain sorghum. While a water meter would indicate how much water had been applied by the center pivot, it would not indicate to which crop the water had been applied. Meter readings about the amount of water pumped are also incomplete in the sense that they contain no information about the need for watering. So even in those cases where one could be sure that the water pumped was applied to a specific crop, this information would need to be supplemented by soil moisture and weather information before one could reasonably determine if the water was applied in adequate amounts at the times that it was needed.

A potential alternative would be information collected from soil moisture sensors situated in various locations in an insured field. In principle, soil moisture sensors could provide a much richer source of information for underwriting than what would be available from a water meter. In a Texas A&M bulletin on the use of soil moisture sensors for irrigated grain sorghum, New (Undated) suggests sensors installed at 1-, 2- and 3-foot depths to identify soil moisture levels, monitor moisture changes, and record the depth of water penetration. Multiple sensors are suggested with recordings occurring at least twice a week during the irrigation season (see also Aguilar, Rogers and Kisekka, 2015 and Enciso et al., 2007). O'Shaughnessy et al. (2013) describe how wireless soil moisture sensors can be used for irrigation management in grain sorghum. Their field studies demonstrate that it is feasible to use a network of wireless soil moisture sensors for irrigation management on a field-scale level.

There are at least two ways that soil moisture sensors could be used in underwriting crop insurance for irrigated grain sorghum. One option would be to require growers to use sensors to qualify for insurance coverage under an irrigated practice. The problem with this option is that while the use of soil moisture sensors is increasingly viewed as a best management practice for irrigated crop production in the southern plains, it is still a relatively new technology with only limited adoption.

We would suggest instead that a new practice be created that could be called something like "sensor-reported irrigated practice." As an example, policy language for this new practice might read something like the following.

> To be eligible to insure your acreage under a sensor-reported irrigated practice you must provide evidence from soil moisture sensors that the crop on the insured unit was irrigated consistently with best practices for a minimum of one year prior to the insurance year for which the sensor-reported irrigated practice will apply. During the insurance year for which the sensor-reported irrigated practice is applied, you must provide moisture sensor data with a minimum of X sensors per 100 acres. These records must cover the full growing season with a frequency of X readings per week and include geolocation and depth of the sensor. If you do not have such documentation, the acreage may only be insured under the standard irrigated practice.

The policy language should likely also stipulate soil moisture minimum thresholds (by depth) and the maximum amount of time that the crop would be allowed to remain below those thresholds before coverage on the sensor-reported irrigated practice was invalidated or reverted back to the standard irrigated practice. Should the RMA wish to pursue this alternative, they are encouraged to consult with agronomists and irrigation engineers to develop appropriate policy language and loss adjustment procedures.

It is logical to conclude that, for those who select this practice and meet these requirements, expected grain sorghum yields will be higher (all else equal) than for irrigated growers who do not choose this practice. This suggests that the reference yields and t-yields for the sensor-reported irrigated practice should also be higher than for the current irrigated practice that does not require sensors. The question becomes how to support adjustments to the reference and T-yields for this proposed new practice. Ultimately, experience data for the new practice can be compared to that for dryland yields or (yields from the irrigated practice that does not require sensors) to estimate a differential. We suggest that this be done with the first five years of experience data.

Until sufficient experience data is available, it will be necessary to estimate factors that can be used to adjust reference yields and T-yields for the dryland practice into analogous measures for the proposed sensor-reported irrigated practice. We suggest estimating these factors based on either (1) the average ratio of irrigated to dryland grain sorghum yields from areas where irrigation water is less constrained than it is in the southern plains; or, (2) the average ratio of irrigated to dryland yields for an alternative crop (e.g., corn) in the southern plains. A potential limitation with the first suggestion is that regions where irrigation water is less constrained may also have very different climatic conditions than the southern plains. Potential limitations for the second suggestion include the limited production of dryland corn in parts of the southern plains and a concern that dryland corn is physiologically less drought tolerant than dryland sorghum so the ratio of irrigated to dryland corn yields might overstate the factor needed to adjust dryland grain sorghum reference yields and T-yields for the certified irrigated practice.

Earlier we argued that one strategy for overcoming the information asymmetry problem with irrigated grain sorghum production in the southern plains was to provide potential insureds with a menu of policies or policy options that are designed such that, by their policy choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum. This proposal for a sensor-reported irrigated practice is an attempt to do just that. We recognize that initially there may only be a limited number of growers who would have the required data from soil moisture sensors to qualify for the sensor-reported irrigated practice but, because the sensors effectively address much of the information asymmetry challenges, the premium rate for those who qualify for the practice could be reduced considerably. For example, we would suggest that as a starting point the premium rate for the sensor-reported irrigated practice for grain sorghum could be set at the current premium rate for irrigated corn. Over time, the premium rate would adjust based on realized loss costs but presumably would remain well below the rate for the standard irrigated practice. This would then create an economic incentive for others to adopt the soil moisture sensor technology – something that would have the added benefit of contributing to more efficient irrigation water management in the region.

When presented with this recommendation, the NSP was generally supportive. They told the contractor that as few as 2-3 soil moisture readings at critical points during the growing season would provide considerable information about whether the crop had sufficient moisture to reach its full yield potential. The NSP also suggested that soil moisture data for a limited number of farms could be used to “ground truth” satellite imagery data that could then be used to help determine whether other grain sorghum units insured under an irrigated practice in that region had actually received sufficient irrigation water.

Reduce Coverage for Drought Peril

The task order instructed the contractor to consider various options related to reducing coverage for drought and related causes of loss. Examples presented in the task order included possibly removing these perils as insurable causes of loss or limiting indemnities on losses caused by these perils. Another example was to only allow drought-related indemnities based on a secondary trigger such as a drought classification for the region where the policy is located. These options could be used individually or in combination.

Paragraph 301 E of the Loss Adjustment Manual clearly states that drought is not an insurable cause of loss for an irrigated practice. However, this same paragraph goes on to say that, while the likelihood is less than for a non-irrigated practice, it is possible for factors such as heat or hot winds to be insurable causes of loss under an irrigated practice. The reason provided is that under the right climatic conditions, hot dry winds may cause the amount of evaporation of irrigation water to be so great that the irrigation equipment cannot deliver the water at a fast enough rate to benefit the crop. When such claims are made, the Loss Adjustment Manual states that the AIP must verify and document whether: (a) other producers using the same type of irrigation system had the same problem; and (b) the problem can be attributed to hot dry winds in the area for the dates in question by verifying: (i) what the local weather conditions and sub-soil moisture levels were for the dates in question, and (ii) with agricultural experts in the area, who are knowledgeable of the irrigation practice method and irrigation equipment used, what the expected results would be utilizing the irrigation practice method and irrigation equipment under the particular conditions and soil types for the dates in question.

Despite these qualifications, RMA cause of loss data indicate that “hot dry” conditions have been specified as the cause of loss for almost 45% of U.S. irrigated grain sorghum indemnities for the period 2001-2018. Figure 39 presents RMA irrigated grain sorghum and irrigated corn cause of loss data for counties located in the Southwest agricultural district of Kansas for the period 2001-2018. On average, in this district, 53% of irrigated grain sorghum indemnities and 45% of irrigated corn indemnities have been due to hot, dry conditions.

Figures 40 and 41 present the same information for the Texas Northern High Plains and Southern High Plains agricultural districts, respectively. In the Northern High Plains, 38% of irrigated grain sorghum indemnities and 36% of irrigated corn indemnities have been due to hot, dry conditions. In the Southern High Plains, 47% of irrigated grain sorghum indemnities and 44% of irrigated corn indemnities have been due to hot, dry conditions.

Figure 39. Kansas Southwest Average Percentage of Irrigated Grain Sorghum and Irrigated Corn Indemnities by Cause of Loss, 2001-2018

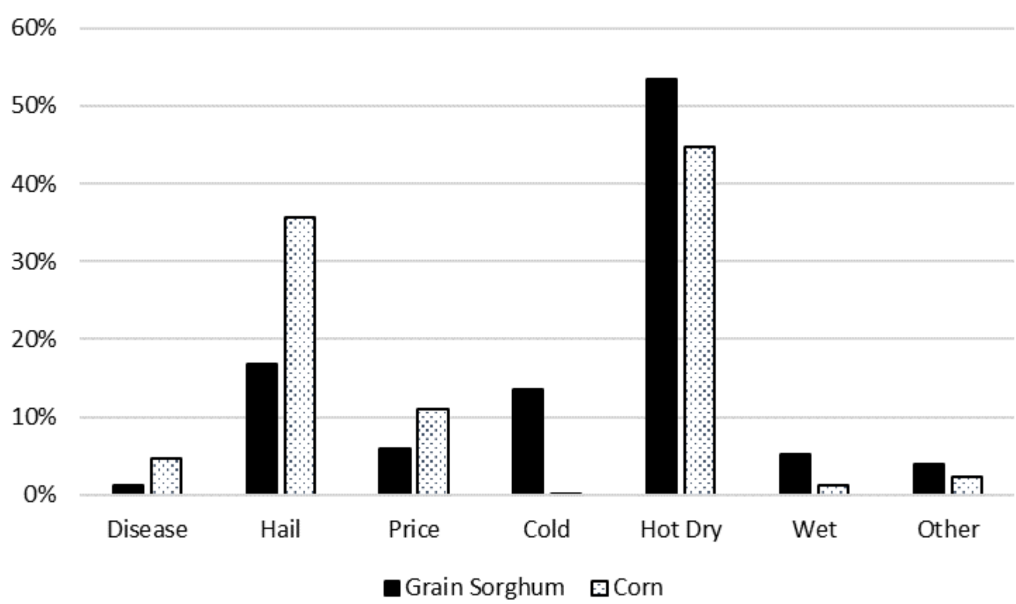


Figure 40. Texas Northern High Plains Average Percentage of Irrigated Grain Sorghum and Irrigated Corn Indemnities by Cause of Loss, 2001-2018

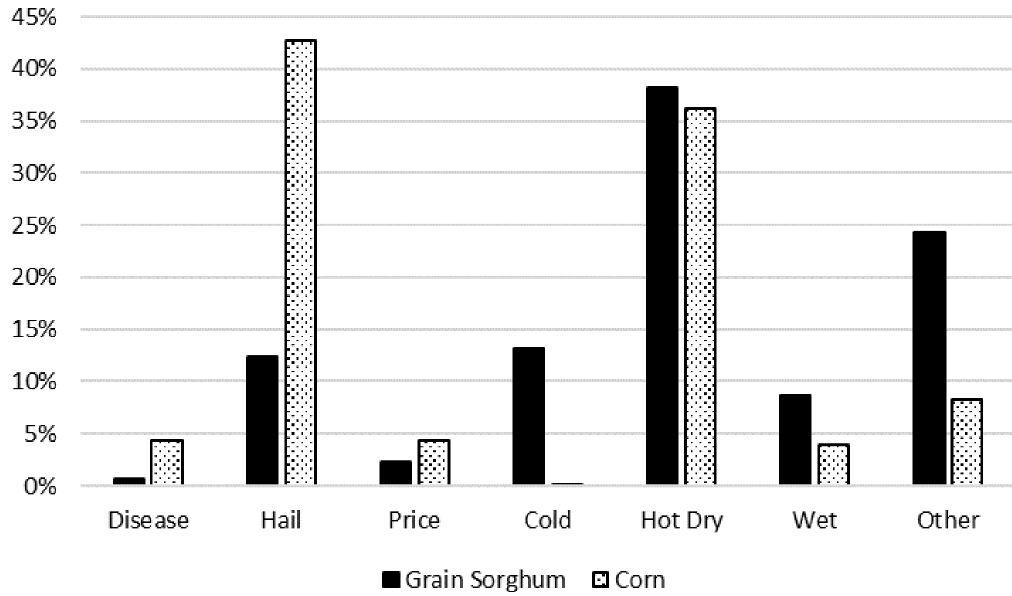
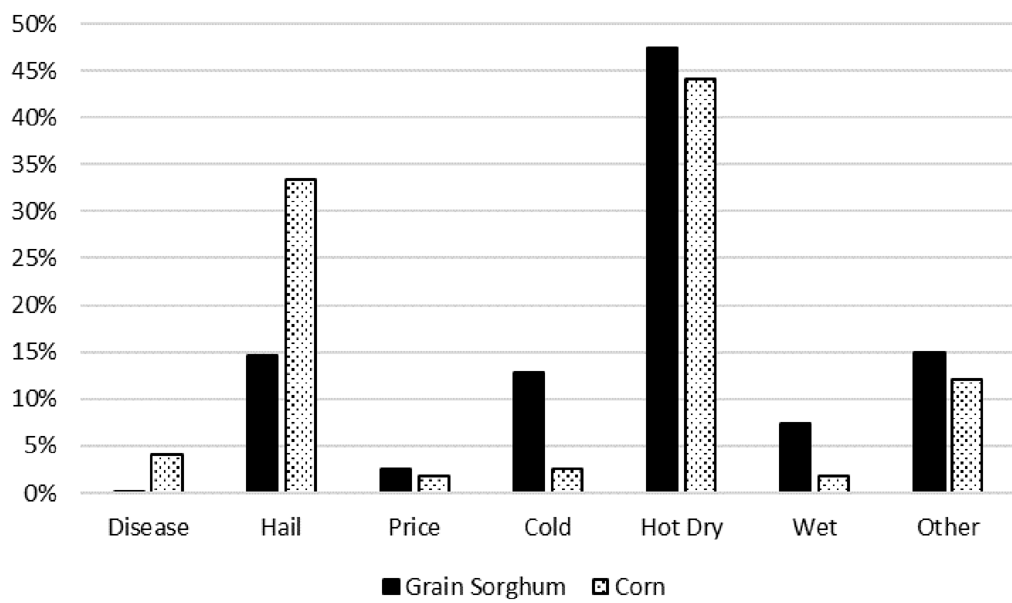


Figure 41. Texas Southern High Plains Average Percentage of Irrigated Grain Sorghum and Irrigated Corn Indemnities by Cause of Loss, 2001-2018



These data are also interesting in that for all three agricultural districts a higher percentage of irrigated grain sorghum indemnities have been attributed to hot, dry conditions than is the case for irrigated corn indemnities. This is surprising given that grain sorghum is generally considered more tolerant of hot dry conditions than corn. One wonders if, despite the limitations specified in the Loss Adjustment Manual for when hot dry conditions can be considered an acceptable cause of loss for an irrigated practice, losses caused by grain sorghum being a residual claimant on available irrigation water are being indemnified under a “hot, dry” cause of loss.

The cause of loss data suggest that an “across the board” elimination of, or reduction in, coverage for hot dry conditions is likely to be extremely unpopular with many growers of irrigated grain sorghum. In fact, this concern was voiced by the NSP during a meeting with the contractor.

A better option might be to offer insureds a choice of whether they want an irrigated grain sorghum policy that includes coverage for “hot, dry” conditions. Based on the cause of loss data, it seems obvious that a policy which excluded coverage for this cause of loss could be offered at considerably lower premium rates. In making this choice, insureds would also be revealing information about their access to irrigation water and/or the likelihood that available irrigation water would be applied to grain sorghum. Those who suspect that they will (will not) be able to provide grain sorghum with sufficient irrigation water will be less (more) likely to choose a policy that maintains coverage for drought. The NSP suggested that if such an option were offered, it should probably contain language that included drought-related perils as an insured cause of loss only if the insured unit was in an area that had received a D3 or D4 drought classification.

It is important to note that the contractor can provide no evidence of whether growers of irrigated grain sorghum would be interested in a policy that excludes coverage for hot, dry conditions. It is also important to note a potential implementation problem with offering an irrigated policy that excludes coverage for “hot, dry” conditions. It can be extremely difficult for a loss adjuster to assign losses to a specific cause. In some cases, stress caused by hot, dry conditions can render crops more susceptible to other causes of loss. This has always been an advantage of the multiple-peril coverage offered by federal crop insurance. While loss adjusters have been asked to assign losses to various causes, this assignment generally does not impact the insured’s indemnity (unless the loss is due to a cause that is explicitly identified as uninsurable). This would no longer be the case if the proposed option were made available to growers of irrigated grain sorghum. Furthermore, if growers choose to insure using an option that excludes coverage for hot, dry conditions, competition among AIPs may create significant pressures for loss adjusters to attribute losses to a covered cause of loss.

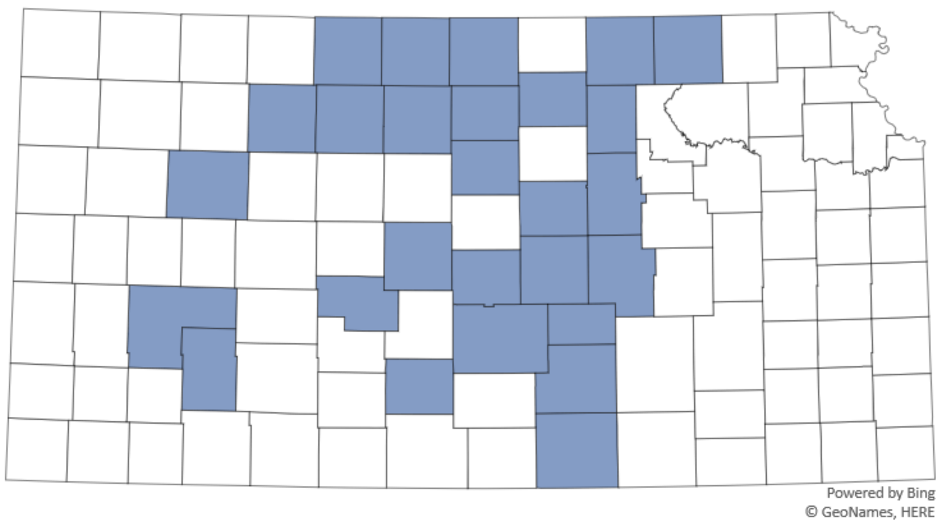
Increase Availability of Irrigated Grain Sorghum Area Products

Increasing the availability of irrigated grain sorghum Area Yield Protection (AYP), Area Revenue Protection (ARP), and Area Revenue Protection with Harvest Price Exclusion (ARP-HPE) might also be an indirect way of addressing the underlying asymmetric information problem with irrigated grain sorghum YP, RP, and RP-HPE.

An area product for irrigated grain sorghum will only pay an indemnity when there is a widespread loss event. An example from the southern plains might be a widespread, hot, and dry weather event of such magnitude that growers cannot apply enough water to save the crop. This means that an area product is unlikely to pay an indemnity when crop losses occur on a single farm because the grower had insufficient access to irrigation water or chose to apply available irrigation water to a higher-valued crop. For this reason, growers who have concerns about whether they can apply sufficient irrigation water to grain sorghum would be unlikely to purchase an area product. If an area product is available, those growers who continue to purchase YP, RP, and RP-HPE, especially at high premium rates, are revealing that they may not have access to sufficient irrigation water and/or that they are likely to apply available irrigation water to a higher-valued crop.

Figures 42 and 43 indicate the counties where AYP, ARP, and ARP-HPE are currently available for grain sorghum in Kansas and Texas, respectively. Area products are available for grain sorghum in 27 Kansas counties but only 2 of those counties are in the Southwest agricultural district. Area products are available for grain sorghum in 18 Texas counties, 9 of which are in the Northern High Plains agricultural district and 4 of which are in the Southern High Plains agricultural district.

Figure 42. Kansas Counties where Area Yield Protection and Area Revenue Protection are Available for Grain Sorghum in 2020

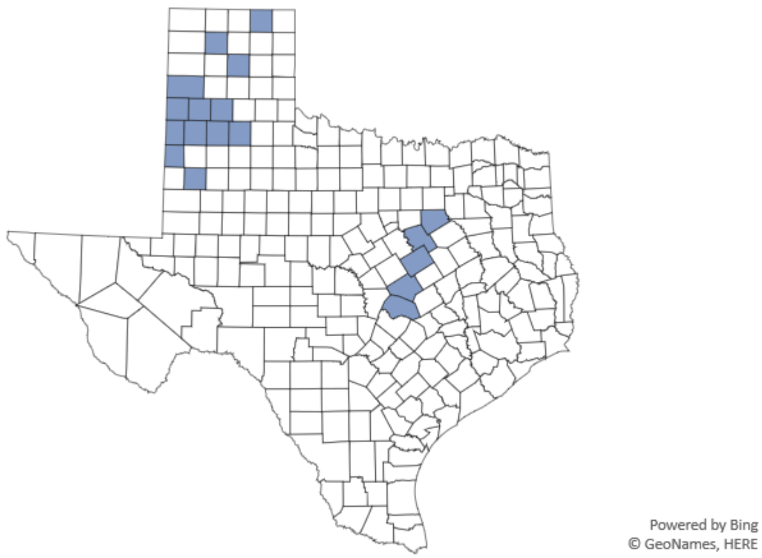


We are certainly not saying that the information asymmetry problem for irrigated grain sorghum crop insurance can be solved simply by adding area products for grain sorghum in more counties. We are, however, suggesting that adding area products in more counties: 1) would provide an alternative form of insurance coverage for those who have access to sufficient irrigation water and are unwilling to pay the high premium rates on YP, RP, and RP-HPE coverage for irrigated grain sorghum; and, 2) reveal information about insureds access to sufficient irrigation water and/or likelihood of applying that irrigation water to grain sorghum based on their choice of insurance product.

In our conversation with the NSP about increasing the availability of area products for grain sorghum, they pointed out that growers, in general, have not been enthusiastic about area products. This comment is supported by the summary of business data. Grain sorghum and/or wheat are insurable under area products for some (but not all) counties in the Kansas Southwest agricultural district. However, over the period 2015-2019, no area policies have been sold in this district. Likewise, grain sorghum and/or cotton are insurable under area products for some (but not all) counties in the Texas Southern Plains agricultural district (wheat is also insurable in Lamb County) but, over the period 2015-2019, no area policies have been sold. Grain sorghum, wheat, and/or cotton are insurable under area products for some (but not all) counties in the Texas Northern High Plains agricultural district. Over the period 2015-2019, no cotton area yield policies have been sold in the district. In 2015, 2,854 acres of grain sorghum and wheat were insured under area policies in the district representing a little over

$347,000 in liability. These numbers have decreased over time such that in 2019, only 90 acres of wheat representing slightly more than $19,000 in liability was insured under area policies in the district. No grain sorghum area policies have been sold in the district since 2017 when 95 acres of grain sorghum were insured under area policies.

Figure 43. Texas Counties where Area Yield Protection and Area Revenue Protection are Available for Grain Sorghum in 2020



Despite the lack of demonstrated interest in area products from growers, when we showed the NSP an example of grain sorghum yield insurance premium rates for a Texas county, they were surprised by how much lower the area-level rate was relative to the unit-level rate. Ultimately, they said that they would likely support this recommendation simply because it would give more grain sorghum growers access to an alternative insurance product.

Indexing

The crop insurance challenges associated with grain sorghum being a residual claimant on irrigation water could be addressed in part through indexing – that is, by tying aspects of an irrigated grain sorghum insurance policy to a policy for a proxy crop. Specifically, we would propose that the realized loss cost on an irrigated grain sorghum policy could be based on the realized loss cost on the insured's irrigated corn or cotton policy. The advantage of such an indexing arrangement is that no indemnity would be paid on the irrigated grain sorghum policy unless an indemnity was paid on the policy for the higher-valued irrigated proxy crop (corn or cotton). This greatly reduces the likelihood that irrigated grain sorghum yield losses would occur simply because irrigation water was diverted to the higher-valued proxy crop.

This approach would simply add the liability from the irrigated grain sorghum policy to the liability on the policy for the irrigated proxy crop. Since the realized loss cost on the irrigated sorghum policy is based on the policy for the higher-valued proxy crop, the premium rate would also be based on the proxy crop. The plan type (YP, RP, RP-HPE) and coverage level for the irrigated grain sorghum policy would be the same as that for the irrigated proxy crop.

Consider an example where irrigated grain sorghum is indexed to an insured irrigated corn crop. Both crops are covered by a YP plan of insurance with a 75% coverage level. The approved yield on the irrigated grain sorghum is 80 bushels per acre and the projected price for grain sorghum is $3.50 per bushel. Thus, the liability on the grain sorghum policy is $210 per acre (80 × $3.50 × 75%). Assume that the premium rate on the irrigated corn proxy is 5% so the unsubsidized premium on the grain sorghum policy is $10.50 per acre ($210 × 5%). Now suppose that after harvest the realized loss cost on the irrigated corn proxy policy is 10%. The indemnity on the irrigated grain sorghum policy would be $21 per acre ($210 × 10%) regardless of the realized yield on the insured unit of irrigated grain sorghum.

In choosing between a traditional irrigated grain sorghum insurance policy or an alternative indexed policy, growers would also be revealing information about the likelihood that they will be able to provide adequate irrigation water to their grain sorghum crop. The more (less) the grower anticipates being able to provide adequate irrigation water to the grain sorghum crop, the more (less) likely the grower will be to choose an indexed policy with a lower premium rate rather than a traditional, unit-level, irrigated grain sorghum policy.

There are several questions that would need to be addressed if this indexing approach were to be implemented.

1. **What crop could be used as the proxy?** The examples used here are corn and cotton because they are the primary alternative crops to grain sorghum in the three agricultural districts that are the focus of this report. However, other crops might work better in other areas. An important consideration is that yields on the irrigated proxy crop should be correlated to those of irrigated grain sorghum in the region. Given the data analyzed in this report, there are likely instances where there is significant basis risk between the index crop and grain sorghum.
2. **What about the potential for moral hazard on the proxy crop?** In other words, could indexing irrigated grain sorghum loss cost to the loss cost of a proxy crop create incentives for moral hazard behavior related to the proxy crop? Remember that with indexing one is essentially adding additional liability to the proxy crop. Is it possible that by doing so, one could end up in a situation where the proxy crop is worth more lost than harvested? This is a reasonable concern and care must be taken to reduce incentives for moral hazard relative to the proxy crop. For example, we think that eligible proxy crops should be required to have a higher value per acre than irrigated grain sorghum. This requirement would be met for both corn and cotton in the three agricultural districts examined in this report. Also, the total liability on the proxy crop should be required to exceed the total liability on the irrigated grain sorghum. This would prevent situations where a large amount of grain sorghum liability could be indexed to a very small amount of a proxy crop. One might even consider a more restrictive requirement which would be that the total acres on the proxy crop must exceed the total acres of insured irrigated grain sorghum.
3. **Can the proxy crop be non-irrigated?** For example, could irrigated grain sorghum be indexed to non-irrigated corn or even non-irrigated grain sorghum? In principle, yes, but this is not something that we would recommend. In many regions, the risk profile for non-irrigated crops would be significantly different than that for irrigated crops. This means that the yields on

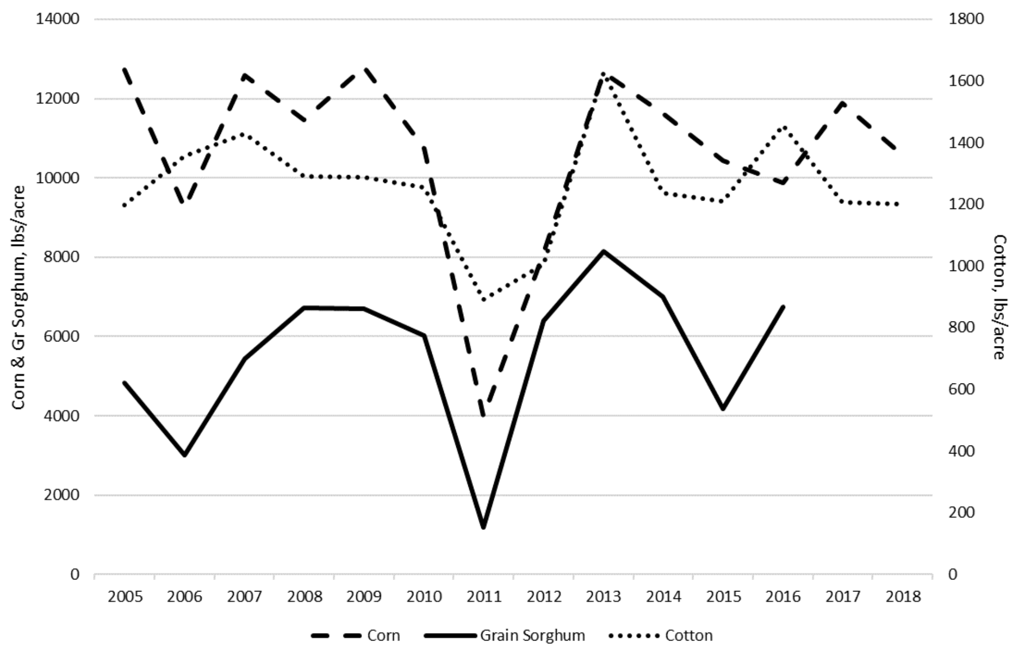
irrigated grain sorghum are not likely to be highly correlated to yields on a non-irrigated proxy crop.

4. **What about basing approved yield on the irrigated proxy crop?** In principle, one could also make the approved yield on irrigated grain sorghum some factor of the approved yield on the irrigated proxy crop. However, this is not our recommendation. We earlier discussed how mechanisms such as personal T-yields could be used to adjust irrigated grain sorghum approved yields. We believe this to be a more direct approach to handling situations where circumstances have changed such that the approved yield is no longer indicative of the expected yield on the insured unit. Simply basing the irrigated grain sorghum approved yield on some factor of the proxy crop approved yield could create situations where the grain sorghum effective coverage level exceeds the nominal coverage level because the liability exceeds the real expected value of the crop.
5. **What if the insured does not produce an eligible proxy crop?** The existing grain sorghum policies would still be available including, in some regions, the area-based products. In regions that do not have area-based products for grain sorghum, it might also be possible to index against an area product for eligible proxy crops in the region. For example, the grain sorghum liability could be based on a unit-level irrigated grain sorghum YP, RP, or RP-HPE policy but the loss cost could be based on an area product (AYP, ARP, or ARP-HPE) for a proxy crop. There are some obvious implementation challenges that would need to be worked out if the irrigated grain sorghum policy is being indexed to an area product for a proxy crop (e.g., how to calculate the liability on the grain sorghum policy since area products use different coverage levels and which premium subsidy percentage to use). Furthermore, indexing to an area product proxy crop likely decreases the correlation between the insurance outcome and the yield outcome on the irrigated grain sorghum crop. A benefit of indexing to an area product on a proxy crop is that it eliminates the potential for the grain sorghum liability to create moral hazard incentives on the underlying policy for the proxy crop. In many areas, irrigated corn would be an obvious proxy crop for irrigated grain sorghum. While the availability of AYP, ARP, and ARP-HPE for corn is limited largely to the Midwestern United States, the Supplemental Coverage Option (SCO) area product is available for irrigated corn in most areas that produce irrigated grain sorghum.

To assess the feasibility of indexing irrigated grain sorghum to irrigated corn, the task order requested an examination of the correlation between irrigated grain sorghum and irrigated corn yields or losses. It also specifically, asked that such an analysis be based, at least in part, on data from the Texas Alliance for Water Conservation (TAWC). The TAWC was established in 2004 as a multi-disciplinary and multi-university/agency/grower team with the purpose of understanding adoption of water conservation techniques while maintaining profitability. Phase I of the project, from 2005-2013, began with 26 grower sites on 2,118 acres and grew to 30 sites on 4,941 acres in 2013 in two counties with different crop and livestock production systems. Phase II, beginning in 2014, expanded to include 36 grower sites on 5,223 acres in 9 counties. A key strategy of the project is to monitor and measure production management decisions on the sites which are grower-owned and grower-managed.

The contractor met with TAWC personnel at Texas Tech University and obtained yield data from which to calculate correlation coefficients for this study. More specifically, the TAWC data used to calculate correlation coefficients came from sites that produced irrigated grain sorghum, irrigated corn, and irrigated cotton from 2005-2018. Mean harvested acre yields from these data are plotted in figure 44.

Figure 44. Texas Alliance for Water Conservation (TAWC) Irrigated Corn, Cotton, and Grain Sorghum Yields, 2005-2018



Source: Texas Alliance for Water Conservation

Table 3 shows that the Pearson correlation coefficient between irrigated grain sorghum and irrigated corn yields for the TAWC data was 0.70. The Pearson correlation coefficient between irrigated grain sorghum and irrigated cotton yields was 0.59. For purposes of comparison, the table also shows correlation coefficients for RMA reported yields (reported production / reported production acres), RMA loss costs, and NASS harvested acre yields. Empty cells indicate that the contractor did not have access to the data required to make the calculation. "NS" indicates that the correlation coefficient was not statistically different than zero at a significance level of 0.10.

The Southwest agricultural district of Kansas has the highest yield and loss cost correlation coefficients between irrigated grain sorghum and irrigated corn. It is important to note, however, that the correlation coefficient based on NASS data is for harvested acre yields and only for the period 1999-2009 because NASS stopped breaking out grain sorghum data in Kansas by irrigation practice after 2009.

The results for Texas are mixed. While correlations between irrigated grain sorghum and irrigated corn based on RMA yield and loss cost data and NASS yield data are higher in the Southern High Plains than in the Northern High Plains, they still do not reach the level of 0.70 obtained from the TAWC yield data. One wonders if this could be due to TAWC participants being more likely to provide sufficient water to their irrigated grain sorghum relative to the larger population of irrigated grain sorghum growers in the region.

In the Texas Southern High Plains, irrigated grain sorghum yields and losses based on RMA and NASS data are more correlated with irrigated cotton than with irrigated corn. This contrasts with the TAWC data. In the Texas Northern High Plains, NASS yield data indicate a high level of correlation between irrigated grain sorghum and irrigated cotton yields but this is not confirmed by the RMA loss cost data.

Table 3. Pearson Correlation Coefficients for Irrigated Crops in Focal Regions

Data Source	Area	Years	Variable	Grain Sorghum-Corn	Grain Sorghum-Cotton
RMA	Kansas Southwest	1989-2019	Yield	0.67	
RMA	Kansas Southwest	2002-2019	Loss Cost	0.64	NS
NASS	Kansas Southwest	1999-2009	Yield	0.87	
RMA	Texas Northern High Plains	1989-2019	Yield	0.47	0.43
RMA	Texas Northern High Plains	2002-2019	Loss Cost	0.45	NS
NASS	Texas Northern High Plains	1999-2018	Yield	0.58	0.75
RMA	Texas Southern High Plains	1989-2019	Yield	0.66	0.37
RMA	Texas Southern High Plains	2002-2019	Loss Cost	0.51	0.70
NASS	Texas Southern High Plains	1999-2018	Yield	0.50	0.66
TAWC	Texas High Plains	2005-2018	Yield	0.70	0.59

NS indicates “not statistically significant”

It is important to note that correlation coefficients between irrigated grain sorghum and irrigated corn or cotton are much lower for NASS planted acre yields than for harvested acre yields. We interpret this to mean that weather events that stimulate abandonment in irrigated grain sorghum do not necessarily stimulate abandonment in corn or cotton, and *vice versa*.

The RMA and NASS correlations in table 3 are based on aggregate data for the entire agricultural district. Thus, the RMA or NASS yield correlations are based on annual acreage-weighted average yields for each year (sum of production divided by the sum of planted acres). Likewise, the RMA loss cost correlations are based on annual liability-weighted average loss costs for each year (sum of indemnities divided by sum of liability).

To examine county-level differences in these measures, correlations were also calculated at the county level based on RMA reported irrigated yields and loss costs. Results are provided only for correlation coefficients that were statistically different than zero at a significance level of 0.10.

Consistent with the findings at the agricultural district level, the correlation between irrigated grain sorghum and irrigated corn is generally higher in the Kansas Southwest agricultural district than in either of the Texas agricultural districts. Figure 45 shows that, in the Kansas Southwest agricultural district, the statistically significant correlations based on RMA reported yields vary between 0.39 (Morton County) and 0.72 (Ford County). The statistically significant correlations based on RMA loss costs vary between 0.50 (Kearny County) and 0.82 (Ford County).

In the Texas Northern High Plains (figure 46), only a few counties (e.g., Floyd and Hale Counties) provide evidence of a strong correlation between irrigated grain sorghum and irrigated corn yields and irrigated grain sorghum and irrigated corn loss costs. Potter and Ochiltree Counties have relatively high positive correlations between irrigated grain sorghum and irrigated corn reported yields but the correlations between irrigated grain sorghum and irrigated corn loss costs are not statistically different than zero. Conversely, Oldham County has a relatively high degree of positive correlation between irrigated grain sorghum and irrigated corn loss costs but the correlation between irrigated grain sorghum and irrigated corn reported yields is not statistically different than zero. Figure 47 shows that in the Texas Northern High Plains there is only limited evidence of correlations between irrigated grain sorghum and irrigated cotton reported yields. There is even less evidence of correlations between irrigated grain sorghum and irrigated cotton loss costs.

Figure 45. Kansas Southwest County-level Correlations Between Irrigated Grain Sorghum and Irrigated Corn based on RMA Reported Yields and RMA Loss Costs, 1989-2019

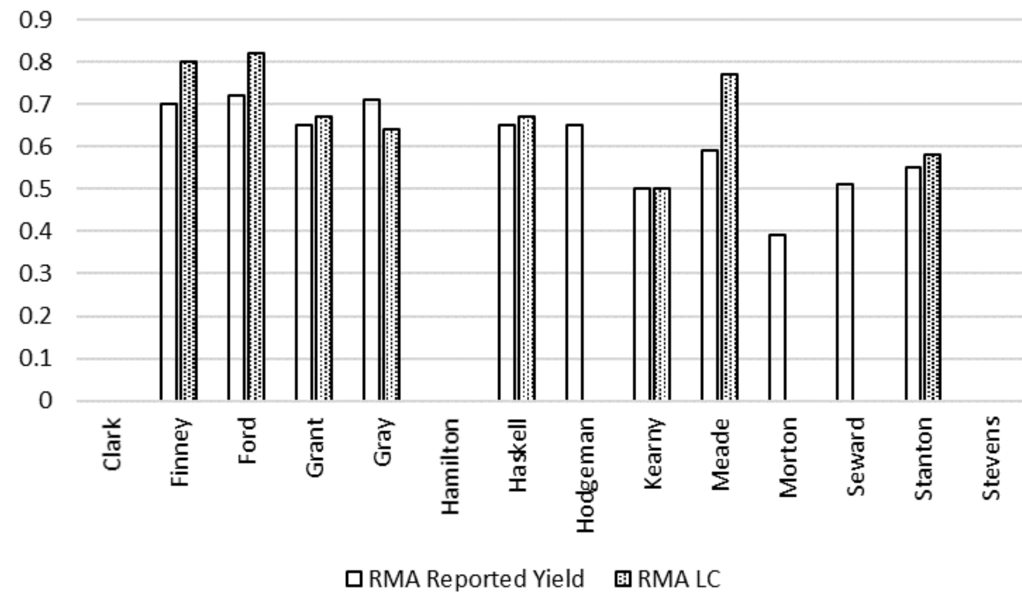


Figure 46. Texas Northern High Plains County-level Correlations Between Irrigated Grain Sorghum and Irrigated Corn based on RMA Reported Yields and Loss Costs, 1989-2019

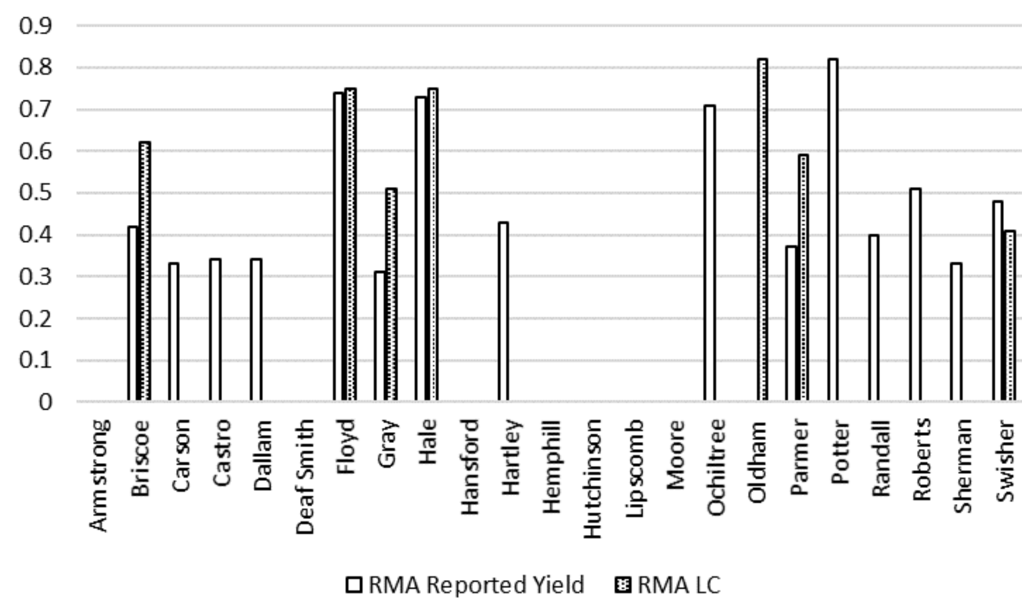


Figure 47. Texas Northern High Plains County-level Correlations Between Irrigated Grain Sorghum and Irrigated Cotton based on RMA Reported Yields and Loss Costs, 1989-2019

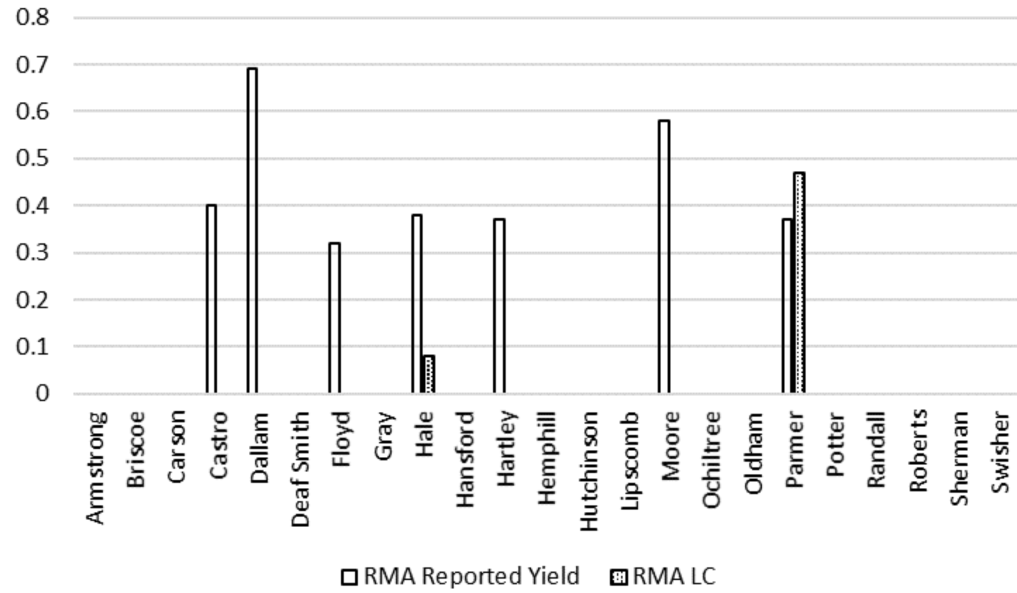
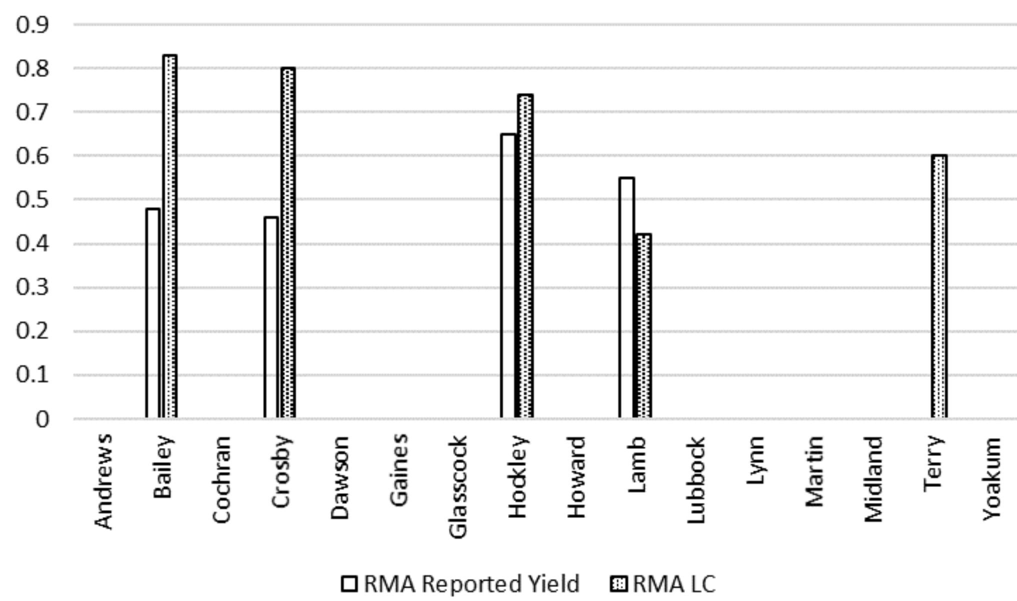


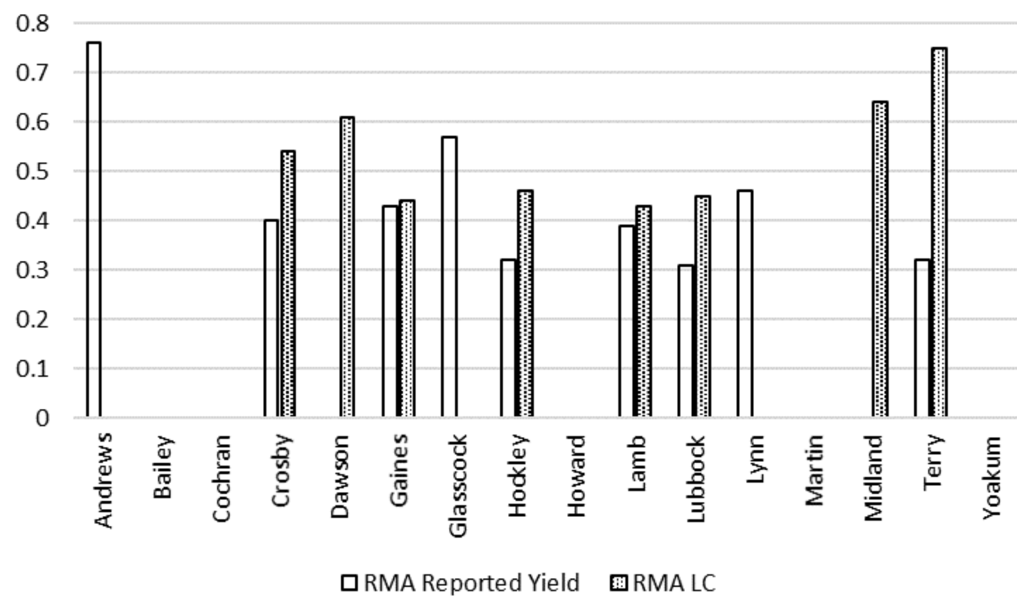
Figure 48 shows that, in the Texas Southern High Plains, only a few counties exhibited statistically significant correlations between irrigated grain sorghum and irrigated corn reported yields. The highest of these correlations was only 0.65 in Hockley County. Bailey, Crosby, and Hockley Counties all had relatively high correlations between irrigated grain sorghum and irrigated corn loss costs.

Figure 48. Texas Southern High Plains County-level Correlations Between Irrigated Grain Sorghum and Irrigated Corn based on RMA Reported Yields and Loss Costs, 1989-2019



Comparing figure 49 with figure 48 one can see that, in the Texas Southern High Plains, more counties demonstrate evidence of irrigated grain sorghum being correlated with irrigated cotton than demonstrate evidence of irrigated grain sorghum being correlated with irrigated corn. Having said that, outside of a few counties (e.g., Andrews, Midland, and Terry Counties) the magnitude of the correlation coefficients is modest. Furthermore, it seems strange that Andrews County has a very high correlation coefficient between irrigated grain sorghum and irrigated cotton reported yields but the correlation coefficient between irrigated grain sorghum and irrigated cotton loss costs is not statistically different from zero. Similarly, Midland and Dawson counties have reasonably high correlation coefficients between irrigated grain sorghum and irrigated cotton loss costs but the correlation coefficient between irrigated grain sorghum and irrigated cotton reported yields are not statistically different from zero.

Figure 49. Texas Southern High Plains County-level Correlations Between Irrigated Grain Sorghum and Irrigated Cotton based on RMA Reported Yields and Loss Costs, 1989-2019



These analyses suggest some general findings: 1) the yield or loss cost correlation between irrigated corn and irrigated grain sorghum is higher in the Southwest agricultural district of Kansas than in either Texas agricultural district; 2) the yield or loss cost correlation between irrigated cotton and irrigated grain sorghum may be as high in the two Texas agricultural districts as the correlation between irrigated corn and irrigated grain sorghum; and 3) yield or loss cost correlations calculated at geographically aggregated levels, such as an agricultural district, can mask significant variability in the correlations at the county level. It is also important to remember that if, as we expect, the data used to calculate these correlations reflect irrigated grain sorghum being grown as a residual claimant on irrigation water, they will understate the correlation that one would expect to find if both crops were receiving sufficient irrigation water. If the two crops are also being grown on the same farm (perhaps under the same pivot) so that the soil types are similar, one would expect even higher correlations.

The purpose of the correlation analysis was to consider the possibility of indexing irrigated grain sorghum insurance indemnities to the loss cost experience of a proxy crop such as irrigated corn or irrigated cotton. While the data available provide some insights, they are likely not adequate to really determine how well indexing might work at a farm level if both crops received adequate irrigation. If such indexed policies are offered, individual growers will ultimately have to decide if they want their irrigated grain sorghum policy indexed to another crop such as irrigated corn. Those who choose to do so, however, will be revealing information that suggests that they intend to adequately irrigate their grain sorghum. In this manner, allowing growers the option of an indexed policy would help to address the underlying asymmetric information problem.

The NSP expressed enthusiastic support for this recommendation. They stated that they understood the need for some requirements (such as those suggested earlier) to reduce the potential for moral hazard on the indexed crop. They also understood that a pilot test with geographic limitations and only one potential proxy crop (likely corn) would be needed to provide "proof of concept."

Conclusion

Grain sorghum generally has a lower value per acre than other field crops (e.g., corn or cotton). In the southern plains, when irrigation water is limited, growers typically apply water first to higher-valued crops. Thus, irrigated grain sorghum is often managed as a residual claimant on irrigation water.

For crop insurance, the problem is that growers know much more than the RMA or AIPs about their access to irrigation water and the likelihood that grain sorghum will receive sufficient irrigation water to reach its full yield potential. This asymmetrically distributed information leads to a situation where those who have less (more) access to irrigation water and/or are less (more) likely to apply available water to grain sorghum, are more (less) likely to purchase crop insurance on irrigated grain sorghum. As is common with these situations, the result has been high levels of loss cost (indemnities/liability) which has led to high premium rates.

There is no one single solution to this problem. Instead, this report makes several recommendations that collectively may help mitigate (but likely not fully alleviate) the problem. These recommendations are based on standard insurance understandings of how to address information asymmetry problems. The recommendations fall into two general categories. The first is to implement underwriting requirements that compel potential insureds to reveal more information about their access to irrigation water and/or the likelihood that available irrigation water will be applied to grain sorghum. The second is to provide potential insureds with a menu of policies or policy options designed such that, by their policy choices, insureds reveal information about their access to irrigation water and/or the likelihood that they will apply sufficient water to grain sorghum.

A related problem is that, due to many growers producing grain sorghum as a residual claimant on irrigation water, T-yields for irrigated grain sorghum are well below the actual yield potential for sufficiently irrigated grain sorghum. With reduced water availability from aquifers in many regions of the southern plains, some growers are recognizing that they should be switching out of corn and/or cotton into grain sorghum because grain sorghum requires less irrigation water. However, with the low T-yields on irrigated grain sorghum, these growers cannot obtain sufficient crop insurance liability to securitize an operating note with their lender. Thus, to obtain financing, the lender requires the grower to instead produce corn or cotton which requires more irrigation water. This report recommends extending the personal T-yield pilot program to irrigated grain sorghum production in the southern plains to help address this problem.

Summary of Recommendations

The following list summarizes the recommendations contained in this report for irrigated grain sorghum crop insurance. The recommendations are prioritized based on conversations with the NSP.

Highest Priority

- Allow irrigated grain sorghum growers to index grain sorghum indemnities to another irrigated crop.

Secondary Priority

- Create a "sensor-reported irrigated practice" for those who provide soil moisture sensor information.
- Extend personal T-yield pilot to grain sorghum in the southern plains.

Tertiary Priority

- Consider requiring information from aquifer maps to assess water availability.
- Create an irrigated policy option that excludes coverage for "hot, dry" cause of loss.
- Increase the availability of area-based products for grain sorghum.

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