Alternative enterprise opportunities for Southwest Kansas in the face of declining water availability: the case of sesame

by

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Abstract

Continued depletion of the Ogallala Aquifer raises pumping costs and threatens the irrigated corn that anchors farm income in southwest Kansas. Sesame requires much less irrigation than corn and is a candidate alternative, but whether it can replace corn income depends on price, yield, and the acreage a farm can devote to it. This study asks what sesame price, yield, and acreage would let a farm reach a benchmark income, and how much irrigation water would be saved in the process. Enterprise budgets (KSU 2026 irrigated corn and Texas A&M sesame) are combined with the mean Kansas Farm Management Association net farm income for 2004–2024 ($118,315) to derive break-even acreage and price thresholds and a set of whole-farm scenarios.

At the base sesame budget (1,000 lb/ac at $0.37/lb with 4 inches of irrigation), sesame returns $75.52 per acre above direct expenses, compared with $383.02 for corn with 13 inches. Matching the benchmark income with sesame alone would take 1,567 acres, below the 1,683-acre typical farm. Sesame would need to reach $0.368/lb for the typical farm to match the benchmark, $0.569/lb if only the 496 corn acres are converted, and $0.678/lb to equal corn's gross profit per acre. Replacing corn acre for acre saves 3,878 acre-inches, or 69% of the water used on those acres, at a forgone income of $34.17 per acre-inch. In the whole-farm scenarios, an all-sesame farm earns 107% of the benchmark income at 1,000 lb/ac and 62.6% at 1,200 lb/ac, while irrigation falls by 52%.

At current price and yield, sesame is not economically feasible for farmers in Southwest Kansas. Even under dryland production, sesame earns less gross profit per acre than corn and grain sorghum at the baseline yield of 600 lb per acre. It needs also higher yield or price to be competitive, exactly like irrigated condition. Therefore, these results suggest that sesame is a

water-saving option rather than a one-for-one replacement for corn at current prices and yields. Its viability depends on higher prices, higher yields, or policy that rewards water conservation, since private producers respond to farm-gate returns rather than the aquifer benefits their choices create.

Table of Contents

List of Figures vii
List of Tables viii
Acknowledgements ix
Dedication x
Chapter 1 - Introduction 1
1.1 Research Problem 2
1.2 Research Question 5
1.3 Objectives 6
1.4 Outline of thesis 7
Chapter 2 - Literature Review 8
1.1 Groundwater constraints 8
1.2 Crop choice and irrigation economics 10
1.3 Transition to rainfed production 11
1.4 Sesame evidence 12
1.5 Adoption and market constraints 13
1.6 Sesame uses and market demand 16
Chapter 3 - Methods And Data 25
3.1 Approach 25
3.2 Typical farm and income target 25
3.3 Enterprise budgets 26
3.4 Irrigation cost 30
3.5 Gross profit analysis 30
3.5.1 Income-equivalent sesame acreage 31
3.5.2 Price, yield, and pumping thresholds 31
3.6 Sesame in the typical portfolio 32
3.6.1 Scenario conditions 32
3.6.2 Replacement of the corn acres 33
3.6.3 Sensitivity analysis 33
3.7 Water economics 34
Chapter 4 - Results And Discussion 36
4.1 Typical farm baseline 36
4.2 Irrigation cost 36
4.3 Gross profit per acre 37

4.3.1 Revenue, variable cost and gross profit 37
4.3.2 Income-equivalent sesame acreage 39
4.3.3 Price and yield thresholds 40
4.3.4 Price scenarios 41
4.4 Replacement of the corn acres 42
4.5 Water saving 43
4.6 Dryland comparison 45
4.7 Whole-farm replacement scenarios 47
Chapter 5 - Implication And Conclusion 50
5.1 Implications 50
5.2 Limitations 51
5.3 Conclusion 52
Reference 54

List of Figures

Figure 1.1 Estimated usable lifetime for the Kansas High Plains aquifer 3

Figure 2.1: Sesame Varieties by Color..... 17

Figure 2.2: U.S. Sesame traditional production area 19

Figure 2.3: U.S. Import and Export Sesame Oil Price (2000 and 2024) 20

Figure 2.4: Distribution of U.S Sesame Oil Imports and Exports and by destination..... 21

Figure 2.5 The U.S. Sesame Supply-Chain Map 23

Figure 3.1: Acreage Allocation Across the Four Crops in Southwest Kansas 26

Figure 4.1 Return above direct expenses 39

Figure 4.2: Water saved when sesame replaces corn acre-for-acre..... 43

Figure 4.3. Net farm income after replacing crops with sesame, as a share of Y* 49

List of Tables

Table 1.1 Water requirement per crop in Southwest Kansas (Low yields level) 6

Table 3.1 Baseline crop allocation 27

Table 3.2 Yield and the irrigation applied per level 28

Table 3.3 Budget inputs (low irrigation level) 29

Table 4.1 Cost of pumping irrigation water, natural gas and diesel 37

Table 4.2 Values at the low irrigation level 38

Table 4.3 Sesame acreage by income target 40

Table 4.4 Thresholds (price at 1,000 lb/ac; yield at $0.37/lb) 40

Table 4.5 Sesame acreage and irrigation by price scenario (target Y*) 41

Table 4.6 Change in Irrigation Water Use (Sesame vs Corn) 44

Table 4.7 Dryland Baseline crop allocation 45

Table 4.8 Dryland sensitivity analysis 46

Table 4.9 Whole-farm replacement scenarios 48

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Dedication

This thesis is dedicated to my wife Eulalie Akotmo and our children Bakhita, Emmanuella, Victoria (deceased) and Archibald, to my mother Bainadi Balandi, my late father General Zamtato Gane-Bang, to Mirella, Annie, Patrick, Ndi Saba, Ngoh, and all my siblings.

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Chapter 1 - Introduction

Water is a fundamental resource required for agricultural production, and it affects farm and ranch productivity and profitability. In arid and semi-arid regions, agriculture has historically relied on highly variable and frequently insufficient rainfall. These limitations have been addressed with irrigation throughout history. As far back as 6,000 BCE, canals and diversions were used to bring water from the Tigris and the Euphrates to irrigate desert farmlands in Mesopotamia. The Egyptians used the shaduf (level lifter) to enhance crop production, drawing surface water from the Nile from about 2,000 to 1,500 BCE. The Archimedes Screw, aqueducts, and water wheels came into use from about 300 BCE to 100 CE in the Roman Empire and in China and India. Medieval Europe adopted windmills and dikes from 500 to 1,500 CE to overcome water limitations in crop production, and by the 19th Century, motorized pumps have started to change agricultural production and productivity in arid and semi-arid areas. They led to sprinkler systems and enabled the lifting of groundwater for irrigation using technologies like center pivot by the middle of the 20th Century.

The progression of irrigation technologies, especially motorized pumping, has lowered the cost of accessing groundwater, making the cultivation of certain crops economically attractive in areas where limited naturel water availability would otherwise constrain production. The outcome is that groundwater and aquifers are experiencing stressors they have not experienced before more irrigation technologies, and that is causing concern to farmers first, then among other water users, like households and industrial users. Better technologies in the last 50 years have improved water use efficiency, but the adverse effects of irrigation in arid and semi-arid areas have also accelerated over that period. This is primarily a result of a focus on efficiency without appreciation of the overall impact of water users' actions.

The main economic problem farmers in southwest Kansas are really facing is not whether there will be enough groundwater in the next decades. The major challenge that farmers will be confronted to is the declining usable irrigation capacity (Araya et al., 2019). The depletion of groundwater has reduced the capacity of many wells to meet crop irrigation requirements. The implications for farm returns are directly perceptible to variable costs for crops like corn, wheat, or sorghum. As the wells go deeper, it requires more energy to lift the groundwater to the surface to irrigate farms.

Rather than focusing solely on the hydrological aspects of Ogallala Aquifer depletion, this study emphasizes the economic implications of groundwater access. It asks how farmers can maintain profitability if the cost of accessing groundwater continues to rise, even where water remains physically available. The purpose of this study is to explore the adaptation options available to farmers. Even where groundwater remains physically available, rising pumping costs can reduce the profitability of irrigated production and create incentives to adjust irrigation practices or crop choices (Himanshu et al., 2021)

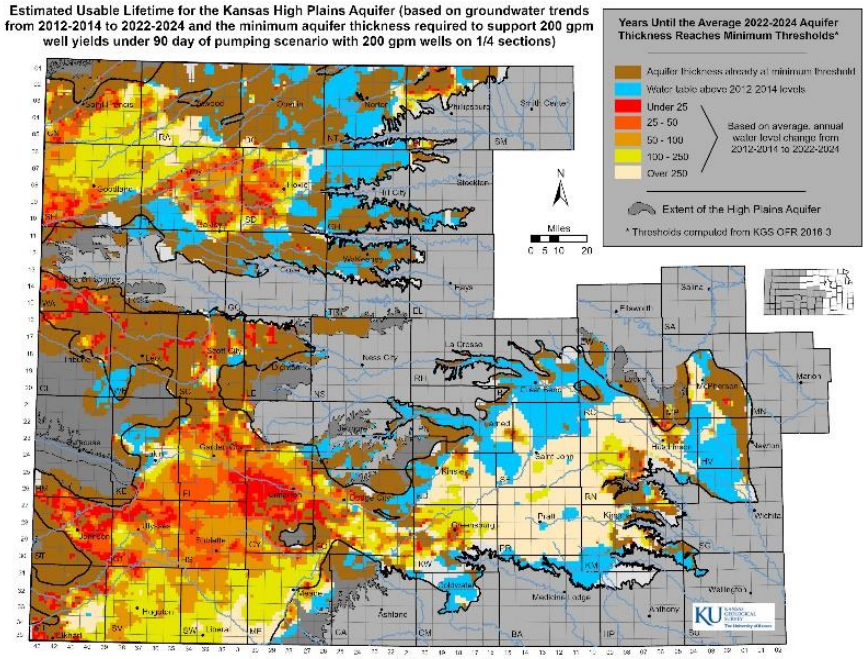
1.1 Research Problem

In 2022, Kansas has roughly 28 million acres of total cropland, with 20.31 million (or 72%) harvested cropland. Irrigation covered 2.34 million acres, approximately 11.5% of harvested cropland (USDA NASS, 2024). Farms using irrigation accounted for 40.1% of the state's agricultural product sales. This condition is resulting from the development and adoption of center-pivot irrigation systems in the 1950s (Nutt-Powell & Landers, 1979).

Thanks to this technological revolution, this part of the Midwest experienced the expansion of new water-intensive, allowing farmers to choose crops and irrigation levels (Steward et al., 2013) according to expected returns, costs and water availability.

The intensification of irrigation carries some disadvantages, one of which is the accelerated depletion of the Ogallala Aquifer, the principal source of groundwater for regional agriculture. Water levels in the aquifer have declined in some areas by an average of 1.7 feet (Figure 1.2) since 1996 (Gloaguen et al., 2021), driven by pumping rates that far exceed natural recharge (Steward et al., 2013; Mc Guire, 2014). This ongoing decline calls into question the long-term viability of producing highly water-consuming crops and underscores the need to explore alternative enterprises that are less dependent on irrigation. Deines et al. (2020) describe the question facing communities as "more a question of when than whether" they must sustain livelihoods without irrigation.

Figure 1.1 Estimated usable lifetime for the Kansas High Plains aquifer



Source : Kansas Geological Society

This reality underpins the motivation behind the alternative enterprise project for enhancing water security, which seeks to evaluate the economic feasibility of alternative crops not yet widely adopted in Southwest Kansas but potentially better suited to limited-water

conditions. Parts of the region receive less than 20 inches (≈508 mm) of precipitation per year. Limited and variable rainfall can constrain crop yields, making supplemental groundwater irrigation an important option for supporting agricultural production. (Steward et al., 2013a). At the same time, farmers are facing recurring droughts in the region. Drought has been defined as a deficiency of precipitation over an extended period that results in a water shortage (National Integrated Drought Information System).

Within the next five to ten years, the main challenge facing farmers in Southwest Kansas will not only be water availability but the rising cost of accessing that water (Deines et al., 2020). As groundwater levels continue to decline, wells must be drilled deeper, and more energy is required to lift blue water to the surface; consequently, pumping costs increase sharply as water depths increase (Perrone & Jasechko, 2019). Simulations for southwest Kansas show that returns above variable cost for corn rise from $16/ha with no irrigation to $530/ha at 5 mm/day capacity, so income from corn depends heavily on how much water a well can deliver (Araya et al., 2019).

Producers still have several options. Under the LEMA in northwest Kansas, water use fell 26%, and most of the response was lower irrigation intensity on the same crops, not switching crops or reducing acreage (Drysdale & Hendricks, 2018). Optimization modeling suggests that stricter pumping limits shift optimal cropping from corn toward sorghum (Yu et al., 2024). It is worth adding that transitioning to dryland is not always uniformly available either: 13% of land likely to lose irrigation is unsuitable for dryland crops, and not considering this overstates the economic benefit of transition by 12–45% (Deines et al., 2020).

Higher pumping costs will inevitably reduce farm profitability and depress land values, since land with diminished or uncertain water access is presumed to carry lower economic potential. Because farmers are under increasing pressure to use irrigation water more efficiently,

there is growing interest in thinking about different agriculture enterprises. In the United States, particularly in semi-arid regions such as the High Plains, agriculture depends heavily on groundwater extracted from aquifers. Continued depletion of this resource is not only a hydrological concern but also an economic one, as declining water tables increase the energy required for pumping and, consequently, the overall cost of irrigation (Mc Guire, 2014; Perrone & Jasechko, 2019).

1.2 Research Question

According to Jim Butler, senior scientist at the Kansas Geological Survey, "the only way to slow water-level declines is to reduce pumping in conjunction with modification of agricultural practices" (Tollefson & Butler, 2023). Reducing water use in Southwest Kansas is non-negotiable. Total pumping for irrigation must go down, and that rule cannot change. What can still be adjusted are the strategies: alternative crops, improving irrigation practices, and/or introducing more drought-tolerant crop varieties. For water management to be effective and not cause significant social welfare losses, its goal must be expanded to include the preservation of the farm household's ability to earn a living and continue operating. In this research, we explore whether the income of crop farmers in Southwest Kansas can be maintained with alternative crop enterprise combinations while reducing water use at the same time. In other words:

What economic conditions (price, yield or pumping cost) would make sesame a viable alternative to irrigated corn under water scarcity in Southwest Kansas?

The irrigation water requirements by the major cash crops currently produced in Southwest Kansas are given in Table 1.1. The table shows that irrigation water requirement for

corn is 3.25 times that of sesame at 13 and 4.0 ac-in per year, respectively. It also shows that soybeans, at 9.0 ac-in per year, demands about 225% more irrigation water than sesame. Also, sorghum's irrigation water demand is approximately 265% higher than sesame's. Saving the water does not help sustain farm families and their communities in Southwest Kansas if those families lose their livelihoods. Therefore, it is important to assess how farm income may be maintained while reducing water use.

Table 1.1 Water requirement per crop in Southwest Kansas (Low yields level)

Crop	Water applied (in)	Yield (bu)
Corn	13	185
Soybeans	9	55
Sorghum	10.5	144
Canola	4	22
Cotton	6.8	40
Sesame	4	22

Source: K-State AgManager 2026

Table 1.1 suggests that sesame and canola might offer significant water saving opportunities in Southwest Kansas. However, their economics would be the final decision variable in their ability to sustain farm family incomes.

1.3 Objectives

The overall objective of this research, given the foregoing, is to evaluate sesame's viability as an alternative enterprise under irrigation water constraints by comparing its ability to replace or exceed corn's contribution to farm family income. The specific objectives are as follows:

1. Evaluate the relative irrigation was consumed by the typical farm in Southwest Kansas to produce the average annual farm family income of $118,315 over the past 20 years as estimated from USDA farm income statistics (NASS, 2025)
2. Determine the irrigation water that could be consumed in the production of sesame to produce the same average farm family income as determined above.
3. Analyze the technical and economic feasibility of producing sesame in Southwest Kansas.
4. Determine the economic conditions under which sesame could be included as an alternative crop in Western Kansas capable of producing the historical average farm family income.

1.4 Outline of thesis

The study is organized as follows: the next chapter presents the relevant literature on alternative crops to consider when irrigation water is constrained. The specific literature on sesame as a potential water-saving crop in arid and semi-arid places is reviewed to provide the context for sesame consideration as a potential alternative crop. Chapter III presents the conceptual framework and describes the enterprise budgets used in the study. These budgets provide the foundational data used for the empirical analyses in this theses. Chapter IV reports the research, and Chapter V provides the summary and conclusions of the study. This chapter also provides suggestions for future work that must be done to find sustainable solutions to the farm income-water conservation challenge facing farmers in Southwest Kansas. This work is important because it provides the foundation for exploring sustainable solutions to the water challenge once and for all.

Chapter 2 - Literature Review

This chapter reviews the literature on groundwater constraints, crop choice and irrigation economics in arid and semi-arid environments, the transition to rainfed production, sesame as an alternative, and market constraints. The chapter is organized into three sections. The first section discusses the depletion of the Ogallala Aquifer and examines changes in groundwater levels. The second section addresses the challenges faced by agriculture under water-constraints and introduces alternative crops. The third section reviews the agronomy of sesame, its uses, and market demand.

1.1 Groundwater constraints

The High Plains Aquifer supports irrigated agriculture across western Kansas and several other states. In Southwest Kansas, pumping has been exceeding the recharge rate for several years of drought conditions and inadequate rainfall in recharge regions. Across the aquifer, irrigation pumping is estimated to exceed average recharge by a factor of 2–7 (Basso et al., 2013). In Kansas, (Steward et al., 2013) estimated that about 30% of the groundwater in their study area had already been depleted and that, if pumping continue at current trends, , a further 39% would be depleted over the next 50 years. Because natural recharge is small relative to withdrawals, it supplies about 15% of current pumping and would take an average of 500–1,300 years to refill a depleted aquifer. Steward & Allen, (2016) estimated that the annual rate of depletion in Kansas peaked around 2010. It is worth mentioning that as the peak has passed, does not mean that depletion has stopped, because the projections still show declining saturated thickness. Business-as-usual projections from the same study suggest that by 2060 only 18% of the original saturated thickness would remain in west-central Kansas and 27% in southwest Kansas (Perez-Quesada & Hendricks, 2021).

In 2009, irrigated acreage accounted for more than 70% of the combined production value of five major crops in southwestern Kansas (Rogers & Lamm, 2012). The authors observed that irrigated production accounts for a greater share of total crop value under dry conditions, when dryland yields decline. The production of wheat, grain sorghum, corn, soybeans, and alfalfa thanks to irrigation accounted for nearly $789 million for this year.

Butler et al., (2014) argued that the logistic-curve projections of Steward et al. (2013) rest on an inadequate hydrologic basis and have "little bearing on future conditions" in western Kansas. Estimations of the pumping reduction needed to sustain the aquifer accordingly differ broadly: about 80% in Steward et al. (2013), against 21–33% in Butler et al. (2016, 2018), both as summarized by (Perez-Quesada & Hendricks, 2021). Castaño-Sánchez et al., (2025) put the necessary reduction at 25–30% to stabilize water levels on a decadal scale.

What matters the most for farmers is not the date at which the aquifer will be exhausted, but when wells can no longer deliver enough water for a given crop. This is the real challenge producers and policymakers focus on. In some areas of Kansas and Texas, farmers can no longer pump enough water to meet crop demand (Basso et al., 2013). Irrigation is generally considered impractical once saturated thickness falls below about 9 m, and the share of the Ogallala Aquifer below this threshold is projected to rise from 25% to 40% between 2012 and 2100 under status quo management (Haacker et al., 2016, as cited in Deines et al., 2020). So, the aquifer's disappearance is not the biggest concern, it is its irrigation capacity. That is why this study treats declining irrigation capacity as the condition under which the economic comparison is made, without depending solely on a particular depletion forecast.

1.2 Crop choice and irrigation economics

The Ogallala formation is the largest part of the High Plains aquifer system shared among eight States: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. Farmers' crop and irrigation choices in these states respond to water availability, but the evidence suggests they adjust slowly and mostly along one margin. Hornbeck & Keskin (2014) show that when farmers gained access to Ogallala groundwater, they first increased irrigation intensity and only later shifted land toward more water-intensive crops such as corn. They note that the reverse should hold when groundwater access is lost, i.e., in the short run, farmers reduce irrigation intensity, and in the long run they shift land away from water-intensive crops. (Basso et al., 2013) add that crop selection is "driven primarily by economics," which is why irrigated corn has persisted in places where water is declining.

The Kansas experience with the Sheridan-6 Local Enhanced Management Area (LEMA) shows how farmers respond to water restrictions. Under a five-year allocation of 55 inches per authorized acre, roughly a 20% cut from historical use, water use fell 26%. Most of the reductions came from less irrigation on the same crops (21 percentage points), with a smaller contribution from changes in crop mix (4.5 percentage points) and no significant change in irrigated acreage (Drysdale & Hendricks, 2018). Earlier Kansas studies of water-price response also found most of the adjustment along the intensive margin (Hendricks and Peterson, 2012; Pfeiffer and Lin, 2014, as cited in Drysdale & Hendricks, 2018). The authors note that this exposes farmers to greater production risk. Yu et al., (2024), in a preprint article using stochastic optimization, find that optimal cropping shifts from predominantly corn to sorghum as pumping limits tighten. They also find that the model's strategy outperformed observed farmer strategies during the first two LEMA periods (2013–2022).

The economics of the crop choice depends on irrigation capacity. In simulations for southwest Kansas for example, the return above variable cost for corn rose from $16/ha with no irrigation to $530/ha at a capacity of 5 mm/day, while the median returns for rainfed wheat ($252/ha) and grain sorghum ($180/ha) exceeded those for the irrigated versions ($169–192/ha and $104–110/ha) (Araya et al., 2019). The authors warn that corn income at high capacity "may not last long" given falling water levels. Suttles et al., (2024), combining climate and crop modeling with farmer interviews, identified also sorghum in place of corn as a feasible switch, and Castaño-Sánchez et al., (2025) found that in the Sheridan-6 LEMA, corn and soybeans were replaced by sorghum and wheat, with yield reductions of 1.2–15% and a 28% fall in blue water use. These studies concentrate on sorghum, wheat and similar conventional crops. Beyond conventional crops, Eugene, (2026) takes a different approach for southwest Kansas by benchmarking against typical farm income and evaluating a high-value alternative enterprise (greenhouse tomatoes), reframing the problem "from water conservation to income preservation."

1.3 Transition to rainfed production

Formerly known as the “Great American Desert”, the High Plains’ agricultural production changed completely with the development of groundwater pumping, turning the region into the “Breadbasket of the World” (Steward & Allen, 2016). Irrigation allows crops to be grown across a wider range of soil and climate conditions than rainfed production can support, so the move away from irrigation is not a uniform shift to dryland cropping.

Deines et al., (2020) mapped projected irrigation losses across the High Plains Aquifer at 30 m resolution and estimated that 24% of currently irrigated land may be unable to support irrigation by 2100. The losses are concentrated in the south and center of the aquifer, at 54% of

irrigated areas in the Southern High Plains and 40% in the Central High Plains, compared with 10% in the Northern High Plains. Using soil capability, slope and location, they estimated that 87% of the lost area could support dryland crops and 13% is better suited to pasture. Studies of the economic effects of depletion have often assumed that all lost irrigated land becomes dryland cropland. Deines et al., (2020) tested this assumption in six counties, including Finney County, Kansas, where 57% of current irrigated cropland is projected to lose irrigation by 2100 and 18% of that lost area is more suited to pasture. Gross revenue from dryland crops averaged 10.8 times that of pasture across the six counties. Ignoring land suitability overstated cumulative gross revenue from transitioned land by 23.3% across the six counties by 2100, and by 12–45% across individual counties (13.9% in Finney County).

The returns to the rainfed alternatives thems elves are not uniform, and they benefit low-water crops. For southwest Kansas, Araya et al., (2019) simulated median returns above variable cost of $252/ha for rainfed wheat and $180/ha for rainfed grain sorghum, which exceeded those of irrigated wheat ($169–192/ha) and irrigated sorghum ($104–110/ha). Corn, by contrast, had its lowest simulated return under no irrigation ($16/ha). Zhu et al., (2025) project that irrigated systems have higher yield stability and economic returns than dryland systems under climate change, while dryland wheat shows moderate but consistent gains in revenue and cost savings.

1.4 Sesame evidence

Evidence on sesame as a low-water crop in the Southern High Plains comes mainly from agronomic trials. Pabuayon, Singh, & Ritchie, (2019) grew sesame, safflower and sunflower under four levels of deficit irrigation (about 51–279 mm target) in 2017 and 2018 at New Deal, Texas. Sesame seed yield ranged from 1,241 to 1,359 kg/ha and did not differ significantly among the irrigation treatments. The authors found that sesame did not need irrigation beyond

about 55 mm applied between planting and germination (two-year mean), and they report that combined irrigation and rainfall of 345 mm was sufficient to avoid yield and oil-content penalties. A companion study (Pabuayon, Singh, Lewis, et al., 2019) found that sesame yield and biomass did not respond significantly to irrigation, even where sorghum and cotton lost 25% and 40% of their yield. They concluded that the limit for sesame is "the yield potential associated with a baseline irrigation level far below that of cotton or sorghum", not water. This finding cuts both ways for farm economics. Increasing water availability does not increase sesame yields, so irrigation cannot be used to increase sesame yields as found with corn. The Pabuayon trials report no costs or prices, and the authors call for economic evaluation to follow.

Economic evidence comes from other production systems . In Mato Grosso, Brazil, Christo et al., (2024) compared sesame with off-season corn between 2016 and 2023 and found that sesame production costs were less than 40% of those of corn. Sesame gross profits were higher in most years, and their variability was lower (a standard deviation of 24% against 37% for corn gross profits). The advantage reversed in 2021 and 2022, when corn prices surged and sesame input costs rose without a matching increase in sesame prices. That study concerns a double-crop system in a tropical climate with a different market. Smallholder studies in Benin (Dossa et al., 2023) show sesame as a profitable venture but identify constraints in labor and land access, uneven ripening, lack of storage and improved seed.

1.5 Adoption and market constraints

A crop that is agronomically suited to limited irrigation still must be sold, and farmers' adoption decisions depend on markets as much as on agronomy. Extension guidance on alternative crops stresses that "the bottom line" is the prime driver of adoption. That is, whether there are availability of feasible markets and a positive net income at the end. and (Sauer &

Sullivan, 2000). The same guide notes that diversification "may not actually increase profits" but can make profitability more reliable by smoothing the difference between good and bad years.

Evidence specific to sesame on market and adoption constraints comes mainly from other regions. For Ethiopia, Sirany & Tadele, (2022) list low productivity, pests and diseases, and limited access to technology as supply-side constraints, and global price volatility, a highly concentrated export market and intense international competition on the demand side. Smallholders surveyed in northern Benin identified access to labor and land, uneven ripening, lack of storage facilities and access to improved seed as the main constraints (Dossa et al., 2023). In Brazil, Christo et al., (2024) conclude that seed quality, mechanization and market access must be addressed to realize sesame's potential, and their gross profit results show the price risk directly: in 2021–2022, sesame input costs rose without a matching rise in sesame prices, reversing sesame's advantage over corn. Sesame area in Brazil also grew from 53 thousand to 175 thousand hectares in a single season (2018/2019 to 2019/2020), which illustrates how quickly supply can respond to price signals.

The Kansas literature on adoption concerns conservation more than crop choice, but it indicates why change is slow. Perez-Quesada & Hendricks, (2021) found that although a majority of farmers agree action is needed to slow down depletion, local management plans have not substantially reduced water use, and voluntary plans did not receive more support than mandatory ones. Fischer & Sanderson, (2022) report that water-conservation norms are weaker where the environment is more arid, which they describe as a limited form of "mal-adaptation." As noted in Section 2.2, farmers under the Sheridan-6 LEMA adjusted mainly by reducing irrigation on the same crops (Drysdale & Hendricks, 2018). For farmers considering a new enterprise with an unfamiliar market, Eugene, (2026) offers a close analogue: price was the

dominant risk, a perishable product (tomatoes) required new market infrastructure, and widespread adoption could depress prices. The thesis warns that these regional price effects were not modeled.

Replacing corn with sesame in farms and a region that did produce sesame in the past carries multiple risks. They can be grouped in four major parts: yield, price, cost and insurance. For the sesame production in dryland environment, yield is tested at 500, 600 and 700 lb per acre, based on Trostle (2025) and the Texas A&M AgriLife District 2 budget. The global dryland sesame average yield has been estimated at between 446-535 lb by (Croptrust). In our scenario, we opted for three levels of yield. But the risk of being below this level was not measured in this analysis, however it needs to be raised.

There is no publicly available market price for sesame. Therefore, we have used the contract price formula used by Sesaco, which is the November soybean futures price divided by 60 and multiplied by 2.3 (Trostle, 2025). Cash at risk is variable cost per acre multiplied by the acres planted, and it is compared with irrigated corn. Crop insurance is based on the Risk Management Agency (RMA) sesame pilot program, with coverage up to 75 percent of actual production history (USDA FCIC, 2024).

Suttles et al. (2024) recommend the use of alternative crops and the increase of water use efficiency for the current crops as a solution to water scarcity in Kansas. For the authors, changing the mix of crops grown in Kansas can maintain profitable and nutritionally valuable production under midcentury climate change. The study has the merit of pointing out that diversified and climate-resilient crops can increase the share of alternative crops from 16% in 2021 to 46% in 2050. The impact of this shift in crop choice reduces water demand by 12%.

These results support studies that recommend the transition of irrigated cropland to dryland crop production (Wheeler et al., 2008; Deines et al., 2020), mainly due to irrigated area shrinkage.

1.6 Sesame uses and market demand

Our research led us to explore sesame (*Sesamum indicum L.*), one of the oldest cultivated oilseed crops in the world, with evidence of production dating back more than 5,000 years in ancient Mesopotamia and the Indus Valley (Bedigian, 2003; Wei et al., 2022). Sesame seed is one of the highest oil contents among oilseeds. It usually has around 40–60% oil and about 25% protein (Pathak et al., 2014; Baghery et al., 2023; Mourad et al., 2025). Sesame is cultivated across many arid and semi-arid regions in Africa and Asia. It is among the first of the oil seeds to be domesticated by man but remains an "orphan-crop" in much research despite its global importance.

It is reported that Thomas Jefferson, an American Founding Father and the 3rd president of the United States, mentioned sesame (which he called benne seeds) in a letter he wrote to seedsman Bernard Mc Mahon in 1811 (Looney, 2006). In the letter, he indicated producing and using sesame oil which he considered superior to olive oil. There are three sesame varieties currently in production in various locations around the globe: white, black and brown (Figure 2.1). The white is sweet, light and buttery while the brown is nutty, earthy, and firm. The black variety has a bold and intense smoky taste which is slightly bitter. Regarding nutrient density, the white variety tends to be lower in fiber, calcium and iron while brown is high in fiber, minerals, and healthy fats used heavily for oil extraction. The white variety has the highest iron and antioxidant content.

Figure 2.1: Sesame Varieties by Color



Source: Pacific Spice Company

Key agronomic characteristics of sesame include its drought tolerance and pest resistance (Baghery et al., 2023; Sanni et al., 2024),(D. R. Langham, 2007; Yadav et al., 2022). Sesame production is well-suited to hot, semi-arid climates (Trostle, 2022), but it is vulnerable early in the season and performs poorly under waterlogging or cool/wet conditions (Sanni et al., 2024).

Langham & Kimberly (2021) have listed the major diseases that may affect the yield from 10-30% or destroy the fields. They identified foliar diseases (Alternaria, Cercospora, Pseudomonas, and Xanthomonas) such as mildew and soil-borne diseases (Macrophomina, Phytophthora, and Fusarium). At early stage, young sesame plants do not compete with weeds (Trostle, 2025). Five labeled herbicides are recommended to kill weeds without harming sesame at different stage from pre-plant/pre-emerge to over-the-top grass control.

Capsule shattering represents one of the primary constraints to sesame production, with harvest losses reported to reach up to 50% (Langham & Kimberly, 2021). Advances in breeding have resulted in the development of non-dehiscent varieties (Sanni et al., 2024), primarily by Sesaco Corporation, suitable for mechanical harvesting, thereby mitigating this limitation.

Two main food products are derived from sesame seeds: sesame oil and tahini (Wei et al., 2022). Sesame seed oil is widely used as an edible oil and as a flavoring in salad dressings and

other dishes, mixed with other oil, it can be used to make margarine. For many years, sesame oil and seeds have been used in different countries and cultures as antioxidants, pharmaceutical, feeds, fertilizer, insecticide, fuels or cosmetics (Pathak et al., 2014; Wei et al., 2022). Tahini is a smooth paste made by grinding hulled, lightly roasted sesame seeds, and it is a staple ingredient in Middle Eastern and Mediterranean cuisines.

Sudan, China, India, Myanmar, and Nigeria are currently the five largest sesame-producing countries worldwide (FAOSTAT 2023). The global sesame system is commonly characterized by primary production concentrated in Asia and Africa, where cultivation is largely dominated by smallholder-based systems . In contrast, processing and consumption hubs are more geographically dispersed, including major markets in East Asia, the Middle East, Europe, and North America.

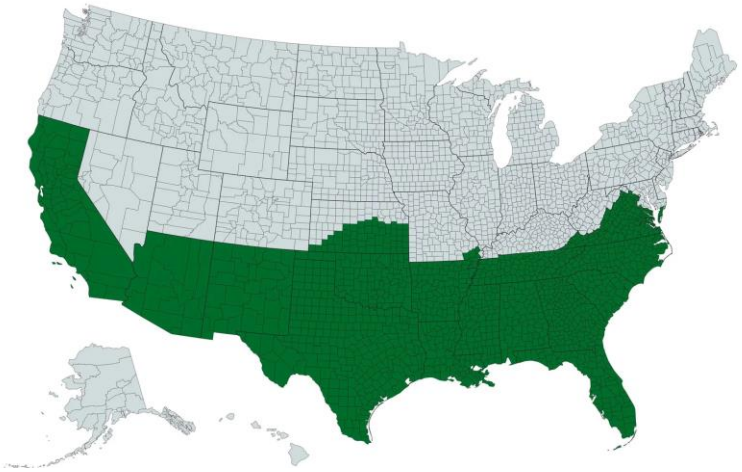
According to FAOSTAT (2023), global sesame production reached approximately 7.2 million tons in 2023, representing an 8.3% increase compared to the previous year and nearly doubling (+97%) relative to 2003 levels. Over the same period, harvested area expanded to 13.3 million hectares, up 3.3% year-over-year and 73% higher than in 2003. The strong growth in production over the past two decades has therefore been driven primarily by area expansion rather than substantial gains in yield.

In many producing countries, sesame harvesting remains largely manual due to the prevalence of traditional, shattering-prone varieties (Sanni et al., 2024). Hand harvesting increases labor requirements, raises production costs, and limits scalability, contributing to relatively low average yields compared to other major oilseeds.

Sesame acreage in the U.S. has decreased over the period 2017–2022, going from 54,083 acres in 2017 to 40,940 acres in 2022 (USDA NASS, 2024). Texas with 22,505 acres (55%) and

Oklahoma with 18,435 acres (45%) are the two main sesame producers in the U.S. Looking at 2017 data, Oklahoma with 30,305 acres accounted for 56%, Texas with 22,253 acres represented 41%, and Kansas with 1,510 acres contributed 3%. No additional data for Kansas in 2022 was found. Figure 2.2 is a broader U.S. sesame-growing region, not only the three states above.

Figure 2.2: U.S. Sesame traditional production area



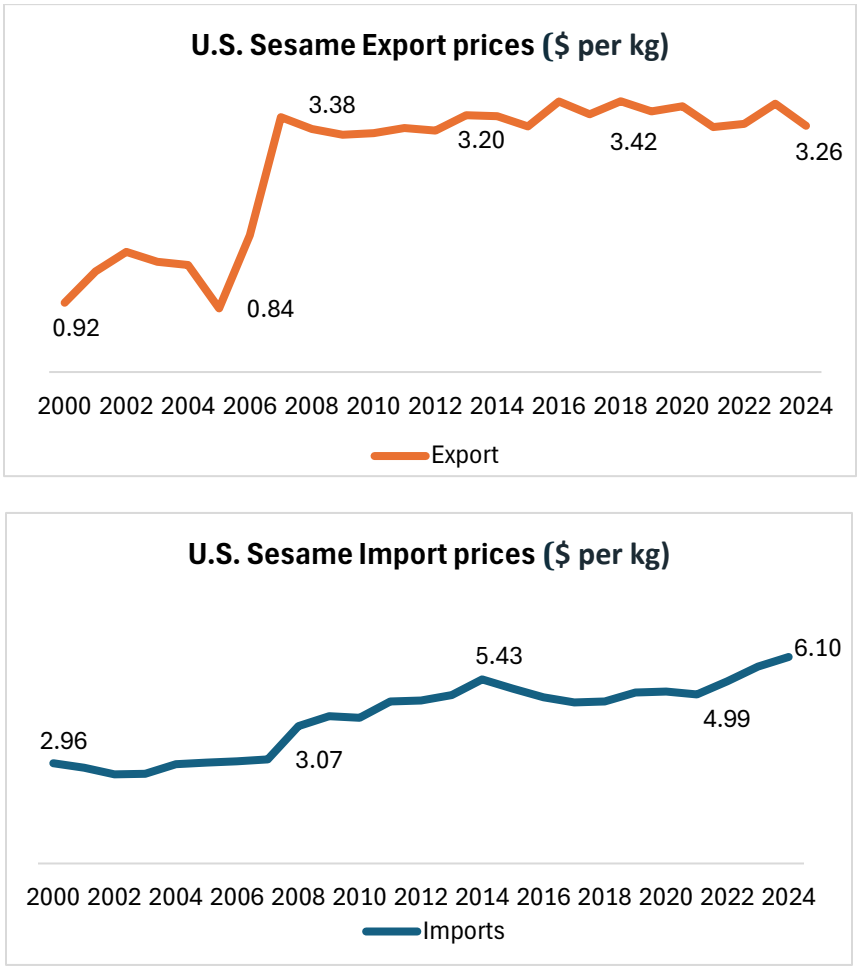
Source: Sesaco Corporation (2022)

U.S. sesame production lags its sesame demand, resulting in significant imports of sesame and sesame products into the U.S. In 2024, for example, 10.7 metric tons of sesame were produced in the U.S. (USDA NASS, 2025) and imports of sesame oil were nearly double that at 22.0 MT with an estimated value of $134.2 million (USDA FAS, 2025). These imports were up 5.4% compared to the 2023 and up 66% compared to 2014 (USDA FAS, 2025). The top five countries supplying U.S. with sesame oil are Japan (33%), Mexico (30%), Taiwan (19%), China (5%), and India (4.8%). It should be noted that the U.S. is also an exporter of sesame oil, with 1.7 MT ($5.6 million) exported (USDA FAS, 2025). Figure 2.5 shows the U.S. import and export prices trend from 2000 to 2024. The import price more than doubled, moving from $2.96 per kg

in 2000 to $6.1 per kg 2024. The export price recorded the highest increase, moving from $0.92 per kg in 2000 to $3.26 per kg, a 3.54 times increase in the four years.

Imported and exported sesame oil are not necessarily the same product, so their unit values should not be compared directly. The higher import price may reflect premium grades, organic oil or the country of origin. The exported oil may be a different type or grade, or it may be re-exported oil that was originally imported.

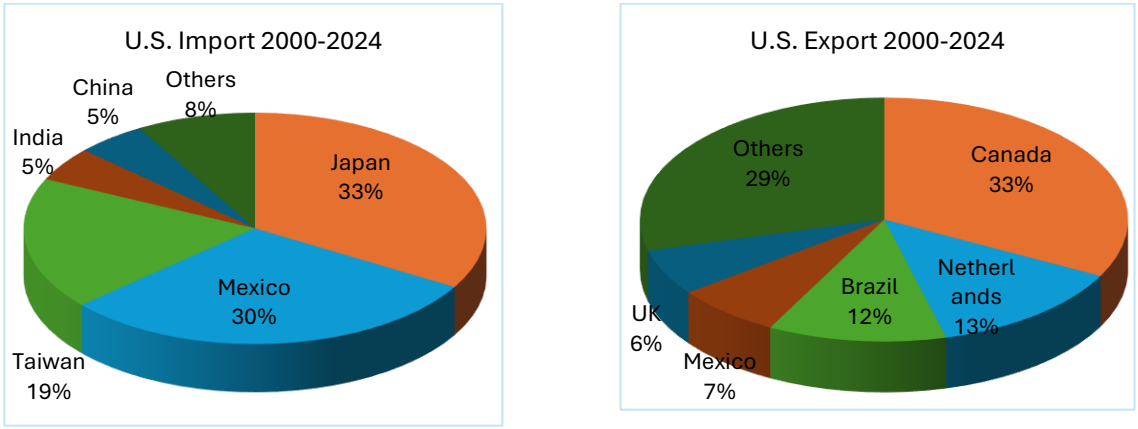
Figure 2.3: U.S. Import and Export Sesame Oil Price (2000 and 2024)



Source: USDA Foreign Agricultural Service 2025

The top destinations for U.S. sesame oil are Canada (33%), Brazil (12%), the United Kingdom (6%), India (3.4), and China (3.3%). Figure 2.5 shows the U.S. import and export sesame oil in value and quantity, as well as the origin and destination of sesame oil.

Figure 2.4: Distribution of U.S Sesame Oil Imports and Exports and by destination



Source: USDA Foreign Agricultural Service 2025

Inputs & Services: Thanks to research conducted since the 1970, Sesaco Corporation serves as the leader in the U.S. industry, controlling proprietary non-shattering seed genetics that made mechanized sesame production viable in the U.S. Plains (Langham, 2007). The company provides contract, input and enabling services to farmers.

Production: Oklahoma, Texas and Kansas are the main sesame producer state in the U.S., with small trials recorded in Arkansas, Alabama, California, Florida, Gorgia, Luisiana or Mississippi under Sesaco contract.

Aggregation & Marketing: At harvest, farmers haul sesame to Sesaco delivery points in Oklahoma (Hobart, Seiling, Alva), incurring transport costs of $0.03–$0.05/lb. Sesaco's aggregation network consolidates loads, performs moisture and quality testing, and transports seed to the Hobart processing facility. There, three cleaning lines operate year-round, segregating seed by size, color, and quality, and packaging food-grade sesame for U.S. manufacturers.

Processing & Manufacturing: Sesaco's GFSI[1] certification and lot-level traceability enable sales to major food companies requiring third-party food safety assurance. The company also operates a tahini manufacturing facility in Detroit, Michigan. Seeds 'n Snacks is the U.S. subsidiary of Rasagra, Turkey's largest producer and exporter of hulled sesame seed and tahini. In September 2023, the company opened a tahini factory in Oklahoma City capable of processing 4,000 lb of sesame seed per hour, making it the largest tahini plant in the United States. The company currently imports all its seed but chose Oklahoma specifically because of its proximity to Oklahoma and Texas sesame-growing regions.

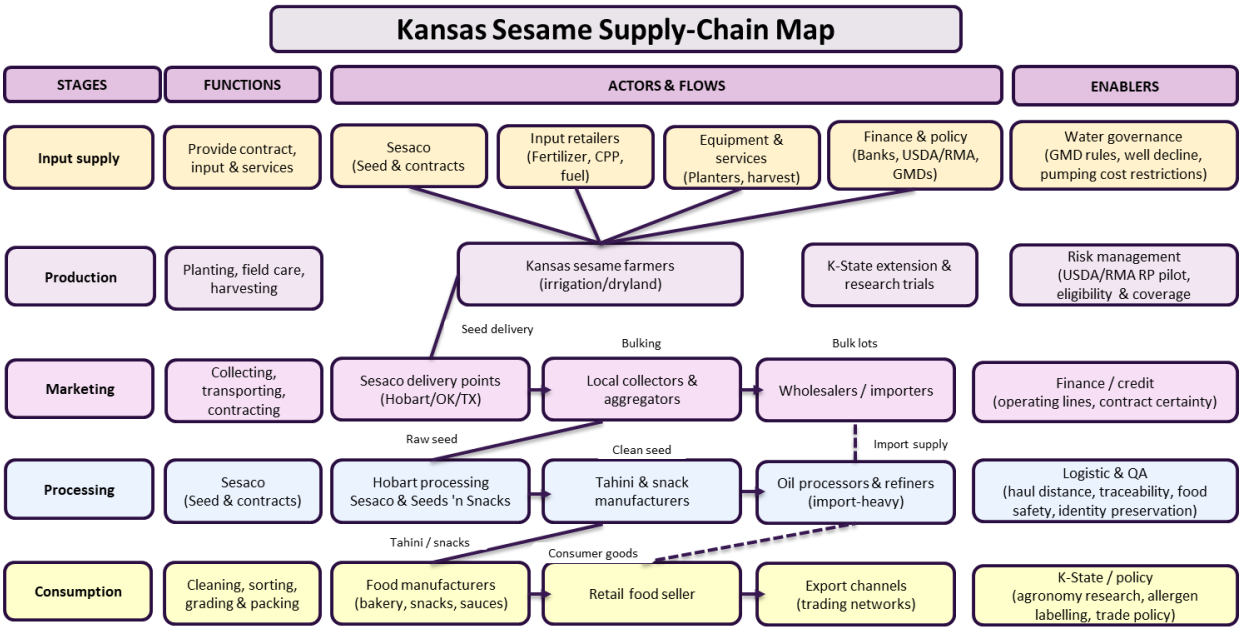
Consumption Markets: the downstream buyers are food manufacturers (bakeries, snack, sauce or condiment from whole sesame seeds), retails (grocery chains of tahini, sesame oil, sesame-topped breads and crackers), food service (restaurant, fast casual chains) and export channels.

As presented above, the U.S. sesame supply chain is import-dependent, vertically thin system controlled by one dominant domestic integrator, Sesaco Corporation. The market is growing but counts small domestic farming base around 126 operations in 2022 (USDA NASS, 2024). Figure 2.4 is the U.S. supply chain map to describe sesame industry. Sesame in the Southern Plains is produced under contract with Sesaco, which processes grain at Hobart, Oklahoma (Trostle, 2025). Alva, in northwestern Oklahoma, is the nearest listed point to Southwest Kansas, at about 184 miles in from Garden City (estimate). Its basis is +$3.00 per cwt, against +$5.00 at Hobart, and a Southwest Kansas grower would deliver there at the grower's own freight cost. One possibility is Garden City as a collection point, where sesame could be received, cleaned and stored before a bulk shipment to Alva or Hobart. This

[1] Global Food Safety Initiative

arrangement is hypothetical: neither the Garden City elevators nor Sesaco has been shown to handle sesame, and the cost of cleaning, storage and freight is not yet known.

Figure 2.5 The U.S. Sesame Supply-Chain Map



Source: The author

The interest for this crop in the United States started in the 1940's (Kinman & Martin, 1954). Yadav et al., (2022) find that in addition to handling drought well, sesame seeds germinate quickly and grow well when temperatures are around 25°C, and flowers form at this temperature.

The literature on water requirements of sesame shows that the plant requires approximately 50% less water than corn throughout the growing season, making it a more water-efficient crop choice (D. R. Langham, 2007; Pabuayon, Singh, Lewis, et al., 2019; Trostle, 2022). In Kansas, wheat, corn and soybeans are among the primary crops produced (Suttles et al., 2024), with variable water requirements going from 15-23 inches for wheat, 20-27 inches for corn, or 17-24 inches for soybeans (Rogers et al., 2015). Growing sesame in Southwest Kansas is

intended to support a crop that uses less water, performs well in semi-arid conditions, and provides additional income for farmers.

Experiments in the U.S. show that sesame grows best in fertile, well drained, medium textured or sandy loam soils, with a pH roughly between 5 and 8 (Natural Resources Conservation Service, USDA). The plant prefers neutral to slightly alkaline conditions with moderate fertility. It does not grow well on heavy clay soil, cannot tolerate standing water or high salt levels in the soil or irrigation water (Texas A&M AgriLife Research, 2007). Sesame is often planted in areas where cotton can grow, under conditions where few other crops can survive and with relatively low input needs.

The production of sesame is mainly managed over a processor contract, which establishes if the crop can be insured. The Federal Crop Insurance Corporation's sesame requirements cover clean, dry seed of non-dehiscent varieties grown under a written processor contract. Regarding the base contract price in that contract, it is used to calculate premium and any indemnity (USDA FCIC, 2024). If a formula price is found not finalized with the processor by the acreage reporting date, the insurer averages the futures agreement prices for the five trading days before that date arrive.

Chapter 3 - Methods And Data

3.1 Approach

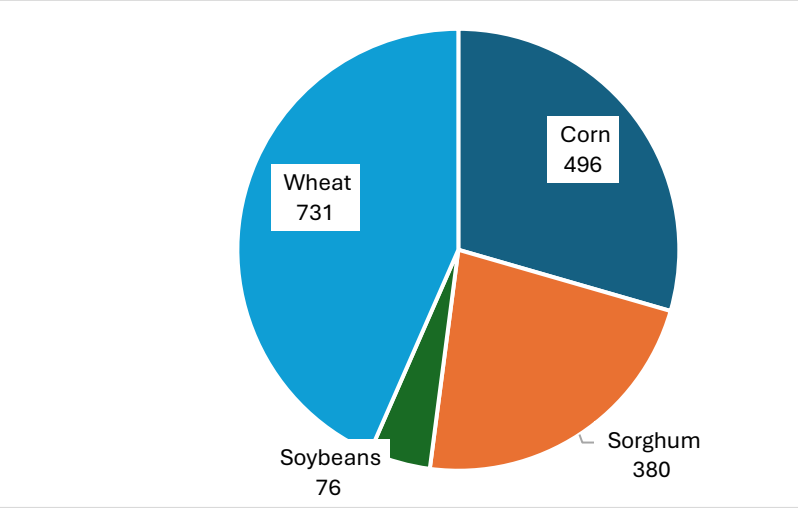
This study asks how much sesame acreage is needed, in place of corn, to preserve farm income under low irrigation in southwest Kansas. The comparison is made on the gross profit or the return above direct expenses per acre as reported in the K-State enterprise budgets (Ibendahl, 2025). Gross profit is the total income (Revenue) minus the total direct expenses (Variable Costs) per acre. It excludes fixed expenses (cash rent and capital recovery) and is therefore not net profit. The analysis follows the income-equivalence approach used by Eugene (2026), which explore the alternative enterprise acreage requirements necessary to generate the same farm income under current production condition. The analysis is annual and deterministic. Unlike Eugene (2026), who used a 20-year discounted cash flow for a capital-intensive greenhouse, this study uses annual gross profit since existing capital (machinery and equipment) are assumed to be applicable to sesame production (Trostle, 2025).

3.2 Typical farm and income target

Average crop farm income for Southwest Kansas was estimated at $118,315 between 2004 and 2024, with a standard deviation of $66,009. The reported income ranged from $6,744 in 2015 to $319,180 in 2021. Government payments averaged $36,797 per farm, about 31% of estimated average income. It is assumed after Eugene (2026) that the typical crop farm in Southwest Kansas operates a mixed enterprise comprising corn, sorghum, soybeans, and wheat. It is also assumed that the average acreage distribution of the average acreage of the typical farm among these four crops was 29.5%, 22.6%, 4.5%, and 43.4%, respectively. This means that for the typical farm with 1,683 acres, the acreage distribution among the four crops is as presented in

Error! Reference source not found.. It is assumed to be produced by the typical crop farmer. This means the introduction of any new enterprise requires some substitution of existing crop enterprise based on water requirements and its production economics.

Figure 3.1: Acreage Allocation Across the Four Crops in Southwest Kansas



3.3 Enterprise budgets

Production economics is drawn from assumptions about crop budgets reported by AgManager.info, the outreach portal for Kansas State University's Department of Agricultural Economics (www.agmanager.info). The average yield, price, and variable cost of production for each of these crops as presented in multiple budgets for 2020 to 2024 are summarized in Table 3.1. Also included in the table are the summary statistics for sesame derived from budgets reported by Texas A&M University Extension and Oklahoma State University for the same periods.

Table 3.1 Baseline crop allocation

Irrigated_Baseline crop allocation, prices, variable costs, and irrigation fuel expenses

Crop	Allocated acreage (acres)	Crop price ($/lb)	Yield (lb/ac)	Variable cost ($/ac)	Irrigation depth (inches)	Pumping cost per ac-in
Corn	496	$0.08	10,360	$492	13.0	39.0
Soybeans	76	$0.17	3,300	$224	9.0	27.0
Sorghum	380	$0.08	8,064	$311	10.5	31.5
Wheat	731	$0.09	3,600	$215	4.0	12.0
Sesame	0	$0.39	1,000	$294	4.0	12.0

Table 3.1 shows a typical Southwest Kansa farm acreage split among corn (496 ac), soy (76 ac), grain sorghum/milo (380 ac), wheat (731 ac) for a total of 1,683 acres. With 43.4%, wheat has the highest acreage followed by corn and sorghum with 29.5% and 22.6% respectively. Sesame has no known acreage in 2025. Crop price per pound and yield per acre was computed using conversion figures. The savings from the lower irrigation water use offers two principal advantages for sesame adoption as a substitute for corn. First, lower variability in sesame gross profit offers farmers who grow it some control over their income risk. Second, the water that is not pumped has value which could be “sold” to conservation initiatives to prevent its use the way land conservation organizations, such as Nature Conservancy, have purchased land to prevent their development.

AgManager farm budgets report three yield levels associated with different irrigation levels: Low, Middle, and High. The low irrigation level represents strict water deficit, close to dryland conditions with only limited or rescue irrigation. The middle irrigation level represents planned supplemental irrigation under normal production conditions. The high irrigation level

corresponds to favorable conditions in which the crop receives relatively high amounts of irrigation water. In this analysis, we retain the low irrigation level. Because both price and yield are tied to the irrigation level in the AgManager budgets, we consistently use the price and yield associated with the low irrigation scenario. We converted the yields from bushels (bu) to pounds (lb) using grain conversion calculator (www.omnicalculator.com) as sesame is weighted in pounds. Table 3.2 presents the yield and the irrigation applied per level.

Table 3.2 Yield and the irrigation applied per level

	Yield and irrigation per levels				
Inches water applied (in)	Corn	Soybeans	Sorghum	Wheat	Sesame
Low level	13	9	10.5	4	4
Middle level	15	11	12.0	6	6
High level	17	13	13.5	8	8
Yields (bu)	Corn	Soybeans	Sorghum	Wheat	Sesame
Low level	185	55	144	60	16.7
Middle level	225	65	160	70	20.0
High level	245	75	172	80	25.0
Yields (lbs.)	Corn	Soybeans	Sorghum	Wheat	Sesame
Low level	10,360	3,300	8,064	3,600	1,000
Middle level	12,600	3,900	8,960	4,200	1,200
High level	13,720	4,500	9,632	4,800	1,500
Conversion 1bu in lbs.	56	60	56	60	46

The corn values come from the 2026 K-State AgManager irrigated corn budget for Southwest Kansas (1 November 2025), at its low planning level: 185 bu/ac at $4.73/bu, direct expenses $492.03, gross profit $383 and 13 acre-inches of irrigation.

No Kansas sesame budget exists in K-State AgManager to date. Sesame values come from Texas A&M AgriLife Extension budgets (Southwest Extension District 10, 2025) and (Trostle, 2025): 1,000 lb/ac at $0.37/lb, direct expenses $294.48/ac, gross profit $75.52 and 4 acre-inches of irrigation, within Trostle's recommended 4 - 6 inches.

For each crop i and irrigation scenario $s \in$ {Low, Middle, High}, gross profit, and gross profit per acre-inch are:

$$GR_i = P_i\, y_i$$

$$\pi_i = P_i\, y_i - VC_i$$

$$\pi_i = (\, P_i\, y_i - w_i) \,/\, \omega_i$$

where GR_i is the gross revenue ($), P_i is the market price ($/lb), y_i is the yield (lbs/acre), VC_i the variable cost, π_i is the gross profit and ω_i the water required per crop. Table 3.3 shows budget inputs for corn and sesame.

Table 3.3 Budget inputs (low irrigation level)

	Enterprise budgets (corn and sesame)	
	Corn	Sesame
Price	$0.08/lb	$0.37/lb
Yield	10,360 lb/acre	1,000 lb/acre
Variable cost	$492.03/acre	$294.48/acre
Irrigation applied	13 ac-in	4 ac-in
Gross profit	$383.02	$75.52

Source: K-State AgManager 2026 irrigated corn budget, simulated sesame budget

3.4 Irrigation cost

Irrigation is defined here as the depth of water applied to the crop through an irrigation system. It is measured in acre-inches per acre, as presented in the enterprise budget. It is not the crop water requirement which is the total water the crop needs to reach its yield, which also includes rainfall and soil water moisture.

Irrigation or pumping cost is separated from the other direct expenses so that it can be analyzed explicitly as one of the possible causes of sesame's economic infeasibility. For crop i, direct expenses are split as:

$$w_i = w_i^o + \omega_i \cdot e$$

where w_i^o is the direct expense excluding irrigation energy ($/ac), ωi is the irrigation applied (acre-inches per acre) and e is the pumping cost per acre-inch ($/ac-in). Gross profit after irrigation cost is then

$$\pi_i = P_i\, y_i - w_i^o - \omega_i \cdot e$$

The K-State budgets report irrigation energy as a separate line. It is priced for natural gas at 0.71 mcf per acre-inch and $4.22 per mcf, which is about $3.00 per acre-inch, or $38.95 per acre for corn at 13 acre-inches. The same cost per acre-inch is applied to 4 acre-inches sesames ($11.98 per acre).

3.5 Gross profit analysis

This step uses the budget values as published to evaluate whether sesame is economically feasible under status quo conditions. Feasibility is judged on gross profit per acre after irrigation cost and on the acreage, sesame would need to reach the income target Y*. If sesame is not feasible, the thresholds below show whether the shortfall comes from price, yield or the cost of pumping irrigation water.

3.5.1 Income-equivalent sesame acreage

Income from A_s acres of sesame is $A_s \cdot \pi_s$. Setting it equal to the KFMA income target Y* of $118,315, which is the mean KFMA net farm income for 2004–2024, and solving for acreage:

$$Y^* = A_s \cdot \pi_s \Rightarrow$$

$$A_s = \frac{Y^*}{\pi_s}, \text{ with } \pi_s > 0$$

where π_s is sesame gross profit.

The most sesame can earn on the whole farm (F) is given by the equation below. It multiplies the typical southwest Kansas farm by the gross profit realized by producing sesame:

$$Y_{max} = F \cdot \pi_s, \text{ compared with } Y^* \text{ as } Y_{max} / Y^*$$

Where $Y_{\max}$is the net farm income generated by growing sesame exclusively across the entire farm, and Frepresents the typical farm.

3.5.2 Price, yield, and pumping thresholds

The sesame price and yield at which one sesame acre matches one corn acre ("corn- gross profit-equivalent"), holding direct expenses constant, are:

$$P* = \frac{\pi_c + VC_c}{y_s} \text{ and } Y* = \frac{\pi_c + VC_c}{p_s}$$

Sesame covers the target on all F acres when the gross profit per acre is Y*/F, which requires

$$P_F = (Y^*/F + w_s) / y_s$$

$$y_F = (Y^*/F + w_s) / P_s$$

For A_s to equal the corn acres replaced:

$$P_A = (Y^*/A_c + w_s) / y_s$$

Pumping cost also has a threshold. Setting sesame's gross profit per acre equal to corn's and solving for the pumping cost per acre-inch gives

$$e^* = [P_{c*}y_c - w_c^o) - (P_{s*}y_s - w_s^o)] / (\omega_c - \omega_s)$$

e^* is the break-even pumping cost per acre-inch at which sesame generates the same gross profit per acre as corn, and w_c^o/w_s^o are corn and sesame variable costs excluding irrigation energy.

Because sesame uses fewer acre-inches than corn, a higher pumping cost narrows the gap. If e^* lies far above the pumping costs reported in the previous section, pumping cost would have to rise well beyond current levels before sesame matches corn per acre-in.

If the price and yield thresholds lie above the values observed under status quo conditions, sesame is not economically feasible, and the threshold furthest from its observed value identifies the main cause. These thresholds generalize the break-even logic of Eugene (2026) by setting the target to a gross profit instead of zero.

3.6 Sesame in the typical portfolio

3.6.1 Scenario conditions

Three conditions are used: the mean, the mean plus one standard deviation, and the mean plus two standard deviations of the soybean price S, converted to a sesame price with the contract formula below.

The Sesaco contract formula links the sesame price to the soybean price (Trostle, 2025):

$$P_s = S \times k / 60 \quad (\$/lb)$$

with k = 2.3, June 2025 multiple. Because k is a 2025 contract term, the formula is used for scenarios, not as a price history. The cases are the budget price ($0.37/lb), S = $0.39/lb (KSU soybean budget price), S = $0.43/lb (the 2010–2024 mean from ASA, 2026) and an illustrative $0.50. Each case recomputes πs , A_s and the water results.

As we have already seen , three conditions follow the K-State yield levels: Bottom (1,000 lb/ac and 4 acre-inches), Mean (1,200 lb/ac and 6 acre-inches) and High (1,500 lb/ac and 8 acre-inches). Direct expenses excluding irrigation are held at the low-yield level value ($294.48 per acre) because no budget exists for the other levels, and pumping cost is recomputed for the irrigation applied.

3.6.2 Replacement of the corn acres

In each scenario sesame replaces corn acre for acre. The gross profit earned by the corn acres replaced and the changes from the replacement are as follows:

$$T = A_c \cdot \pi_c$$

The equation with T as the target acres gives the sesame acreage:

$$A_s^T = T / \pi_s$$

If sesame replaces the corn acre for acre, the change in gross profit is

$$\Delta M = A_c (\pi_s - \pi_c)$$

3.6.3 Sensitivity analysis

We ran a sensitivity analysis to test whether the main outcome will hold when changing the irrigation applied. Following the shocks in multiples of σ in Eugene (2026), the target is varied over $Y_j \in \{Y^* - s, Y^*, Y_{2020–24}, Y^* + s\}$. For each j,

$$A_s(j) = Y_j / \pi_s$$

$$\pi_{s,j} = Y_j / F, \quad P_{F,j} = (Y_j/F + w_s) / y_s$$

Irrigation. ω_s is varied over {2, 3, 4, 5, 6, 6.5} acre-inches, holding yield and direct expenses constant.

3.7 Water economics

Water accounting is computed using the irrigation applied under the same yield condition . Total irrigation applied and the water change are:

$$W_c = A_c \cdot \omega_c$$

$$W_s = A_s \cdot \omega_s$$

$$\Delta W_Y = W_c - W_s$$

Following the acreage-and-intensity decomposition of Drysdale & Hendricks (2018), the change splits into an acreage effect and a per-acre effect:

$$\Delta W_Y = \omega_c (A_c - A_s) + A_s (\omega_c - \omega_s)$$

The percentage change relative to the current corn is

$$\delta = W_s / W_c - 1 = -\Delta W_Y / W_c \quad \text{(positive = more water)}$$

For acre-for-acre replacement, the saving is

$$\Delta W_A = A_c (\omega_c - \omega_s)$$

Sesame saves water at the acreage given by equation 3.8 only if

$$\omega_s < \omega^* = W_c / A_s$$

Equivalently, sesame needs a gross profit of

$$\pi s^* = Y^* \omega_s / W_c$$

at a price and yield of

$$P_w = (\pi s^* + w_s) / y_s, \quad y_w = (\pi s^* + w_s) / P_s$$

The income predictable per acre-inch saved under acre-for-acre replacement is

$$c = (\pi c - \pi s) / (\omega_c - \omega_s) \quad (\$/\text{acre-inch})$$

Because W_c uses the farm's current corn acres, which earn T and not Y*, the equation is a comparison with current corn irrigation and not an equal-income comparison.

This chapter describes how our research measures sesame feasibility to replace irrigated corn in a typical southwest Kansas farm income. We defined first the farm and the target income we want to generate producing sesame. Then we use K-State AgManager for corn budget, and Texas A&M budget to simulate sesame, to get gross profit, variable costs, and pumping irrigation applied. The gross profit analysis was the place to determine how much sesame, a typical farm, would need to generate the target income (KFMA net farm income). We calculate also the price, yield, and pumping cost that would allow us to reach this target income. Water economics, on the other hand, compares the irrigation used by the farm's corn with the irrigation sesame would need, and the income given up per acre-inch saved. Together these steps cover the objectives: the irrigation used by the typical farm to earn the average income; the irrigation sesame would need to earn the same typical farm income, the technical and economic feasibility of sesame, and the conditions under which sesame could be an alternative crop. Chapter 4 presents the results that we found.

Chapter 4 - Results And Discussion

This chapter reports the results of the analysis. It is organized into 6 sections. The first provides a baseline analysis of the typical farm, the irrigation cost, the gross profit per acre, the replacement analysis, the water-saving results, and the whole-farm replacement scenarios. Revenue per acre is price times yield. Variable cost is the cost that changes with production, including the cost of pumping irrigation water. Gross profit is revenue minus variable cost. It excludes fixed costs, so it is not net farm income. All results are deterministic and conditional on the budget values described in Chapter 3. We found three main results summarized as follows:

4.1 Typical farm baseline

The typical farm has 1,683 acres (Figure 3.1). Corn occupies 496 acres. At 13 acre-inches per acre, these acres use Wc = 496 × 13 = 6,448 acre-inches of groundwater each year. The income target is the mean KFMA net farm income, Y* = $118,315 (standard deviation $66,009). At the budget values the corn acres earn a gross profit of T = 496 × $383.02 = $189,978, which is 161% of Y*. T is the amount of income that sesame has to replace when it takes the place of corn.

4.2 Irrigation cost

Table 4.1 reports the cost of pumping irrigation water. The K-State budgets price energy for natural gas. The two diesel columns apply 1.72 gallons of diesel per acre-inch (a 150-foot lift) to the two diesel prices of Chapter 3.

Table 4.1 Cost of pumping irrigation water, natural gas and diesel

	Natural gas (budget)	Diesel, 2024–25 average	Diesel, July–October 2026
Energy price	$4.22 per mcf	$3.66 per gal	$5.73 per gal
Energy used per acre-inch	0.71 mcf	1.72 gal	1.72 gal
Pumping cost per acre-inch	$3.00	$6.28	$9.84
Corn, 13 acre-inches ($/acre)	$38.95	$81.69	$127.97
Sesame, 4 acre-inches ($/acre)	$11.98	$25.14	$39.38
Pumping cost saved by sesame ($/acre)	$26.97	$56.56	$88.59

Sources: K-State AgManager 2026 budgets (natural gas); U.S. Energy Information Administration

Pumping cost per acre is proportional to the irrigation applied, so corn (13 acre-inches) costs 3.25 times as much to pump as sesame (4 acre-inches). Diesel costs two to three times as much per acre-inch as the natural gas in the budget, and the July–October 2026 price adds 57% to the 2024–25 diesel cost (U.S. Energy Information Administration, 2026). Sesame's pumping advantage over corn is $27 to $89 per acre depending on the energy source and price.

4.3 Gross profit per acre

This section presents the computation of the revenue, the variable cost, and the gross profit per crop. The income-equivalent for sesame acreage is also calculated. Finaly, the price, yield, and pumping thresholds tell us how much sesame is needed to earn the target income.

4.3.1 Revenue, variable cost and gross profit

Table 4.2 reports the budget values at a low irrigation level, with gross profits computed from price and yield thresholds. Corn earns a gross profit of $383.02 per acre and sesame earns $75.52, which is 19.7% of corn's profit. The gap between the two crops comes mainly from

yields, not from pumping costs. Per acre-inch of irrigation applied, corn earns $29.46 and sesame $18.88 (64% of corn's).

Table 4.2 Values at the low irrigation level

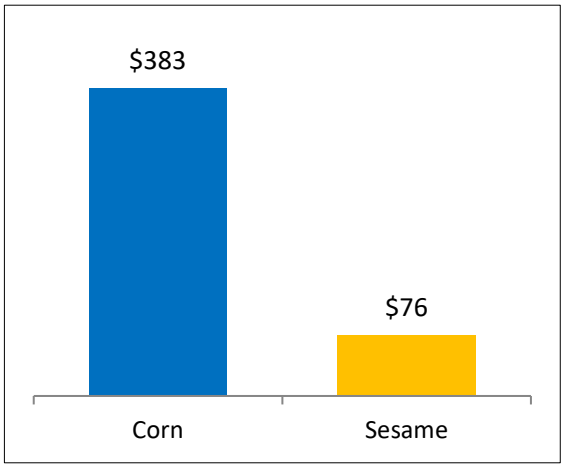
	Corn	**Sesame**
Price, $/lb	0.08	0.37
Yield, lb	10,360	1,000
Revenue	$875.05	$370.00
Variable Cost	$453	$283
Irrigation costs $/ac-in	39	12
Total variable cost	$492.03	$294.48
Gross Profit	$383.02	$75.52
Irrigation applied, ac-in	13	4
Gross profit per acre-inch	**$29.46**	**$18.88**

Source: KSU AgManager 2026 irrigated corn (center-pivot) budget for Southwest Kansas, low level

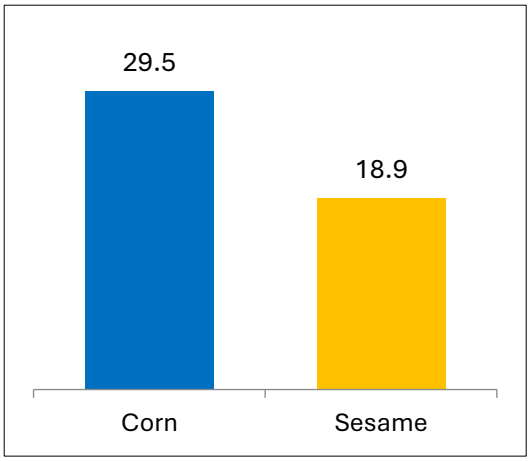
Figure 4.1 shows the gross profit per acre and the gross profit per acre-inch. All results below therefore use gross profits and assume that fixed expenses do not change.

Figure 4.1 Return above direct expenses

(a) Gross profit per acre



(b) Gross profit per acre-inch of irrigation



4.3.2 Income-equivalent sesame acreage

To earn the income target Y* = $118,315 at a gross profit of $75.52 per acre, sesame would need 1,566.7 acres. That is 93.1% of the 1,683-acre farm and 3.16 times the 496 acres of corn. Even on every acre of the farm, sesame would earn $127,100, or 107.4% of Y*. On this farm at status quo values, sesame can reach, but only by using 93.1% of the farm, including land that is now in other crops.

The income target Y* is the mean KFMA accrual net farm income for 2004–2024, $118,315 (SD $66,009), treated as equal to the gross profit . The sesame acreage that earns Y* follows from:

$$A_s = Y^* / \pi_s = 118{,}315 / 75.52 = 1{,}566.7 \text{ acres}$$

This is 93.1% of the 1,683-acre farm (F), so the result is feasible within the farm. It is also 3.16 times the 496 acres of corn grown on the farm . The most that sesame can earn on all 1,683-acres is $Y_{max} = F \cdot \pi_s$ = $127,100, or 107% of Y*. On this farm at status quo values, sesame can reach and goes beyond the income target by 7%.

Table 4.3 describes how many acres of sesame a typical farm needs to reach four different income targets. From the gross profit of $75.52 per acre, we calculate the target income Y* and the acreage As required. The first target is the 2004-2024 mean minus one standard deviation ($52,306), the farm the farm needs 693 acres, or 41.2% of the current farm acreage available, and 1.4 times corn acreage. The second mean target ($118,315) needs 1,567 acres, or 93.1% of the farm. The next two higher targets, the 2020–2024 mean ($174,010) and the mean plus one standard deviation ($184,324), need 2,304 and 2,441 acres respectively. These acreages are 136.9% and 145.0% of the farm, so infeasible because the farm does not have enough land for them. Under these conditions, sesame is feasible only at the two lowest targets, and even at the mean it would take almost all the 1,683 acres typical farm in Southwest Kansas.

Table 4.3 Sesame acreage by income target

	Income-equivalent sesame acreage			
Target	Y*	A_s (acres)	Share of farm	A_s / corn acres
Mean 2004–2024 − 1 SD	$52,306	693	41.2%	1.4
Mean 2004–2024	$118,315	1,567	93.1%	3.2
Mean 2020–2024 (5-yrs)	$174,010	2,304	136.9%	4.6
Mean 2004–2024 + 1 SD	$184,323	2,441	145.0%	4.9

Source: KFMA Net Farm Income 2004–2024.

4.3.3 Price and yield thresholds

Table 4.3 gives the sesame price or yield at which each condition holds, with direct expenses and the other input held constant. The first row is the price at which one sesame acre matches one corn acre (corn- gross profit-equivalent). It is not a zero-profit break-even.

Table 4.4 Thresholds (price at 1,000 lb/ac; yield at $0.37/lb)

	Price and yield thresholds		
Condition	Price ($/lb)	Yield (lb/ac)	Premium over $0.37
One sesame acre matches one corn acre	0.68	1,831	83.1%
A_s equals the whole farm, for Y*	0.36	986	-1.4%
A_s equals the 496 corn acres, for Y*	0.53	-	44.1%

Sesame on the whole farm reproduces Y* at two price points: $0.68/lb for one sesame acre matching one corn acre, and $0.53/lb when sesame acre equals corn acres. Only -1.4% below the budget prices don't reproduce Y*. So, covering the whole farm in sesame is a realistic substitution.

4.3.4 Price scenarios

The Sesaco contract formula links the sesame price to the soybean price: Ps = S × 2.3 / 60 in $/lb, where S is the soybean price in $/bu (Trostle, 2025). The multiple 2.3 is a June 2025 contract term, so these are scenarios, not observed sesame prices. Table 4.5 reports the results for the target Y*.

Table 4.5 Sesame acreage and irrigation by price scenario (target Y*)

Case	Price scenarios					
	P_s ($/lb)	πs ($/ac)	A_s (acres)	Share of farm	Sesame irrigation (acre-in)	vs. corn irrigation
Budget	0.37	$75.5	1,567	93.1%	6,267	-2.8%
KSU soybean ($10.08)	0.39	$91.9	1,287	76.5%	5,149	-20.2%
2010–2024 mean soybeans ($11.12)	0.43	$131.8	898	53.3%	3,591	-44.3%
Illustrative price	0.50	$205.5	576	34.2%	2,303	-64.3%

Table 4.5 shows gross profit at three sesame prices. The first, $0.39 per pound, comes from the Sesaco formula applied to the soybean price in the K-State AgManager budget ($10.08 per bushel). The second, $0.43 per pound, applies the same formula to the 2010–2024 mean soybean price of $11.12 per bushel from the American Soybean Association (ASA, 2026). The third, $0.50 per pound, is an illustrative price. Under the replacement target T, the corresponding acreages are 1,287 acres at the K-State soybean price (76% of the farm) and 898 acres at the historical mean (53%). As the price rises, gross profit per acre increases and the sesame acreage needed to reach the income target falls.

4.4 Replacement of the corn acres

The 496 corn acres earn $T = Ac \cdot \pi c = 496 \times \$383.02 = \$183{,}978$ above direct expenses, 161% of Y*. This is a contribution gross profit, not net farm income. If the target is T, sesame would need

$$A_s T = T / \pi_s = 2{,}516 \text{ acres}$$

which is 149.5% of the farm. If sesame replaces the corn acre for acre, the change in gross profit is:

$$\Delta M = Ac\,(\pi s\ - \pi c\ ) = 496 \times (75.52 - 383.02) = -\$152{,}520$$

or −$307.50 per acre. This loss equals 112% of the mean KFMA net farm income.

4.5 Water saving

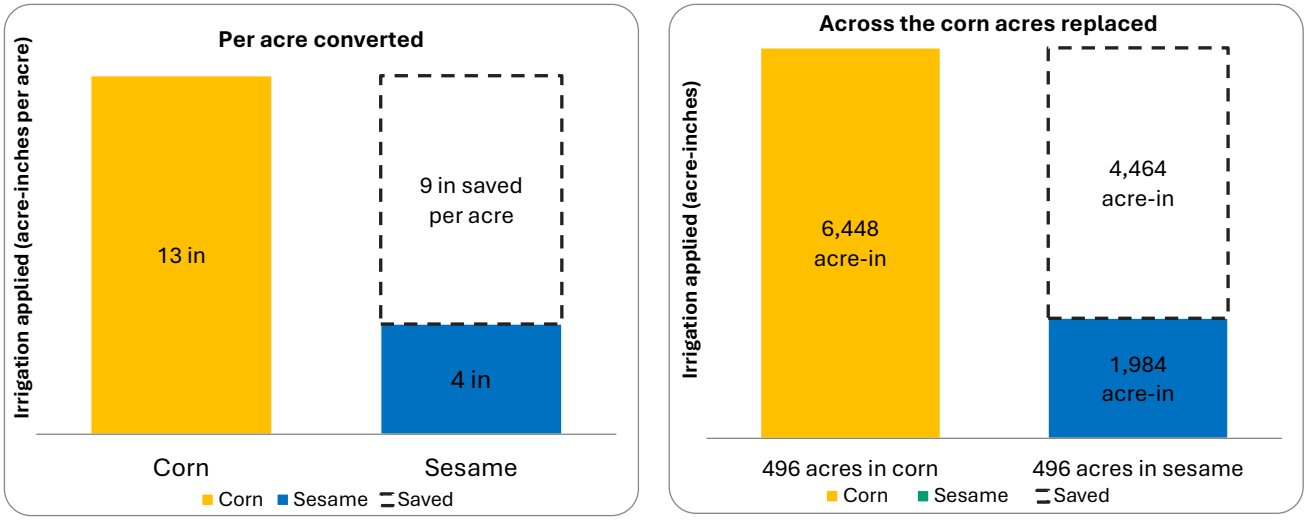
Irrigation is the depth applied, in acre-inches. Converting an acre from corn to sesame saves $\omega_c - \omega_s = 13 - 4 = 9$ in/ac. If sesame replaces the 496 corn acres one for one (equal acreage), the water saved is

$$\Delta W_A = A_c\,(\omega_c - \omega_s) = 496 \times 9 = 4{,}464 \text{ acre-inches}$$

This amount represents 69.2% of the irrigation applied to corn. The income forgone per acre-inch saved is:

$$c = (\pi_c\ - \pi_s\ )/(\omega_c - \omega_s) = 307.50 / 9 = \$34.17 \text{ per acre-inch.}$$

Figure 4.2: Water saved when sesame replaces corn acre-for-acre.



At the sesame acreage needed for Y*, the farm's current corn uses $W_c = A_c \cdot \omega_c = 6{,}448$ acre-inches, and sesame on A_s acres uses $W_s = A_s \cdot \omega_s = 1{,}566.7 \times 4 = 6{,}266.7$ acre-inches. The change is:

$$\Delta W_Y = W_c - W_s = 6{,}448 - 6{,}267 = 171.3 \text{ acre-inches}$$

The result shows that sesame uses 2.9% less irrigation than the farm's current corn. The change splits into an acreage effect, $\omega_c (A_c - A_s) = -13{,}919$ acre-inches, and a per-acre effect, $A_s (\omega_c - \omega_s) = +14{,}100$ acre-inches. Because those corn acres earn \$189, 978, more than Y*, this comparison is against the farm's current corn irrigation and is not an equal-income comparison. The change ΔW_Y is positive if and only if

$$\omega_s < \omega^* = W_c / A_s = 6{,}448 / 1{,}566.7 = 4.12 \text{ in/ac}$$

At 4 inches, sesame is below this threshold. Equivalently, sesame needs a gross profit of $\pi s^* = Y^* \cdot \omega_s / W_c = \$73.4$ per acre, which requires a price of

$$P_w = (\pi s^* + w_s) / y_s = \$0.368 \text{ per lb}$$

or a yield of $y_w = 994$ lb/ac, from the same equation.

Table 4.5 shows how ΔW_Y and δ vary with the irrigation applied to sesame (target Y*, A_s = 1,566.7 acres). Higher irrigation adds no yield or direct expense in this table, so it isolates the water arithmetic.

Table 4.6 Change in Irrigation Water Use (Sesame vs Corn)

	Target $Y^{\wedge}$, A_s = 1,567 acres		
Sesame irrigation (in/ac)	**Sesame irrigation (acre-in)**	**ΔW_Y (acre-in)**	**vs. corn irrigation (δ)**
2	3,133	3,315	-51.4%
3	4,700	1,748	-27.1%
4	6,267	181	-2.8%
5	7,833	-1,385	21.5%
6	9,400	-2,952	45.8%
6.5	10,183	-3,735	57.9%

Although sesame saves 9 inches on every acre converted, the farm-level effect depends on how many acres sesame needs. The acreage needed for Y* is 3.16 times the corn acreage, and at 4 inches this offsets the per-acre saving.

4.6 Dryland comparison

Analyzing irrigated sesame led us to consider sesame production under dryland conditions. The objective is to test a scenario in which irrigation is unavailable, and production relies entirely on dryland conditions. The results below address this scenario. We used K-State AgManager enterprise budgets for non-irrigated production, selecting the middle level (see Table 3.2) for corn, soybeans, grain sorghum, and wheat. For sesame, we used the Texas A&M AgriLife budget for District 2, which is in the South Plains, both areas being semi-arid. We also adjusted the budget, crop insurance around ~6% of revenue to reflect Kansas farming conditions.

Table 4.7 Dryland Baseline crop allocation

Dryland Baseline crop allocation, 500 lb/acre

Crop	Crop price ($/lb)	Yield (lb/ac)	Variable cost ($/ac)	Gross profit ($/acre)	Gross profit per lb
Corn	$0.08	4,592	$274	$114	0.025
Soybeans	$0.17	1,500	$159	$93	0.062
Sorghum	$0.08	4,760	$221	$153	0.032
Wheat	$0.09	3,240	$196	$89	0.027
Sesame	$0.39	500	$144	$49	0.099

Table 4.7 presents the baseline prices and yields for each crop, converted from dollars per bushel to dollars per pound and from bushels per acre to pounds per acre, respectively, using the conversion weights specified previously. Based on the average sesame yield, we assumed a yield of 500 lb/acre and a price of $0.39/lb. For the other crops, we retained the prices used in the irrigated analysis while changing the yields and variable costs to reflect dryland production. Grain sorghum has the highest gross profit at $153/acre, followed by corn, soybeans, and wheat at $114, $93, and $89/acre, respectively. Sesame has the lowest gross profit per acre but the highest gross profit per pound at $0.10/lb. Grain sorghum has the second-highest gross profit per pound at $0.06/lb.

Table 4.8 Dryland sensitivity analysis

Dryland Sesame Sensitivity Analysis

Yield \ Price ($/lb)	$0.39	$0.43	$0.50
500	$49	$69	$106
600	$88	$112	$156
700	$127	$155	$206

To provide a fuller picture of the results at different yield and price levels, we conducted a sensitivity analysis (Table 4.8). We evaluated yields of 500, 600, and 700 lb/acre and prices of $0.39, $0.43, and $0.50/lb, holding variable costs constant at $143.80/acre. Under these assumptions, sesame's gross profit would slightly exceed grain sorghum's baseline gross profit at a yield of 700 lb/acre, and a price of $0.43/lb. Sesame would also exceed grain sorghum's baseline gross profit at a price of $0.50/lb and yields of 600 and 700 lb/acre, generating gross profits of approximately $156 and $206/acre, respectively.

4.7 Whole-farm replacement scenarios

This section widens the comparison to the whole farm. It builds a farm that reproduces the benchmark, then replaces crops with sesame one acre for one in order of their gross profits. The crop shares are those of the KFMA farms (corn 29.4%, sorghum 22.6%, soybeans 4.5% and wheat 43.4%). The total acreage was found by Goal Seek so that the gross profits sum to Y* = $118,315, which gives a calibrated farm of 496 acres: corn 145.9, sorghum 112.2, soybeans 22.3 and wheat 215.2 acres. This applies to the study's assumption that net farm income equals sum of gross profits, so the calibrated acreage is a scale for the comparison, not the size of the typical farm used in Sections 4.2 to 4.6.

Gross profits and irrigation come from the K-State AgManager low-level budgets: corn $383.02 (13 in), sorghum $322.44 (10.5 in), soybeans $330.75 (9 in) and wheat $87.70 (4 in; 60 bu at $5.24 with direct expenses of $226.70). Sesame's yield is the most influential input, so two cases are shown. Case A is the base: 1,000 lb at 4 in, a gross profit of $75.52. Case B uses 1,200 lb, the middle yield and near the upper (Pabuayon, Singh, & Ritchie, 2019) treatment mean of 1,359 kg/ha (1,212 lb/ac), with irrigation kept at 4 in. Direct expenses are held at $294.48 in all cases, so the gross profit is $149.52 in Cases B.

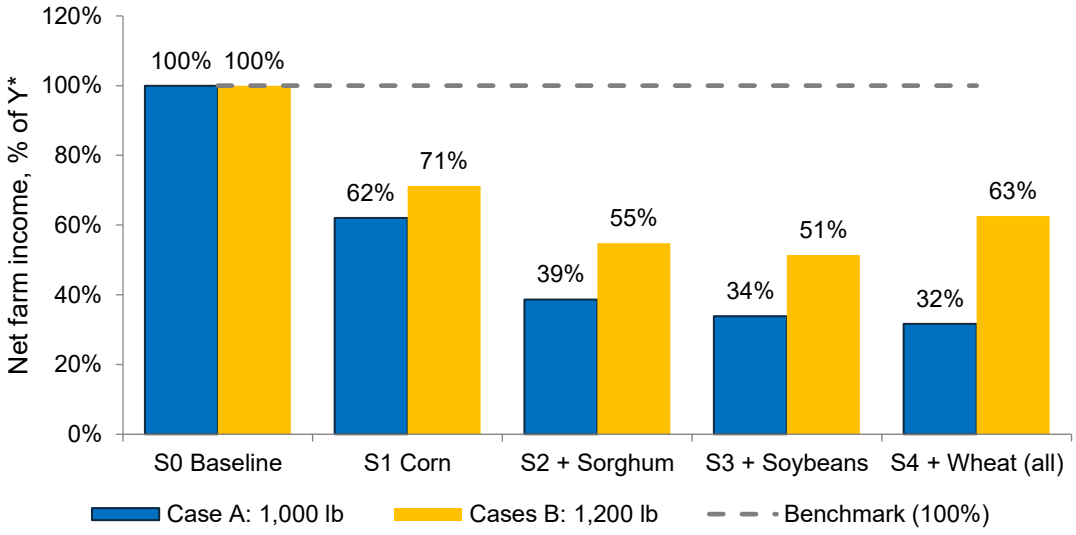
Table 4.9 Whole-farm replacement scenarios

Scenario	Whole-farm replacement scenarios				
	Sesame acres	Net farm income, A ($)	Scenario A, % of Y*	Net farm income, B ($)	Water change, A and B
S0 Baseline	**0**	**118,315**	**100.00%**	**118,315**	**0.00%**
S1 Corn	145.9	73,436	62.10%	84,236	−31.8%
S2 + Sorghum	258.1	45,741	38.70%	64,841	−49.4%
S3 + Soybeans	280.4	40,050	33.90%	60,800	−52.1%
S4 + Wheat	495.6	37,429	31.60%	74,104	−52.1%

Case A = 1,000 lb at 4 in; Case B = 1,200 lb at 4 in. Water change is relative to the baseline of 4,136.5 acre-in.

Three results stand out. First, no scenario reproduces Y*. Income falls to between 32% and 62% of the benchmark in Case A and between 51% and 71% in Cases B, because sesame's gross profit is below that of corn, sorghum and soybeans. Figure 4.6 shows the gross profit given up per acre converted is $307.50 for corn, $246.92 for sorghum and $255.23 for soybeans in Case A, and $233.50, $172.92 and $181.23 in Cases. Second, wheat is the exception. Its gross profit ($87.70) is above sesame in Case A, so replacing wheat in S4 costs a further $2,600, but it is below sesame in Cases B, so income rises from $60,800 in S3 to $74,104 in S4. Third, the water saved is large, 25% to 52% of the farm's irrigation, but it is bought at a high price.

Figure 4.3. Net farm income after replacing crops with sesame, as a share of Y*



The forgone gross profit per acre-inch saved in S1 is $34.17 in Case A, and $25.94 in Case B, and these values do not depend on the calibrated farm size. They are above the highest marginal user cost of groundwater reported by Williams et al., (2017), $18.25 per acre-inch (mean $9.38), although that estimate is for Texas counties and is a rough guide here. Wheat uses 4 inches in the budget, the same as sesame, so replacing wheat saves no water.

Chapter 5 - Implication And Conclusion

The chapter presents the summary of the study's results and is organized in the following manner. The first section addresses the implications for policy and farm strategy. The second highlights its main limitations. The third and final section present the conclusions from the study and offer some ideas on potential future research that may be conducted to address the identified gaps in the study.

5.1 Implications

The Ogallala Aquifer water depletion situation puts Southwest Kansas farmers' activity at risk. The study we conducted aims at exploring alternative enterprises by looking for crops water requirement and gross profit generated. The data and studies that we reviewed in this work suggest that irrigation may remain viable in the near term, but continued groundwater depletion could limit its long-term sustainability if no measures are taken to reduce withdrawals. Rethinking the Southwest Kansas agriculture with crops that thrive well in semi-arid region is adaptability. Sesame is among plants that grow well with little water requirement compared to other crops grown in the region.

At the budget values, sesame reaches the target income only if it is grown on 93.1% of the farm (1,567 of 1,683 acres). It cannot replace the $189,978 gross profit of the corn acres, which would take 2,516 acres (149% of the farm). Replacing the 496 corn acres acre for acre lowers gross profit by about $152,500 a year. The comparison is driven by the gross profit: sesame's $75.52 per acre is a fifth of corn, so even the 69% saving in irrigation under acre-for-acre replacement costs $34.17 per acre-inch saved.

Two results show where the thresholds are. Sesame covers the target on the available land at prices near $0.365/lb, which the Sesaco formula reaches when soybeans are above about $9.5/bu, so the outcome is sensitive to the soybean price. And at the acreage needed for Y* it saves water only above about $0.368/lb at 4 inches, or below 4.12 inches at the budget price.

These findings fit the literature. Araya et al. (2019) found that corn returns increase with irrigation capacity, which makes corn the stronger performer at the low level used here. Pabuayon, Singh, Lewis, et al., (2019) found sesame yield unresponsive to irrigation, so added water would not raise the sesame gross profit, although Trostle (2025) reports a moderate yield response of 20–33% to an extra six inches. The irrigation values of 4 and 6.5 inches in this study bracket Trostle's 4–6-inch recommendation. The split of the water change into an acreage effect and a per-acre effect follows the acreage-and-intensity decomposition of Drysdale and Hendricks (2018,).

5.2 Limitations

This study provides a comparative assessment of crop gross profits and economic risk under modeled conditions, rather than definitive estimates of farm-level profitability. Because the results rely on assumed or simulated yields, prices, and variable production costs, they are sensitive to the underlying assumptions and may not represent the diverse soil conditions, irrigation capacities, weather patterns, and management practices found across all farms in Southwest Kansas.

In addition, the analysis may not fully reflect practical barriers to sesame adoption, including establishment and harvest challenges, pest pressures, quality variation, producer learning costs, and relatively less-developed marketing, contracting, transportation, and price-discovery systems . Since gross-profit analysis measures revenue fewer variable costs, it does not

capture fixed costs, capital investments, or broader whole-farm adjustments that can affect net profitability.

Finally, the study does not explicitly quantify irrigation-water use, or the economic value of conserved groundwater. Therefore, the findings should be interpreted as estimates of relative economic performance and risk under the specified modeling assumptions, not as guaranteed outcomes for individual producers, farms, or production seasons.

5.3 Conclusion

This study demonstrates that sesame offers a compelling risk-adjusted and water-conservation profile relative to corn, but its long-term viability as a diversification crop in the Ogallala Aquifer region depends on factors beyond farm-level agronomics and hydrology. Even at the baseline yield and a price, dryland sesame earns less gross profit than corn and sorghum. It becomes competitive only at higher yields or prices.

The purpose of this study was to evaluate the economic feasibility of sesame production in Southwest Kansas as a strategy to manage the water challenges posed by the current and projected status of the Ogallala Aquifer. The study asked whether sesame could replace irrigated corn in the income of a typical Southwest Kansas farm while using less groundwater. The outcome is mixed. For the first objective, sesame will need to take almost the whole farm to reach the average KFMA net farm income. Producing sesame would save water only if it used lightly irrigation, around 4 inches like calculated in our budget. The second objective determined that irrigated sesame would match corn income only when its price and yield are above the current condition. Even a higher pumping cost does not close the gap. Therefore, sesame is best seen as a water-saving option for farms facing tighter water supplies, not as a one-for-one replacement for corn at today's prices and yields.

For water-conservation policies to be successful, it could be good to align groundwater-saving objectives like design by LEMAs with producer profitability. Therefore, by promoting alternative crops such as sesame, the industry may require further investments in agronomic research, supply chains, marketing systems , and producer risk management as we have seen. Water-saving will not be complete with one year action; it requires continuous program of crop diversification to make long term effect.

If water is sufficient to grow corn, farmers will naturally produce it because the market is well established with insurance and good profitability. The reality is that sesame belongs to thin market, its adoption by farmers still needs to go through different steps before being widely produced. It may become more relevant for producers with a higher yield or price per pound, when irrigation allocation decreases, pumping costs increase, or the well capacity declines significantly. Adoption decisions for sesame should account for local yield potential, seed availability, harvesting equipment, crop insurance availability, processing or marketing channels, and contract opportunities.

For future research, one of the most important thing is sesame data availability. Having fields trial in Southwest Kansas instead of Texas-based budget with local yields, costs and applied irrigation, would provide a better calculation base. Building whole-farm budget with yield, price, variable and fixed cost specifically for Kansas will provide a better based to evaluate the sesame economic. Finally, surveys of farmers and studies of processing, storage and marketing would show what limits adoption and how a larger sesame acreage would affect prices.

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