9. Corn and Grain Sorghum Production Efficiency in Kansas

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Daniel O'Brien was raised on a grain and livestock farm in south central Nebraska, in which he still has an interest with his father and three brothers. He received both Bachelor of Science (1978) and Master of Science (1980) degrees in Agricultural Economics from the University of Nebraska-Lincoln. The focus of his M.S. thesis was on analyzing the impact of agricultural cooperatives on rural Nebraska fertilizer markets. O'Brien then worked as an extension agent in western (Lincoln County) and northeastern (Pierce County) Nebraska for seven years beginning in early 1981. While attending graduate school at Iowa State University beginning in 1987, O'Brien worked as an Extension Assistant in Agricultural Marketing, focusing on analysis of grain and livestock markets and price risk management strategies. He completed his Ph.D. in December 1993, focusing his dissertation research on developing a method by which to forecast the probability of alternative U.S. harvest time corn futures price outcomes. While working as Extension Farm Management Specialist in Northwest Iowa during 1993 through early 1995, he became heavily involved in analysis of the structural changes in the Iowa livestock industry associated with contract hog production. From March 1995 through May 2003, O'Brien worked as the Extension Agricultural Economist in Northwest Kansas based out of the Northwest Research and Extension Center in Colby. He held the position of Northwest Area Extension Administrative Director starting in June 2003 before returning to his Extension Agricultural Economist position in January 2007. Daniel O'Brien's ongoing extension and applied research interests and efforts are in the areas of a) grain market supply-demand analysis, bioenergy impacts and price-income risk management strategies, b) grain industry market structure, conduct and performance – focusing on grain handling and transportation issues, and c) economic analysis of irrigated and dryland cropping systems, and associated cropland leasing arrangements.

Abstract/Summary

The production and economic efficiency of corn and grain sorghum is a critical issue for Kansas farmers. The results of a study by KSU Agronomists and Ag Economists is discussed, focusing on how corn and grain sorghum compare under irrigated and dryland cropping systems, and under what cropping systems and in what geographic regions of the state that crop producers might prefer one crop or another or both in proportion depending on factors critical to their farming operations.

The Efficiency of Corn & Grain Sorghum Production in Kansas

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Results of Joint KSU Agronomy - Ag Economics Study (April 2012 - June 2013)

- Kraig Roozeboom – KSU Agronomy, Manhattan
- Loyd Stone – KSU Agronomy, Manhattan
- Alan Schlegel – KSU Agronomy, SWREC-Tribune
- Curtis Thompson – KSU Agronomy, Manhattan
- Keith Janssen – KSU Agronomy, Eastern Kansas (Retired)
- Mykel Taylor – KSU Agricultural Economics, Manhattan
- Bill Golden – KSU Agricultural Economics
- Daniel O'Brien – KSU Agricultural Economic, NWREC-Colby
- Michael Langemeier – Purdue Agricultural Economics (formerly KSU)
- Yared Assefa Mulisa – KSU Agronomy Post-doc
- Marcus Brix – KSU Agricultural Economics Graduate Assistant

- Project Sponsor: Kansas Corn Commission

Key Corn & Grain Sorghum Issues

A. Identifying key corn / sorghum characteristics in terms of plant morphology, physiology, & phenology that determine each crop's productive capabilities

B. Breakeven dryland yields for corn / sorghum & the impact of environmental factors

C. Impact of drought tolerant corn hybrids

D. Irrigated corn / sorghum breakeven yields & water use efficiency

E. Fall post-harvest soil moisture use for corn / sorghum

Key Corn & Sorghum Issues (more)

F. Harvested acre & price trends for corn & grain sorghum in Kansas

G. Comparing crop nutrient & pesticide use & use efficiencies for corn & grain sorghum

H. How crop rotations, growing seasons & other factors affect Kansas corn & grain sorghum enterprises

I. Determine how farmer's economic cost efficiency is affected by corn, grain sorghum & other farm enterprises in Kansas

A. Key Crop Characteristics

Morphology, Physiology & Development Stages

- Appearance of Corn / Sorghum is similar above ground & in vegetative growth stages (*morphology*)
  - Their *physiology* & *developmental stages* also are similar in resource rich environments.
- Notable Differences (re: Morphology, Physiology & Phenology)
  - Adaptation to different levels of stress conditions

A. Key Crop Characteristics (more)

- **Corn**
  - Tends to have taller stalks & relatively more leaves
  - Favoring greater interception of photosynthetically-active radiation & greater yield in *resource rich environments*
- **Sorghum**
  - Relatively more deeply & densely rooted
  - Maintains physiological activities at higher levels than corn in low water conditions
  - Has plasticity to hasten or delay phenological events (growth stages) under *water deficit stress conditions*

B. Breakeven Dryland Yields

- KSU Corn & Sorghum Performance Trial Results
  - **Corn** – Higher average & max yields than sorghum
  - **Grain Sorghum** – less ⇧⇩ yield variation than corn
- Comparing Yields in "Harsh" Environments
  - Environmental conditions driving dryland grain sorghum yields ⇩ 40 bu /ac were "harsher" than those driving dryland corn yields ⇩ 40 bu /ac
  - Weather conditions in different months were critical for dryland corn versus grain sorghum

B. Breakeven Dryland Yields (more)

- **KSU Variety Trials: 1992-2012**
  - Dryland Corn = 121 bu/ac average
  - Dryland Sorghum = 103 bu/ac average
  - Corn = Sorghum "Cutoff" = 100 bu/ac
- **KSU Variety Trials: 2007-2012**
  - Dryland Corn = 122 bu/ac average
  - Dryland Sorghum = 99 bu/ac average
  - Corn = Sorghum "Cutoff" = 96 bu/ac
- **IF** dryland corn yields **decline** to the level of grain sorghum yields, then grow sorghum *(KSU Variety Trials)*

B. Breakeven Dryland Yields (more)

- **Kansas USDA NASS Yields: 1992-2012**
  - Dryland Corn = 87 bu/ac average
  - Dryland Sorghum = 66 bu/ac average
  - Corn = Sorghum "Cutoff" = 64 bu/ac
- **Kansas USDA NASS Yields: 2007-2012**
  - Dryland Corn = 89 bu/ac average
  - Dryland Sorghum = 68 bu/ac average
- **IF** dryland corn yields **decline** to the level of grain sorghum yields, then grow sorghum *(USDA NASS yields)*
  - *Same result as for KSU Variety Performance Trials*

B. Western KS Dryland Profitability (more+)

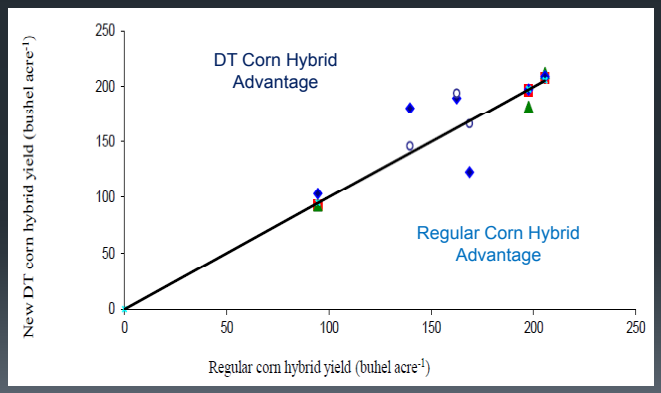
- **Assumptions**
  - KSU Corn / Sorghum Variety Trial Yields (1992-2012)
  - KSU Crop enterprise cost estimates (Farm Mgmt. Guides)
  - Corn vs Sorghum average basis difference
  - Crop Insurance Coverage
- **Results**
  - Northwest Kansas ➲ Advantage dryland corn
  - Southwest Kansas ➲ Advantage dryland sorghum
  - ➢ Reflecting periodic harsh weather patterns & KSU Variety Trial results in 1992-2012 in NW & SW Kansas

C. Drought Tolerant Corn Hybrids

- **DT Corn Varieties by Company**
  - Optimum® AQUAmax™ ⇨ Pioneer
  - DroughtGard™ ⇨ Monsanto
  - Agrisure Artesian™ ⇨ Syngenta
- **Limited DT Corn Yield Public Data**
  - Recent yield experiments at Etter, TX & Topeka, KS
  - At very low & very high yielding environments, regular & DT corn hybrids showed **no** significant yield differences.
  - In medium yielding environments, DT corn had a yield advantage in most cases over regular corn hybrids.

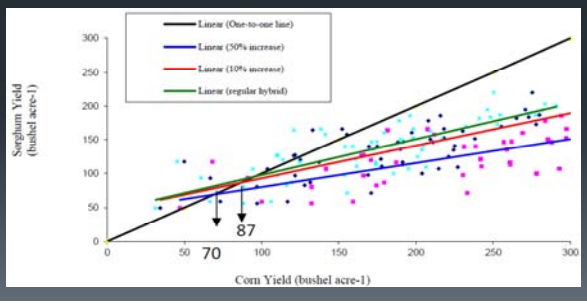
C. Yields of DT Corn vs Regular Hybrids

Etter, Texas & Topeka, Kansas Dryland Corn Yield Variety Tests



C. DT Corn (more)

- **Seed Co. Signals: 10% Yield ⇧ for DT Corn**
  - IF True, THEN for Adj. KSU Variety Trials: 2007-2012
    - IF Dryland Sorghum unchanged @ 99 bu/ac avg
    - "New" Corn / Sorghum "Cutoff" = 87 bu/ac (⇩ 9 bu)

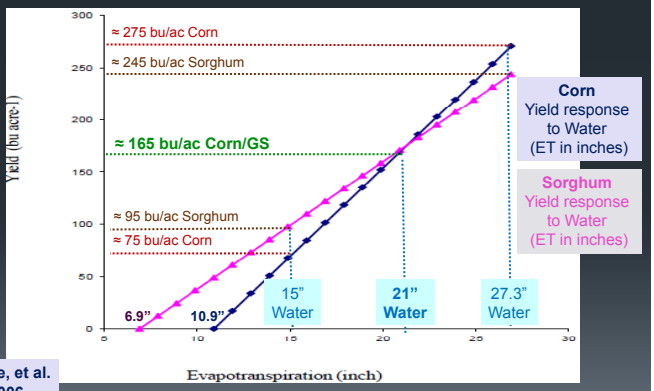


D1. Corn & Sorghum Water Use

- Vegetative Growth Requirements
  - Corn = 10.9 inches / acre minimum
  - Sorghum = 6.9 inches / acre minimum
- Additional Crop Yield per 1" of available water
  - Corn = 16.9 bu/acre / 1" of water/acre
  - Sorghum = 12.2 bu/acre / 1" of water/acre
- Evapo-transpiration (ET) & Water Use Efficiency
  - At ET > 21" ➲ **corn** has better WUE
  - At ET < 21" ➲ **grain sorghum** has better WUE

D2. Corn & Grain Sorghum Water Use

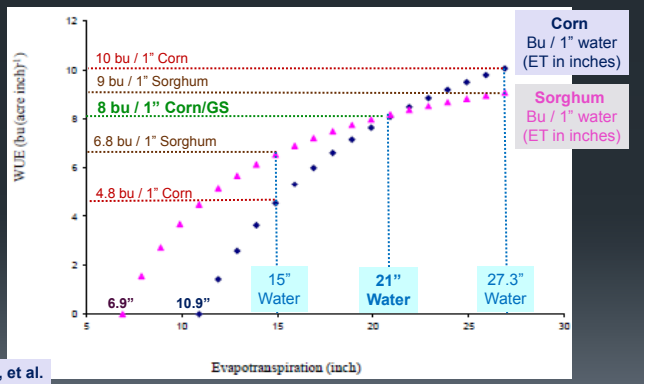
Yield versus Evapotranspiration (ET) (Inches of water use)



Stone, et al. 2006

D3. Corn & Sorghum Water Use (more)

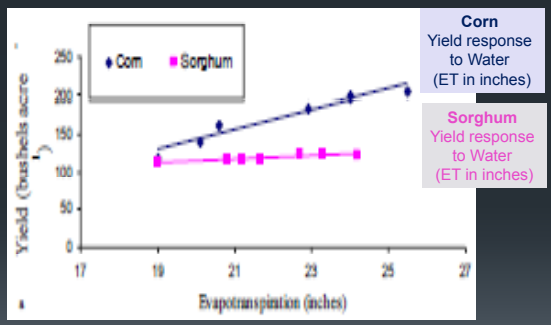
Water Use Efficiency (Bu / 1") vs Water Use in inches (ET)



Stone, et al. 2006

D4. Corn & Sorghum Water Use

Yield versus Evapotranspiration (ET) (Inches of water use)

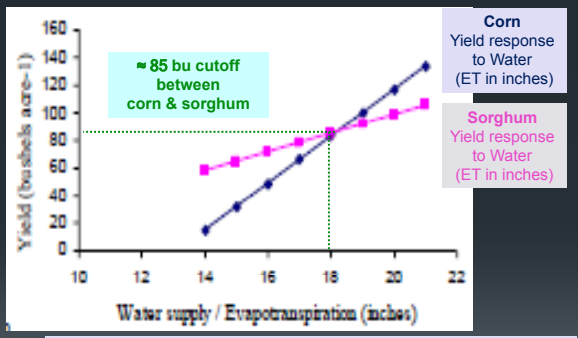


Klocke & Currie 2009

Findings: **> 19 inches of ET (water use)**, corn is more efficient at producing bushels of grain per inch of water than sorghum.

D5. Corn & Sorghum Water Use

Yield versus Evapotranspiration (ET) (Inches of water use)



Klocke & Currie 2009

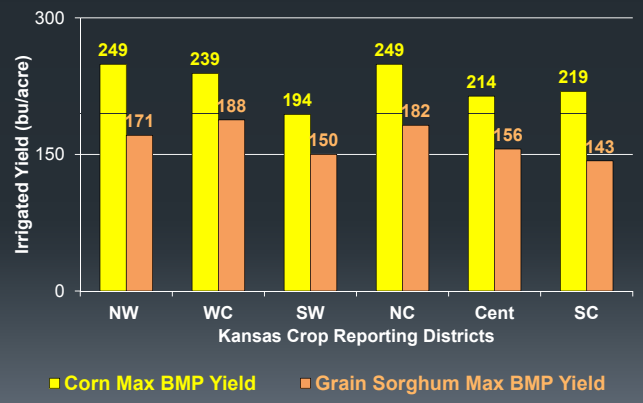
Findings: The corn & sorghum lines intersected about 18 inches of ET (water use). Eighteen inches (18" water) is the suggested cut-off value for water use efficiency of corn & sorghum

D6. Corn & Sorghum Water Use

- Stone et al. (1996) reported that Corn out-yielded Grain Sorghum at total irrigation amounts of 14“ & above at Tribune, KS
  - The gain in crop yield over added irrigation water was greater for Corn over Sorghum starting at 8” applied
  - **Recommendation**: **8” of irrigation water** as a cut-off below which – Grain Sorghum is more efficient, & above which – Corn is more efficient
- Tribune’s normal seasonal (Apr-Sep) rainfall ≈ 13”
  - Applied of 8” + rainfall of 13” = 21” of water use, which equals 21“ cut-off value presented earlier for the ET-yield relationship (Stone, et al – 1996)

D7. Irrigated Corn & Grain Sorghum (Golden)

Maximum BMP Yields by CRD in Western Kansas



D8. Irrigated Corn & Grain Sorghum (Golden)

Maximum BMP Yields by CRD in Western Kansas

	NW CRD10	WC CRD20	SW CRD30	NC CRD40	Cent CRD50	SC CRD60
a) Rainfall Annual Avg.	20.2”	21.2”	19.9”	25.8”	26.6”	25.7”
b) Corn-Sorgh. Breakeven Irrigation Amount (inches)	**4.6”**	**6.4”**	**8.3”**	**2.4”**	**3.2”**	**1.2”**
Total Water @ Breakeven Yield (a) + (b)	24.8”	27.6”	28.2”	28.2”	29.8”	26.9”
Corn-Sorghum Breakeven Crop Yield (bu/ac)	**130 bu**	**154 bu**	**135 bu**	**141 bu**	**130 bu**	**115 bu**

D9. Irrigated Corn & Sorghum (Golden)

Summary of Results by CRD in Western 2/3 of Kansas

- **Central 1/3 of Kansas**
  - In NC, Central & SC Kansas, irrigated Grain Sorghum may ***not*** be a profitable alternative to irrigated Corn.
- **Western 1/3 of Kansas**
  - In NW, WC, & SW KS, irrigated Grain Sorghum may again **not** be a profitable alternative to irrigated Corn ***except*** in areas of ***diminished well capacity***

E. Fall Post-Harvest Moisture Use

Q? How much soil moisture is used by cropland in Corn & Grain Sorghum in fall-after harvest?

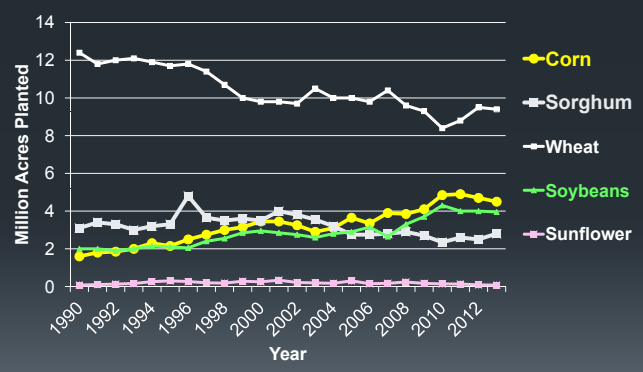
- Soil Moisture Use from Black Layer to Killing Freeze
  Corn = 0.045” /day x days to killing freeze
  Sorghum = 0.085” /day x days to killing freeze

A. Freeze 2 weeks late (14 days)
Corn = 0.045” /day x 14 days = 0.63” soil moisture
Sorghum = 0.085” /day x 14 days = 1.19” soil moisture

B. Freeze 4 weeks late (28 days)
Corn = 0.045” /day x 28 days = 1.26” soil moisture
Sorghum = 0.085” /day x 28 days = 2.38” soil moisture

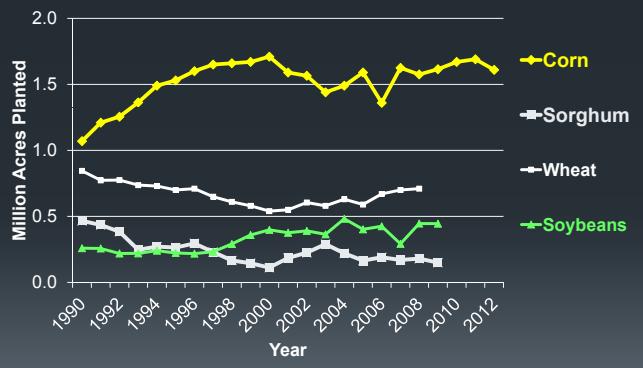
F1. Kansas Crop Planted Acreage: 1990+

Corn, Grain Sorghum, Wheat, Soybeans & Sunflowers



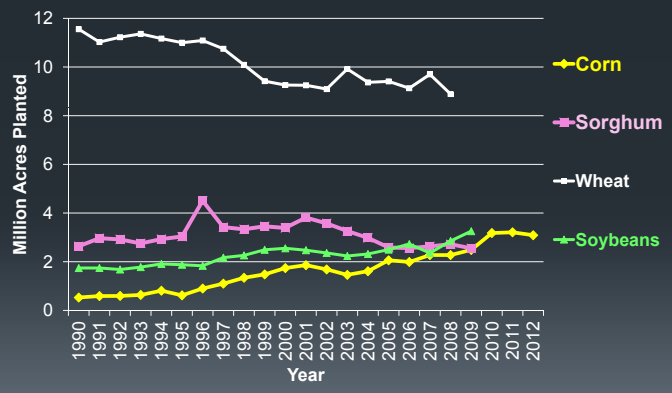
F2. Kansas Corn & Sorghum Irrigated Acres

USDA NASS Acreage Data: 1990-2012



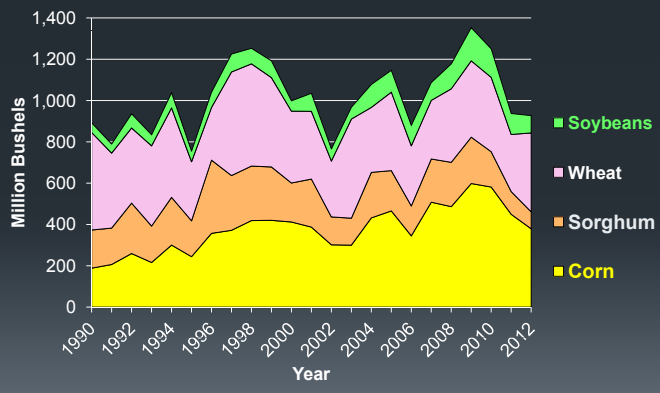
F3. Kansas Corn & Sorghum Dryland Acres

USDA NASS Acreage Data: 1990-2012



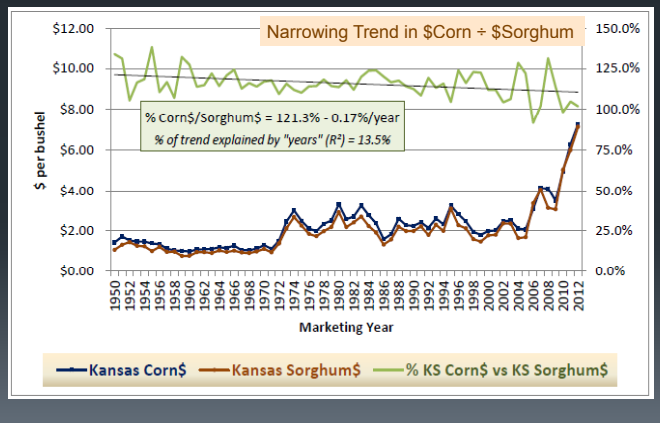
F4. KS Corn, Sorghum, Other Production

USDA NASS Crop Production Data: 1990-2012



F5. Kansas Corn & Sorghum Price Trend

USDA NASS Crop Price Data: 1950-2012



G1. Corn & Sorghum Nutrient Use

- **Corn** responded ***more*** than **Grain Sorghum** to N fertilizer applications of 60 to 200 lb/acre
  - For equal rates of N fertilizer applied, **Corn** responded ≈ 0.5 bu/ac/N# ***more*** than **Grain Sorghum**
  - Fertilizer use efficiency of **Corn** was found to be *greater* than for **Grain Sorghum** at all application rates, as long as water is not limiting
- Results from a long-term (1997-2006) N & P fertilizer use study in Tribune, KS
  - **Corn** responds to applied N & P ***more*** than does **Grain Sorghum** at the application levels considered

G2. Corn-Sorghum Pesticide Use

- Reasonable weed control can be accomplished in **Sorghum** & **Corn** using pre-emergent herbicides
  - Pre-emergent herbicides require adequate rainfall to be activated & control weeds.
    - Without adequate rain, weeds might escape, requiring a post-emergent herbicide application
  - Without glyphosate tolerance in **Grain Sorghum**, post-emergence herbicide options to control grass weeds (in particular) are much less effective than in **Corn**
- **Corn** > **Sorghum** in herbicide use efficiency, assuming similar rates of herbicide application

G3. Corn-Sorghum Pesticide Use

- **Pre**-emergent pesticide application has been shown to increase yield up to 100% compared to untreated plots in both **Corn** & **Grain Sorghum**
- Unlike for **Corn**, **post**-emergent herbicide optins for **Grain Sorghum** have been either:
  1) Not available
  2) More expensive
  3) Not as effective as post-emergent **Corn** herbicides

H1. Crop Rotation Impacts

- Differences exist in placement & effects of each crop in Great Plains cropping systems
  - Rotational studies indicated ***more*** nitrogen (N) was required for equal or better **Wheat** yields when **Wheat** followed **Grain Sorghum** compared to following **Corn**
  - Planting **Wheat** in the same season after **Corn** harvest was found to be ***more*** compatible than **Wheat** after **Sorghum**.
  - However, double-cropping **Grain Sorghum** rather than **Corn** after **Wheat** harvest better optimized water use & available growing season

H2. Irrigated Cropping Systems

- The competitive advantage that irrigated **Corn** maintains over irrigated **Grain Sorghum** is due to…
  1) Herbicide & rotational considerations which provide greater production flexibility for **Corn**
  2) Producer perceptions that disparity in crop insurance minimum or "t-yield" levels favor irrigated **Corn** over irrigated **Grain Sorghum**
  3) How local commodity prices generally have favored **Corn** over **Grain Sorghum** across the state of Kansas over time

I1. Farm Cost Efficiency Impact

- Study determining if **Corn**, **Grain Sorghum** & other farm enterprises were related to cost efficiency in Kansas
  - Based on Kansas Farm Management Association (KFMA) enterprise #s, with whole farm combined crop irrigation & dryland enterprises for 2002-2011
- Statewide % of farm income from **Corn** = 14.7%, from **Grain Sorghum** = 6.5%
  - **Corn**: 7.6% in central to 18.9% in eastern KS
  - **Sorghum**: 2.3% in eastern to 11.4% in central KS

I2. Farm Cost Efficiency Impact

- Both **Corn** & **Grain Sorghum** crop income were positively related to cost efficiency across the state of Kansas
  - **Corn** income was *positively* related to cost efficiency in eastern & western Kansas
  - **Grain Sorghum** income was *positively* related to cost efficiency in central Kansas
  - Both **Corn** or **Grain Sorghum** were ***not negatively*** related to cost efficiency for **any** region of the state
  - **Hay & forage**, **Oilseed**, & **Wheat** production ***were negatively*** related to cost efficiency in parts of the state

Questions?

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