



Carbon Footprint Study

Final Report

April 2020



Carbon Footprint Study

Study Background

April 2020

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 .
- The Sorghum Checkoff Program is now interested in redocumenting and confirming the model estimates using some of the primary predictors from the 2012 Sorghum Carbon Footprint Study. 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 2017, 2018 and 2019:
 - 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 April 2020. 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 2019.

- 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.

	Sampled Growers		Acres Represented		
	Desired	Completed	# of Acres Represented	% of Acres Represented	% of Acres Irrigated
Central	62	62	26,532	56%	3%
East	5	6	2,580	5%	0%
West	33	33	18,455	39%	8%
Total	100	101	47,567	100%	5%



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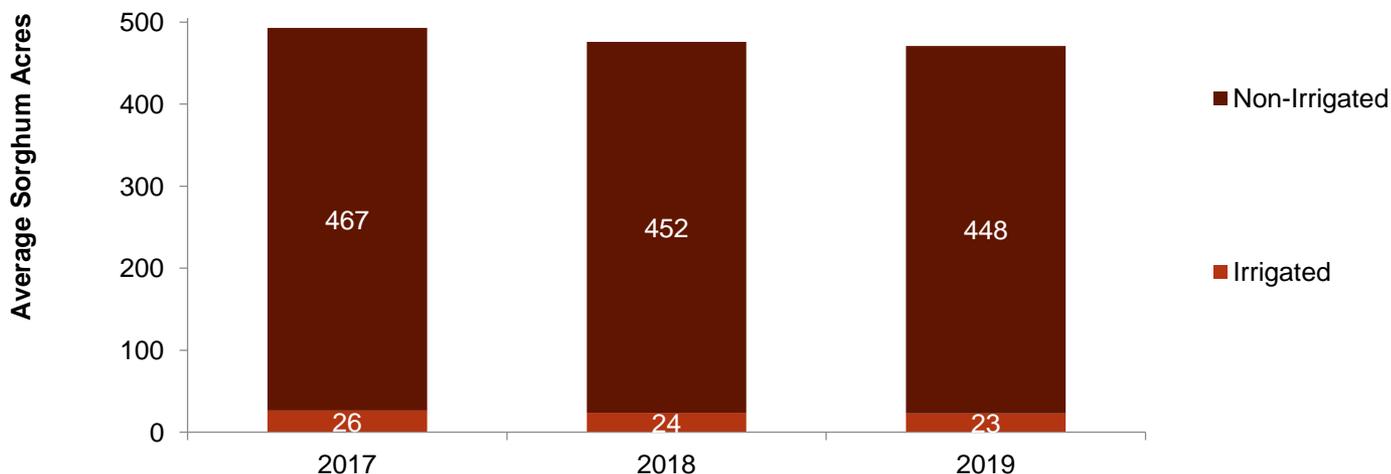
Sorghum Production

April 2020

Sorghum Acres Planted

- About 5% of sorghum acres are irrigated. Growers in this study planted on average 471 sorghum acres in 2019. Sorghum acres increased from 2017 and 2018 by about 8%.

Average Irrigated and Non-irrigated Sorghum Acres*

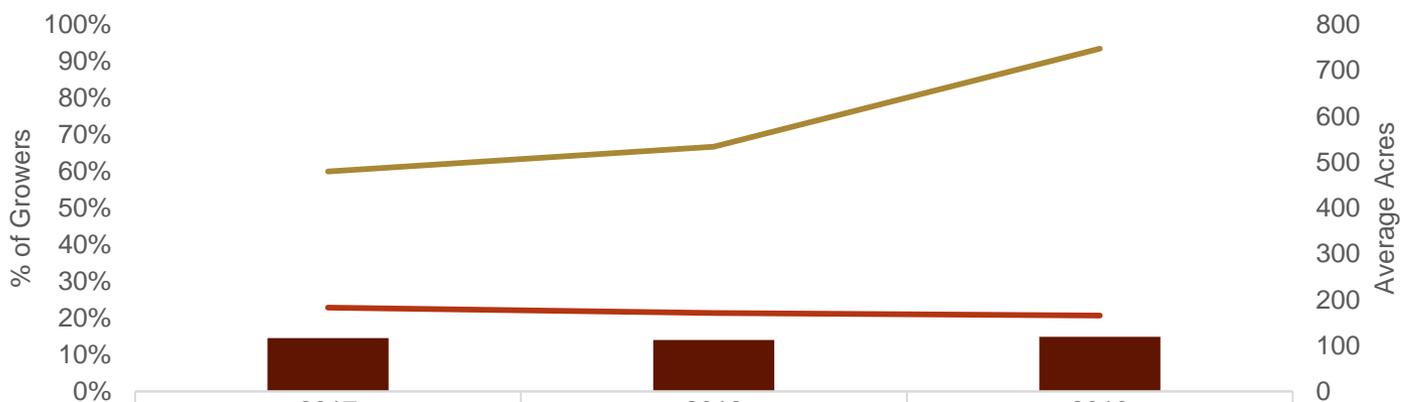


Average Sorghum Acres	439	438	471
% of All Sorghum Acres that are Irrigated	5%	5%	5%
Base	101	101	101

Source: How many [irrigated/non-irrigated] sorghum acres did you plant in the following years? *Includes 0. Base=101.

Irrigation in Sorghum

Average Acres Among Growers with Irrigated Sorghum Acres *



	2017	2018	2019
% Growers With Irrigated Sorghum	14%	14%	15%
Average Acres Irrigated	182	170	165
Average Acres Non-Irrigated	479	533	747

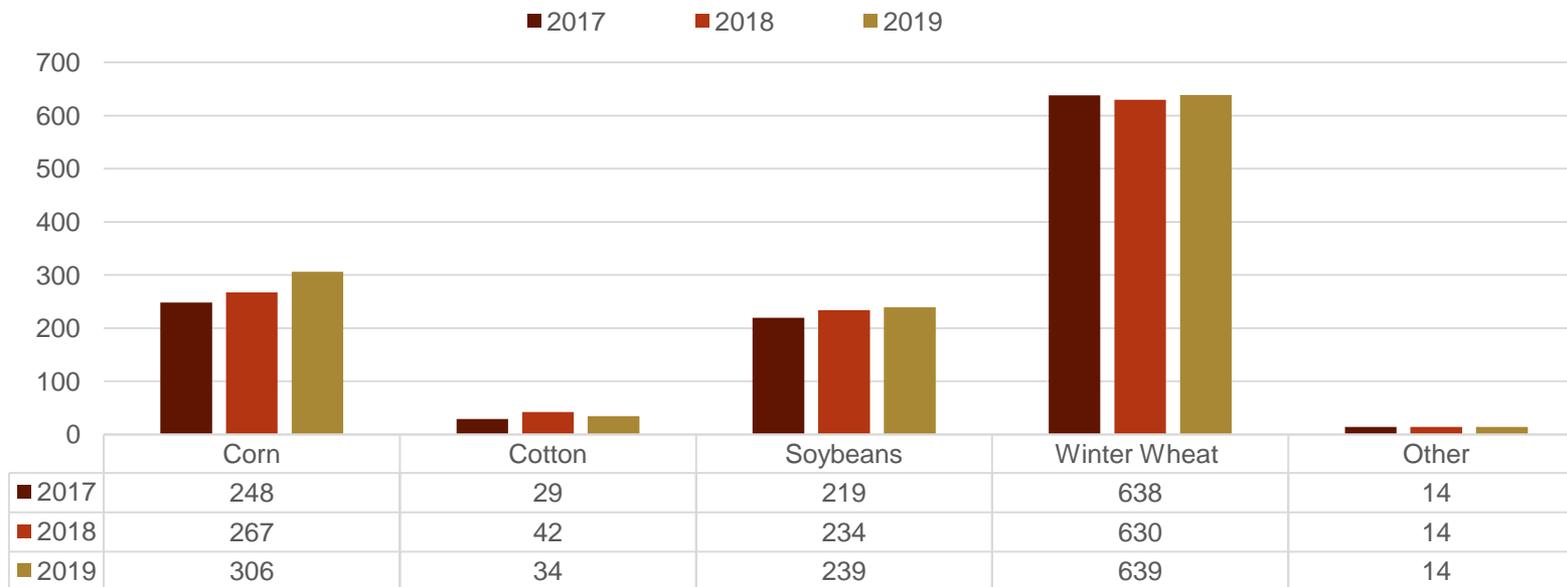
	2017	2018	2019
% of Growers	101	101	101
Average Irrigated	13	13	14
Average non0-irrigated	10	10	12

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.

Other Crops Planted

- Winter wheat is the next most planted crop among sorghum growers.

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

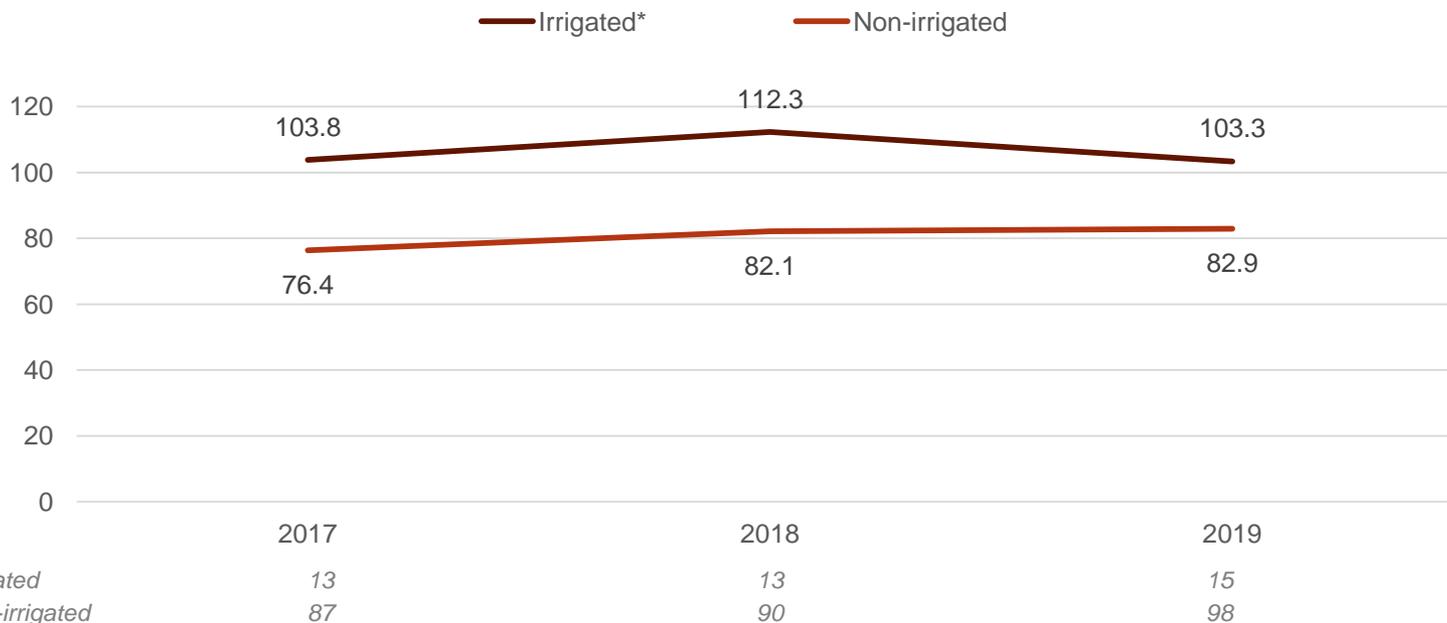


Source: How many acres of the following other crops did you plant in the following years? If none, enter 0. 0's included in average.

Sorghum Yields

- Sorghum yields have remained consistent over the past year at about 82 bushels per acre. Irrigated sorghum acres yield about 20% to 25% more bushels per acre than non-irrigated sorghum.

Average Sorghum Yields (Bushels per Acre) by Year

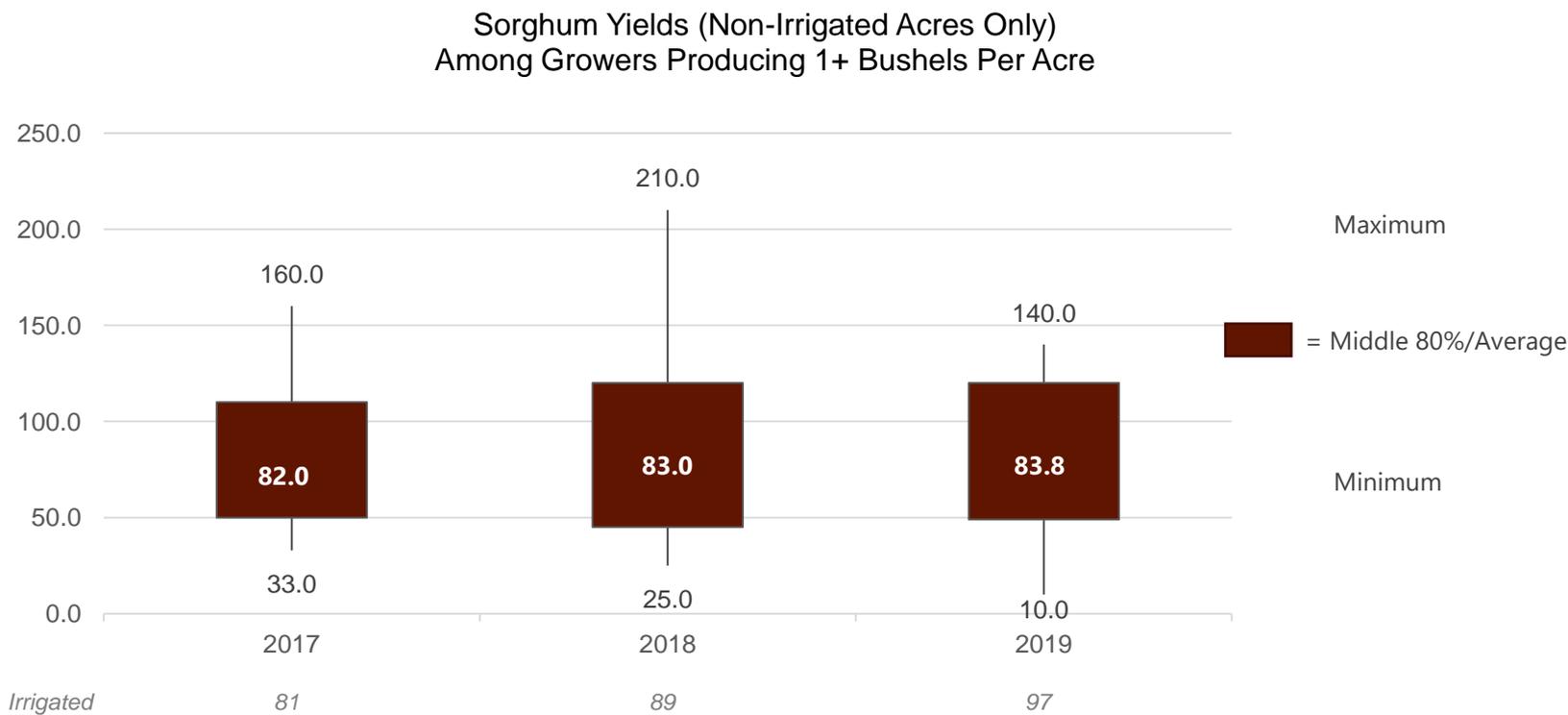


Source: What was your average sorghum yield in bushels per acre or pounds per acre for your [irrigated/non-irrigated] sorghum in the following years? Sorghum yields include 0's (i.e., growers who reported planting sorghum, but said they had 0 yields).

* Caution due to small sample size..

Sorghum Yields (Non-Irrigated Acres Only)

- Growers over the past three years have produced about 83 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?



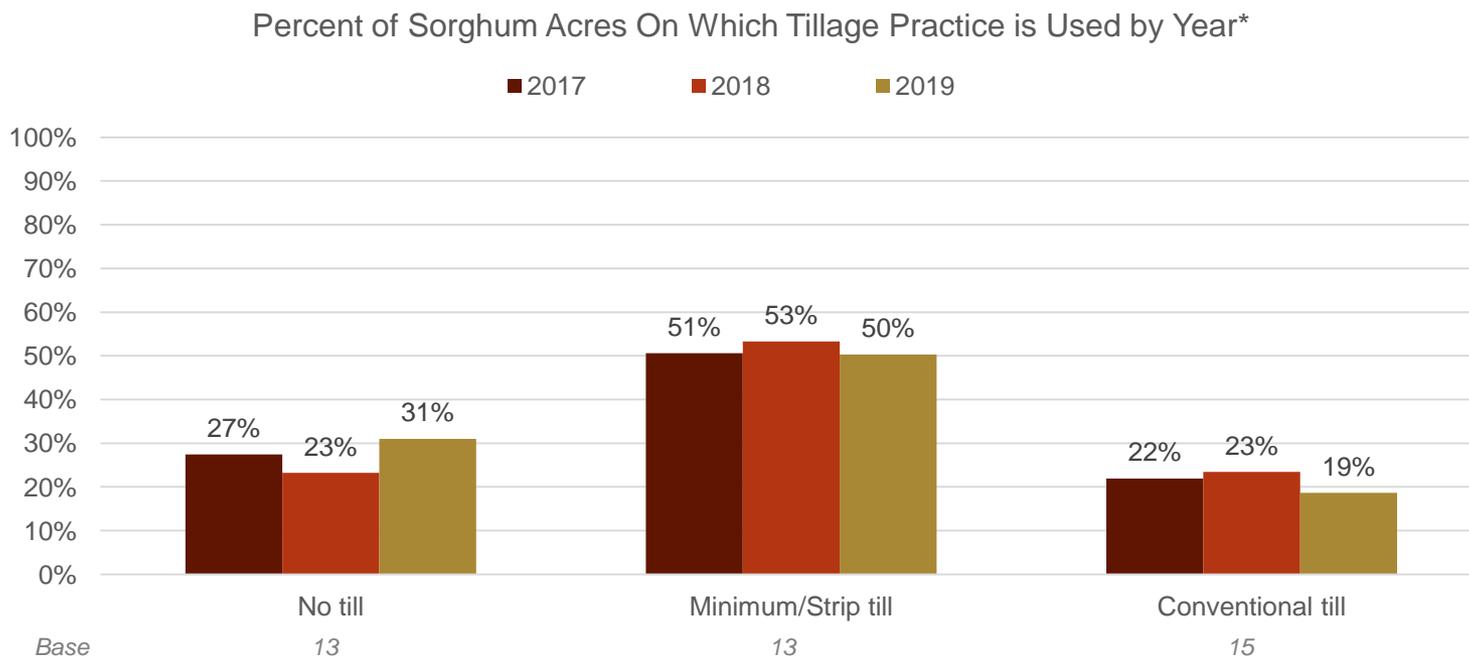
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Tillage Practices

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Tillage Practices on Irrigated Acres

- Roughly half of grower use strip till on their irrigated sorghum acres (50%). This was also true in 2017 and 2018.



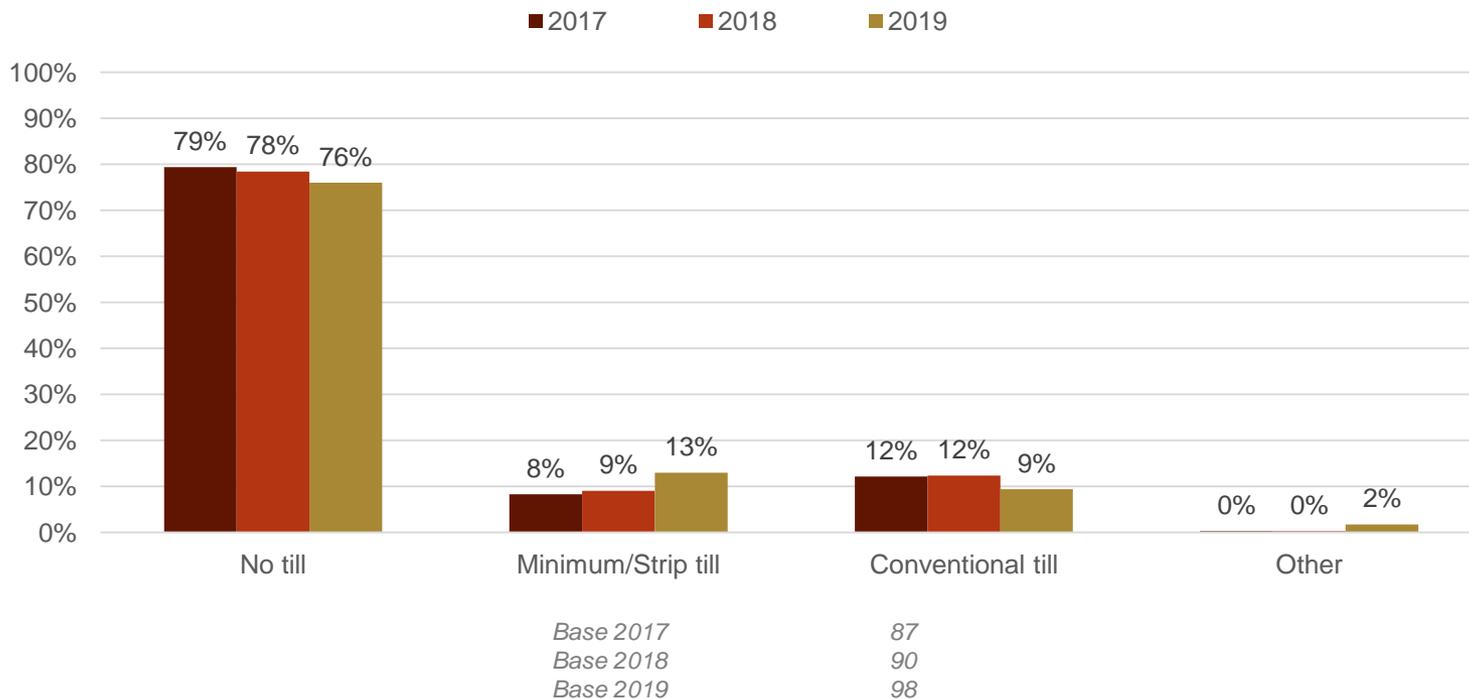
Source: How many of your sorghum acres were no till, minimum/strip till or conventional tillage in [year]?

* Caution due to small sample.

Tillage Practices on Non-Irrigated Acres

- Most all growers practice no till on their non-irrigated sorghum acres (76%). This was true in 2017 (79%) and 2018 (78%).
- Directionally, the practice of no till appears to be declining slightly and minimum till increasing.

Percent of Sorghum Acres On Which Tillage Practice is Used by Year



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



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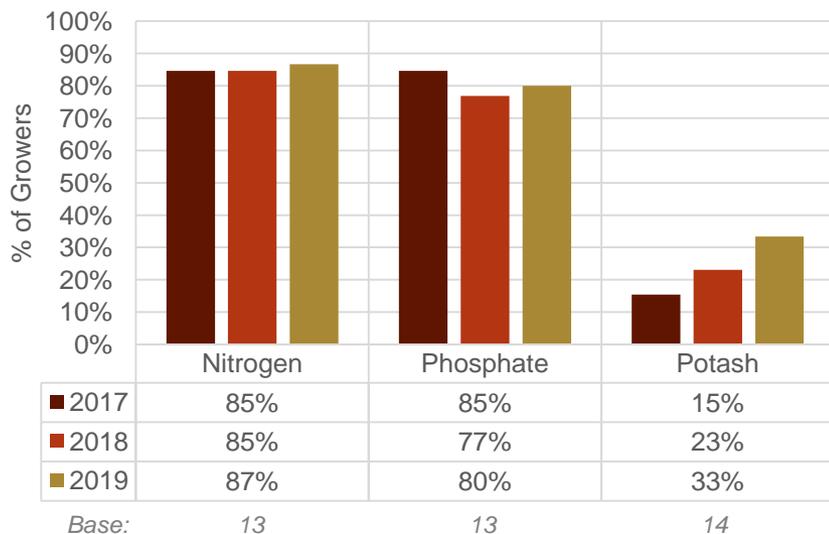
Carbon Inputs

April 2020

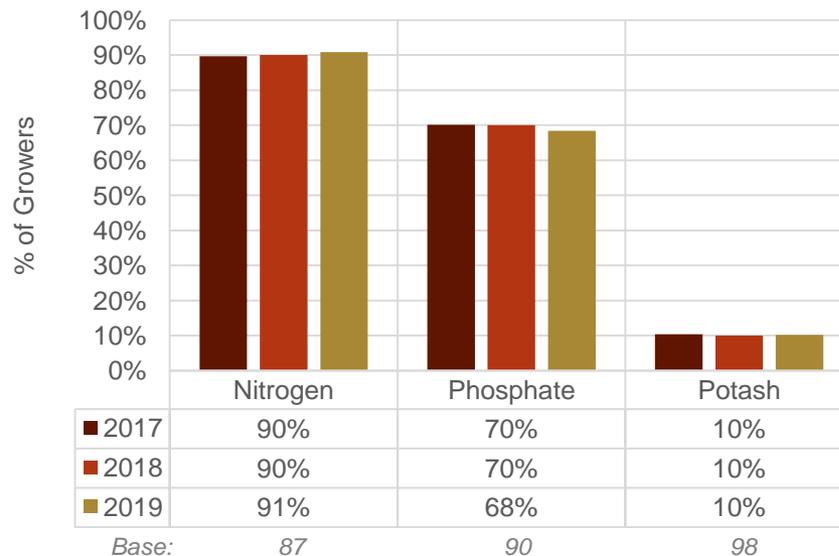
- Roughly 85% of growers apply nitrogen to their irrigated sorghum acres and 90% of growers apply nitrogen to the non-irrigated sorghum acres.
- Most all growers (irrigated and non-irrigated sorghum) apply phosphate to their acres. A higher portion of growers with irrigated acres apply this nutrient than growers with non-irrigated sorghum acres.
- The portion of growers with irrigated sorghum acres who applied potash increased year over year from 2017 to 2019. Few growers with non-irrigated sorghum apply potash (10%)*.

Nutrient Use Among Growers who Plant Sorghum in Indicated Years

Irrigated Sorghum Acres*



Non-Irrigated Sorghum Acres



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 108 lbs. per acre, compared to a target rate of 77 lbs. per acre for growers with non-irrigated sorghum acres. Over the past three years, growers with non-irrigated sorghum apply 30 lbs. to 35 lbs. less per acre to their sorghum than growers with irrigated acres. Growers target rate for nitrogen has not changed significantly over the past three years.
- 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*	2017	2018	2019	Base
Average Target Rate (lbs./acre)	113.6	112.3	107.7	11,11,13
% of Sorghum Acres Treated	87%	93%	87%	13,13,15
Average Sorghum Acres Treated (among users only)	169.1	169.1	137.3	11,11,13

Non-Irrigated	2017	2018	2019	Base
Average Target Rate (lbs./acre)	77.9	78.0	77.4	78,81,89
% of Sorghum Acres Treated	92%	92%	93%	87,90,98
Average Sorghum Acres Treated (among users only)	417.7	402.1	396.4	78,81,89

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.

- Growers generally apply phosphate at a slightly higher rate on their irrigated acres (35 lbs./acre) than non-irrigated acres (29 lbs./acre). Over the past three years, phosphate is applied to 70% to 75% of both irrigated and non-irrigated sorghum acres.

Phosphate Application Rates and Acres Treated at Application Rate

Irrigated*	2017	2018	2019	Base
Average Rate (lbs./acre)	32.3	31.5	35.0	11,10,12
% of Irrigated Sorghum Acres Treated	76%	69%	77%	13,13,14
Average Sorghum Acres Treated (among users only)	162.7	152.0	147.1	11,10,12

Non-Irrigated	2017	2018	2019	Base
Average Rate (lbs./acre)	29.0	29.4	29.2	61,63,67
% of Sorghum Acres Treated	74%	75%	70%	87,90,98
Average Sorghum Acres Treated (among users only)	508.3	502.7	469.6	61,63,67

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 is applied to about 10 percent of sorghum acres (irrigated and non-irrigated) at a rate of about 30 lbs. to 35 lbs. per acre.

Potash Application Rates and Acres Treated at Application Rate

Irrigated*	2017	2018	2019	Base
Average Rate (lbs./acre)	45.0	30.7	40.0	2,3,5
% of Sorghum Acres Treated	7%	10%	20%	13,13,15
Average Sorghum Acres Treated (among users only)	85.0	77.7	91.0	2,3,5

Non-Irrigated*	2017	2018	2019	Base
Average Rate (lbs./acre)	30.8	33.6	31.5	9,9,10
% of Sorghum Acres Treated	11%	9%	10%	87,90,98
Average Sorghum Acres Treated (among users only)	505.6	418.3	444.0	9,9,10

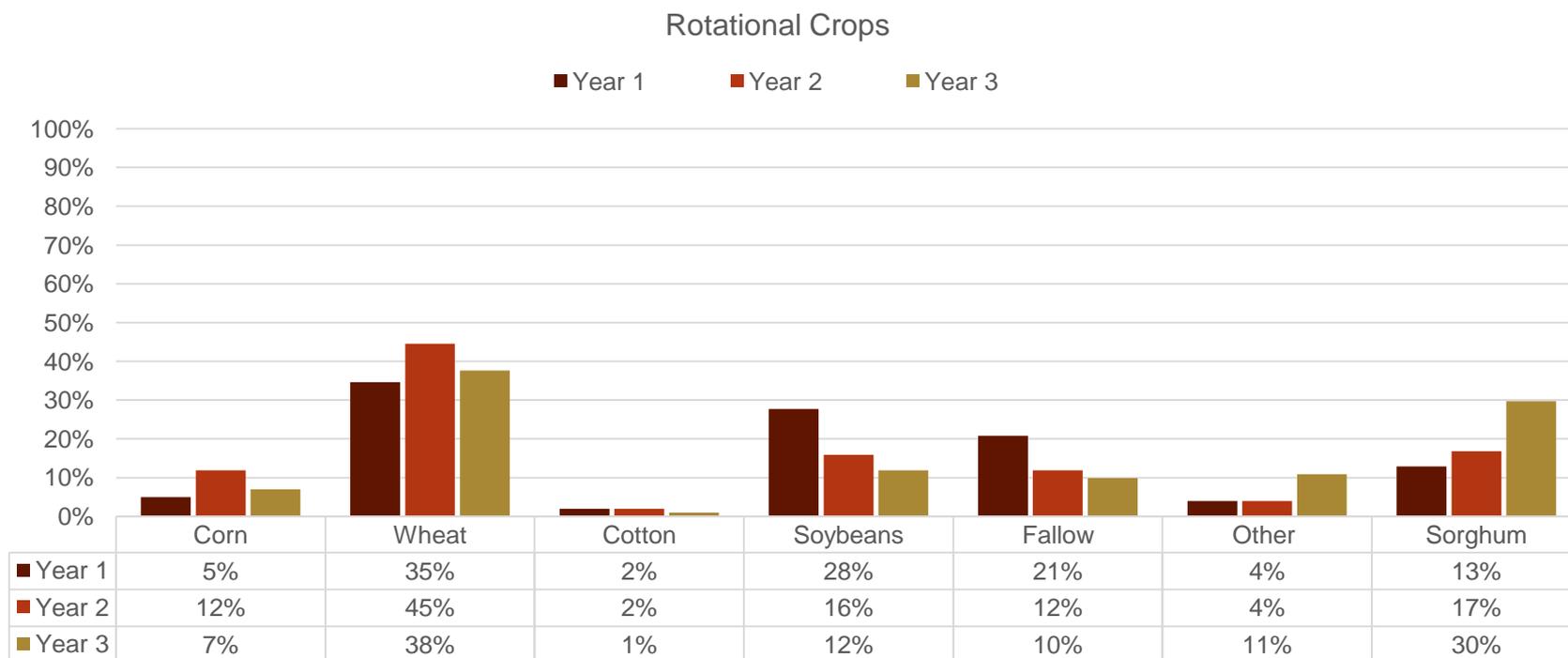
Source: Please tell me the application rate for [potash] to your [irrigated/non[irrigated] sorghum acres in [year]? How many acres were treated at that rate?

* Caution due to small sample.



Other Farm Information

- Wheat is the crop that typically follows sorghum for the single largest portion of growers (38%).

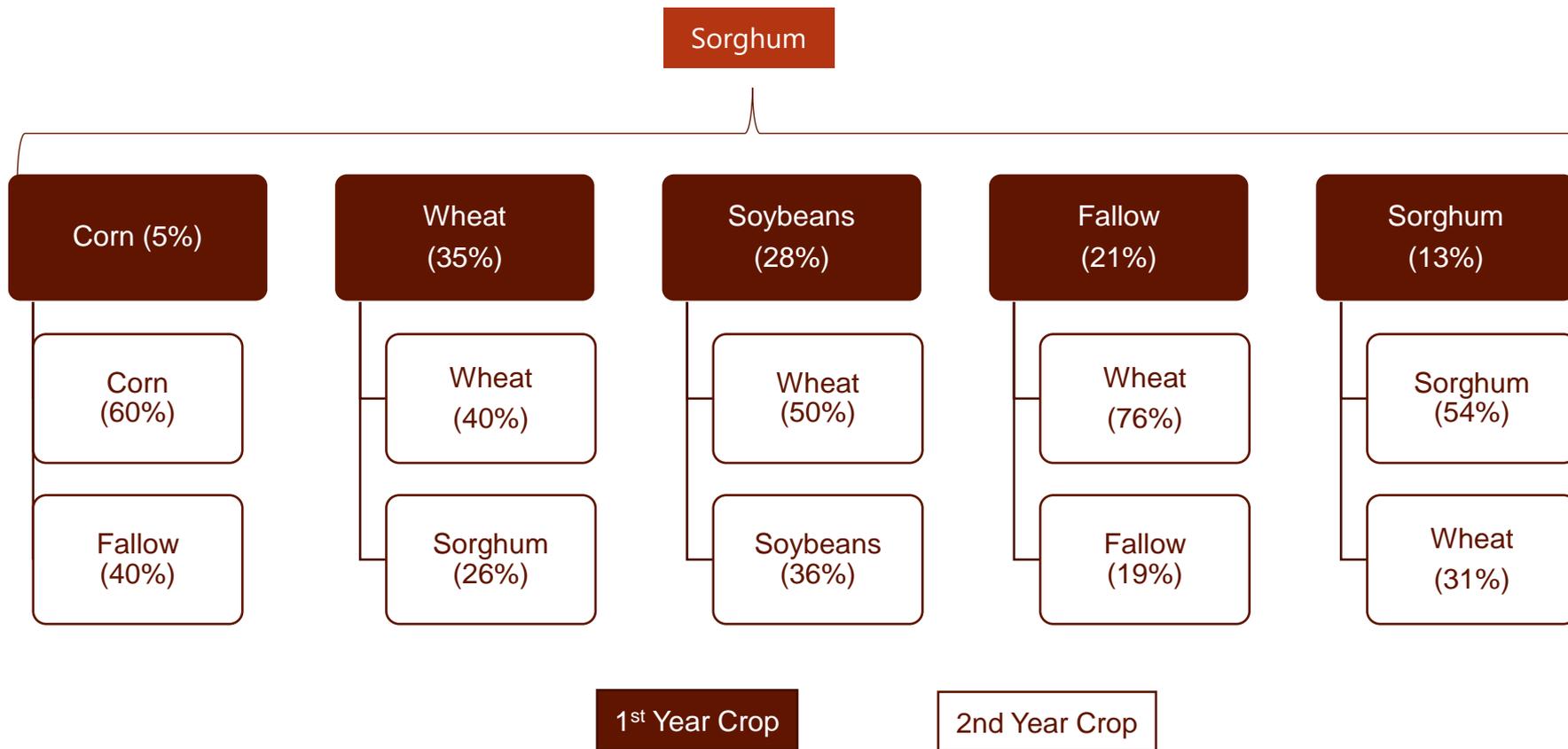


Base =101.

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

1st and 2nd Year Crop Rotations

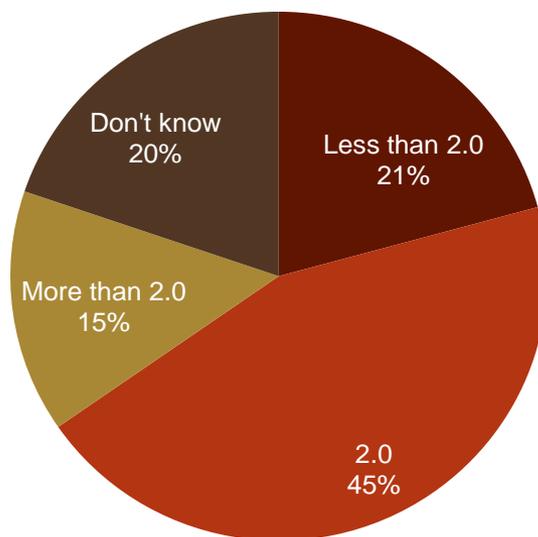
- The diagram below shows crops following sorghum in the first year followed by the two most mentioned second year crops. The highest portion of growers plant wheat (35%) or soybeans (28%) following sorghum in the first year. Half of growers who plant soybeans following sorghum plant wheat in the second year following sorghum.



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

- Growers report an average of 2% organic matter. About 20% of growers did not know the percent of organic matter.

% Organic Matter



Base =101.

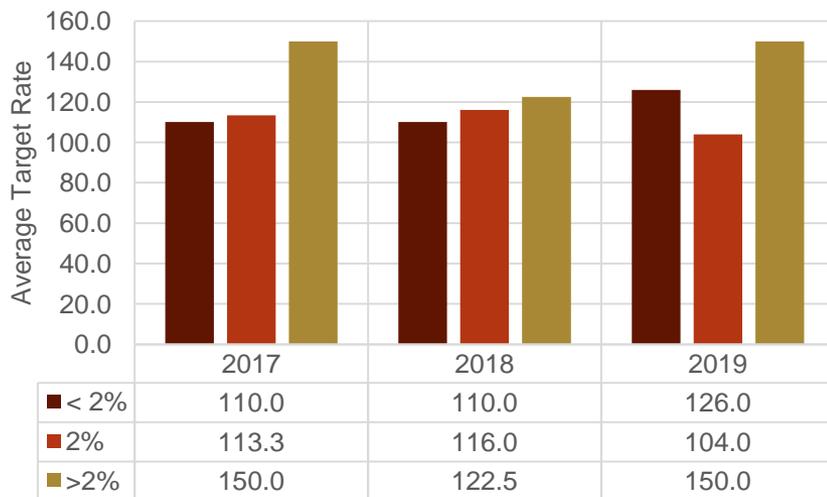
Source: *What is your typical organic matter percentage? For context, typical Kansas soils have organic matter between 0% and 3%.*

Nitrogen Use by Organic Matter

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

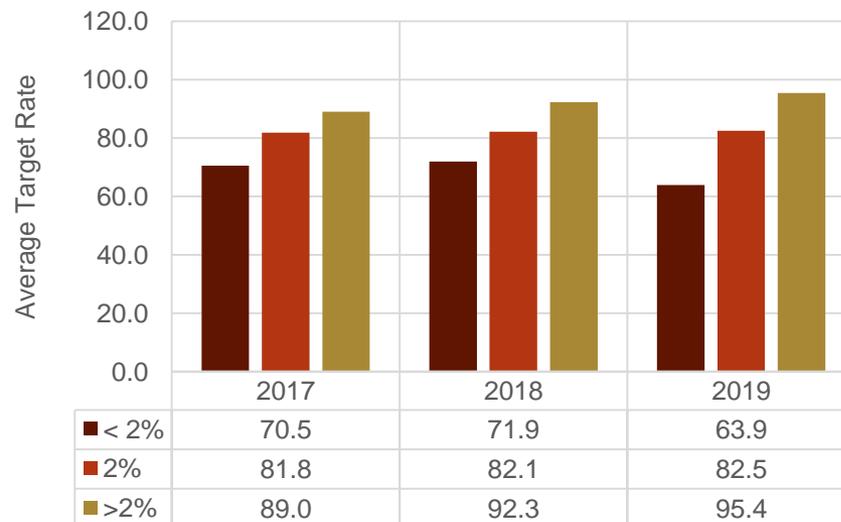
Average Target Nitrogen Rate by Percent Organic Matter

Irrigated Sorghum Acres*



<2% Base:	3	3	5
2% Base:	6	5	5
>2% Base:	1	2	1

Non-Irrigated Sorghum Acres*

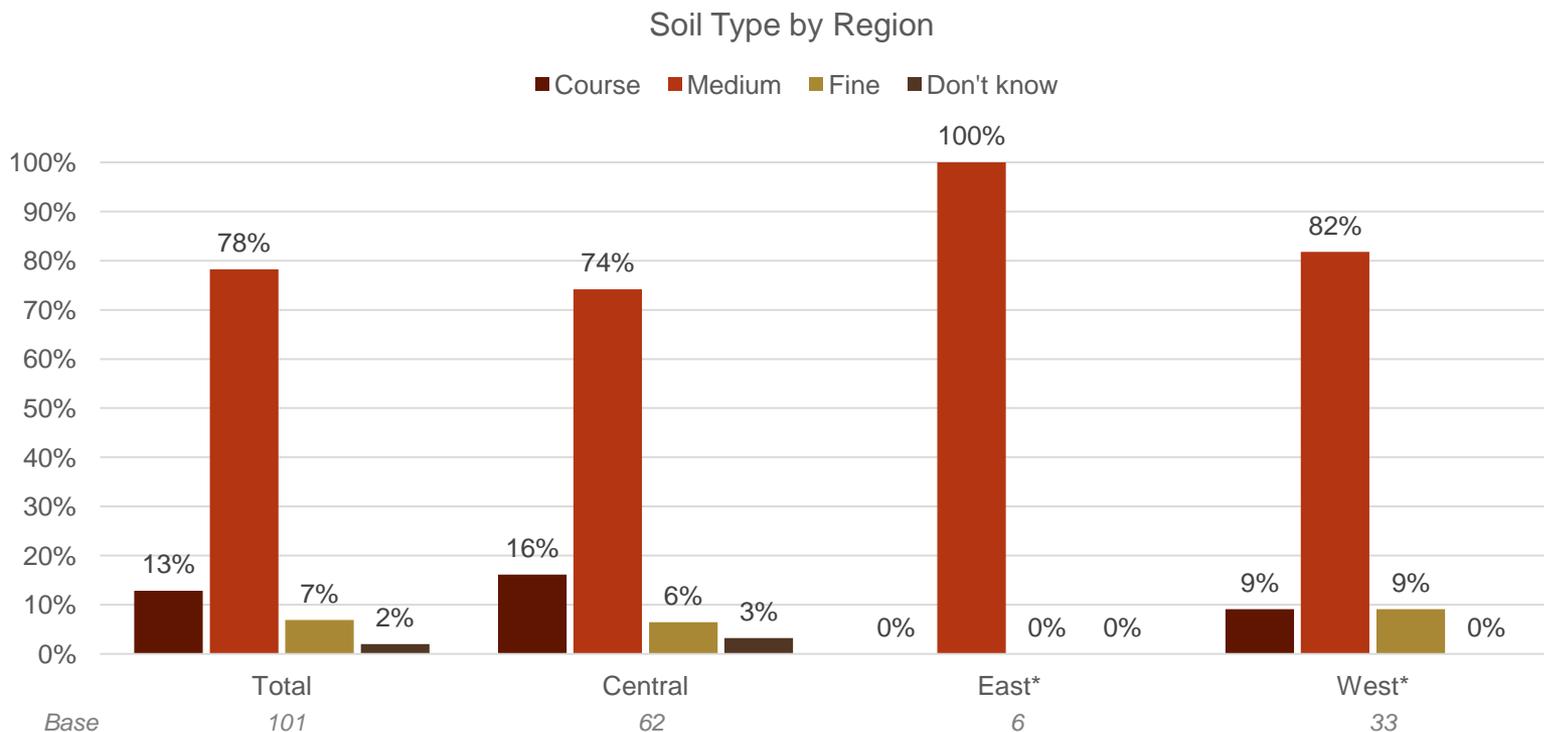


<2% Base:	15	14	17
2% Base:	38	38	40
>2% Base:	10	11	13

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.

- Most growers, regardless of region, describe their soil type as medium.



Source: How would you define your typical soil type---course, medium or fine?

*Caution due to small bases.



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Appendix



Counties in Regions

County	Region	County	Region	County	Region
Barber	Central	Cheyenne	West	Coffey	East
Barton	Central	Clark	West	Douglas	East
Butler	Central	Decatur	West	Johnson	East
Clay	Central	Finney	West	Labette	East
Cloud	Central	Ford	West	Marshall	East
Comanche	Central	Gove	West	Morris	East
Cowley	Central	Graham	West	Nemaha	East
Dickinson	Central	Grant	West	Riley	East
Edwards	Central	Gray	West	Shawnee	East
Ellis	Central	Greeley	West		
Ellsworth	Central	Hamilton	West	Saline	Central
Harper	Central	Haskell	West	Sedgwick	Central
Harvey	Central	Hodgeman	West	Smith	Central
Jewell	Central	Kearny	West	Stafford	Central
Kingman	Central	Lane	West	Sumner	Central
Kiowa	Central	Logan	West	Washington	Central
Lincoln	Central	Meade	West		
Marion	Central	Morton	West		
McPherson	Central	Ness	West		
Mitchell	Central	Norton	West		
Osborne	Central	Rawlins	West		
Ottawa	Central	Scott	West		
Pawnee	Central	Seward	West		
Phillips	Central	Sheridan	West		
Pratt	Central	Sherman	West		
Reno	Central	Stanton	West		
Republic	Central	Stevens	West		
Rice	Central	Thomas	West		
Rooks	Central	Trego	West		
Rush	Central	Wallace	West		
Russell	Central	Wichita	West		