Regional water savings and increased profitability on the Texas High Plains: A case for water efficient alternative crops

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Introduction

The southern portion of the Ogallala Aquifer has experienced substantial declines in saturated thickness due to extensive supplemental irrigation usage to cultivate field crops in this region. Production of traditional crop mixes on the Texas High Plains has become constrained by water availability. Additionally, the continued desertification of this region resulting from climatic changes and excessive recent drought periods are exacerbating these irrigation constraints. Farmers in this semi-arid region are beginning to experiment with new methods to conserve water. One such method has been to only produce half circle pivot irrigated cotton, leaving the remainder of the field in dryland cotton or unutilized acres, and attempting alternative drought-resistant crops such as guar and sorghum.

As seen in Figure 1, the Texas High Plains consists of 54 counties spreading from the top of the Texas Panhandle to the Midland-Odessa Region covering almost 137,000 square kilometers or roughly 53,000 square miles. Agriculture in this region adds roughly $9 billion yearly including livestock and crops. The water needs are growing as population rises meaning that the conservation of water for the future in this region is extremely important over the next 50 years.

There is more than one aquifer situated underneath the Texas High Plains, but the main aquifer, which is the Ogallala Aquifer covers an area from South Dakota to the southern portion of the Texas High Plains, making it the largest groundwater system in North America (Zwingle, 1993) and covering 90,500 square kilometers or 35,000 square miles (Urban, 1992). In 2009 according to the U.S. Geological Survey, 3 billion acre-feet

Figure 1. The Texas High Plains covers 54 counties shown by the box.

Source: http://upload.wikimedia.org/wikipedia/commons/thumb/5/5a/Texas_counties_map.png/600px-Texas_counties_map.png of water was contained over the entire aquifer, but is decreasing at a rate of one foot per year on the Texas High Plains, with the last few years experiencing higher than normal depletion levels reaching above two feet per year due to the drought (Galbraith, 2013). Figure 2 shows the saturated thickness of the aquifer; different areas of the aquifer are experiencing different rates of depletion, but the Texas High Plains is seeing the highest rate of depletion. This high level of depletion is due to producers pumping more water to

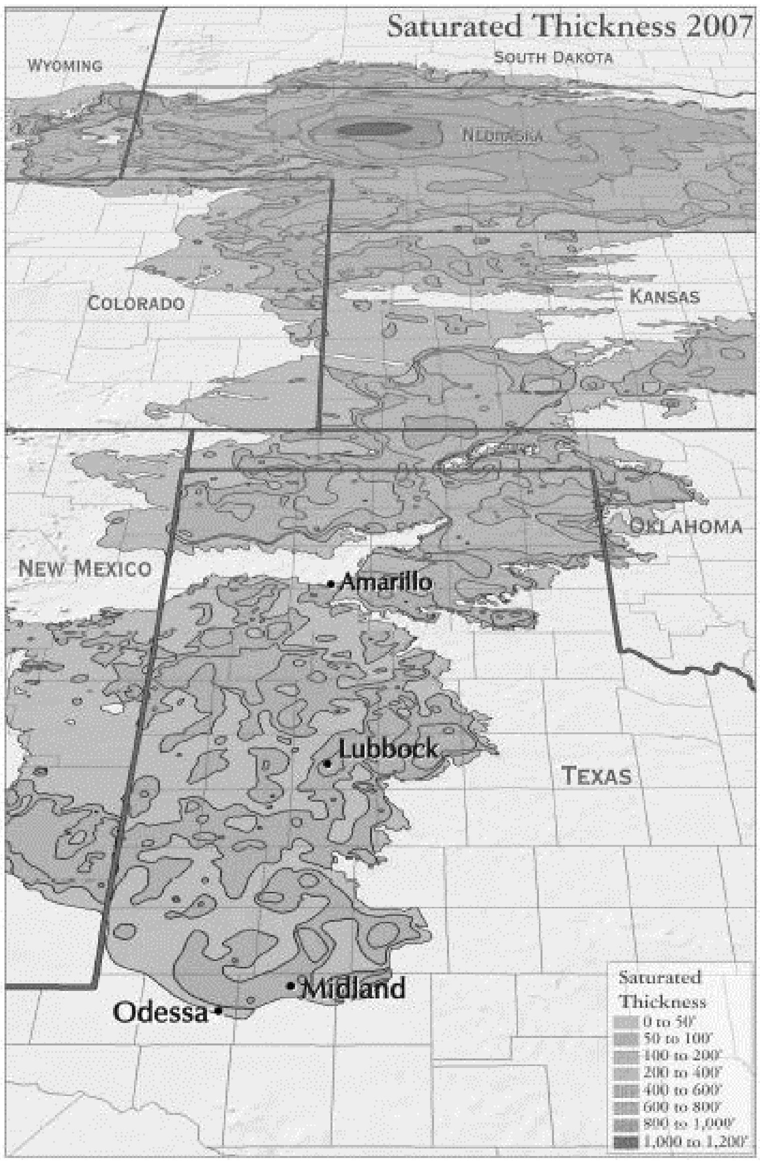

Figure 2. The saturated thickness across the aquifer.

Source: http://texaslandscape.org/maps_ogallalasaturatedthickness/

compensate for lower rates of precipitation with high water crops such as cotton and corn. Helping to limit this high water usage, regional water management boards across the state are starting to limit water usage per well to a certain amount of acre-feet based on the county's historical water usage, normal crop rotation, and water availability due to saturated thickness. Many counties are easing into these restrictions over the next few years by steadily decreasing the amount of water availability until regulating irrigation to just one acre-foot per acre giving a total available irrigation of 1920 acre-inches for an entire 160 acre field. Some farms do not even have the capacity to pump this much at the given time with the dropping saturated thickness. If cotton is kept as the primary crop and planted on the majority of acres, overall yield will suffer greatly with the decrease of available water to only 12 acre-inches per year.

Guar, an annual legume that requires about 9-12 inches (25-30 cm) of irrigation, has traditionally been grown in India and Pakistan, and is now gaining momentum domestically due to guar gum use in hydraulic fracturing (Undersander, "Guar", 1991). Guar is suitable for West Texas due to the similar semi-arid climate that is shared with India and Pakistan. Domestic oilfield service companies such as Halliburton, Schlumberger, and Baker Hughes are paying high prices to import guar gum to the United States. However, if guar is to become a viable alternative crop on the Texas High Plains, there needs to be evidence of profitability.

Sorghum has long been used as cattle feed, but with biofuels being used in greater quantities, its demand has been steadily increasing since the early 2000s. Due to policy changes, there has been a decrease in corn based ethanol production; in light of these changes, many producers are seeking alternative crops, mostly sorghum, to use in ethanol production. New sorghum dwarf varieties have been developed to conserve water and made more suitable for production on the High Plains. Through these developments, sorghum has had higher yields per acre, while ultimately conserving current water sources (Carter, "Sorghum", 1989).

Sesame, an annual oilseed crop, has been one of the longest cultivated crops in history; the high-value oil has high nutritious value due to its high oleic acid content (47%). The meal by-product has a high protein value as well making it great feed for livestock (Oplinger, "Sesame", 1990).   Sesame has historically been hand-harvested due to its ability to shatter on contact; recent technological advances through breeding has made sesame a better option for use on the High Plains with tighter pods that hold in seeds when put through stress situations such as high wind events and mechanical harvesting by way of combining. Sesame is also extremely water efficient, being able to make a profitable crop with about 12 inches (30 cm) of supplemental irrigation.

Based on the experience of producers in the High Plains, guar, sorghum, and sesame are all great options for water efficient crops to be added to crop rotations. Cotton is the most prominent crop on the High Plains, and it will never be able to be completely replaced by other crops due to profitability. The research in this paper tries to make a case for using alternative crops at the same time as cotton on the same circle. This paper tries to look at maximizing profit while holding irrigation as a constraint moving forward into the future.

Methodology and Data

All data for this study was derived from Texas A&M Agrilife Research Extension budgets gathered and updated each year for projecting the return on each crop for the upcoming season. Using linear programming as the method of modeling, the optimal combination of crops has been found based on a circle pivot field with the dimensions of a quarter-mile by quarter-mile. These dimensions give the average field size for a High

Figure 3. Standard Quarter-Section Circle Pivot showing ability to irrigate at different rates across the circle.

Plains farm using 160 total acres with each field only irrigating 120 acres of the total which can be seen graphically in Figure 3. Based on Figure 3, each corner adds 10 acres of dryland crops which are usually planted in a drought-tolerant cotton variety to maximize profits. With the modeling, the expectation is that there can be a higher profit using other crops even with the addition of more capital needed for the differing cultivation and harvest techniques used in cotton. Many constraints were used to model this profit maximization including: total acreage, irrigated acreage, labor, irrigation labor, limit of total irrigation over the season from an average farm across the High Plains, limit of dollar amount to just irrigation. As stated earlier with the decrease in overall irrigation to eventually the proposed one foot per acre, cotton will have to be decreased to a smaller

Crop		Net Profit *($/Acre)*	Supplemental Irrigation Need *(Acre-Inches)*	Irrigation Labor *(hours/acre)*	Irrigation Fixed Cost *($/Acre-Inch)*	Irrigation Total Cost *(Supplemental Irrigation * Irrigation Fuel Cost)*
Cotton	Irrigated	471.69	20	0.9	9	180
	Dryland	116.1	0	0	0	0
Sesame	Irrigated	414.98	12	0.9	9	108
	Dryland	132.51	0	0	0	0
Guar	Irrigated	159.46	9	0.9	9	54
	Dryland	147.73	0	0	0	0
Sorghum	Irrigated	-67.32	16	0.9	9	144
	Dryland	-25.7	0	0	0	0

Table 1. Main constraints used in calculating profit max with irrigation constraints.

part of a circle and not the entire circle such as it is currently. Each crop was calculated using the net profit after direct and indirect expenses have been accounted into the profit per acre. Table 1 shows the profit per acre for each crop producing medium yields using pivot irrigation and dryland techniques as well as other constraints used based on each crop.

Results and Discussion

The model was evaluated repeatedly, using different parameters as limiting factors. The following scenarios are below and represented by bar graphs: A producer with unlimited resources except for land constraints (Figure 4), low water availability and low amount of

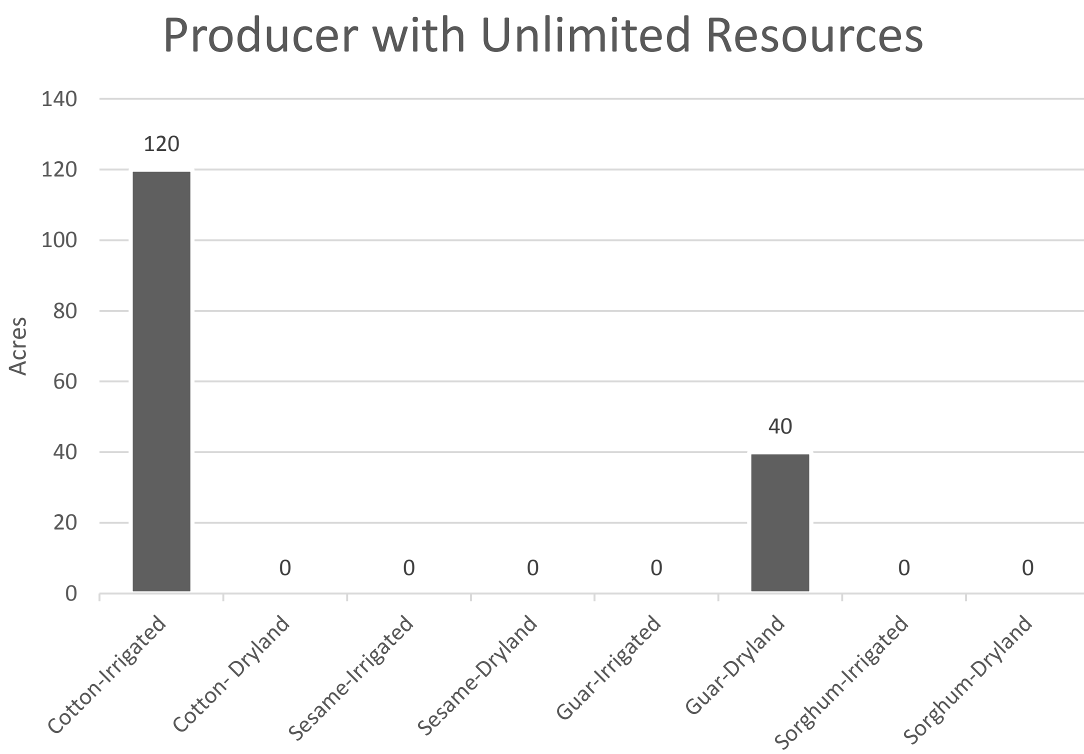

Figure 4. Producer with unlimited resources; only constrained by irrigated land.

labor (Figure 5), high water availability and low amount of labor (Figure 6), low maximum irrigation costs and high amount of labor (Figure 7), low maximum irrigation costs and low amount of labor (Figure 8), and finally a medium cost with medium amount of labor and water availability (Figure 9). All of the following scenarios are within a 25% increase or decrease in the medium amount of available constraints; for example, a low water availability would be 25% less than an average amount of about 1000 acre-inches available over the entire year or about 750 acre-inches.

The producer in Figure 4 has optimized his operation with only irrigated land limiting his profit. If this scenario plays out, his maximized net profit will be $62,512

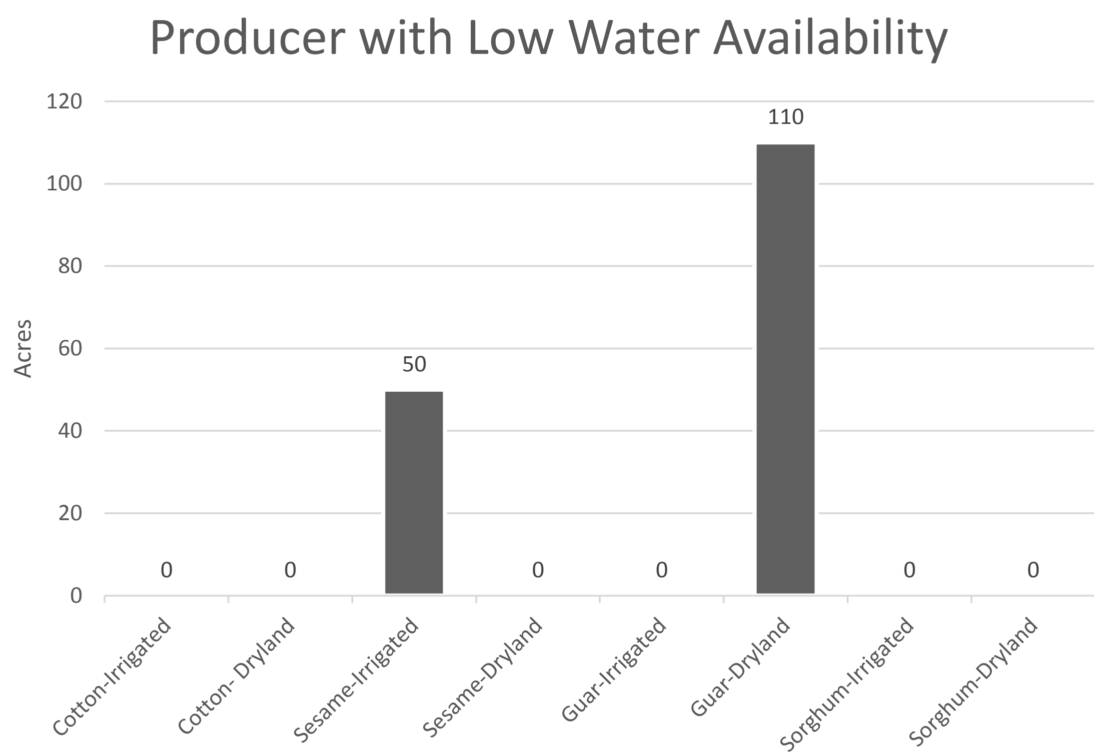

Figure 5. Producer with Low Water Availability and Low Labor; only constrained by water availability.

using strictly irrigated cotton inside the pivot and guar in the corners. This is taking into account a 1500 lb/acre (~1500 kg/ha) yield at $0.76/lb and a 700 lb yield at $0.45/lb for the guar.

The producer in Figure 5 has optimized his operation with a low irrigation availability such as that found in the southern portions of the High Plains. The only limiting factor in this scenario is the amount of irrigation available to him from the aquifer itself and not through regulation. His overall profit has dropped substantially to just under $37,000. Considering the irrigated sesame is much more water efficient and is only $56.71/acre lower than irrigated cotton, then this scenario seems extremely

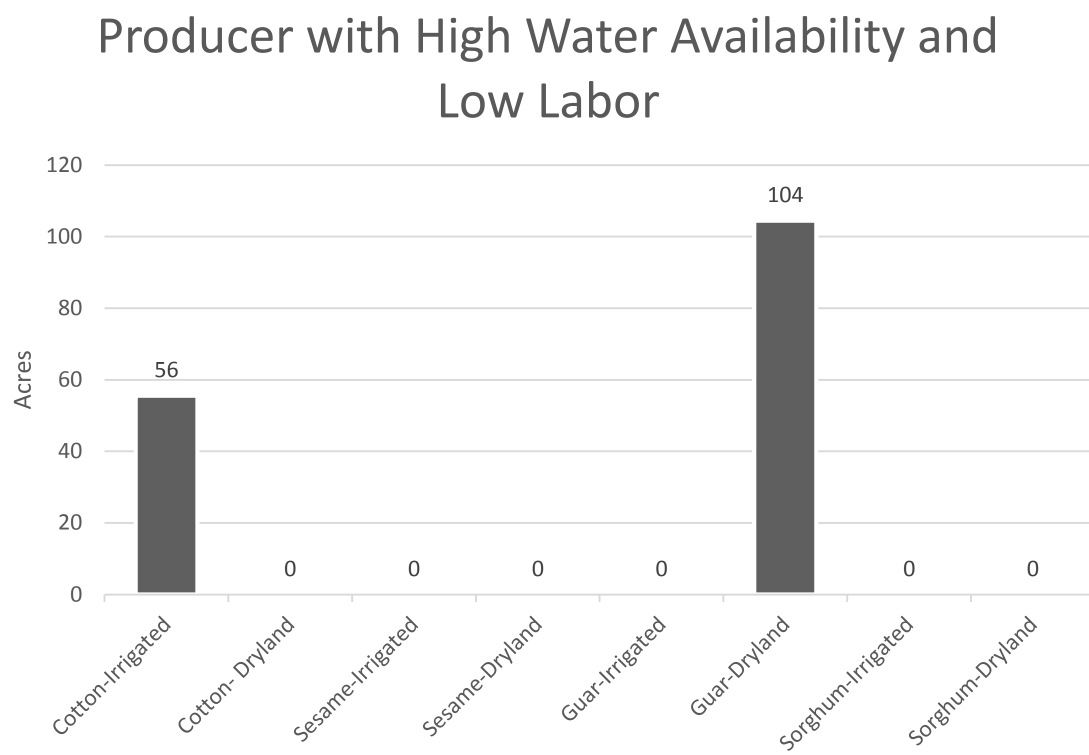

Figure 6. Producer with High Water Availability and Low Labor; only constrained by the available labor.

plausible for a producer on the High Plains that does not have the same amount of water available as in the past. If he could find one more acre-inch over the season, he could increase his profit by roughly $22.

Figure 6 shows a different scenario for a producer with high water availability but a low amount of labor. The overall profit has increased to about $41,500 due to higher supplemental irrigation, but the only limiting factor is the lower amount of labor that he can use. If he could find one more employee to help him on the farm, his profits could increase by $360.

Figure 7 depicts a producer that wants to keep his irrigation costs at a minimum but has a high amount of labor that he can use. His optimized profit would be almost $42,200, and his only constraint would be the amount of money he wants to pay for irrigation. If he added one more dollar to irrigation costs, his overall profit would increase by almost $2.50.

Figure 8 shows a very interesting and plausible situation found with many farmers on the High Plains, he wants to reduce costs that he deems unnecessary such as irrigation costs and extra labor. His overall profit is around $37,000, but if he increased labor by one hour, he would increase profits by $202. If he only increased irrigation costs by $1, his profit would increase by $.78.

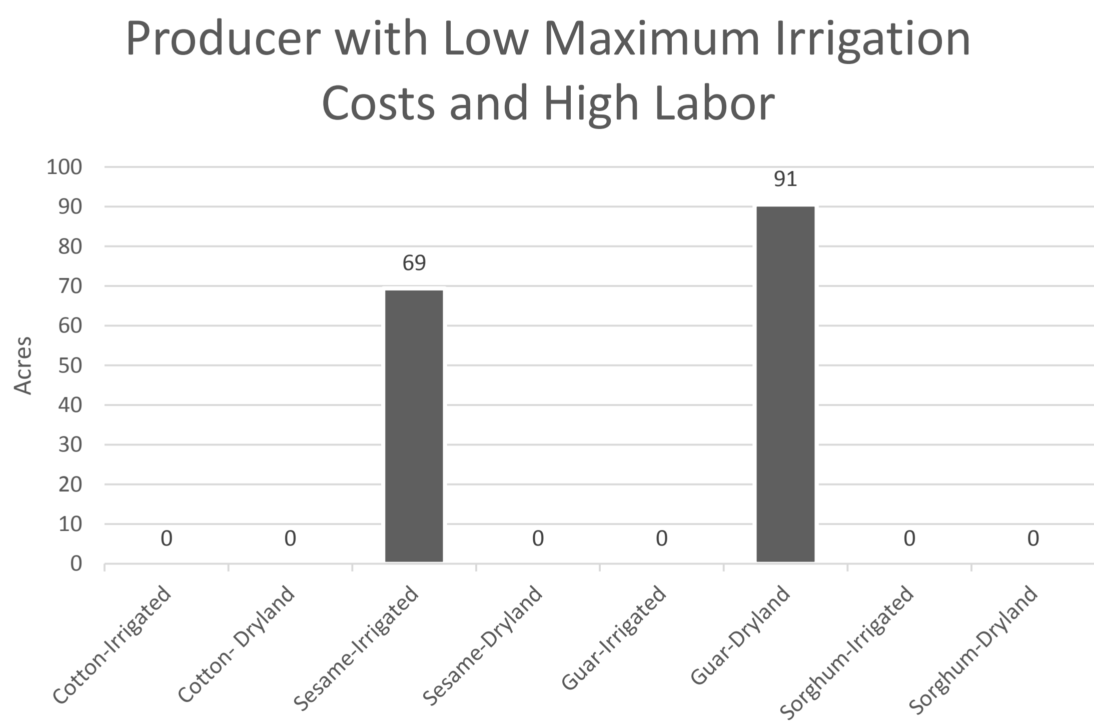

Figure 7. Producer that wants to minimize his irrigation costs, but has a high amount of labor; only constrained by the low irrigation costs.

Finally the last scenario is the average scenario for most farmers across the West Texas and the High Plains, a "middle-of-the-road" take on the situation with average constraints on everything: labor, water, costs, etc. Figure 9 shows the average producer,

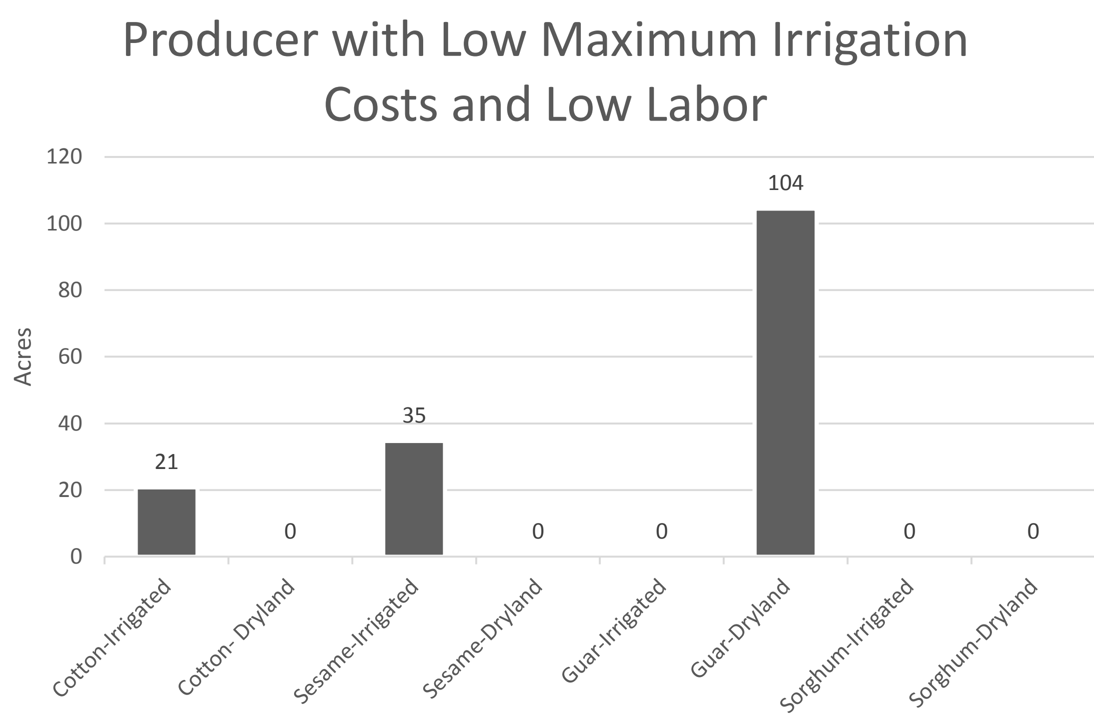

Figure 8. Producer that wants to minimize all costs, including irrigation costs and labor costs; constrained by irrigation costs and labor.

and how it would play out in a perfect situation. He could use very little water at all, and focus all the irrigation on 30 acres of cotton production that could yield upwards of 4-5 bale cotton (2000-2500 lb/ac). The rest of the 130 acres could be planted in dryland guar and bring about a profit of just under $33,500. The only constraint that he has would be more land, and if he has multiple crop circles, this could be a viable option. If he added one more acre of land, then his profit would increase by $132.50.

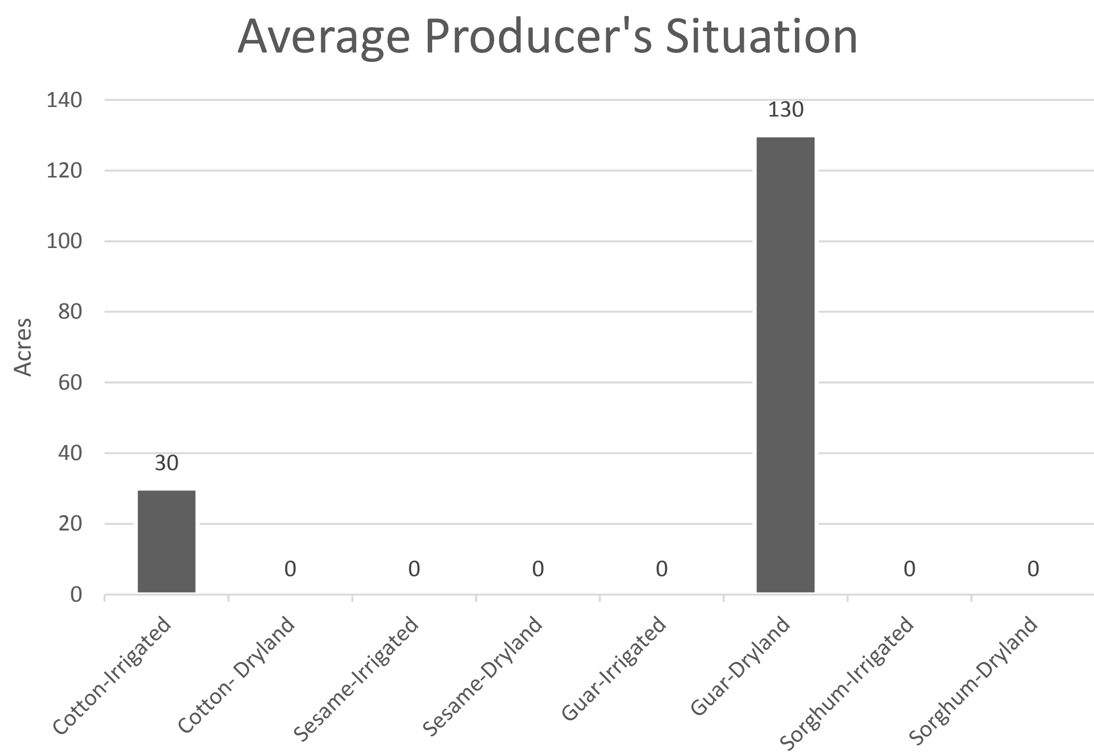

Figure 9. Average producer on the High Plains with average inputs and water availability; only constrained by land.

Conclusion

As we look towards the future, many producers will need to look into new, alternative crops that will maximize their profits while minimizing irrigation use. The Texas High Plains is a thriving region and in 2010 there were almost one million people living in the 54 counties that it represents (U.S. Census Bureau, 2010). There will be more people moving towards the High Plains with the rise in oil and gas production, meaning that there will be a higher water need in the coming years. If we want to continue to thrive, producers will need to look hard at new technology such as Variable Rate Irrigation and Subsurface Drip Irrigation to maximize irrigation efficiency while maximizing yields with less land available. Guar and sesame are vertically integrated industries, so it might be difficult for new producers to enter into the market and find contracts; meaning that cotton will continue to be the staple crop grown on the High Plains as long as there is plenty of water. Producers can integrate these alternative crops into their current crop rotation and enjoy benefits of higher yields and less disease using an appropriate rotation.

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