SORGHUM™ THE SMART CHOICE

Updated Carbon Footprint Study

Topline Information

May 2022

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Study Background

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Study Background & Purpose

- In 2012, The United Sorghum Checkoff Program developed a model to analyze the carbon footprint of sorghum used for ethanol production based on information obtained from sorghum growers. This information was collected in an extensive study over time and included the following:
  - Sorghum acres – including both irrigated and non-irrigated acres in past five years; seeding rate; crop acres preceding 2012 sorghum.
  - Sorghum inputs (brands and acres treated) - including fertilizer, herbicide, insecticides, fungicides, seed treatments.
  - Sorghum outputs - including yields, sorghum stubble for grazing and bale.
  - Field operations (type of operation and sorghum acres covered) – including specific tillage practices; fertilizer, herbicide, insecticide and fungicide application methods; planting methods, cultivation methods, and harvest methods.
  - Energy use (type and quantity) – including energy for drying; energy for irrigation; residual energy; energy for delivery .

- In 2020, the United Sorghum Checkoff Program confirmed the model estimates using some of the primary predictors from the 2012 Sorghum Carbon Footprint Study. Now the United Sorghum Checkoff Program is interested in obtaining updated information for 2022. Thus, the current study will gather information from growers, with the purpose of confirming estimates and verifying near future estimates or sorghum's carbon footprint.

- Specifically, this study will gather the following information about sorghum production for both non-irrigated and irrigated acres for the years 2019, 2020 and 2021:
  - Sorghum production acres (seeding rates and crop acres)
  - Yields
  - Tillage practices (no till, minimum/strip till and conventional till acres)
  - Crop inputs (nitrogen fertilizers, phosphorus, potassium, sulfur and lime application rates and acres treated)
  - Organic matter percentage
  - Soil type

Methodology & Sample

- To gather information used in this study, phone interviews were conducted with 101 sorghum growers in Kansas in May 2022. Kansas was selected due to its high concentration of sorghum growers and high sorghum output. Kansas produces nearly half (48%) of all sorghum acres grown in the U.S. To participate in this study, growers had to meet the following criteria:
  - Have input into decisions about sorghum for their farming operation.
  - Not employed by or affiliated with advertising, sales promotion, market research or public relations organizations/companies.
  - Not employed by or affiliated with energy manufacturing company, distributor, or dealership.
  - Planted at minimum of 50 sorghum acres in 2021.

- To get a representative sample of sorghum growers across Kansas, counties were divided into three regions: Central, East and West (see appendix for a list of counties in each region). Soft quotas were imposed on each region. Below is the number of interviews completed in each region versus the quota.

- Note, one grower in the West reported producing 18,000 sorghum acres in 2021. Some results in this report exclude this grower from the analysis due to his disproportionate influence on stated results.

	Sampled Growers*		Acres Represented		
	Desired	Completed	# of Acres Represented*	% of Acres Represented	% of Acres Irrigated
Central	63	70	32,688	41%	1%
East/Others	2	4	1,255	2%	0%
West*	36	27	45,100	57%	7%
Total	101	101	79,043	100%	4%

** One sorghum producer reported 18,000 sorghum acres.*

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Sorghum Production

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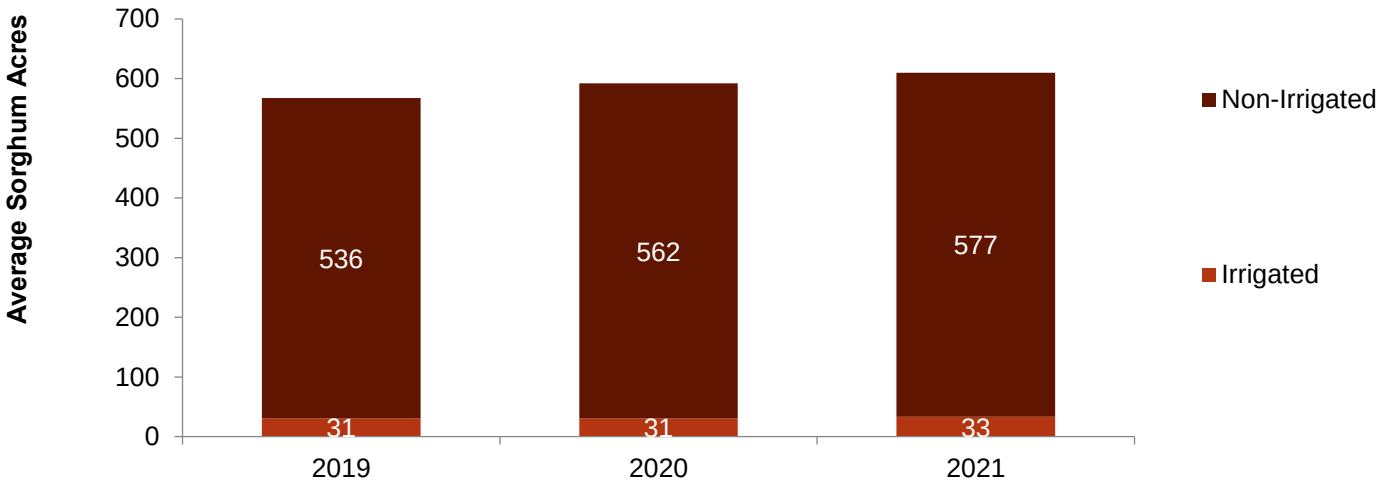
Sorghum Acres Planted

- Growers in this study planted on average 577 sorghum acres in 2021. Year over year, sorghum acres increased by about 4% each year from 2019 and 2021. Consistently, about 5% to 6% of sorghum acres are irrigated year over year. The latter result was similarly observed in the 2020 study.

Average Irrigated and Non-irrigated Sorghum Acres*



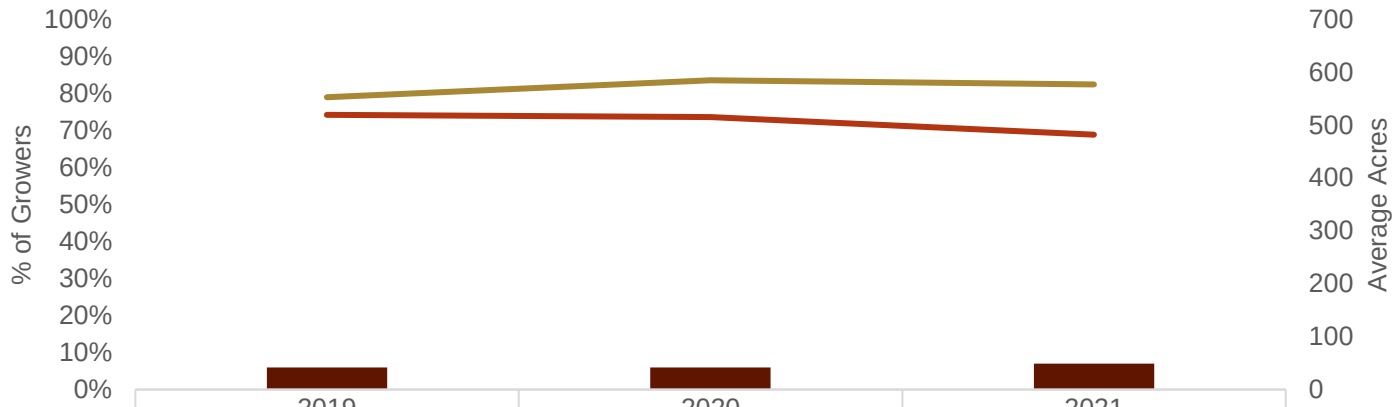
	2019	2020	2021
Average Sorghum Acres	568	593	610
% of All Sorghum Acres that are Irrigated	5%	5%	6%
*Base**	*100*	*100*	*100*

*Source: How many [irrigated/non-irrigated] sorghum acres did you plant in the following years? *Includes 0*
**One grower eliminated due to disproportionate influence on averages.*

Irrigation in Sorghum

- About 7% of growers had irrigated sorghum in 2021, similar to the previous two years.

Average Acres Among Growers with Irrigated Sorghum Acres *



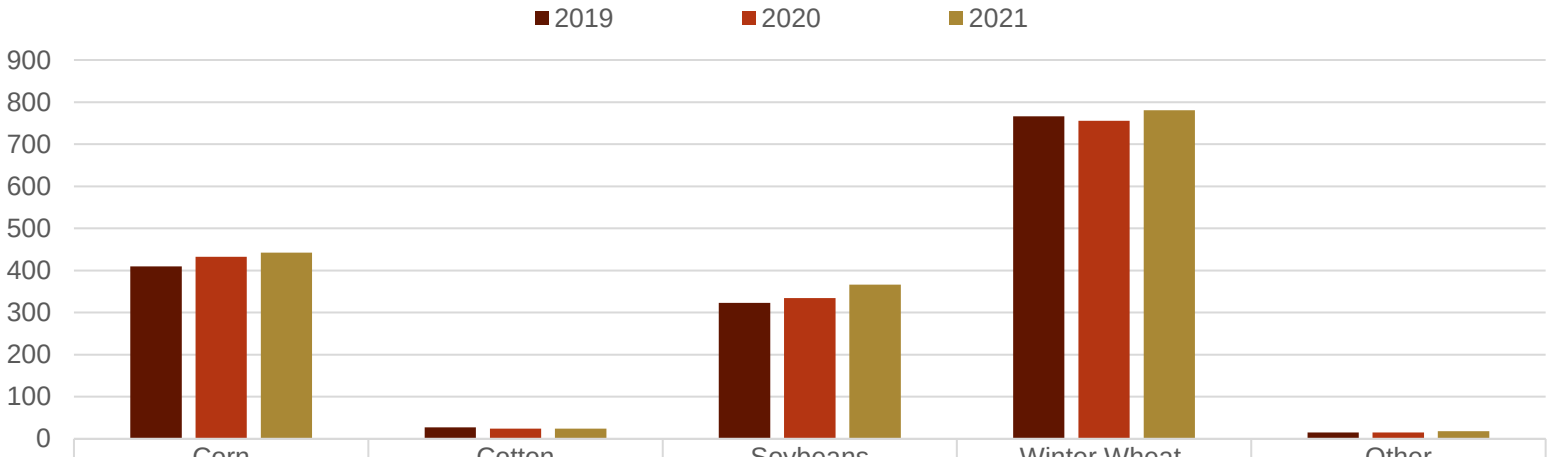
	2019	2020	2021
% Growers With Irrigated Sorghum	6%	6%	7%
Average Acres Irrigated	519	516	482
Average Acres Non-Irrigated	553	585	577
% of Growers	*100*	*100*	*100*
Average Irrigated	*6*	*6*	*7*
Average non-irrigated	*97*	*96*	*100*

Source: Were any of your sorghum acres irrigated in [insert year]? How many [irrigated/non-irrigated] sorghum acres did you plant in the following years?
**Caution due to small sample sizes. Excludes 0's. One grower eliminated due to disproportionate influence on averages.*

Other Crops Planted

- Year over year, winter wheat is the other crop planted most among sorghum growers. This result is consistent with the 2020 study results.

Average Acres of Other Crops (Excluding Sorghum) Planted by Year

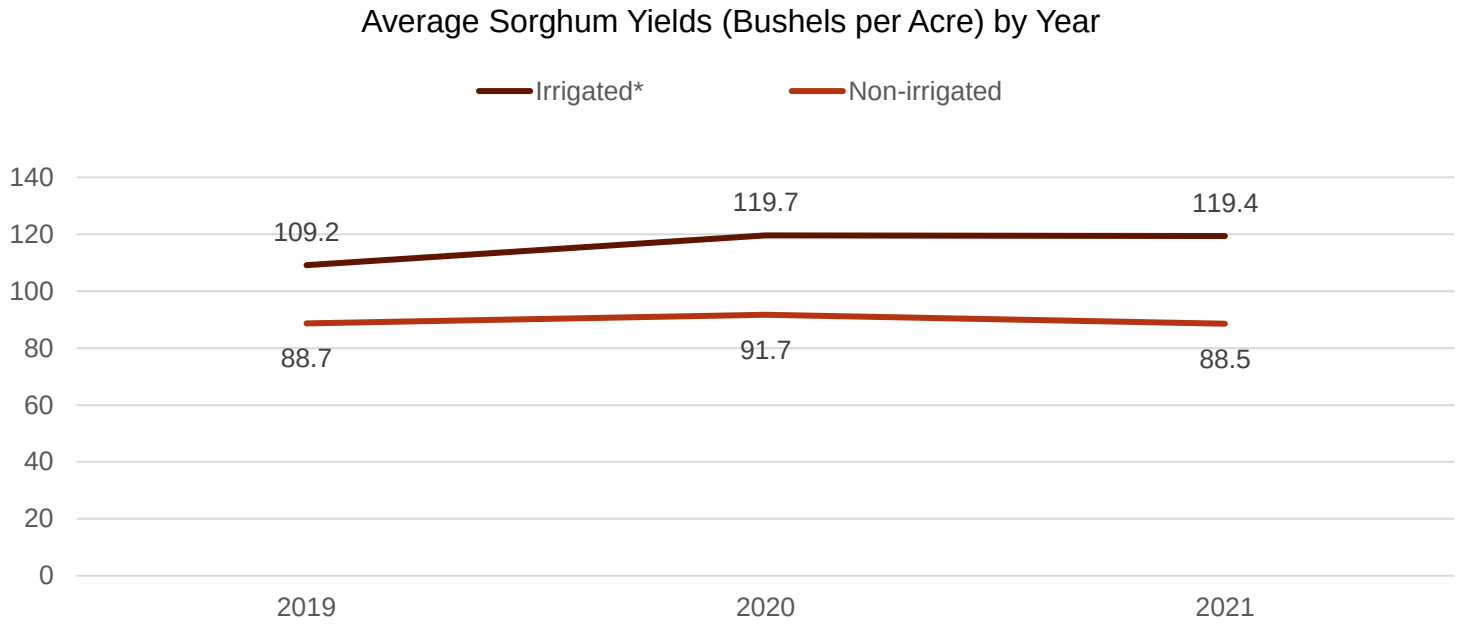


	Corn	Cotton	Soybeans	Winter Wheat	Other
2019	410	27	323	766	15
2020	432	25	335	756	15
2021	442	24	366	780	18

Source: How many acres of the following other crops did you plant in the following years? If none, enter 0. 0's included in average.

Sorghum Yields

- Non-irrigated sorghum yields have remained consistent over the past year at about 89 bushels per acre. Compared to the 2020 study, non-irrigated sorghum yields have increased by about 9%. Irrigated sorghum acres yield about 20% to 25% more bushels per acre than non-irrigated sorghum. This trend is consistent with the 2020 study.

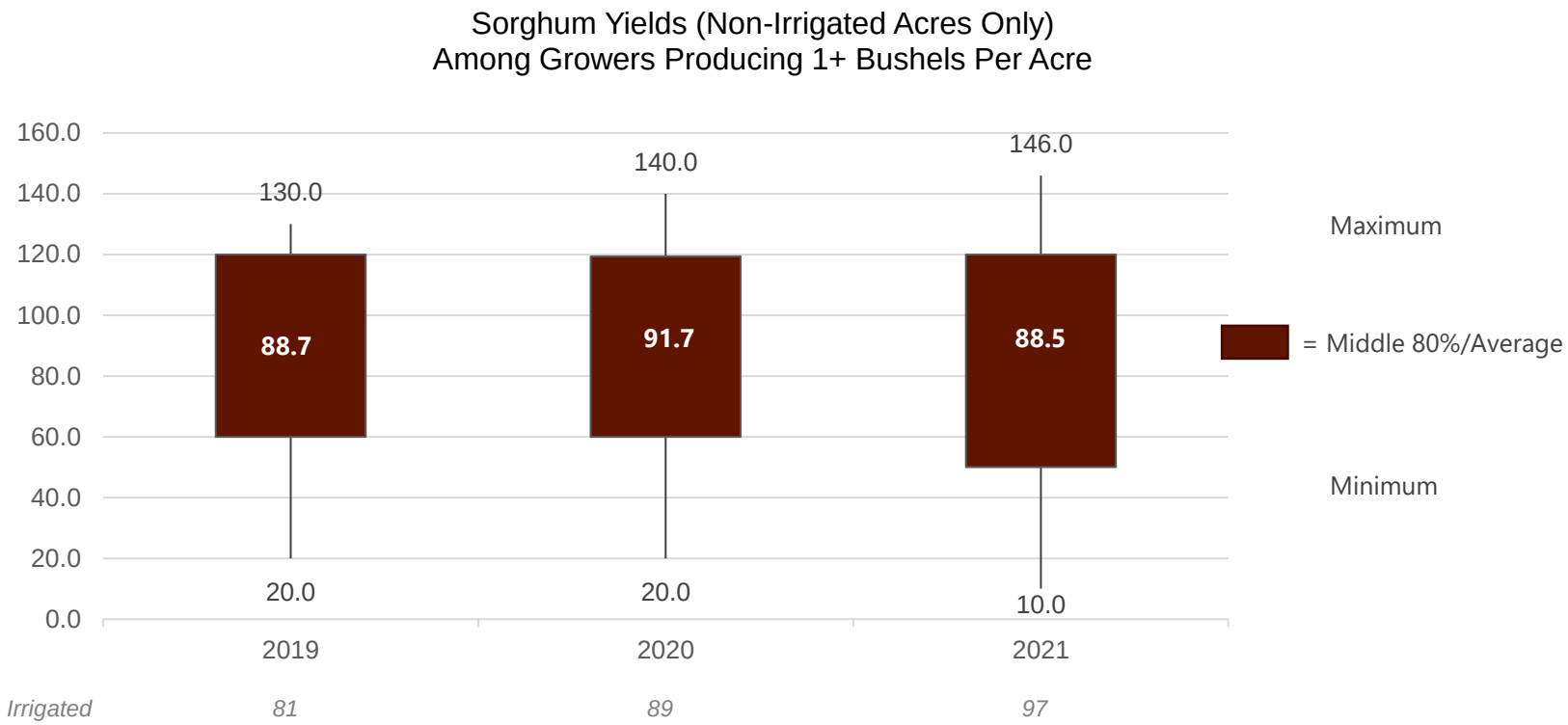


	2019	2020	2021
Base Irrigated	*6*	*6*	*7*
Base Non-irrigated	*96*	*95*	*99*

Source: What was your average sorghum yield in bushels per acre or pounds per acre for your [irrigated/non-irrigated] sorghum in the following years? Sorghum yields include 0's (i.e., growers who reported planting sorghum, cut said they had 0 yields.
** Caution due to small sample size..*

Sorghum Yields (Non-Irrigated Acres Only)

- Growers over the past three years have produced on average about 89 bushels per acre of sorghum on non-irrigated land. However, yields vary widely with most growers (80%) reporting yields between 50 and 120 bushels per acre.



Source: What was your average sorghum yield in bushels per acre or pounds per acre for your [non-irrigated] sorghum in the following years?

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Tillage Practices

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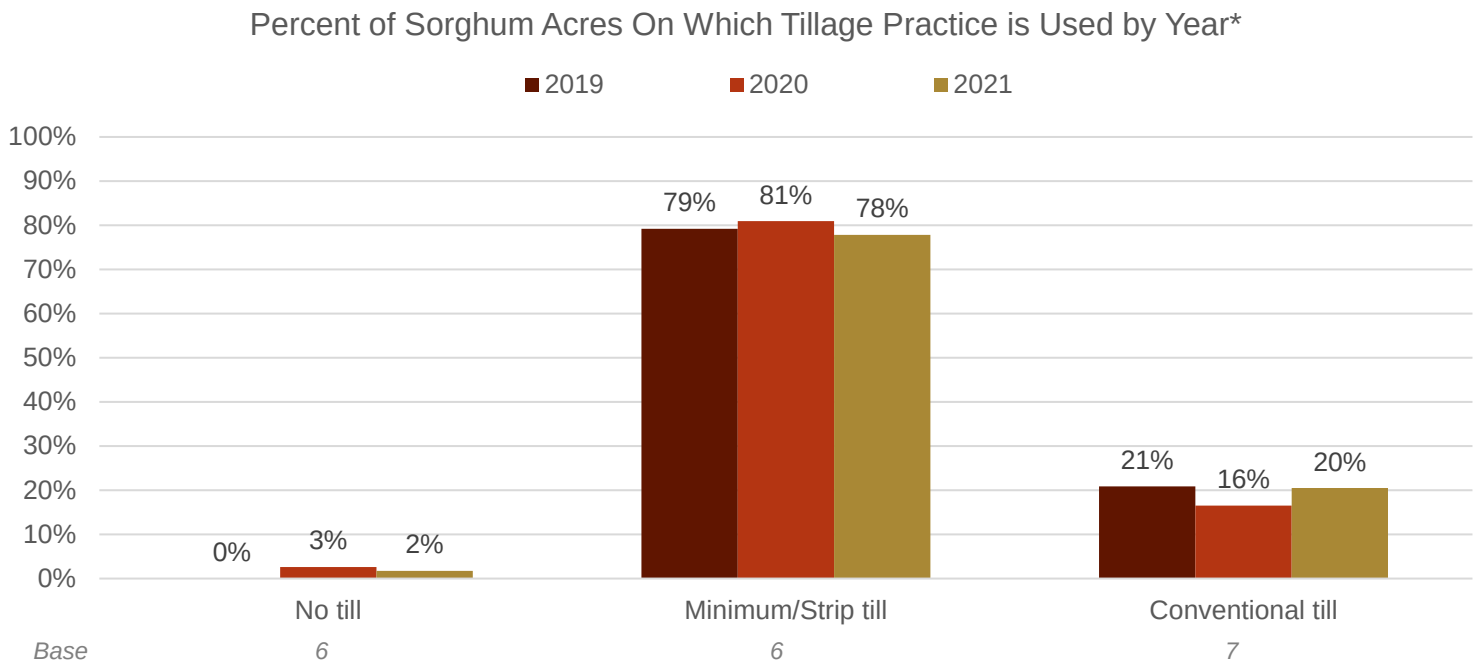
Tillage Practices on Irrigated Acres

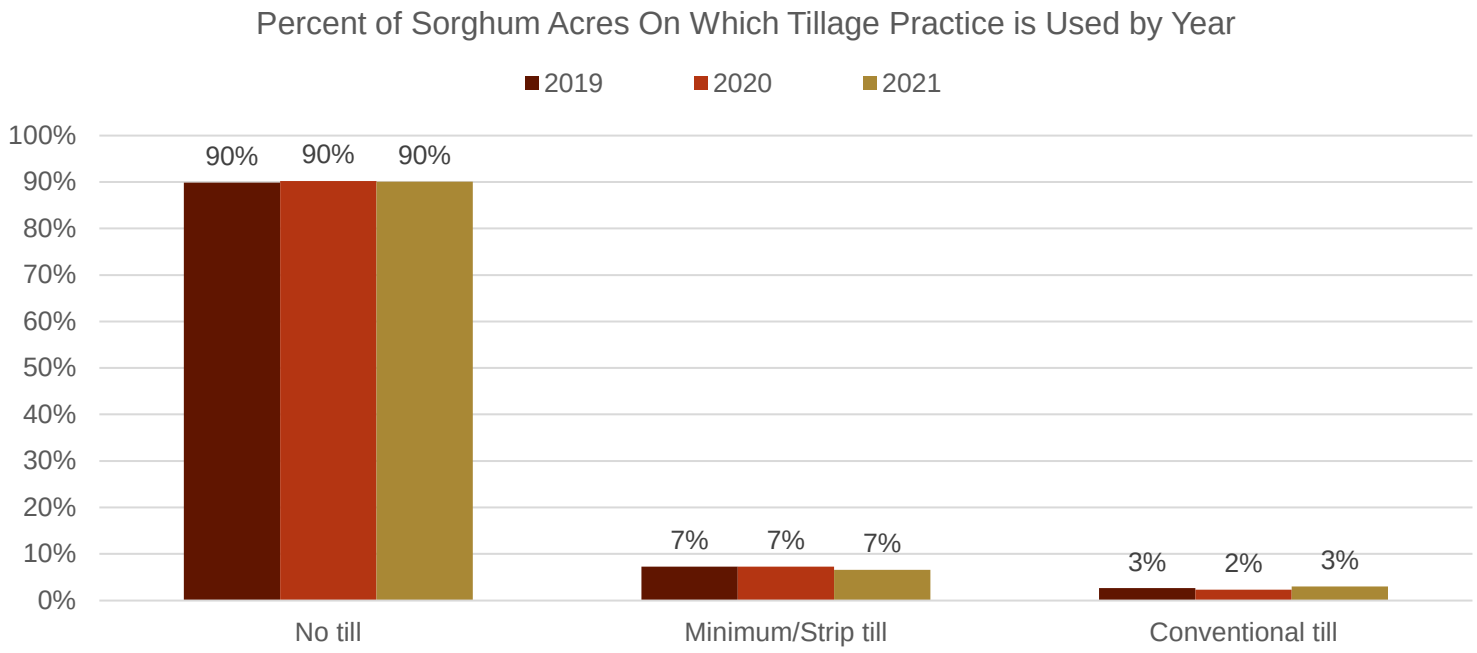
- Year over year, minimum/strip till is used on most all sorghum acres and conventional till is used on another 20% of sorghum acres. Few growers use no till.



Source: How many of your sorghum acres were no till, minimum/strip till or conventional tillage in [year]?
** Caution due to small sample.*

Tillage Practices on Non-Irrigated Acres

- Similar to the 2020 study, no till is used on most all sorghum acres. It is worth noting that the portion of no till sorghum acres increased in the current study by about 15% to 20% compared to the 2020 study, primarily at the expense of conventional till.



Base 2017	*101*
Base 2018	*101*
Base 2019	*101*

Source: How many of your sorghum acres were no till, minimum/strip till or conventional tillage in [READ YEAR[?

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Carbon Inputs

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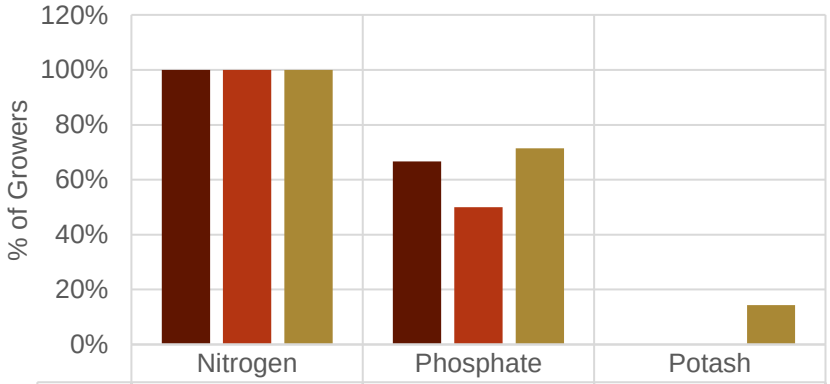
Nutrient Use

- Nearly all growers apply nitrogen to the non-irrigated sorghum acres (96% in 2021).
- Most all growers also apply phosphate to their non-irrigated acres.
- Few growers with non-irrigated sorghum apply potash (13% in 2021)*.
- For non-irrigated sorghum acres, these trends were also observed in the 2020 study.

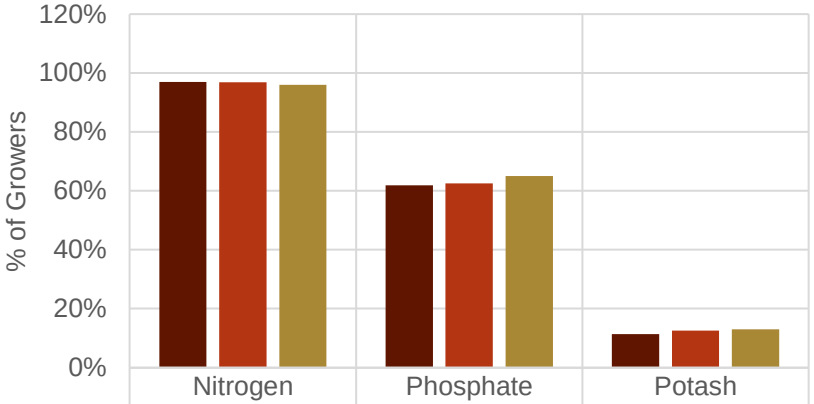
Nutrient Use Among Growers who Plant Sorghum in Indicated Years

Irrigated Sorghum Acres*



	Nitrogen	Phosphate	Potash
2019	100%	67%	0%
2020	100%	50%	0%
2021	100%	71%	14%
Base:	*6*	*6*	*7*

Non-Irrigated Sorghum Acres



	Nitrogen	Phosphate	Potash
2019	97%	62%	11%
2020	97%	63%	13%
2021	96%	65%	13%
Base:	*97*	*96*	*100*

Source: What was your nitrogen fertilizer target [lbs/acre] in [year] for your [irrigated/non-irrigated] sorghum acres? Please tell me the application rate for [phosphate/potash] to your [irrigated/non[irrigated] sorghum acres in [year]?
**Caution due to small sample.*

Nitrogen Use

- Growers with irrigated sorghum acres generally apply nitrogen at a rate of 115 lbs. per acre, compared to a target rate of 87 lbs. per acre for growers with non-irrigated sorghum acres. Compared to the same information gathered in 2020, results suggest growers increased their target rate for nitrogen over the past few years for both irrigated and non-irrigated sorghum acres.
- Most growers (with or without irrigated acres) treat the majority of their sorghum acres with nitrogen.

Nitrogen Target Application Rates and Acres Treated at Target Rate

Irrigated*	2019	2020	2021	*Base*
Average Target Rate (lbs./acre)	120.8	114.2	115.0	*6,6,7*
% of Sorghum Acres Treated	100%	100%	100%	*6,6,7*
Average Sorghum Acres Treated (among users only)	519.3	515.5	482.0	*6,6,7*

Non-Irrigated	2019	2020	2021	*Base*
Average Target Rate (lbs./acre)	85.6	85.7	87.3	*83,81,84*
% of Sorghum Acres Treated	99%	95%	91%	*97,96,100*
Average Sorghum Acres Treated (among users only)	819.7	902.1	717.5	*94,93,96*

Source: What was your nitrogen fertilizer target rate in lbs. per acre in [year] for your [irrigated/non-irrigated] sorghum acres? For context, a recent study found a target rate of 0.91 pounds per bushel. How many acres were treated at that rate in [year]?
**Caution due to small sample.*

Phosphate Use

- Growers generally apply phosphate at a rate of roughly 32 lbs./ acre on non-irrigated sorghum acres. Over the past three years, phosphate is applied to 70% to 75% of non-irrigated sorghum acres. Compared to the 2020 study, the phosphate rate increased slightly on non-irrigated sorghum acres from about 29 lbs./acre.

Phosphate Application Rates and Acres Treated at Application Rate

Irrigated*	2019	2020	2021	*Base*
Average Rate (lbs./acre)	32.5	30.0	44.0	*4,3,5*
% of Irrigated Sorghum Acres Treated	19%	20%	25%	*6,6,7*
Average Sorghum Acres Treated (among users only)	146.5	207.7	168.8	*4,3,5*

Non-Irrigated	2019	2020	2021	*Base*
Average Rate (lbs./acre)	32.6	32.4	32.8	*62,62,66*
% of Sorghum Acres Treated	71%	75%	72%	*97,96,100*
Average Sorghum Acres Treated (among users only)	922.9	1107.6	838.1	*60,60,65*

Source: Please tell me the application rate for [phosphate] to your [irrigated/non[irrigated] sorghum acres in [year]? How many acres were treated at that rate?
** Caution due to small sample.*

Potash Use

- Potash is applied to about 7% of sorghum acres at a rate of about 30 lbs. to 35 lbs. per acre. Rate results are consistent with results observed in 2020, although acres treated may have decreased slightly.

Potash Application Rates and Acres Treated at Application Rate

Irrigated*	2019	2020	2021	*Base*
Average Rate (lbs./acre)	-	-	80.0	*0,0,1*
% of Sorghum Acres Treated	-	-	8%	*6,6,7*
Average Sorghum Acres Treated (among users only)	-	-	260.0	*0,0,1*

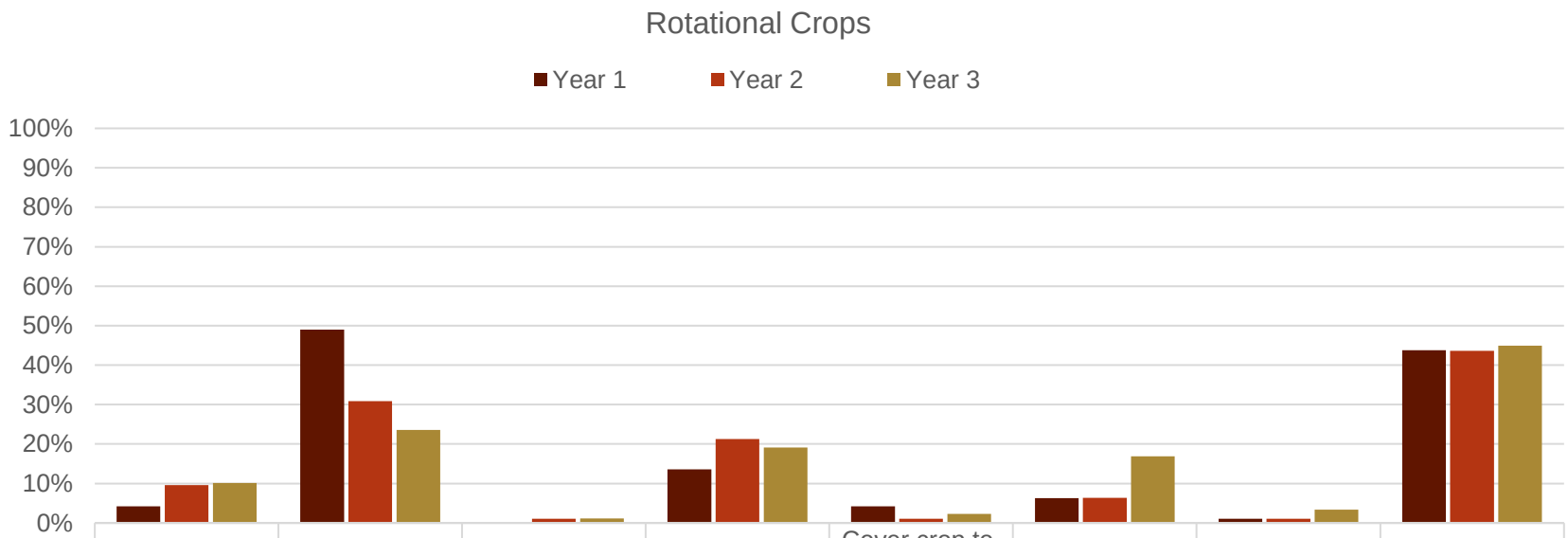
Non-Irrigated*	2019	2020	2021	*Base*
Average Rate (lbs./acre)	29.7	36.4	35.2	*11,12,13*
% of Sorghum Acres Treated	6%	5%	7%	*97,96,100*
Average Sorghum Acres Treated (among users only)	394.5	382.5	401.5	*11,12,13*

Source: Please tell me the application rate for [potash] to your [irrigated/non[irrigated] sorghum acres in [year]? How many acres were treated at that rate?
** Caution due to small sample.*

Other Farm Information

Crop Rotation

- Wheat is the crop that typically follows sorghum for the single largest portion of growers. Similar results were observed in the 2020 study.



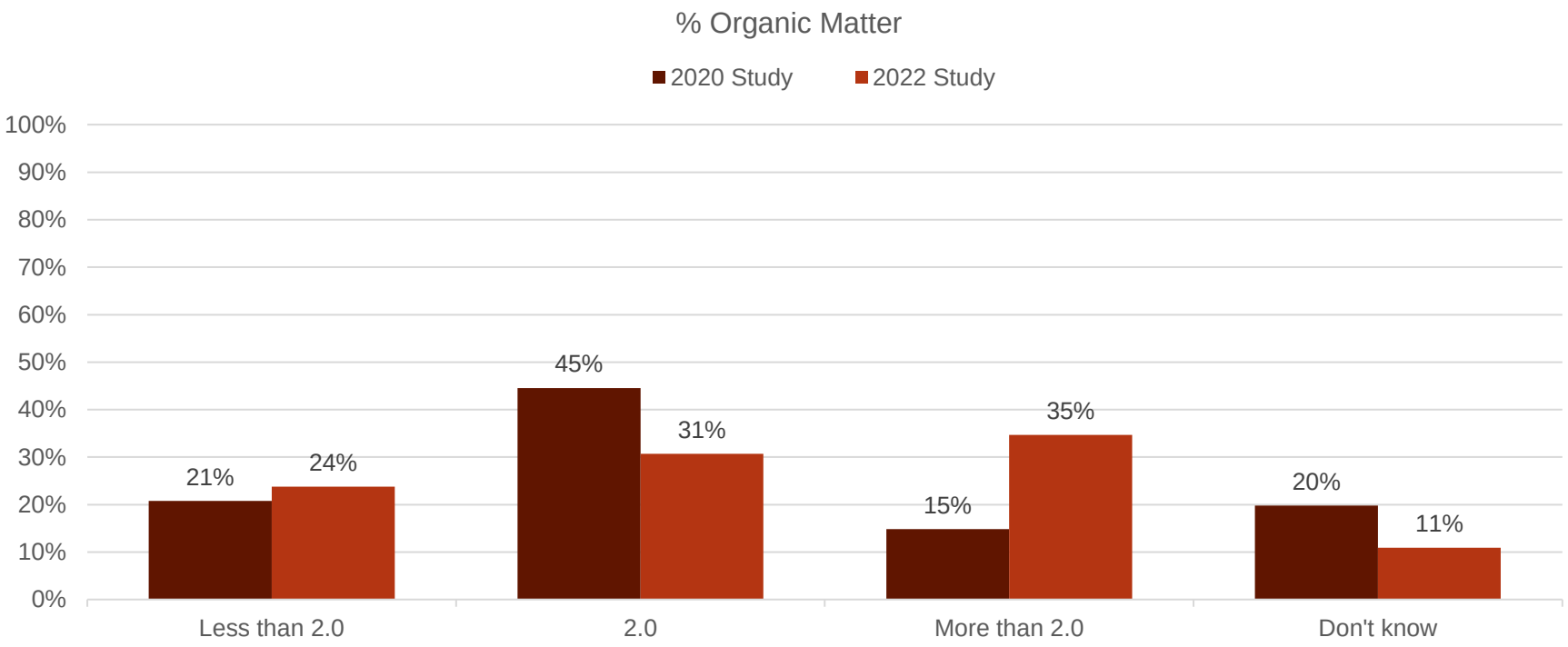
	Corn	Wheat	Cotton	Soybeans	Cover crop to control erosion	Fallow	Other	Sorghum
Year 1	4%	49%	0%	14%	4%	6%	1%	44%
Year 2	10%	31%	1%	21%	1%	6%	1%	44%
Year 3	10%	24%	1%	19%	2%	17%	3%	45%

Base =101.

Source: Common Kansas rotational systems include sorghum-wheat and sorghum-soybeans. What is your typical sorghum rotation?

Organic Matter

- Growers report an average of 2% organic matter in both 2020 and 2022.



Base =101.

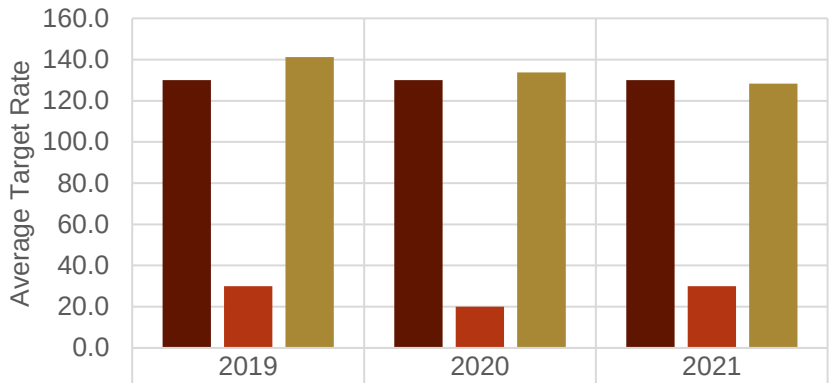
Source: What is your typical organic matter percentage? For context, typical Kansas soils have organic matter between 0% and 3%.

Nitrogen Use by Organic Matter

- Among growers with non-irrigated sorghum acres, growers with higher percentages of organic matter (>2%) report having a higher target rate for nitrogen on average.

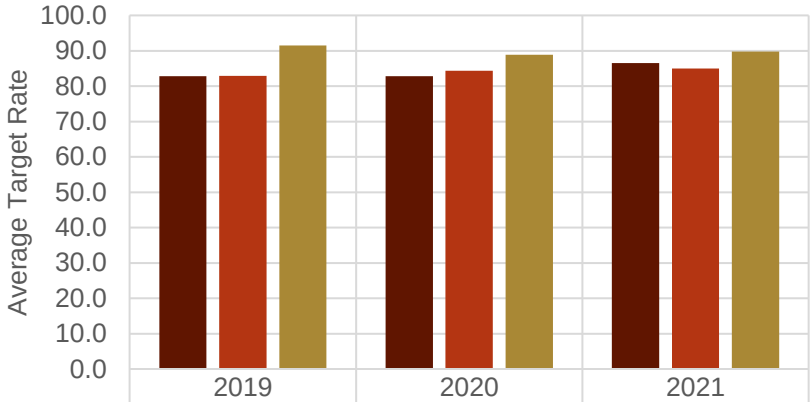
Average Target Nitrogen Rate by Percent Organic Matter

Irrigated Sorghum Acres*



	2019	2020	2021
< 2%	130.0	130.0	130.0
2%	30.0	20.0	30.0
>2%	141.3	133.8	128.3
<2%. Base:	*1*	*1*	*3*
2% Base:	*1*	*1*	*1*
>2% Base:	*4*	*4*	*3*

Non-Irrigated Sorghum Acres*

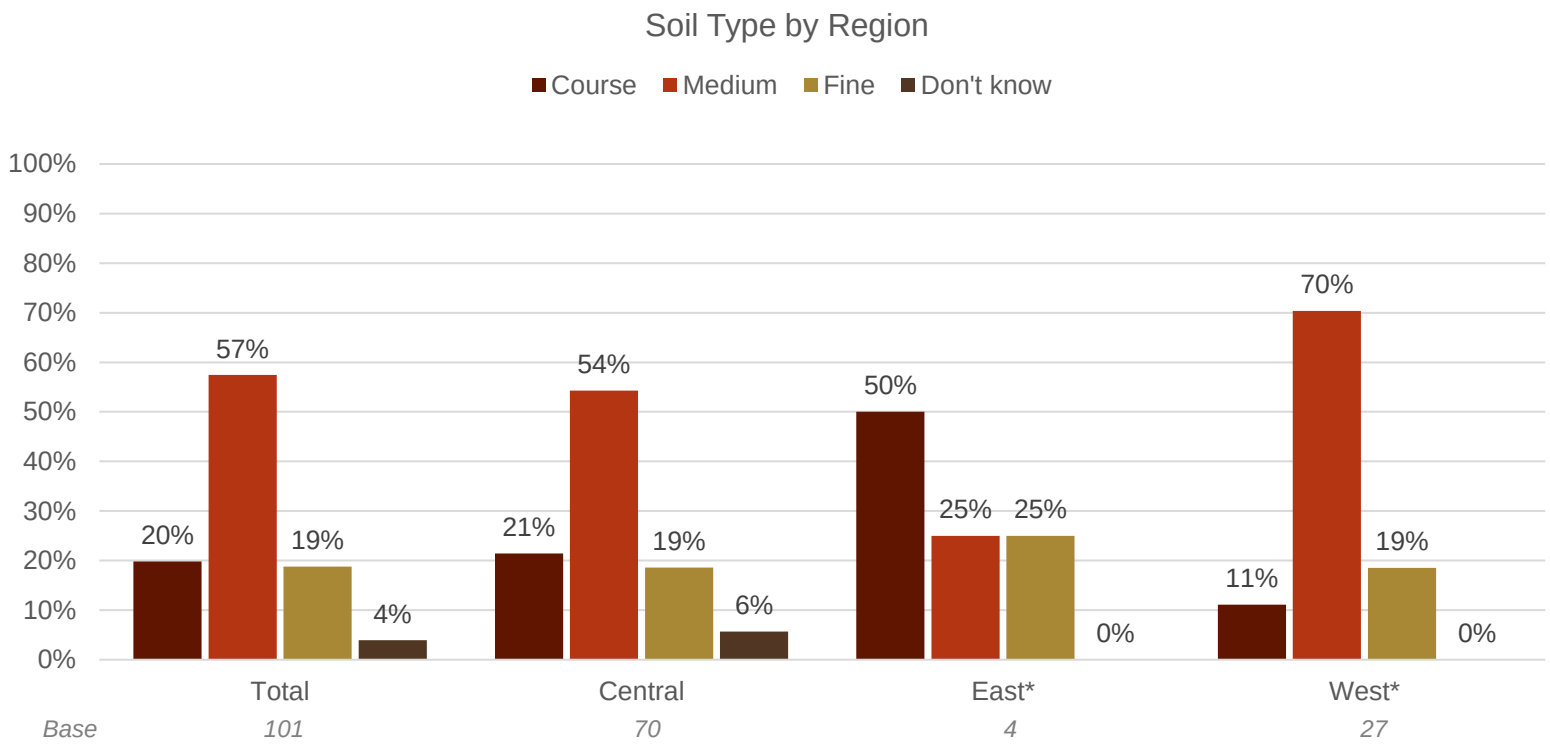


	2019	2020	2021
< 2%	82.8	82.8	86.6
2%	82.9	84.4	85.0
>2%	91.5	88.9	89.8
<2%. Base:	*22*	*22*	*21*
2% Base:	*26*	*26*	*27*
>2% Base:	*26*	*26*	*27*

Source: What was your nitrogen fertilizer target [lbs/acre] in [year] for your [irrigated/non-irrigated] sorghum acres? Please tell me the application rate for [phosphate/potash] to your [irrigated/non[irrigated] sorghum acres in [year]? What is your typical organic matter percentage? For context, typical Kansas soils have organic matter between 0% and 3%.
**Caution due to small sample.*

Soil Type

- Most growers describe their soil type as medium. This is especially true in the Western counties.



Source: How would you define your typical soil type---course, medium or fine?
**Caution due to small bases.*