ENHANCING PRODUCER PROFITABILITY WITH VEGETABLE PRODUCTION IN THE TEXAS HIGH PLAINS

by

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ABSTRACT

In the Ogallala Aquifer, the Texas High Plains' primary water source, withdrawals continue to exceed the aquifer's limited recharge. Producers are compensating with water-conserving production techniques such as transitioning to more efficient irrigation technology, implementing conservation tillage practices, reducing the amount of irrigation applied, and alternating the crops they plant. Given the current condition of the semi-arid region, alternative production methods are necessary to enhance farm profitability. One alternative being considered by producers is the production of high-value crops.

High-value crops, including vegetables, can increase overall producer profitability. Initial project experiments have demonstrated the potential for viable vegetable production; however, no studies exist to prove the economic viability of these crops in the Texas High Plains. This study analyzes the economic feasibility of producing high-value vegetables so producers may make an informed decision regarding the incorporation of vegetable production into their existing operation. This information will benefit not only producers faced with declining water availability but also small landowners considering more productive uses of their land.

Tomatoes, jalapeño peppers, and sweet corn were produced in an open field at the USDA-ARS CPRL/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas using surface drip irrigation both with and without the use of black plastic mulch. Field

production data including water use, labor hours, input costs, and yields were collected through personal communication with research faculty. Additional data were collected from the Texas A&M AgriLife Extension crop budgets, the United States Department of Agriculture's Agriculture Marketing Service, the United States Department of Agriculture's Economic Research Service, and a review of existing vegetable production literature.

These data were compiled to create enterprise budgets including revenue, variable costs, fixed costs, and total profit for each vegetable with mulch and without mulch under surface drip irrigation, on a per-acre basis. Economic data for traditionally irrigated corn, cotton, and wheat were obtained from the Texas A&M AgriLife Extension crop budgets. Several economic measures, including return on investment, profit per acre-inch of irrigation water applied, and breakeven prices were analyzed to provide producers with the information needed to make decisions. In addition, sensitivity analyses were conducted to evaluate how changes in crop prices and labor hours would affect producer profit.

An online survey was distributed to producers implementing vegetable production within the study region to identify current management practices. Innovative production systems such as high tunnel systems and greenhouses offer several benefits to these producers, specifically protection from the harsh environment. Additionally, survey respondents provided information regarding higher revenue possibilities that exist through other marketing outlets including farmer's markets, local grocery stores, and restaurants.

Implementing vegetable production in an existing enterprise is an alternative that can help increase or maintain overall producer profits, especially for producers faced with declining water availability. Despite the high investment and high labor costs, the results indicate vegetable production in the Texas High Plains has great profit potential. It is important to note that conservative estimates of revenue were utilized in this study. In addition, because specialty crops are not eligible for Agricultural Risk Loss Coverage, Price Loss Coverage, or Marketing Assistance Loan programs, producers should consider the risk associated with field production and methods to reduce the risk. Further research should be conducted to evaluate the economic feasibility of vegetable production in high tunnel systems and the use of other locally-grown fruits and vegetables to enhance farm profitability.

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God Bless and Go Buffs!

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CHAPTER 1

INTRODUCTION

The Ogallala Aquifer, an aquifer underlying eight states in the Great Plains of the United States, is the primary resource for agricultural irrigation in the Texas High Plains. The water table has declined immensely due to water withdrawals from the aquifer exceeding the rate of natural recharge (Colaizzi et al., 2009). The semiarid nature of the region, warm summer temperatures, and limited rainfall are factors hindering the natural recharge of the aquifer (Almas, Colette, and Wu, 2004). The effects of aquifer depletion and available agricultural irrigation are becoming more prominent after more than 50 years of heavy pumping demand for agricultural production, creating unsatisfactory environmental conditions for agriculture in the region (Terrell and Johnson, 1999).

Economic growth in the Texas High Plains agricultural industry requires consideration of innovative farming techniques in relation to the availability of groundwater from the Ogallala Aquifer. Given the physically and environmentally unsatisfactory condition of the Ogallala Aquifer region of the Texas High Plains, many research studies evaluate methods to enhance farm profitability such as the adoption of high-value crops and growth potential in new crop species. The adoption of innovative farming techniques is prevalent in regions around the world because of the need for increasing production in agricultural enterprises. Included in these innovative techniques are alternative water management plans used to conserve or optimize water usage.

Alternative water management plans have become more prevalent as water is continuously pumped from the aquifer to irrigate crops and sustain livestock production (Almas, Colette, and Wu, 2004). Producers in the area have begun to adopt efficient irrigation methods as a means to extend the life of the aquifers (Terrell and Johnson, 1999) including converting to center pivot irrigation systems or subsurface drip irrigation (SDI) which has shown increased water-use efficiencies in the area (Amosson et al., 2011). Irrigation efficiencies make it economically feasible to irrigate "more acres or irrigate the same acres more intensely" (Wright, Hudson, and Mutue, 2013), however, some producers are forced to convert to dryland farming practices (Terrell and Johnson, 1999).

Counties with the lowest water availability are more likely to adopt efficient technology to extend the life of the aquifer (Wright, Hudson, and Mutue, 2013). However, it is speculated that reducing irrigation usage in agricultural practices will cause a decrease in agricultural revenue (Almas, Colette, and Wu, 2004). As such, producers forced to implement dryland production into their enterprise have seen deficits in revenues as water levels in the aquifer continue to diminish (Terrell and Johnson, 1999).

Producers need to continuously reevaluate their cropping systems as groundwater availability from the Ogallala Aquifer depletes (Terrell and Johnson, 1999). One alternative for producers to mitigate reduced agricultural profit is to obtain more value from water withdrawals. Incorporating vegetable production into an enterprise can improve the economic efficiency of water use by increasing total profit per acre-inch of irrigation water applied and enhancing overall farm profitability. Since vegetables typically use more water per acre than irrigated corn, cotton, and wheat, and production is labor intensive, producers may hesitate to incorporate vegetable production into their current enterprise (Mendelsohn, 2016). Therefore, it is vital to critically evaluate the potential benefits of incorporating vegetable crops.

In 2017, the impact of agricultural production and agribusiness was approximately $47.85 billion dollars to the Texas economy (Grahame and Robinson, 2018). Beef, milk, feed corn, cotton lint, cottonseed, wheat, and sorghum are the top-ranked commodities by economic impact in the Texas High Plains. However, vegetable and food corn production ranked among the top 20 commodities in the region, accounting for 1.41 percent and 0.97 percent of the economic impact in Texas A&M AgriLife Extension Districts 1 and 2, respectively (Grahame and Robinson, 2018). Currently, vegetables account for an estimated value of approximately $65 million and $47 million in Texas A&M AgriLife Extension Districts 1 and 2, respectively. Total vegetable production accounts for 1.50 percent of all agricultural production and agribusinesses in Texas. The estimated value of vegetable and food corn production fluctuated with the Texas agriculture economy from 2008 to 2017 with the high at over $419 million in 2010 and a low of $310 million in 2015 (Grahame and Robinson, 2018; Cleaver and Robinson, 2012).

Agricultural producers are heterogeneous, and improved practices, such as incorporating vegetable production into their enterprise, need to fit the needs of the individual producer. It is important to consider the economic cost associated with vegetable production in the Texas High Plains because "the choice to adopt new technology can be thought of as an economic decision where individuals switch to a new innovation because it increases their net revenue from the production of a good. Therefore, "the decision to adopt will be driven in part by the cost associated with the new technology" (Wright, Hudson, and Mutue, 2013). Communication studies provide insight into the innovation-decision processes, anticipating when and why producers will decide to incorporate innovation with current agricultural practices. Through effective communication using community outreach and education, researchers encourage the adoption of beneficial agricultural innovations (Taylor and Zilberman, 2015).

Preliminary research trials conducted at the United States Department of Agriculture-Agriculture Research Service Conservation and Production Research Laboratory (USDA-ARS CPRL)/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas, indicated the possibility of high-value vegetable production in the Texas High Plains. In 2016, researchers grew over 11,000 pounds of tomatoes between field production and high tunnel systems. Tomatoes, jalapeño peppers, and sweet corn were produced using pivot irrigation, surface drip irrigation, and high tunnel production. However, neither water optimization nor economic practicalities were considered in these trials (Rush, 2018). Combining this production data with the current conditions of the Ogallala Aquifer presents a need to evaluate how vegetable production could supplement producer income in the region.

It is hypothesized that production of tomatoes, jalapeño peppers, and sweet corn could enhance total farm profitability in the Texas High Plains. While vegetable production can result in higher initial investments, the benefits of high yields and increased farm profits through alternative marketing outlets could allow producers to supplement income as they change their field crop production. By determining the economic feasibility of each vegetable, the following specific objectives will be evaluated in this study:

- determine return on investment for each vegetable and compare to that for traditionally irrigated field crops produced in the region;
- determine which crop, tomatoes, jalapeño peppers, or sweet corn, generates higher profit per acre-inch of irrigation water; and
- identify current vegetable production methods and marketing outlets utilized by area producers.

CHAPTER 2

LITERATURE REVIEW

The purpose of this section is to review existing studies that relate to economic analysis and communication of vegetable production practices. As current literature analyzing vegetable production in the study region is limited, this literature review examines studies focused on economically enhancing vegetable production and the methods used therein. The literature review is delineated into the following sections: irrigation technology, vegetable production practices, production considerations, economics of production, and producer and consumer communication.

Irrigation Technology

Irrigated agriculture uses four different methods of irrigation depending on the distribution of water through a field: surface, sprinkler, drip or trickle, and subsurface irrigation. Encompassed in these methods are furrow or flow irrigation, center pivot sprinkler irrigation, surface drip irrigation, and SDI. “Surface drip irrigation” and “surface irrigation” may be used interchangeably but are quite different in the application of water. Surface drip irrigation is a mechanical irrigation method, but surface irrigation is distributed by gravitational flow rather than by mechanical pump (NRCCA, 2010). Each of these irrigation methods is used in the Texas High Plains for field crop, hay, fruit, and vegetable production.

Irrigation research indicated efficient irrigation technologies tend to have increased adoption rates in hotter, drier climates with limited water availability (Mendelsohn and Dinar, 2003). One such technology, variable rate irrigation technology (VRI), is a modification to center pivot irrigation systems that positively influenced yield in water sensitive, high-value crops. Although Almas et al. (2003) reported not all fields were ideal for VRI, if field variability is sustained and crop prices remain high, the irrigation technology would be a profitable investment.

SDI research indicated a high efficiency rate resulting in the ability to conserve energy and labor by providing small daily quantities of water to row crops. However, research also indicated SDI is not economically feasible when used in low-water scenarios because of the small increase in water-use efficiency and high investment cost. SDI may be beneficial in high-value crop production but should only be used in areas where a center pivot cannot be implemented for traditional grain crop production (Amosson et al., 2011). Specific irrigation costs and efficiencies vary based on crop use and geographic location (Mendelsohn and Dinar, 2003).

Climate, precipitation, water use efficiency, yield, and profit are some factors that may influence producers' decision regarding the type of irrigation system to implement into production practices. The following studies estimated the economic viability of drip irrigation in vegetable production by comparing several methods of irrigation. Drip irrigation demonstrated high yields and water use efficiency in each study and resulted in higher overall profits for producers.

Mendelsohn and Dinar (2003) analyzed the interaction between climate, water, and agricultural production to determine land value based on the water source and the likelihood of agricultural producers adopting irrigation technologies. Due to variations in irrigation cost, efficiency in crop yields, and geographical location, analyzing the economic impact on individual farms was challenging. Producers chose to adopt gravity and drip irrigation systems to compensate for lack of precipitation and rising temperatures. Drip irrigation was most commonly used in regions with hot climates and little to no rainfall. Precipitation levels did not carry much influence on producers' decision to convert irrigation systems (Mendelsohn and Dinar, 2003).

Narayanamoorthy, Bhattarai, and Jothi (2018) analyzed the techno-economic viability of drip method irrigation compared to flood irrigation in India. The specific objective was to determine the economic impact of drip irrigation in vegetable production in South Asia by analyzing water and electricity consumption, cost of cultivation, crop yield, profits, and economic viability of the investment. Results determined a significant reduction in water and electricity use, increased water use efficiency, and higher profit in vegetable production with drip irrigation (Narayanamoorthy, Bhattarai, and Jothi, 2018).

Flood irrigation was the primary irrigation used in India and often resulted in crop water stress, low-quality crop yields, and excessive loss of water. Adoption of drip irrigation tended to increase as water tables in the region continued to decline and several benefits to implementing drip irrigation into farm practices were indicated. Drip irrigation saved approximately 40 percent of water used, by directly watering the root zone, but tended to require applications that are more frequent. Lesser water consumption led to reduced water pumping from wells and saved producers approximately 41 percent in electricity usage (Narayanamoorthy, Bhattarai and Jothi, 2018).

Water use efficiency of drip irrigation also resulted in an overall lower cost of cultivation and higher vegetable yields. Drip irrigation reduced the cost of labor, preparatory work, and weed control as water was applied directly to the root zone. Cultivation costs showed a 20 percent reduction when using drip irrigation compared to flood irrigation. Moreover, more direct water application resulted in fewer competitive weeds and 1.5 times larger vegetable yields. Drip irrigation methods returned 54 percent more profit compared to flood irrigation and achieved greater water use efficiency (Narayanamoorthy, Bhattarai and Jothi, 2018).

Kuşçu, Çetin, and Turhan (2009) evaluated irrigation amounts on marketable yield along with total cost and profit on vegetable products in Turkey. The regional climate was typically semi-humid; however, summers tend to be hot and dry with limited rainfall. Cultural practices, water costs, and water availability determined production practices used for each vegetable. Results indicated a relationship between varying amounts of irrigation and marketable yields of each vegetable in the study. Some crops yielded highest at 100 percent pan evaporation treatment while other crops maximized output at lower irrigation treatment levels. Water application and marketable yields reported high correlation for tomato, pepper, green bean, and eggplant production (Kuşçu, Çetin, and Turhan, 2009).

Economic analysis indicated highest profitably in pepper production using drip irrigation, followed by tomatoes. The total cost of production varied by crop variety and increased with increased irrigation levels; however, water pumping costs were determined insignificant when compared with other production expenses. As in most commodity studies, labor costs represented approximately half the total production costs.

Drip irrigation systems tend to require a higher initial investment, capital, and maintenance; however, vegetable production showed the potential to offset the cost through premium market prices for high-value produce. The significance between water application and marketable yield indicated a need for technology adoption in the region. Based on the results, agricultural producers can maximize profit during hot, dry summer months and ultimately increase farm profitability with the addition of drip irrigation to vegetable enterprises (Kuşçu, Çetin, and Turhan, 2009).

Vegetable Production Practices

Farm profitability can be improved through additional innovative production practices, especially when paired with the efficiency of precision irrigation systems. Innovative practices can include but are certainly not limited to the use of plastic mulch, open field systems, high tunnel systems, or low tunnel systems. These methods have the potential to further enhance farm income when paired with drip irrigation.

Plastic mulches have shown numerous benefits in vegetable production, especially when paired with drip irrigation methods. Lamont (1993) noted several positive advantages of plastic mulch including weed control, increased yields, and higher quality vegetables. Black plastic mulch is most commonly used in vegetable production, likely because of its ability to increase soil temperature while reducing light penetration. With few exceptions, plastic mulch eliminates weeds with the assistance of an herbicide suitable for vegetables. The impermeability of plastic mulch reduces water loss by evaporation, implying higher water use efficiency in crops grown with drip irrigation and plastic mulch. Although incorporating plastic mulch increases initial production costs, it has to the potential to increase total returns by reducing labor costs while increasing crop yield (Lamont, 1993).

Singh et al. (2009) conducted a study to evaluate yield, water-use efficiency, net profit, and return on investment in tomato production using drip irrigation and black polyethylene mulch. Eight irrigation treatment consisted of altered combinations of drip irrigation and surface irrigation with or without polyethylene mulch. Several analyses were piloted to evaluate differences in water use and yield between treatments (Singh et al., 2009).

Results indicated a significant increase in growth, yield, and water use efficiency in tomato plants with the use of drip irrigation over surface irrigation. Additionally, each of these attributes increased when black polyethylene plastic mulch was added to the cultivation process. Irrigation utilizing 80 percent evapotranspiration rates calculated the highest water-use efficiency rate thus was the optimal treatment, irrespective of mulch. Tomato weight and yield using drip irrigation without plastic mulch increased 27.8 percent and 54.8 percent, respectively. The addition of plastic mulch resulted in a 27.1 percent and 60.5 percent increase in weight and yield, respectively, over drip irrigation alone (Singh et al., 2009).

Researchers noted a decrease in tomato weight with the use of surface irrigation without plastic mulch, recording the lowest weight of the eight treatments. However, the addition of black plastic mulch to surface irrigation resulted in a 22.5 percent increase in yield. Weed control through the use of plastic mulch contributed to increased yields in mulched treatments, while treatments without mulch relied on manual weed control during each growing season. Drip irrigation increased yields and water use efficiency over surface irrigation due to the lack of evaporative water loss with direct root zone application. Overall, profits and return on investment were higher with the use of drip irrigation, both with and without plastic mulch. Economic analysis indicated optimum returns and ratios were obtained using plastic mulch (Singh et al., 2009).

Vegetable production techniques tend to vary by crop and regional climate. High and low tunnel production, used worldwide, is becoming more prominent in the United States due to the opportunity for crop protection, expanded crop varieties, and extended growing seasons. Numerous vegetable studies are conducted in open fields, likely because of a lack of capital for the initial cost of constructing protective systems. High tunnel systems increased crop protection and lengthened growing seasons in various regions around the world (Kaiser and Ernst, 2014). In some climates, high tunnels extend growing seasons by planting approximately four to five weeks earlier than the field in the spring (Lamont, 2009).

Another advantage of high tunnels is the production from unfavorable weather conditions they provide for high-value crops like tomatoes. A study in the Texas Panhandle provided a detailed example of the difficulties weather can bring to vegetable crop production. In 2016, a project investigating the potential for high tunnel vegetable production was conducted at the USDA-ARS CPRL/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas. Tomatoes and peppers were planted in an open field and inside high tunnels to determine which system would produce higher marketable yields. While open field crops had a slightly higher yield than the high tunnels at the end of the first production year, researchers noted the marketability of the vegetables inside the tunnels was much higher than in the field. However, during the second production season, a mid-summer hail storm destroyed the open field crops (Ledbetter, 2017). Considering the fact that such weather events are common in the Texas Panhandle, the research team determined that high tunnel production was well worth the initial expense. However, in this preliminary study, neither economic nor water use efficiency rates were analyzed (Rush, 2018).

An economic analysis of tomato and lettuce production in high tunnel and open-field systems was conducted in western Washington. The specific objectives of the study were to estimate the economic potential and identify factors contributing to or hindering economic profitability for each vegetable in both systems. Results indicated the advantages of using protected high tunnel systems to produce higher quality tomatoes and lettuce, and they detailed profit comparisons for each system. Results were divided into categories detailing total production cost per unit, relative cost of field activities, and profitability of vegetables produced (Galinato and Miles, 2013)

Total cultivation cost per square foot was eight times greater in high tunnel production than open-field production. Total labor costs, involving harvest, post-harvest activities, and tunnel maintenance, were the highest category of all production costs in both systems. Labor costs for tomato production in open field and high tunnel systems were \$0.30 per square foot and \$12.87 per square foot, or 63 percent and 75 percent of total production cost, respectively. Lettuce production returned lower labor costs in open field at \$0.14 per square foot and in high tunnel systems at \$0.89 per square foot, accounting for 58 percent of total production cost for both systems. Increased cost in high tunnels was caused by necessary materials for additional construction not required by open-field production. Tomato harvest and post-harvest activities, including harvest, packing, and marketing, comprised 32 percent and 39 percent of the total cost in open-field and tunnel production, respectively, while lettuce harvest and post-harvest activities encompassed approximately 64 percent and 24 percent, respectively (Galinato and Miles, 2013).

High cost requirements of high tunnel systems have the potential to be countered by larger marketable yields than in open field production systems. High tunnels produced tomatoes with a higher marketable yield per square foot than open-field production, 2.25 pounds per square foot and 0.56 pounds per square foot respectively, which resulted in higher profits. Similar results were determined for lettuce as high tunnels produced marketable yields of 0.90 head per square foot and open field produced 0.36 head per square foot. A sensitivity analysis indicated open-field tomato profit was 62 percent less when compared to high tunnels, given the aforementioned yields and varying prices throughout the season. Vegetable profitability was dependent on seasonal demand, as price received tended to be higher outside the main growing season (Galinato and Miles, 2013).

Doug Waterer (2003) analyzed warm season vegetable development, yield, and production economics utilizing high tunnel and low tunnel systems in Canada. Short Canadian growing season limited production of warm-season produce such as tomatoes, peppers, and muskmelons, piquing interest in innovative agricultural production technologies enhancing vegetable growth during non-traditional growing seasons. Results indicated rapid and improved yield quality of vegetables in high tunnel production systems compared to low tunnel systems. (Waterer, 2003).

Economic analysis indicated higher gross returns per vegetable unit cultivated in high tunnels. Returns were dependent on the crop produced and market demand. For example, mature red peppers commanded premium price outside the regular growing season, which led to higher gross returns. High tunnel systems required larger initial investment costs due to more extensive construction than low tunnel systems. High tunnels remained structurally sound over the three-year study period apart from replacing the plastic cover due to seasonal wear and tear. Costs associated with repairs and maintenance varied with regional climate conditions. A cost-benefit analysis based on local vegetable market prices would help producers determine the exact number of payback years (Waterer, 2003).

Production Considerations

Orzolek et al. (2006; 2010; 2011), Ernst (2018), and Kaiser and Ernst (2018a; 2018b) developed enterprise budgets for area grown, fresh market tomatoes, peppers, and sweet corn. Detailed fact sheets were created for each specialty commodity including ideal marketing outlets, average yield, and best production practices. Production practices vary by specific variety; however, the use of black plastic mulch has shown to prevent weed growth and preserve soil moisture content, thus increasing crop yield and leading to higher profit when paired with drip irrigation (Ernst, 2018). Extension services recommend producing each crop on a small scale or as a part-time enterprise on less than five acres. Due to variations in available equipment, labor, and other resources, economists noted the challenges associated with estimated budgets fitting each agricultural producer.

Fresh market tomato production provided marketing opportunities in niche markets, because of color and heirloom varieties, making it easier for producers to find the perfect crop to expand their enterprise (Orzolek et al., 2010). Poor shipping characteristics of heirloom tomatoes gave a competitive advantage to producers who chose local marketing outlets, including farmer's markets and roadside stands. Transplanting established plants allowed for earlier tomato growth and harvest, securing premium prices associated with out of season consumer demand. Tomato production tends to be more labor intensive due to support systems and multiple harvests; however, enterprise budgets determined revenue benefits outweighed additional costs (Ernst, 2018).

Kaiser and Ernst (2018a) determined that pepper production would be a profitable addition to an enterprise due to increased demands in niche markets for ethnic and spicy cuisine. Labor was less intensive in pepper production than other specialty crops because of the availability of hot pepper mechanical harvesters (Orzolek et al., 2010). Trellis systems can be used for pepper production, but pepper yields are not as sensitive as tomato yields. Additionally, researchers recommend not growing peppers after or close to tomato crops due to disease susceptibility (Kaiser and Ernst, 2018a).

Lastly, sweet corn production was determined to be labor intensive and require more space than other crops but tended to require lower initial investments on a small-scale farming operation (Kasier and Ernst, 2018b). Equipment used in sweet corn production can be used for other purposes since corn was typically planted in an open field as seed rather than transplant. Like peppers, mechanical harvesters are available but hand harvesting can be substituted, varying by capital or labor available to the producer

(Orzolek et al., 2011). Prices for each vegetable were dependent on consumer demand at different times during the growing season. Crop, farm, and income insurance were recommended for each enterprise to account for these discrepancies (Orzolek et al., 2006).

Biermacher et al. (2007) determined the cost of production for popular produce selections in smaller markets and estimated the probability of differentiated prices consumers were willing to pay for products. Agricultural production scientists and horticulturalists collaborated to produce and retail 27 types of fresh market fruits, vegetables, and flowers grown in open field and high tunnel system. The study provided insightful information to produce production practices and consumer habits that could prove vital to agricultural producers interested in niche markets (Biermacher et al., 2007).

Results illustrated consumer willingness to pay higher prices for high quality, locally grown produce, however not all harvested crops were of marketable quality. Tomato prices averaged of $0.46 to $0.55 higher than area supermarkets. Survey results confirmed 99 percent of consumers were willing to pay premium prices for fresh market tomatoes. Approximately 64 percent of field tomatoes did not yield marketable quality, and similar results were reported for okra, squash, and bell pepper production. Due to a lack of available storage, many crops perished before they sold, which resulted in a large percent of wasted tomatoes and peppers (Biermacher et al., 2007).

Variable costs of production accounted for the largest percentage of the total cost of production for each crop in the study. Labor costs, assuming hired wages, attributed approximately 55 percent of variable costs, of which 24 percent were associated with harvest activities. Researchers noted experienced family labor could decrease variable costs for this study by nearly 45 percent. Change in irrigation methods, such as implementation drip irrigation and overhead sprinkler irrigation, could also decrease total cost of production. Overhead irrigation methods require additional fuel costs, accounting for 16 percent of the total cost. Finally, capital expenses, including machinery and building expenses, accounted for seven percent of total costs. (Biermacher et al., 2007).

Economics of Vegetable Production

Crop yields and economic returns are largely dependent on production technique (Kaiser and Ernst, 2014). Drip irrigation and plastic mulch are two production practices proven to increase water use efficiency and yield in many crop varieties, including vegetables (Paul et al., 2013). Several studies indicated high profit for vegetables given varies prices and yields.

Kuşçu, Çetin, and Turhan (2009) reported higher profits for pepper production using drip irrigation. Given a price of $0.07 per pound, a profit of $2,976 per acre was reported for peppers production. Tomato production resulted in profits of $2,739 per acre given a price of $0.05. Profit increased with both crops with higher yields given increased irrigation, despite the study reporting optimum irrigation at lower levels. Given the same prices for each crop, profits of $3,081 and $2,816 per acre were received for peppers and tomatoes, respectively (Kuşçu, Çetin, and Turhan, 2009).

Galinato, Miles, and Ponnaluru (2012) reported high profit for fresh market field-grown tomatoes with drip irrigation and black plastic mulch. Enterprise budgets assumed a per acre basis and a growing season from February to September. Given a price of $2.00 per pound and total production yield of 30,360 pounds per acre, total profit equaled $34,737 per acre. A sensitivity analysis estimated a loss of $9,733 per acre given a price of $1.00 per pound and a yield of 15,000 pounds per acre. However, profit as high as $93,233 was estimated with a price of $3.00 per pound and a yield of 40,000 pounds per acre (Galinato, Miles, and Ponnaluru, 2012).

Ernst (2017) published enterprise budgets for small-scale and large-scale jalapeño peppers, tomatoes, and sweet corn production. Small-scale production consisted of crops grown using approximately 0.10 acres for tomatoes and sweet corn and a 100-foot row for jalapeño peppers. Vegetables grown on five acres or more were classified as large-scale production. Each crop was produced using trickle, or drip, irrigation in both production scenarios. Tomatoes and peppers were produced using black plastic mulch while sweet corn was grown without mulch (Ernst 2017).

Budgets resulted in a positive profit for each vegetable and profit increased with the size of production. Small-scale tomatoes returned an estimated profit of $1,820 per 0.10 acre. Profit was determined given a price of $2.00 per pound and a yield of 2,400 pounds of tomatoes per 0.10 acre. Jalapeño peppers and sweet corn had lower returns of $15.14 per 0.10 acre and $14.21 per 0.10 acre, respectively. Jalapeño peppers were measured in bushels per box, given 45 boxes each containing half a bushel, 55 pounds, of peppers. Each box received a price of $12.00. Sweet corn received a price of $5.00 per dozen and yielded 160 dozen ears (Ernst 2017).

Large-scale tomatoes and sweet corn were sold in different units of measurement than small-scale production. Jalapeño peppers in both scenarios were sold as the same unit but at different prices. Given a price of $14.00 per 25-pound box, yielding 1600 boxes or 40,000 pounds, tomatoes returned an estimated profit of $5,104. Sweet corn returned an estimated profit of $255 per acre given a price of $9.00 per crate and a yield of 340 crates. Jalapeño peppers received a price of $7.50 per box, yielding 2,000 half bushel boxes and returned an estimated profit of $1,321 (Ernst 2017).

Producer and Consumer Communication

A change agent, or researcher, can be instrumental in the dissemination of information and in assisting producers in their decision to adopt new technologies. Extension services provide publications and broadcasts to target a variety of audiences, preparing specific information needed by both producers and consumers. Finally, consumer knowledge is vital in the diffusion and adoption process because the consumer ultimately determines the product demand and producer profitability. This section details the importance of communicating innovative production practices to producers and consumers through the diffusion of innovations.

Taylor and Zilberman (2015) analyzed the diffusion of process innovations through the adoption of drip irrigation systems in California. The innovation, diffusion, and eventual adoption of these systems played a significant role in the economic growth of crop production by increasing crop productivity and decreasing production costs. The specific objective of the study was to determine the factors contributing to the producer's decision-making process as they considered adopting new technology and calculating the impact on yields and their total net income (Taylor and Zilberman, 2015).

In this study, diffusion and adoption processes were quantified in this empirical study of the evolution of drip irrigation. Drip irrigation was analyzed because of its high adoption rates in regions suffering severe droughts. Since consideration of adopting or delayed adoption of new processes is likely based on input and output prices, the value of economic impact was estimated based on high yields and water savings. Drip irrigation systems exhibited a 5 percent to 16 percent farm revenue increase and therefore resulted in a 2.6 percent to 7.4 percent increase in total farm income. These estimates did not account for additional benefits of drip irrigation such as efficiency in field operations. For example, reduced labor costs in preparatory activities were not considered. (Taylor and Zilberman, 2015).

Implementation of drip irrigation in California was a process that coevolved across several facets of agricultural production. It led to changes in pre-planting activities and provided more efficient water application, reducing labor throughout much of the growing season. Cooperative extension research and outreach efforts were vital during these adjustments in production practices to ensure the success of implementation and confirmation of a decision. It is important to continue outreach initiatives and ensure agricultural producers are able to continuously adapt to changes associated with the adoption of a new process. For this reason, cooperative extension outreach could be improved through upgraded data collection and record keeping which ensures accurate data for studies of this nature (Taylor and Zilberman, 2015).

In order for change agents to effectively distribute information, they must understand the audience in which they are targeting. Jones, Diekmann, and Batte (2010) surveyed Ohio producers on the likelihood and frequency that they would use Extension publications, websites, workshops, and other services, based on various farmer characteristics. The goal was to determine if the delivery method varied by type of audience and their informational needs. (Jones, Diekmann, and Batte, 2010).

Results indicated an influence of age and farming experience to the Extension information outlet that farmers most commonly used. Older farmers were overall less likely to use Extension information but producers who had more farming experience were more likely to seek information from printed publications, workshops, and media broadcasts and use them more often. This implied producers who did not begin farming until later in life, older farmers with little experience, are the least likely group to use Extension resources (Jones, Diekmann, and Batte, 2010).

College education was also a factor in the likelihood for respondents to seek information through online and radio methods. Researchers assumed that college-educated respondents were business-minded therefore familiar with the workings of the internet and the classroom setting. This mindset was assumed to encourage respondents to receive frequently changing information through the internet and workshops. Older producers were less likely to use these information resources because of their unfamiliarity, which reflected the higher percentage of print publications used by older respondents (Jones, Diekmann, and Batte, 2010).

Overall, printed publications were the most widely adopted form of communication, with respondents reporting nearly 95 percent usage. Website usage was reported at less than 50 percent and workshops were used least frequently among Ohio farmers. Researchers recommended special considerations be taken in order to provide the correct information through the ideal outlet for the target demographic (Jones, Diekmann, and Batte, 2010).

Consumer knowledge is an important factor for the producer to consider, especially in fresh-market vegetable production. Biermacher et al. (2007) stressed the influence of consumer knowledge on the profitability of their small-scale, fresh market produce retail market. The program was not economically profitable, but researchers attributed consumer education and communication as an important factor in the success of the project. During the first year of production, the retail section of the project relied on advertisement through various marketing mediums including newspaper, radio, and social media. Educational events and public tours were hosted to bring consumer awareness to the project and benefits of locally grown produce production in south-central Oklahoma. Emphasizing the utilization of public awareness, the second year of production relied more on word of mouth and website responsiveness (Biermacher et al., 2007).

Farmers, scientists, extension agents, and teachers visited the production area and retail market to learn about fresh produce through educational programs and site tours. The program surveyed retail consumers and noted approximately 30 percent learned about the facility from an acquaintance. Researchers also reported a higher public understanding of ongoing research projects, an advantage for research institutions but not for local agricultural producers (Biermacher et al., 2007).

Consumer perception is essential to the sustainability of agricultural production practices. Perception also plays a key role in the successful consumer understanding of effective communication plans. It was found that higher consumer education increased consumer demand of locally grown vegetables. The Oklahoma produce study highlighted the need for better information through educational programs to provide consumers accurate facts regarding the economic and nutritional benefits of purchasing vegetables from their neighborhood grower (Biermacher et al., 2007).

Communication practices are an instrumental tool in agricultural research. Innovative technologies and processes affect the consumer as well as the producer, implying the need for understanding from both parties. Extension specialists expressed the importance of publications, social media communication, local presentations, and on-farm field days to connect consumers to locally-grown food (Ernst, 2018). These same methods can be used to communicate research information to the producer.

CHAPTER 3

DATA AND METHODS

General Approach

The economic feasibility of using high-value vegetable crops to supplement producer income using water efficient methods was analyzed in this study. Enterprise budgets for tomatoes, jalapeño peppers, and sweet corn were created to determine profit and return on investment as well as breakeven prices and yields. Due to risks associated with adopting new cropping systems, a sensitivity analysis was conducted to analyze alternative prices and yields for each vegetable. Finally, a survey was distributed to area producers to identify enterprise activities of local vegetable production practices.

Study Area

The focus area for this research includes 45 counties collectively defined as the Texas High Plains. The Ogallala Aquifer underlies eight states in the Great Plains of the United States: Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming. The Southern portion of the Ogallala Aquifer encompasses the Texas High Plains and has suffered drastic reductions in water levels with limited recharge (Colaizzi et al., 2009).

This research concentrates on the following counties in the Texas High Plains: Andrews, Armstrong, Bailey, Borden, Briscoe, Carson, Castro, Cochran, Crosby, Dallam, Dawson, Deaf Smith, Dickens, Donley, Floyd, Gaines, Garza, Glasscock, Gray, Hale, Hansford, Hartley, Hemphill, Hockley, Howard, Hutchinson, Lamb, Lipscomb, Lubbock, Lynn, Martin, Midland, Moore, Motley, Ochiltree, Oldham, Parmer, Potter, Randall, Roberts, Sherman, Swisher, Terry, Wheeler, and Yoakum (Figure 1). These counties were primarily chosen because of their reliance on the Ogallala Aquifer for irrigated agriculture.

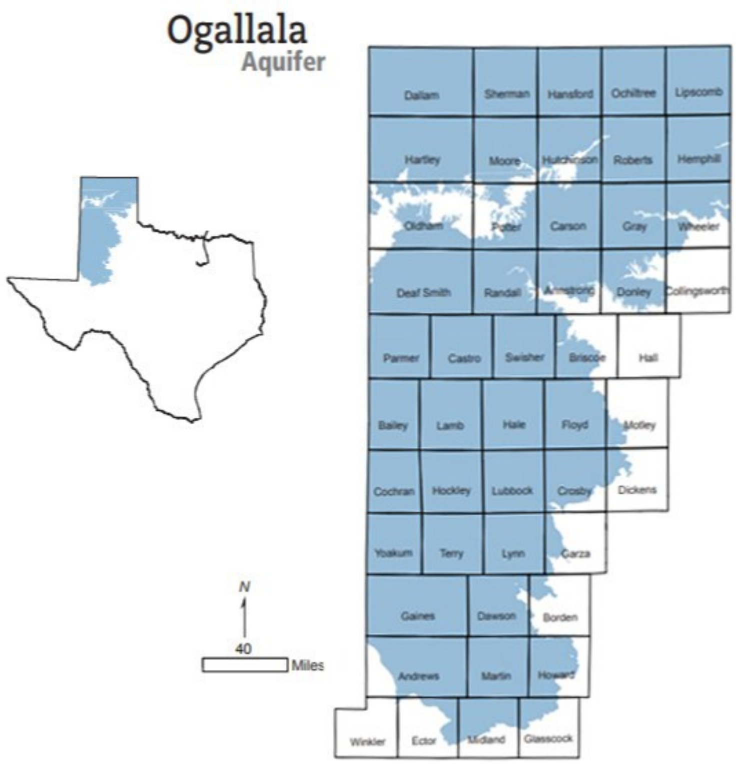

Figure 1. The study area over the Ogallala Aquifer.
Source: George, P., R. Mace, R. Petrossian, 2011

Data Collection

The data for this study is primarily based on vegetable production practices, conducted at the USDA-ARS CPRL/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas, hereafter referred to as “the field experiment”. Tomatoes, jalapeño peppers, and sweet corn were each grown using surface drip irrigation both with and without plastic mulch (Arthur, personal communication, 2019; Gray, personal communication, 2018; Gray, personal communication, 2019; Rho et al., 2018).

Prices for each vegetable were collected from the USDA Agricultural Marketing Service (AMS) National Retail Report. The weekly retail prices in 2018 were averaged for tomatoes, jalapeño peppers, and sweet corn (AMS, 2019). A three-year average farm share was applied to each retail average to determine the money received by producers from each retail dollar spent. A 25 percent farm share was applied to the retail price for fresh, field grown tomatoes (ERS, 2018a) and a 26 percent farm share for fresh vegetable baskets was applied to the retail price for jalapeño peppers and sweet corn (ERS, 2018b).

Inputs used in the production of each vegetable and field activity for the field experiment were tracked by research staff to ensure accurate records were kept of all activities. Enterprise activities included: applying fertilizer, laying black plastic mulch and drip tape, transplanting tomato and jalapeño pepper seedlings, planting sweet corn seeds, hand-weeding, applying herbicide treatment, setting tomato support trellises, and harvesting.

Input costs varied by production method. Costs were collected from Texas A&M AgriLife Extension Projected Crop and Livestock Budgets for the Texas High Plains (Jones et al., 2018; Cornforth, personal communication, 2019) and from data collected during the field experiment at Bushland (Gray, personal communication, 2019; Rho et al., 2018). Since vegetable production is not as prominent in the Texas High Plains, additional input costs were collected from area garden retailers (GardenTech, 2018).

Additional market prices and production practice data were collected from producers who responded to our survey. Surveys were developed using the Qualtrics online survey software to collect production and economic information from agriculturalists currently employing vegetable production in the Texas High Plains. Questions included demographic information, farming experience, vegetable production system methods, irrigation methods, vegetable management practices, yield and revenue information, and communication information. Respondents were required to give the zip code associated with the vegetable enterprise; zip codes from any of the study area counties were included in the aggregate data while all others were discarded.

Production methods conducted at a research facility are often more complex than practices implemented by an average producer because of overall objectives, available funds, and labor. Data collected from the field experiment, Qualtrics online survey, and empirical analyses of existing literature were used collectively to calculate a relevant budget for area producers. Research procedures and calculations for each vegetable budget are described below.

Research Procedures

The USDA-ARS CPRL/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas was the growing site for tomatoes, jalapeño peppers, and sweet corn in this study. Each crop was grown in two treatment zones, one treatment under drip irrigation with black plastic mulch and one treatment under drip irrigation without black plastic mulch. Each zone was comprised of three 50-foot by five-foot rows and was replicated four times. This design resulted in 12 zones of drip irrigated vegetables with black plastic mulch and 12 zones of drip irrigation without plastic mulch. Twenty-four zones totaled 18,000 square feet, or 0.41 acres of land (Figure 2). Enterprise activities given for the field experiment were divided by 0.41 to convert enterprise quantities to a per acre basis. Linear footage was also used for several enterprise calculations throughout the study. Linear feet was calculated by multiplying three 50-foot plots per zone by 24 zones, resulting in 3,600 feet. Linear feet per acre for this study totaled 8,780.5 feet.

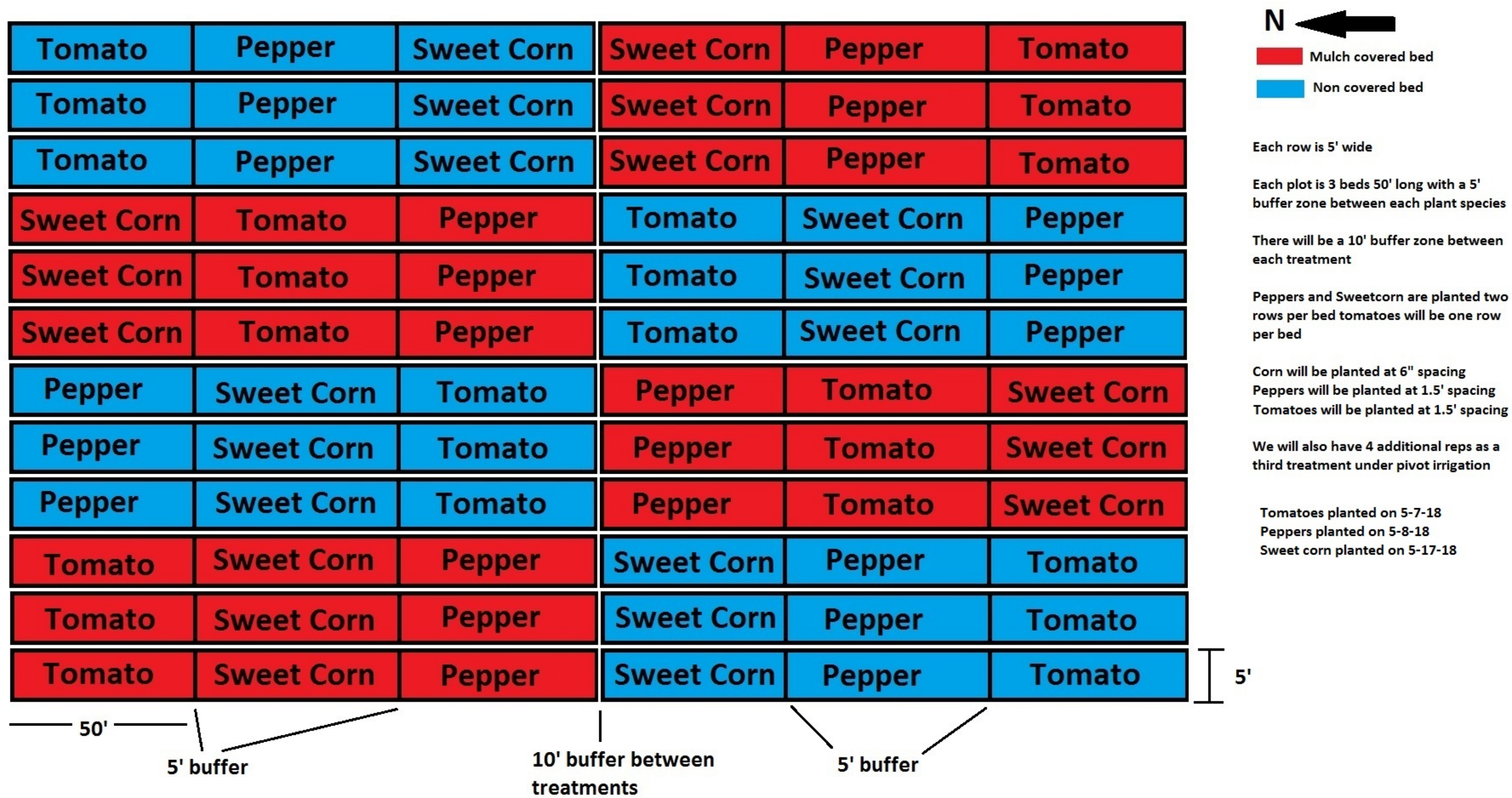

Figure 2. Ogallala Aquifer Project vegetable field plot, 2018.
Source: Gray, personal communication, 2018

Enterprise Budgets

Numerous enterprise calculations were common for all six treatments: including yield, land preparation, fertilizer application, herbicide application, drip irrigation tape and fittings, irrigation energy and labor, hand weeding labor hours, custom harvest and haul, and equipment and fuel usage. Each vegetable had unique production requirements, planting dates, space between plants, support equipment, and harvesting dates. This section details variable enterprise expenses common for all crops and costs specific to each vegetable. Fixed costs, including depreciation and investment calculations, are also described.

Yield

Yield data was calculated for one acre of each vegetable by harvesting a ten-foot section of one 50-foot vegetable row. Fresh weights were measured in kilograms per square foot. Yield weight was then converted to milligrams per hectare. Then, the yield data was converted to hundredweight (cwt) per acre. Tomatoes in this study were not harvested continually throughout the 2018 production season. Thus, yield estimates are conservative as they were based on a single harvest at the end of the growing season (Rho et al., 2018).

Production Costs

Fertilizer and herbicide treatments were applied to the field prior to planting. Urea 46-0-0 fertilizer was applied evenly across all field experiment zones prior to placing drip irrigation lines and plastic mulch, totaling 150 pounds of nitrogen granules broadcasted per acre (Gray, personal communication, 2019). Input cost for dry nitrogen was $0.38 per pound and an additional fertilizer application rate of \$5.12 per acre per application was used (Jones et al., 2018).

Pre-plant herbicide treatments were applied after irrigation and mulch were in place but prior to planting. Metolachlor was applied to the field at a rate of 1.33 pints per acre. Ideally, Treflan could have been applied at a rate of 1.33 pints per acre prior to laying plastic mulch to further reduce weed germination. Both herbicides cost \$100.00 for a 2.5-gallon jug, which results in a cost of \$5.00 per pint (Gray, personal communication, 2019). An application rate of \$5.12 per application per acre was used in addition to the unit cost (Jones et al., 2018).

Insecticide was not applied to the vegetables in this study but was highly recommended. Several products were compatible with vegetable production, however, Sevin is considered very effective and was therefore used in the enterprise budget (Gray, personal communication, 2019). The manufacturer recommends diluting a four-ounce concentration for every 8,000 square feet. The quantity needed on a per acre basis was determined by the following calculation:

(1) $$\frac{4 \text{ ounces}}{8{,}000 \text{ square feet}} \times \frac{1 \text{ gallon}}{128 \text{ ounces}} \times \frac{43{,}560 \text{ square feet}}{1 \text{ acre}} = 0.17 \text{ gallons/acre}$$

Sevin is available at most farm and garden retailers. Price per gallon varied based on retail store; \$87.99 per gallon was used for this study (GardenTech, 2018). An insecticide application rate of \$5.12 per application per acre was used (Jones et al., 2018).

Black plastic mulch was used for tomato, jalapeño pepper, and sweet corn production but only on half of the field experiment. The plastic mulch used in this study was purchased in 4,000-foot rolls for \$177.00 per roll (Gray, personal communication, 2018). Linear feet per acre were divided by 4,000 feet per roll to estimate 2.2 rolls of black plastic mulch were needed per acre.

Drip irrigation and mulch were installed simultaneously in mulched treatments, but all drip tape was applied with a mulch layer. Toro 15-mil drip tape (4,000-foot rolls at $150.00 per roll) with 12-inch drip emitter spacing for application of 0.27 gallons of water per hour was used in the field. The length of drip tape needed was calculated by dividing the linear feet per acre by 4,000 feet per roll, resulting in 2.2 rolls of drip tape per acre. Three drip fittings were installed per plot at $1.60 per fitting (Gray, personal communication, 2018). Three fittings per plot across three plots totaled nine fittings per zone. For 24 zones, 216 fittings were needed for the field experiment, which is equivalent to 527 fittings per acre.

Irrigation was distributed approximately evenly among the field experiment. Tomatoes and jalapeño peppers were irrigated with 11 acre-inches of irrigation water over 22 irrigation events and sweet corn was irrigated with 10.22-acre-inches over 21 irrigation events (Gray, personal communication, 2019). This resulted in an average of approximately 0.5 acre-inches of irrigation water applied to the field per irrigation event. Irrigation energy costs were $3.40 per acre-inch (Jones et al., 2018). Average irrigation labor of 0.2 hours per acre was calculated by using an average from Texas A&M AgriLife Extension District 12 drip irrigated fruit under black plastic mulch (Zapata, personal communication, 2019). Cost for irrigation labor per hour was $13.03 per hour (Jones et al., 2018).

Labor hours required for manual weed control differed by mulched and non-mulched treatments. Tomatoes and jalapeño peppers grown under black plastic mulch were assumed to utilize 90.21 hours per acre of hand weeding hours for the growing season determined through existing literature (Bangarwa et al., 2010). Hand weeding labor hours for peppers grown without plastic mulch were estimated by using a percent change of labor hours needed to weed when compared to tomatoes. An average hand weeding labor hour requirement of 220.5 hours per acre for tomatoes was estimated in a growing season. A 62.2 percent increase hand weeding labor hours was calculated for jalapeño peppers based on the difference in labor hours between each crop and tomatoes (Gianessi and Sankula, 2003). While most labor costs in the budgets are approximately $13.00 per hour, it was assumed hand labor for weeding implemented a reduced hired labor rate of $8.50. It was assumed that sweet corn would be maintained like field corn and utilized no labor hours for hand weeding.

Custom harvest and pack rates for fresh market fruits and vegetables included harvest, count, sort, and grade for quality. Custom hauling cost was included with vegetable harvest costs and was estimated per cwt. Custom harvest and pack cost averaged $10.00 per cwt (Zapata, personal communication, 2019).

Interest on credit line given in the enterprise budgets was developed using the summation of several interest calculations for each enterprise activity. Interest calculations were estimated for gasoline and fuel, labor, tractor, implement, and irrigation energy, and repairs and maintenance assuming six-months of interest on non-cash expenses. Days of interest for each enterprise activity are measured from the date the activity was executed to the sale of production date, or the end of the season (Cornforth, personal communication, 2019). For this study, it was assumed that producers were charged interest on one-third to half the pre-harvest expenses, not accounting for the interest days of each activity. Loan amounts vary by enterprise and need to be considered in the planning process.

Vegetable Specific Costs

The remaining enterprise calculations are specific to each vegetable, varying only slightly with or without the use of plastic mulch. The differences in enterprise activities and inputs in the following calculations were transplant seedlings or seeds from each vegetable, harvest dates, and labor hours required for mulched and non-mulched treatments.

Tomato seedlings were transplanted into mulched and non-mulched treatments using the RainFlow 1600 waterwheel transplanter on May 7, 2018. Tomato production in the field required trellis support installed approximately three to four weeks after planting. Seedlings were planted in a single row with one and a half foot spacing between each plant, resulting in 99 plants per zone. Ninety-nine plants were multiplied by 24 zones, then divided by 0.41 acres to determine 5,796 tomato transplants would be planted per acre at one and a half foot spacing. Tomato seedlings were priced at $80.00 for 1,000 plants plus $100.00 in shipping, which totals $0.18 per transplant. Final harvest for the tomato crop was September 10, 2018 (Gray, personal communication, 2019).

Trellis support in the field experiment consisted of five metal posts and 10 wood posts that were set at 15 and 30 posts per zone, respectively, resulting in 879 metal and 1,757 wood posts. Metal posts were priced at $5.00 each and wood posts were purchased for $1.00 each. Rolls of trellis twine needed, at $7.00 per roll, were calculated by multiplying the per acre linear feet by two and dividing by 7,000 feet per roll. Laborers needed two hours to install posts and twine in eight zones (Gray, personal communication, 2019). A per acre calculation for two laborers was estimated by diving four hours by 0.41 acres, resulting in 9.76 hours per acre needed to set t-posts and twine. This calculation is listed as unallocated labor in both tomato enterprise budgets (Table A1 and Table A2).

Jalapeño peppers were transplanted into mulched and non-mulched beds shortly after tomatoes, on May 8, 2018. Pepper seedlings were planted in two rows and spaced one and a half feet apart, totaling 198 plants per zone. This number was then multiplied by 24 zones and divided by 0.41 acres to determine that 11,591 pepper plants were needed for one acre. Seedlings were purchased for $80.00 for 1,000 plants plus $100.00 for shipping, equaling $0.18 per pepper seedling. Jalapeño peppers in each treatment were harvested on September 4, 2018 (Gray, personal communication, 2019).

Sweet corn was planted from seed in mulched and non-mulched beds with a PolyPlanter vacuum seed planter on May 17, 2018. Sweet corn seeds were planted in two rows and spaced six inches apart, comprising 600 seeds per zone (Gray, personal communication, 2019). Seed count was multiplied by 24 zones and divided by 0.41 acres, totaling 35,122 seeds planted per acre. Seeds were donated to the field experiment but had an average estimated cost of $272.50 per bag of 4,700 seeds (Arthur, personal communication, 2019). By dividing 35,122 seeds by 4,700 seeds per bag, it was concluded that 7.47 bags were needed to seed one acre with the same spacing specifications. Sweet corn ears were harvested on August 16, 2018 (Gray, personal communication, 2019).

Equipment Expenses

Equipment for the field experiment consisted of a four-wheel drive tractor, a mounted tandem disc, a mulch layer, a gasoline pickup truck, a vegetable transplanter, and a seed planter. Other general use equipment consisted of wood and metal t-posts used for tomato support trellises. Estimated life, salvage value, repair and maintenance costs, labor hours, fuel and gasoline usage, depreciation, and equipment investment for these inputs are described in this section.

A 75-horsepower, four-wheel drive tractor with a seven-year estimated life was used for the field experiment (Gray, personal communication, 2019). The salvage value was estimated at 10 percent of cost, and repair and maintenance for the life of the tractor was estimated at 70 percent of cost. The tandem disc was assumed to have a seven-year life with a salvage value of 10 percent of the cost, and repair and maintenance for the life of the implement was estimated at 80 percent of the cost. The mulch layer had an estimated a fifteen-year life with a salvage value of 10 percent of the cost, and repair and maintenance was estimated at 70 percent of the cost of the implement (Texas A&M AgriLife Extension, 2019). Estimated hours of use for the tractor and implements were calculated based on duration use for each vegetable (Gray, personal communication, 2019).

Tomatoes and jalapeño peppers were transplanted with a RainFlow 1600 water wheel transplanter while sweet corn seeds were planted using a PolyPlanter vacuum seed planter. (Gray, personal communication, 2019). The estimated life of a transplanter was 15 years with a salvage value at 10 percent of cost and repair and maintenance over the life of the implement of 70 percent of cost. A three-row 80-inch seed planter was estimated to have a 12-year life with a salvage value at 10 percent of cost and repair and maintenance of 70 percent of cost (Texas A&M AgriLife Extension, 2019).

Machinery labor was comprised of tractor operator labor and labor for those who assist in machinery operations but are not on the tractor. Machinery labor was determined by the following formula:

$$\textbf{(2)} \qquad \text{Tractor labor hours} = \left(\frac{\text{times used}}{\text{acres per hour}} \times \text{tractor labor \%}\right) \times \text{\% hourly labor}$$

where "times used" reflects the total number of field passes the tractor needed to make, "acres per hour" is predetermined by tractor efficiency, "tractor labor percent" is the percentage of time the tractor operator is paid for each hour the tractor runs, and "percent hourly labor" is the percentage of labor paid hourly labor hired for this enterprise (Texas A&M AgriLife Extension, 2019).

Other labor hour required for machinery operation was the additional laborers besides the tractor operator. Each additional 100 percent was equivalent to one additional person (Cornforth, personal communication, 2019). Total other labor required per acre was estimated by multiplying the tractor labor hours required by the percentage of other laborers used for the activity (Texas A&M AgriLife Extension, 2019).

Tractor fuel usage was estimated based on percent used for each crop and annual fuel usage. In these budgets, it was assumed tractors and other self-propelled machinery used diesel fuel. Diesel cost for each machine was estimated given the following formula:

$$\textbf{(3)} \qquad \text{Diesel gallons per acre} = \frac{\text{Fuel per hour}}{\text{Acres per hour}} \times \text{times used}$$

where "fuel per hour used" represents the amount of fuel used by each machine per hour, "acres per hour" represents a 90 percent equipment efficiency, and "times used" refers to the number of times an activity is completed in the field(Texas A&M AgriLife Extension, 2019). Diesel required in all tractors and other self-propelled equipment was summed to estimate total diesel fuel per crop.

A gasoline pickup truck was assumed for field experiment purposes. The pickup had an estimated life of 10 years, estimated salvage value at 37 percent of cost, and estimated repair and maintenance cost at 75 percent of cost for the life of the vehicle. It was assumed that two percent of the truck's overall usage was allocated to vegetable production. The cost of gasoline per acre was estimated by multiplying the annual gallons of gasoline used by the price of fuel and then multiplying the percentage of the annual average total equipment used, particular to the specified crop (Texas A&M AgriLife Extension, 2019).

Trellis posts were considered general use equipment fixed cost due to the extensive life of metal and wood t-posts. Salvage value was estimated at 25 percent of cost for metal t-posts with zero percent allocated to repair and maintenance. Wood posts were not given an estimated salvage value, however, an estimate of two percent of cost was allocated to repair and maintenance (Texas A&M AgriLife Extension, 2019).

Repair and maintenance estimates for general use, irrigation, self-propelled, and implements were calculated by using the following formula:

$$\textbf{(4)} \qquad \text{Annual repair and maintenance} = \frac{(\text{cost} \times \text{Percent R\&M})}{\text{Expected Life}}$$

where "cost" represents the original list price of equipment and "percent R&M" represents the estimated percentage of repair and maintenance in relation to the original cost of the equipment. Once annual repair and maintenance costs were determined, a per crop per acre calculation was needed to include in the budget. This was done by multiplying the annual cost by the percentage of the annual average total equipment used, particular to the specified crop, and then divided by total enterprise acreage (Texas A&M AgriLife Extension, 2019).

Annual depreciation was a fixed cost based on the original purchase price of the equipment or implement, estimated salvage value, and life of the input. Depreciation for each crop was calculated with the following formula:

$$\text{Depreciation} = \frac{\text{cost - salvage value}}{\text{estimated life}} \quad \textbf{(5)}$$

where "cost" is the price paid for the equipment or implement and "salvage value" is the estimated salvage value as a percent of cost. The depreciation value was then multiplied by the percentage used for each crop (Texas A&M AgriLife Extension, 2019).

Equipment investment costs are fixed costs calculated for self-propelled, general use equipment, implements, and permanent irrigation. Investment costs were estimated using the following formula:

$$\text{Equipment Investment} = \frac{\text{cost} \times \text{percent use on crop} \times (1 + \text{SV})}{2} \quad \textbf{(6)}$$

where "cost" represents the price paid for the equipment or implement and "SV" represents the estimated salvage value as a percent of cost (Texas A&M AgriLife Extension, 2019).

Enterprise budgets were used to determine the economic feasibility of tomatoes, jalapeño peppers, and sweet corn by calculating the gross revenue, total cost and net profit for each vegetable. Additional economic measures were estimated to assist producers in determining the ideal vegetable production to include in their enterprise.

<u>Economic Measures</u>

The objectives of this study were to use the decision tool created through enterprise budgets to determine the economic feasibility of high-quality vegetables;

determine return on investment for each vegetable and field crop, and determine which crop, tomatoes, jalapeño peppers, or sweet corn, generated a higher profit per acre-inch of irrigation water applied. Several economic measures were calculated to evaluate these objectives. The descriptions of each of these calculations follow.

Total revenue for each vegetable was calculated by the following formula:

$$\text{Total Revenue} = Q_x \times P_x \qquad (7)$$

where “x” represents the vegetable of interest, “Q” represents the quantity or yield, and “P” represents the price received. Total cost for each vegetable was determined by:

$$\text{Total Cost} = \text{variable costs} + \text{fixed costs} \qquad (8)$$

where “variable costs” are associated with the quantity of input used specific to each vegetable and “fixed costs” represent all annual costs associated with equipment and land ownership. Total profit for each crop was calculated by:

$$\text{Total Profit} = \text{total revenue} - \text{total cost} \qquad (9)$$

Vegetables that reflect positive revenue are considered economically feasible.

Return on investment was used to determine the crop and treatment combination that provided the most benefit to producers. This was important to consider because of the additional costs associated with the implementation of black plastic mulch in the treatments. Return on investment was estimated by using the following equation:

$$\text{Return on Investment} = \frac{\text{total profit}}{\text{total cost}} \times 100 \qquad (10)$$

Profit per acre-inch of irrigation water was calculated using the following formula:

$$\text{Profit per acre-inch} = \frac{\text{total profit}}{\text{acre-inches of irrigation water applied}} \qquad (11)$$

Tomatoes, jalapeño peppers, and sweet corn under black plastic mulch and without black plastic mulch were compared to determine which crop had a higher profit per acre-inch of irrigation water applied.

Several sensitivity analyses were developed in this study due to the variability associated with each agricultural enterprise. The variable factors include yield, amount of irrigation water applied, hand weeding labor input, and price received. The effect of variation in these factors on profitability was estimated to allow producers to consider both production and market risks.

A sensitivity analysis to cover variable and total costs was conducted to provide producers breakeven price information should they yield less than or more than budgeted in the growing season. A range of possible yields was first determined by calculating 75, 90, 100, 110, and 125 percent of the yield produced in the enterprise budgets. Breakeven prices needed to cover variable costs were estimated using the following formula:

$$\textbf{(12)} \qquad \text{Breakeven price to cover variable costs} = \frac{\text{TVC - TCHC + (HC} \times \text{New Yield)}}{\text{New Yield}}$$

where "TVC" represents the total variable cost of production, "TCHC" represents total custom harvest costs for the original yield, "HC" represents the custom harvest per unit costs, and "new yield" represents the newly estimated yield. Similarly, breakeven prices needed to cover total costs were estimated using the above equation, however, TVC was replaced with total costs of production (TC).

A sensitivity analysis on amount of acre-inches of irrigation water applied, ceteris paribus, was examined to determine the effect on total profit per acre-inch. This analysis did not estimate the effect of irrigation application on total yield since the information was collected through a coinciding study and a production function was not given.

Furthermore, since rainwater was not measured in enterprise budgets, it was not considered in this study or the sensitivity analysis. A typical range of irrigation water applied by producers was reported by the Department of Horticulture at Texas A&M AgriLife Extension Service for tomatoes, peppers, and sweet corn (Masabni, 2011a; 2011b; 2011c).

Sensitivity analyses were also conducted to estimate the effects of labor hours and price received on total profit for each vegetable grown in the study. Several producer and enterprise characteristics such as family-labor, self-labor, and other vegetable and marketing outlets can result in higher or lower profitability. Labor hours used for hand weeding was adjusted on a percentage scale from zero to 150 percent, ceteris paribus, to estimate the changes in profitability due to changes in labor input. Price received estimates were made to capture the possibility of alternative prices available through various marketing outlets. Alternative prices for tomatoes and jalapeño peppers were calculated using a scale from 50 to 300 percent of the budgeted price.

Producer Survey

The primary purpose of the survey was to gather information from area producers regarding their vegetable production practices currently in place, demographics, and motivation to implement vegetables into their enterprise. The instrument was developed using Qualtrics online survey software (Appendix B). Recruitment letters and anonymous survey links were provided via email and Facebook groups focused on vegetable production in the region. Raw data was downloaded from the online software, incomplete survey responses were removed from the dataset, and responses outside of the study region were eliminated prior to analyzing the data.

The Institutional Review Board (IRB) at West Texas A&M University reviewed the survey prior to distribution. The survey was approved by the IRB on December 11, 2018 (WTAMU IRB #12-11-18 Approved: 12/17/2018 Expiration Date: 12/16/2020) (Appendix B). Participation was completely voluntary and did not result in any benefits or consequences to respondents. No personally identifying information was asked in the survey and it did not increase the risk for subjects more than minimally beyond the ordinary risks of daily life.

Emails containing a recruitment letter and an anonymous survey link were sent to 14 agriculturalists who were acquainted with Texas A&M AgriLife Research Center Bushland and Texas A&M AgriLife Research and Extension Lubbock faculty (Appendix B). In an effort to increase the survey population, snowball sampling was used by asking the respondents for their assistance in sharing the survey link with other vegetable producers in the study area. Additionally, the survey was shared through Facebook social media groups focused on vegetable production in the Texas High Plains. The recruitment letter and anonymous link were posted to The Texas Panhandle Young Farmers Coalition, West Texas Vegetable Gardeners, and Texas Young Farmers groups. Group members were also asked to share the survey link with others who produced vegetable crops.

The survey contained 62 questions, including a consent statement (Appendix B). All responses were anonymous, and respondents were only required to answer the willingness statement and provide their zip code. Questions were arranged in seven sections; consent statement, demographic information, vegetable production systems, irrigation, vegetable production practices, revenue, and other.

The consent form indicated respondents understood they would be answering economic and production related questions and all results were confidential and anonymous. Respondents were free to exit the survey at any time with no consequence and there was no direct benefit to completing the survey. If they were willing to complete the survey, producers would begin the next block of questions; however, if they selected they were not willing to participate, the survey would skip to the end.

Respondents were asked general demographic information in section two. Age, education, employment status, farm experience, and current crop production information was acquired. Respondents who did not produce vegetables finished the survey with this section and were taken to the end of the survey.

Section three requested information about vegetable production systems. Producers were asked which vegetables they produced and the type of system in which they were grown. This section focused on the area of greenhouses, high tunnels, and open-field production associated with each vegetable grown.

Irrigation information was acquired in section four. This included how often they irrigated and with what type of irrigation system. If drip irrigation was used, producers were asked after how many seasons the tape was replaced.

Section five focused on vegetable production practices and management. Questions included conventional production methods such as herbicides and fertilizers, organic production methods, mulching material, and planting methods. This section also included the number of labor hours, both self and hired, and equipment allocated specifically to total vegetable production.

Yields and marketing outlets available for selling vegetables were identified in section six. Respondents were asked about the quantity of vegetables produced, where they were sold, and the approximate price per pound received.

The final section of the survey was created to give researchers insight on how to better disseminate data to the producer. Farmers were asked why they made the decision to produce vegetables and how they receive information regarding vegetable production.

The initial survey was distributed via email on December 27, 2018, and two reminder emails followed on January 14, 2019, and February 8, 2019. The recruitment letter and anonymous link were posted to The Texas Panhandle Young Farmers Coalition, West Texas Vegetable Gardeners, and Texas Young Farmers groups on January 23, 2019. The survey was closed on February 15, 2019, and results were downloaded from the online survey software on February 18, 2019.

Surveys were downloaded from the Qualtrics online survey software into Microsoft Excel file. Incomplete responses, responses with a zip code outside the study region, and responses that did not answer vegetable related questions were removed from the file. Data were analyzed using descriptive statistics via the SPSS statistical package. Means, standard deviations, and frequency percentages were used for the description of the data.

CHAPTER 4

RESULTS

Enterprise Budgets

Tomatoes with Black Plastic Mulch

Tomatoes grown using drip irrigation and black plastic mulch return a gross revenue of $13,205.46 per acre, given a price of $39.49 per cwt and a yield of 334.4 cwt per acre (Table 1 and Table A1). Total variable costs of production are $7,354.76 per acre, largely comprised of transplant costs, irrigation equipment, and custom harvest costs. Drip tape, drip fittings, and black plastic mulch collectively describe irrigation equipment in this section. Tomato transplants account for 14 percent of the total variable costs, and irrigation equipment and harvest costs are 21 percent and 45 percent of variable costs, respectively. Labor costs, including setting support trellises, hand weeding, irrigation labor, and machinery labor, account for 13 percent of production costs. Total fixed costs equal $852.41 per acre, resulting in a total cost of production of $8,207.17 per acre. Total profit for tomatoes produced with black plastic mulch is $4,998.28 per acre (Table 1 and Table A1).

Table 1. Revenue, costs, and total profit per acre for tomatoes grown using black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$13,205.46	$7,354.76	$852.41	$8,207.17	$4,998.28

Tomatoes without Black Plastic Mulch

Drip irrigation without black plastic mulch yielded 259.6 cwt of fresh market tomatoes per acre, which with a price of $39.49 per cwt results in gross revenue of $10,251.60 per acre (Table 2 and Table A2). Total variable costs are $7,325.45 per acre, reflecting reduced expenses without black plastic mulch, an increase in hand weeding expense, and a lower custom harvest cost with reduced yield. Tomato transplants account for 14 percent of variable costs, while irrigation equipment and custom harvest costs made up 16 percent and 35 percent, respectively. Twenty-eight percent of the variable costs are labor expenses. Total fixed costs are $852.41 per acre as the same equipment was used for each type of tomato production. The total cost for tomatoes grown without black plastic mulch is $8,177.86 per acre, which results in a total profit of $2,073.75 per acre (Table 2 and Table 2A).

Table 2. Revenue, costs, and total profit per acre for tomatoes grown without using black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$10,251.60	$7,325.45	$852.41	$8,177.86	$2,073.75

Jalapeño Peppers with Black Plastic Mulch

Jalapeño peppers grown with black plastic mulch a yielded 325.1 cwt per acre, which with a price of $23.12 per cwt results in gross revenue of $7,516.31 per acre

(Table 3 and Table A3). Total variable costs are $8,170.65 per acre. Twenty-six percent of variable costs are for pepper seedlings, which were planted in two rows rather than one row like tomato plants. Irrigation equipment comprises 19 percent of variable costs. Custom harvest accounts for 40 percent of variable costs while approximately 10 percent is hand weeding labor. Labor hours in pepper production are lower than hours required in tomato production with black plastic mulch because no support trellises are used in pepper production. Total fixed costs of jalapeño pepper production are $218.71 per acre, again reflecting the reduced cost of general equipment without utilizing t-posts for trellis support. Total costs per acre are $8,389.36 per acre which results in a loss of $873.05 per acre (Table 3 and Table A3).

Table 3. Revenue, costs, and total profit per acre for jalapeño peppers grown using black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$7,516.31	$8,170.65	$218.71	$8,389.36	-$873.05

Jalapeño Peppers without Black Plastic Mulch

Similar to tomato production, jalapeño peppers had a lower yield of 235.9 cwt per acre when produced without black plastic mulch (Table 4 and Table A4). Gross revenue for peppers without black plastic mulch at a price of $23.12 per cwt was $5,454.01 per acre. Total variable costs are higher, $9,188.51 per acre, despite reduced costs in irrigation equipment and harvest because of the increase in hand weeding labor without implementing plastic mulch. Transplants comprise 23 percent, irrigation equipment accounts for 13 percent, custom harvest costs are 26 percent, and labor expenses are 34 percent of variable costs. Implementation of the same equipment in both pepper production practices results in total fixed costs remaining at $218.71 per acre. The total cost for jalapeño peppers without black plastic mulch is $9,407.22 per acre, which results in -$3,953.21 total profit per acre (Table 4 and Table A4).

Table 4. Revenue, costs, and total profit per acre for jalapeño peppers grown without black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$5,454.01	$9,188.51	$218.71	$9,407.22	-$3,953.21

<u>Sweet Corn with Black Plastic Mulch</u>

Sweet corn has the lowest variable costs at $4,950.73 per acre because there is no handing weeding labor hours required. Sweet corn yielded 87.6 cwt per acre when grown under black plastic mulch, which with a price of $10.78 per cwt results in gross revenue of $944.33 per acre (Table 5 and Table A5). Corn seeding rates in the field experiment were higher than tomato and pepper transplant rates. Sweet corn seeds account for 41 percent of variable expenses. Approximately 32 percent and 18 percent of variable expenses are due to irrigation equipment and custom harvest, respectively. Fixed costs for sweet corn production are $220.01 per acre, which results in a total cost of $5,170.73 per acre. Profit for sweet corn production under black plastic much is -$4,226.41 per acre (Table 5 and Table A5).

Table 5. Revenue, costs, and total profit per acre for sweet corn grown using black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$944.33	$4,950.73	$220.01	$5,170.73	-$4,226.41

Sweet Corn without Black Plastic Mulch

Sweet corn grown without black plastic mulch yielded a higher quantity than sweet corn grown with black plastic mulch at 92.2 cwt per acre (Table 6 and Table A6). Sweet corn without black plastic mulch has a gross revenue of $993.92 per acre at a price of $10.78 per cwt. Variable costs are $4,600.08. Seeds, irrigation equipment, and custom harvest costs result in approximately 45 percent, 26 percent, and 20 percent of variable expenses, respectively. Total fixed costs for sweet corn remain at $220.01 per acre, resulting in a total cost of $4,820.09 per acre. Sweet corn has a profit of -$3,826.17 per acre (Table 6 and Table A6).

Table 6. Revenue, costs, and total profit per acre for sweet corn grown without black plastic mulch.

Gross Revenue	Total Variable Costs	Total Fixed Costs	Total Costs	Total Profit
$993.92	$4,600.08	$220.01	$4,820.09	-$3,826.17

Economic Measures

Vegetables are considered economically feasible if production results in a positive profit per acre. Enterprise budgets for tomatoes grown using black plastic mulch and without black plastic mulch indicate positive profit per acre in this study. Jalapeño peppers and sweet corn, grown with and without black plastic mulch, result in losses, indicating neither is economically feasible to produce (Table 7 and Figure 3). When compared to irrigated corn, cotton, and wheat, tomatoes grown with and without black plastic mulch have larger total costs than traditionally irrigated field crops but higher profit per acre. Although irrigated wheat results in a loss of $128.50 per acre, sweet corn results the greatest loss of all crops analyzed in this study (Table 7 and Figure 3).

Table 7. Revenue, total costs, and total profit per acre by crop for tomatoes, jalapeño peppers, and sweet corn grown with and without black plastic mulch.

Commodity	Gross Revenue	Total Costs	Total Profit
Tomato†	$13,205.46	$8,207.17	$4,998.28
Tomato‡	$10,251.60	$8,177.86	$2,073.75
Peppers†	$7,516.31	$8,389.36	-$873.05
Peppers‡	$5,454.01	$9,407.22	-$3,953.21
Sweet Corn†	$944.33	$5,170.73	-$4,226.41
Sweet Corn‡	$993.92	$4,820.09	-$3,826.17

† Vegetables grown using black plastic mulch

‡ Vegetables grown without black plastic mulch

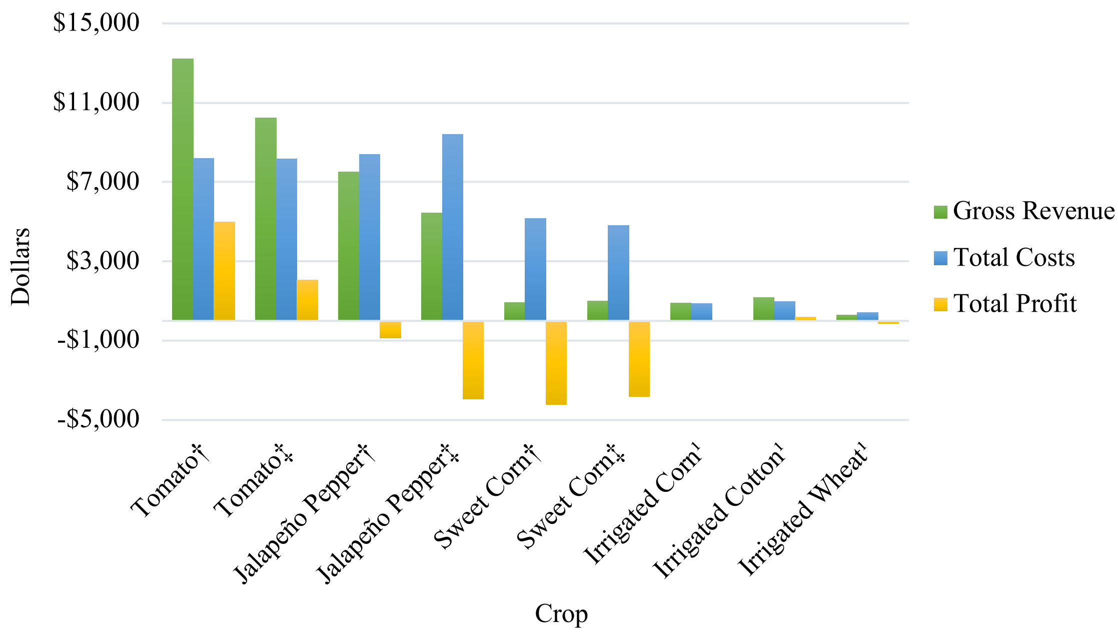

Figure 3. Revenue, total costs, and total profit per acre by crop for vegetables and traditionally irrigated field crops.

† Vegetables grown using black plastic mulch

‡ Vegetables grown without black plastic mulch

[1] Source: Jones et al., 2018

Return on investment for each vegetable and field crop results in similar trends as profit. However, this measurement is valuable since the cost of irrigated grain production per acre is much lower than the cost of vegetable production per acre. Tomatoes grown with and without black plastic mulch along with irrigated corn and cotton have a positive return on investment. Jalapeño peppers and sweet corn grown with and without black plastic mulch along with irrigated wheat have a negative return on investment due to negative profit. Return on investment was highest in tomato production with black plastic mulch (61%) followed by tomatoes grown without black mulch (25%). Two traditionally irrigated field crops also have a positive return on investment. Irrigated cotton has a return on investment of 22 percent while irrigated corn has a return on investment of four percent (Figure 4).

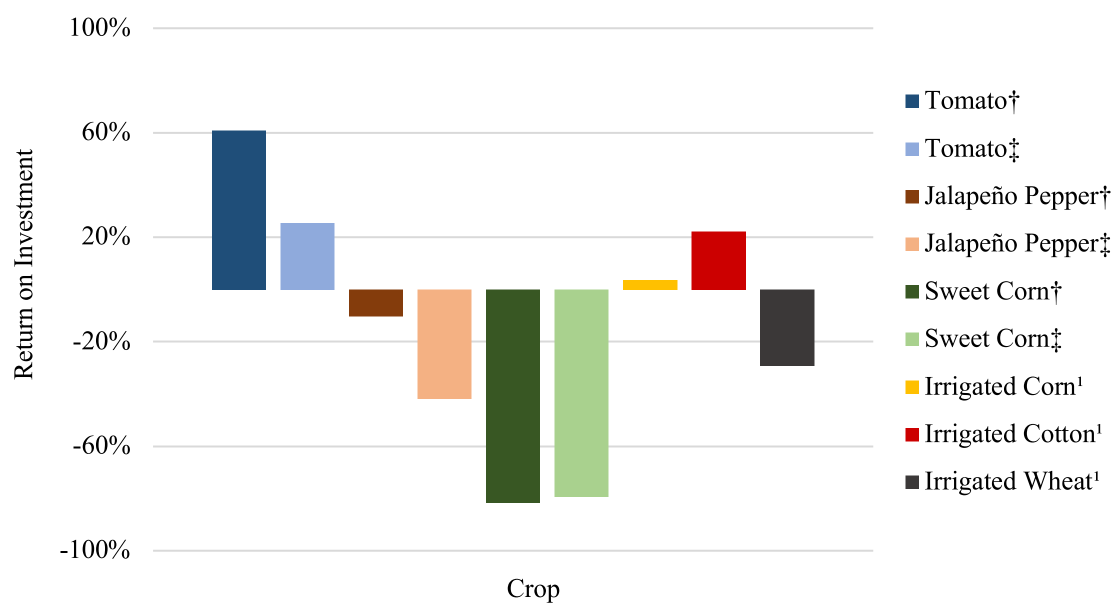

Figure 4. Return on investment by crop for vegetables and traditionally irrigated field crops.
† Vegetables grown using black plastic mulch
‡ Vegetables grown without black plastic mulch
[1] Source: Jones et al., 2018

Profit per acre-inch of irrigation water applied was higher in vegetable production than irrigated field crops. Tomatoes and jalapeño peppers received 11 acre-inches of water during the growing season and sweet corn received 10.22 acre-inches. Rainwater was not recorded or budgeted for vegetable growth. Corn, cotton, and wheat received 22, 12, and 10 acre-inches of irrigation water, respectively (Jones et al., 2018). Tomatoes grown under black plastic mulch return $454.39 per acre-inch and $188.52 per acre-inch without black plastic mulch. Jalapeño peppers returned -$79.37 and -$359.38 per acre-inch with and without black plastic mulch, respectively. Profit per acre-inch of irrigation water applied to sweet corn is -$413.54 using black plastic mulch and -$374.38 without black plastic mulch. Irrigated corn, cotton, and wheat have profits of $1.47, $18.05, and -$12.85 per acre-inch of irrigation water, respectively (Figure 5).

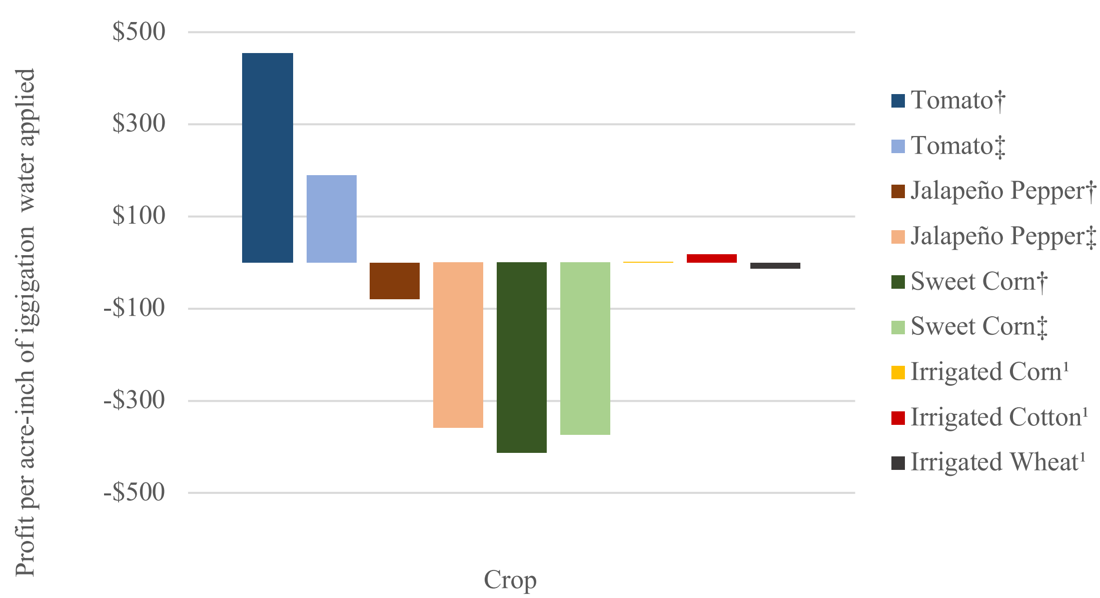

Figure 5. Profit per acre-inch of irrigation water applied by crop for vegetables and traditionally irrigated field crops.
† Vegetables grown using black plastic mulch
‡ Vegetables grown without black plastic mulch
[1] Source: Jones et al., 2018

A range of yields was calculated to provide a sensitivity analysis of possible production outcomes for producers to cover variable and total costs for each crop produced in this study. Yields were calculated based on percentages of 75, 90, 100, 110, and 125 percent of the budgeted yield to account for variation across different seasons. The resulting breakeven prices indicate the vegetable price necessary for producers to cover either variable or total production costs for the season.

Tomatoes grown with black plastic mulch yielded 334.4 cwt per acre, resulting in in a breakeven price of $21.99 per cwt and $24.54 per cwt to cover variable and total costs of production, respectively. A tomato yield of 250.8 cwt per acre at 75 percent of the budgeted yield results in a breakeven price of $25.99 per cwt to cover variable costs and $29.39 per cwt to cover total costs. A higher yield level of 418 cwt per acre results in lower breakeven prices of $19.60 per cwt to cover variable costs and $21.63 per cwt to cover total costs of tomato production using black plastic mulch (Table 8).

Table 8. Breakeven prices to cover variable and total costs for tomato production using black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	**Yield (cwt)**	**Variable Costs**	**Total Costs**
75%	250.80	$25.99	$29.39
90%	300.96	$23.33	$26.16
100%	334.40	$21.99	$24.54
110%	367.84	$20.90	$23.22
125%	418.00	$19.60	$21.63

Tomatoes grown without black plastic mulch require higher breakeven prices as a reflection of lower yields under this treatment. Tomatoes in the field experiment yielded 259.6 cwt per acre which results in a breakeven price of $28.22 per cwt to cover variable costs and $31.50 per cwt to cover total costs. Production of 75 percent of the budgeted yield, 194.7 cwt per acre, results in prices of $34.29 per cwt and $38.67 per cwt to cover variable and total costs, respectively. Higher production of 324.5 cwt per acre results in a breakeven price of $24.57 per cwt to cover variable costs and $27.20 per cwt to cover total costs of tomato production without utilizing black plastic mulch (Table 9).

Table 9. Breakeven prices to cover variable and total costs for tomato production without black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	Yield (cwt)	Variable Costs	Total Costs
75%	194.70	$34.29	$38.67
90%	233.64	$30.24	$33.89
100%	259.60	$28.22	$31.50
110%	285.56	$26.56	$29.55
125%	324.50	$24.57	$27.20

Jalapeños yielded 325.1 cwt per acre under black plastic mulch which results in a breakeven price of $25.13 per cwt to cover variable production costs and $25.81 per cwt to cover total costs. Lower production of 243.83 cwt per acre at 75 percent of the budgeted yield results in breakeven prices of $30.18 per cwt and $31.07 per cwt to cover variable costs and total costs, respectively. Jalapeños at 125 percent of the budgeted yield, 406.38 cwt per acre, result in a breakeven price of $22.11 per cwt and $22.64 per cwt to cover variable and total costs for jalapeño pepper production using black plastic mulch, respectively (Table 10).

Table 10. Breakeven prices to cover variable and total costs for jalapeño pepper production using black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	Yield (cwt)	Variable Costs	Total Costs
75%	243.83	$30.18	$31.07
90%	292.59	$26.81	$27.56
100%	325.10	$25.13	$25.81
110%	357.61	$23.76	$24.37
125%	406.38	$22.11	$22.64

Jalapeños grown without black plastic mulch yielded 235.9 cwt per acre, which results in breakeven prices of $38.95 per cwt and $39.88 per cwt to cover variable and total expenses, respectively. Production of 75 percent of the budgeted yield, 176.93 cwt per acre, results in a breakeven price of $48.60 per cwt to cover variable costs and $49.84 per cwt to cover total costs. A higher yield level of 294.88 cwt per acre results in a lower breakeven price of $33.16 per cwt to cover variable costs and $33.90 per cwt to cover total costs of jalapeño production using black plastic mulch (Table 11).

Table 11. Breakeven prices to cover variable and total costs for jalapeño pepper production without black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	**Yield (cwt)**	**Variable Costs**	**Total Costs**
75%	176.93	$48.60	$49.84
90%	212.31	$42.17	$43.20
100%	235.90	$38.95	$39.88
110%	259.49	$36.32	$37.16
125%	294.88	$33.16	$33.90

Sweet corn, both with and without black plastic mulch, results in higher breakeven prices than tomatoes and jalapeño peppers due to the low budgeted yield of sweet corn. Sweet corn yielded 87.6 cwt per acre when grown with black plastic mulch, which results in a breakeven price of $56.52 per cwt to cover variable costs and $59.03 per cwt to cover total costs. A lower yield level of 65.7 cwt per acre results in a breakeven price of $72.02 per cwt to cover variable costs and $75.37 per cwt to cover total costs. A sweet corn yield of 125 percent of the budgeted yield, 109.5 cwt per acre, results in a lower breakeven price of $47.21 per cwt and $49.22 per cwt to cover variable and total costs, respectively (Table 12).

Table 12. Breakeven prices to cover variable and total costs for sweet corn production using black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	**Yield (cwt)**	**Variable Costs**	**Total Costs**
75%	65.70	$72.02	$75.37
90%	78.84	$61.68	$64.47
100%	87.60	$56.52	$59.03
110%	96.36	$52.29	$54.57
125%	109.5	$47.21	$49.22

Sweet corn grown without black plastic mulch yielded higher, 92.2 cwt per acre, than when grown with black plastic mulch and results in breakeven prices of $49.89 per cwt and $52.28 per cwt to cover variable and total costs, respectively. A lower yield level of 69.15 cwt per acre results in a breakeven price of $63.19 per cwt to cover variable costs and $66.37 per cwt to cover total expenses. A sweet corn yield of 125 percent of the budgeted yield, 115.25 cwt per acre, results in a breakeven price of $41.91 per cwt to cover variable costs and $43.82 per cwt to cover total costs of production (Table 13).

Table 13. Breakeven prices to cover variable and total costs for sweet corn production without black plastic mulch under alternative yields.

		Breakeven price ($/cwt) to cover:	
Yield Percent	**Yield (cwt)**	**Variable Costs**	**Total Costs**
75%	69.15	$63.19	$66.37
90%	82.98	$54.32	$56.98
100%	92.20	$49.89	$52.28
110%	101.42	$46.27	$48.44
125%	115.25	$41.91	$43.82

Profit per acre-inch of irrigation water applied was analyzed given the reported upper limit of irrigation water applied to vegetable crops (Masabni, 2011a; 2011b; 2011c), ceteris paribus*,* and compared to traditionally irrigated corn, cotton, and wheat (Figure 6). Increasing the irrigation water applied to vegetables reduces the profit per acre-inch scale by over half. Tomatoes result in higher profit per acre-inch of irrigation water than traditional field crops, despite the higher cost associated with irrigation and holding yield constant. Tomatoes grown using black plastic mulch have a profit of $199.93 per acre-inch given an irrigation level of 25 acre-inches per acre. Tomatoes produced without black plastic mulch have a profit per acre-inch of irrigation water applied of $82.95 utilizing 25 acre-inches per acre of irrigation in the season.

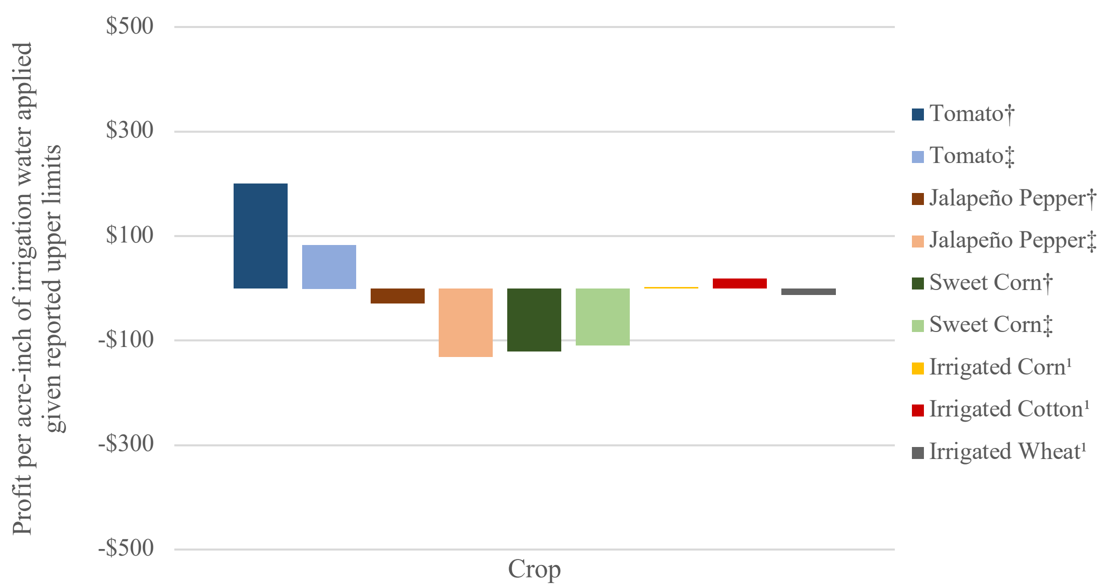

Figure 6. Profit per acre-inch of irrigation water applied by crop for vegetables under the reported upper limits of irrigation and traditionally irrigated field crops.
† Vegetables grown using black plastic mulch
‡ Vegetables grown without black plastic mulch
[1] Source: Jones et al., 2018

Results of a sensitivity analysis of labor hours indicate a large change in labor costs and total profits when adjusting the hours spent hand weeding, ceteris paribus. Overall, profit increases with reduced weeding hours. Labor hours listed at 100 percent are the labor hours associated with the initially developed enterprise budgets.

Reducing hand weeding hours to zero percent results in a 15 percent increase in profit at $5,763.29 per acre, for tomatoes grown using black plastic mulch. A decrease to 50 percent of labor hours results in hand weeding labor costs of $382.50 per acre, which results in a profit increase of eight percent at $5,380.79 per acre. However, increasing weeding hours to 135 hours results in hand weeding labor costs of $1,147.50 per acre and an eight percent decrease in profit per acre at $4,615.79 per acre (Table 14).

Table 14. Estimated profit per acre with alternative hand weeding labor hours for tomato production using black plastic mulch.

Percent of Labor	Labor Hours	Labor Cost	Total Profit	Percent Change in Profit
0%	0.0	$0.00	$5,763.29	15%
25%	22.5	$191.25	$5,572.04	11%
50%	45.0	$382.50	$5,380.79	8%
75%	67.5	$573.75	$5,189.54	4%
100%	90.0	$765.00	$4,998.29	0%
125%	112.5	$956.25	$4,807.04	-4%
150%	135.0	$1,147.50	$4,615.79	-8%

Tomatoes grown on bare ground, without black plastic mulch, result in larger percent changes in profit with the adjustment of weed control hours. Eliminating weeding hours in a growing season results in a 90 percent increase in profit at $3,943.74 per acre. Profit increases by 45 percent by reducing hand weeding labor to 110 hours during the production season. Increasing weeding hours to 330 hours, however, results in a 45 percent decrease in profit at -$1,138.74 per acre (Table 15).

Table 15. Estimated profit per acre with alternative hand weeding labor hours for tomato production without black plastic mulch.

Percent of Labor	Labor Hours	Labor Cost	Total Profit	Percent change in profit
0%	0	$0.00	$3,943.74	90%
25%	55	$467.50	$3,476.24	68%
50%	110	$935.00	$3,008.74	45%
75%	165	$1,402.50	$2,541.24	23%
100%	220	$1,870.00	$2,073.74	0%
125%	275	$2,337.50	$1,606.24	-23%
150%	330	$2,805.00	$1,138.74	-45%

Results indicate a reduction in hand weeding labor hours still does not return a positive profit for jalapeños both with and without black plastic mulch. Eliminating hand weeding labor in jalapeño production results in an 88 percent increase in profit per acre at -$108.05. Reducing labor hours to 45 hours in a growing season results in hand weeding labor costs of $382.50 per acre, which results in a 44 percent increase in profit at -$490.55 per acre. Increasing hand weeding to 135 hours results in hand weeding labor costs of $1,147.50 per acre, which results in a 44 percent decrease in profit at -$1,255.55 per acre (Table 16).

Table 16. Estimated profit per acre with alternative hand weeding labor hours for jalapeño pepper production using black plastic mulch.

Percent of Labor	Labor Hours	Labor Cost	Total Profit	Percent Change in Profit
0%	0.0	$0.00	-$108.05	88%
25%	22.5	$191.25	-$299.30	66%
50%	45.0	$382.50	-$490.55	44%
75%	67.5	$573.75	-$681.80	22%
100%	90.0	$765.00	-$873.05	0%
125%	112.5	$956.25	-$1,064.30	-22%
150%	135.0	$1,147.50	-$1,255.55	-44%

Eliminating black plastic mulch from jalapeño pepper production increases the required labor hours due to additional weeding hours required for proper plant growth. Removing hand weeding labor for jalapeños increases profit by 77 percent at -$910.21 per acre. Decreasing labor hours from 358 hours to 179 hours during the production season results in a 38 percent increase in profit per acre at -$2,431.71. However, an increase in hand weeding to 537 hours increases labor costs to $4,564.50 which results in a 38 percent decrease in profit at -$5,474.71 per acre (Table 17).

Table 17. Estimated profit per acre with alternative hand weeding labor hours for jalapeño pepper production without black plastic much.

Percent of Labor	Labor Hours	Labor Cost	Total Profit	Percent change in profit
0%	0.0	$0.00	-$910.21	77%
25%	89.5	$760.75	-$1,670.96	58%
50%	179.0	$1,521.50	-$2,431.71	38%
75%	268.5	$2,282.25	-$3,192.46	19%
100%	358.0	$3,043.00	-$3,953.21	0%
125%	447.5	$3,803.75	-$4,713.96	-19%
150%	537.0	$4,564.50	-$5,474.71	-38%

Specialty crops, including locally-grown vegetables, have become increasingly popular in farmer's markets, local grocery stores, and home or truck sales. While many consumers demand chemical free products, recent trends indicate less focus on organic and more focus on high-quality, locally-grown produce (Biermacher et al., 2007). This provides opportunities for producers to sell their crops through various marketing outlets and receive a range of prices for their vegetables. In the following sensitivity analysis, alternative prices were evaluated, ceteris paribus, to determine the effect on total profit.

A lower price for tomatoes at 50 percent of the budgeted price, $19.75 per cwt, results in negative profit for tomatoes grown with and without black plastic mulch.

Reducing price received for tomatoes results in a profit of -$1,604.44 per acre and -$3,052.06 per acre with and without black plastic mulch, respectively. A higher price of $59.24 per cwt, 150 percent of the budgeted price, results in a profit of $11,601.01 per acre with mulch and $7,199.55 per acre without mulch. A 300 percent increase in price from the budgeted price for tomatoes is $118.47 per cwt, which results in a profit of $31,409.20 per acre using plastic mulch, and $22,576.95 per acre without mulch (Table 18).

Table 18. Effect of price received on total profit for tomato production with and without plastic mulch.

Percent of Price	Price Received (cwt)	Total Profit†	Total Profit‡
50%	$19.75	-$1,604.44	-$3,052.06
100%	$39.49	$4,998.29	$2,073.74
150%	$59.24	$11,601.01	$7,199.55
200%	$78.98	$18,203.74	$12,325.35
250%	$98.73	$24,806.47	$17,451.15
300%	$118.47	$31,409.20	$22,576.95

† Tomatoes grown using black plastic mulch
‡ Tomatoes grown without black plastic mulch

Producers growing jalapeño peppers both with and without black plastic mulch need higher prices than the budgeted price to obtain a positive profit per acre. A lower price for jalapeño peppers at $11.56 per cwt, 50 percent of the budgeted price, results in a profit of -$4,631.20 per acre and -$6,680.22 per acre with and without black plastic mulch, respectively. A higher price of $34.68 per cwt, 150 percent of the budgeted price, results in a profit of $2,885.11 per acre with mulch and -$1,226.21 per acre without mulch. A 300 percent increase in price from the budgeted price for jalapeño peppers is $69.36 per cwt, which results in a profit of $14,159.58 per acre using plastic mulch, and $6,954.80 per acre without mulch (Table 19).

Table 19. Effect of price received on total profit for jalapeño production with and without plastic mulch.

Percent of Price	Price Received (cwt)	Total Profit†	Total Profit‡
50%	$11.56	-$4,631.20	-$6,680.22
100%	$23.12	-$873.05	-$3,953.21
150%	$34.68	$2,885.11	-$1,226.21
200%	$46.24	$6,643.26	$1,500.80
250%	$57.80	$10,401.42	$4,227.80
300%	$69.36	$14,159.58	$6,954.80

† Jalapeños grown using black plastic mulch
‡ Jalapeños grown without black plastic mulch

Producer Survey

Snowball sampling was used to distribute the survey aimed at identifying vegetable production practices in the Texas High Plains. Thirty-one producers agreed to participate and 15 completed the questionnaire. Two of the 15 producers provided zip codes that did not correspond with the 45 Texas counties in the study area, and one respondent did not produce vegetables. Thus, 12 survey responses are used in the analysis (n=12). Survey skip logic did not provide follow-up questions to respondents if a specific answer was not selected, therefore some questions have less than 12 responses, depending on producer responses. Due to the small sample size and self-reporting nature of the survey, numeric ranges were analyzed as non-normally distributed data. Frequency of response is defined as *f* and % is the percentage of respondents allocated to the frequency of each question.

Participants were first asked to provide demographic information. Respondents were asked to select the category that best describes their age group. Seventy-five percent of respondents are under the age of 55 years old with four people between the ages of 18 and 34 and five between the ages of 35 and 55 (Table 20). Participants were then asked to select the highest level of education completed. All respondents report they have received some level of formal college education with 50 percent having a bachelor's or graduate degree. Approximately 41 percent have not obtained a college degree (Table 21). Finally, participants were asked to provide their employment information. Three-respondents are considered full-time employees, one is a student, and one is retired but farming full time. The remaining 58.3 percent are considered self-employed (Table 22).

Table 20. Age of survey respondents (n=12).

Age	*f*	%
18 - 34 years old	4	33.3
35-54 years old	5	41.7
55+ years old	3	25.0

Table 21. Education level of survey respondents (n=12).

Education	*f*	%
Associate degree/trade school	1	8.3
Bachelor's degree	4	33.3
Graduate degree	2	16.7
Some college	5	41.7

Table 22. Employment status of survey respondents (n=12).

Employment	*f*	%
Employed full time	3	25.0
Retired, farming full time	1	8.3
Self-employed	7	58.3
Self-employed, student	1	8.3

Survey takers indicate several years of farm experience and a wide range of crops produced. One respondent has been farming for less than one year and seven have been farming for more than six years. The remaining four participants have been farming for two to three years (Table 23). Twenty-five percent of respondents produce at least one or more of field crops common in the study area including corn, cotton, wheat, and sorghum. Nine participants produce vegetables and three grow fruit (Table 24). Respondents were given the option to list other crops produced in their enterprise in an open-ended response. Responses include salad greens, numerous types of squash, cucumbers, nuts, and hay. Vegetables produced by survey takers are tomatoes, peppers, sweet corn. All respondents produce tomatoes, 11 grow peppers, and one produces sweet corn. Nine respondents grow a range of other vegetables in their production (Table 25).

Table 23. Farming experience of survey respondents (n=12).

Farm Experience	*f*	%
0-1 year	1	8.3
2-3 years	4	33.3
6+ years	7	58.3

Table 24. Crops produced by survey respondents (n=12).

Crops	*f*	%
Corn, Cotton, Wheat, Sorghum, Vegetables	2	16.7
Cotton, Wheat, Sorghum, Vegetables, Other	1	8.3
Vegetables	5	41.7
Vegetables, Fruit	2	16.7
Vegetables, Fruit, Other	1	8.3
Vegetables, Other	1	8.3

Table 25. Vegetables produced by survey respondents (n=12).

Vegetables	*f*	%
Tomatoes	1	8.3
Tomatoes, Peppers	2	16.7
Tomatoes, Peppers, Other	8	66.7
Tomatoes, Peppers, Sweet Corn, Other	1	8.3

The next section of the survey focused on production techniques and innovations that are commonly used in the region including high tunnel systems, greenhouses, and open field production. Respondents were asked to provide the quantity and dimensions of the system(s) used and the percentage of the specific vegetables grown in relation to the production system.

Five respondents implement high tunnel production systems into their enterprise. Sizes of high tunnels vary by producer: three 30-foot by 96-foot tunnels, one 14-foot by 100-foot tunnel, and one 20-foot by 30-foot tunnel (Table 26). The most common use for high tunnels is strawberries and salad greens. Two respondents using high tunnels report 15 to 25 percent of high tunnels are allocated to tomatoes and one respondent uses 100 percent of a high tunnel for tomato production. Two respondents report allocating 25 percent of a high tunnel to pepper production (Table 27). Lastly, survey respondents who utilized high tunnel systems were asked if they received funding from the USDA Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP). Two of the five participants indicate they have received funding from the program.

Table 26. Size of high tunnels used (n=5).

High Tunnel Size	*f*	%
30' X 96'	3	60
14' x 100'	1	20
20'x30'	1	20

Table 27. Percent of high tunnel allocated for vegetable production (n=5).

	Tomato		Pepper		Other	
Percent of area	*f*	%	*f*	%	*f*	%
0	2	40	4	80	1	20
15	1	20	-	-	-	-
25	1	20	1	20	-	-
50	-	-	-	-	1	20
85	-	-	-	-	1	20
100	1	20	-	-	2	40

Four of the 12 survey takers, or 33 percent, use greenhouses to produce vegetables and similar to high tunnels, the size of the greenhouse varies by producer. Three six-foot by eight-foot greenhouse, two 30-foot by 96-foot greenhouses, one two-foot by one-foot greenhouse, and one 12-foot by 24-foot greenhouse are used by respondents (Table 28). Two respondents use greenhouse sizes not listed in the survey options but did not provide the dimensions. Four respondents report allocating 10 to 20 percent of greenhouse space to tomato production and 2 respondents allocate 20 to 25 percent to pepper production. The highest percentages of greenhouse production are used for strawberry and squash production (Table 29).

Table 28. Size of greenhouses used (n=4).

Greenhouse Size	*f*	%
1' x 2'	1	14
6' x 8'	3	43
12' x24'	1	14
30' x 96'	2	29

Table 29. Percent of greenhouse allocated for vegetable production (n=4).

	Tomato		Pepper		Other	
Percent of area	***f***	**%**	***f***	**%**	***f***	**%**
0	1	25	2	50	-	-
10	1	25	-	-	-	-
20	1	25	1	25	-	-
25	1	25	1	25	1	20
50	-	-	-	-	1	20
60	1	20	-	-	1	20
90	-	-	-	-	1	20
100	-	-	-	-	1	20

Approximately 67 percent of participants utilize open-field production for their vegetables. Field sizes vary; the largest is 30 acres and the smallest is a quarter of an acre. Approximately 57 percent of open-field producers allocate two to five acres for vegetable production (Table 30). Twenty-five percent of respondents indicate 30 to 50 percent of their fields are used for tomatoes. While 87 percent of responses indicate a 25 percent or less allocation to peppers, the remaining 12.5 percent use 50 percent of the field for pepper production. One respondent reports 20 percent of the field is allocated to sweet corn production. Seven respondents indicate fifty percent or more of the field is used for other vegetables including squash, okra, salad greens, and potatoes (Table 31). No respondents report using any other type of production system for vegetable production outside of high tunnels, greenhouses, or open-field.

Table 30. Size of field used (n=7).

Field Acres	***f***	**%**
>1.00	1	14.3
0.25	1	14.3
2.00	1	14.3
3.00	2	28.6
5.00	1	14.3
30.00	1	14.3

Table 31. Percent of open-field allocated for vegetable production (n=8).

	Tomato		Pepper		Sweet Corn		Other	
Percent of area	***f***	**%**	***f***	**%**	***f***	**%**	***f***	**%**
0	1	12.5	3	37.5	7	87.5	1	12.5
10	1	37.5	3	37.5	-	-	-	-
15	1	12.5			-	-	-	-
20	-	-	-	-	1	12.5	-	-
25	1	12.5	1	12.5	-	-	-	-
30	1	12.5	-	-	-	-	-	-
50	1	12.5	1	12.5	-	-	1	12.5
60	-	-	-	-	-	-	1	12.5
80	-	-	-	-	-	-	3	37.5
85	-	-	-	-	-	-	1	12.5
90	-	-	-	-	-	-	1	12.5

Producers were asked if they irrigate vegetables and the type of irrigation system(s) used. Ten respondents report irrigating their vegetables. Approximately 88 percent of respondents irrigate 100 percent of their vegetables and one respondent irrigates 94 percent of their vegetables.

Surface drip, subsurface drip, center pivots, overhead irrigation, and wobbler-micro emitters are the common types of irrigation methods used by survey takers with surface drip irrigation being the most popular. Two of the respondents use surface drip irrigation for 20 to 25 percent of their production and the remaining use it for 100 percent of their vegetable production. One respondent uses subsurface drip for 100 percent of vegetable irrigation. Two respondents use center pivot irrigation: one for 80 percent and one for 100 percent of vegetable production. One participant utilizes overhead irrigation for 75 percent of vegetable production, and one respondent uses a wobbler/micro-emitter to water 100 percent of vegetables grown (Table 32). Respondents who use surface drip or subsurface drip were asked after how many growing seasons drip tape is replaced. Twenty-five percent report replacing drip tape after every production season, 12.5 percent replace after 2 seasons, and 62.5 percent replace after four or more growing seasons.

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Table 32. Percent of irrigation allocated for vegetable production (n=10).

	Surface Drip		Subsurface Drip		Center Pivot		Overhead		Wobbler/ Micro-emitter	
Percent irrigated	***f***	**%**	***f***	**%**	***f***	**%**	***f***	**%**	***f***	**%**
0	3	30	9	90	8	80	9	90	9	0
20	1	10	-	-	-	-	-	-	-	-
25	1	10	-	-	-	-	-	-	-	-
75	-	-	-	-	-	-	1	10	-	-
80	-	-	-	-	1	10	-	-	-	-
100	5	30	1	10	1	10	-	-	1	10

Irrigation frequency ranges from once weekly to twice daily or as needed. Forty percent of respondents who irrigate apply water once weekly, 30 percent once daily, and 30 percent indicate a different time frame than the options provided. Other irrigation frequency responses include twice daily irrigation, every other day, and as needed with the use of technology. Duration of irrigation ranges from five minutes to 12 hours, as well as “as needed” and “dependent on heat”.

Producers were asked if they utilize organic and/or conventional vegetable production practices. Approximately 82 percent of respondents implement organic production methods and 33 percent use conventional practices. Only one respondent who uses organic methods, however, reports the vegetables are USDA certified organic. Of the four conventional vegetable growers, all use fertilizers, two use herbicides, and three use fungicides and pesticides. Most respondents indicate that chemicals are only used as needed, except for one participant who applies fertilizer every other week, one who applies fertilizer once monthly, and one who applied fungicide twice a week (Table 33). Participants were asked the quantities of chemicals used in their production practices in an open-ended response. Respondents did not provide measurable quantities, only that the product is used as little as possible or as needed.

Table 33. Frequency of chemical application for vegetable production (n=5; 6; 4; 4).

	Fertilizer		Herbicide		Fungicide		Pesticide	
Application Frequency	***f***	**%**	***f***	**%**	***f***	**%**	***f***	**%**
As needed	2	50	2	50	2	50	2	50
Once Weekly	-	-	-	-	-	-	1	25
Twice weekly	-	-	-	-	1	25	-	-
Once every other week	1	25	-	-	-	-	-	-
Once Monthly	1	25	-	-	-	-	-	-
Never	-	-	2	50	1	25	1	25

Survey participants were asked if they use mulch in vegetable production, the percentage of vegetables produced using mulch, and what type of mulch. Seven survey respondents report using mulch in their production practices. Of those that use mulch, five respondents report that mulch was used for 50 percent or more of their vegetable production. Three respondents use natural mulch, two use plastic mulch, and two use a combination of natural and plastic. Of the respondents who used a mixture of mulch, one reports using 50 percent plastic with 50 percent natural. The other respondent uses 75 percent plastic mulch with 25 percent natural mulch (Table 34). Three of the four respondents using plastic mulch replace it after every growing season and one after replaces after four or more seasons.

Table 34. Percent of vegetables produced with mulches by mulch type allocated to vegetables if a combination of mulch was utilized (n=6; 2; 2).

	Mulch Used		Plastic Mulch Used		Natural Mulch Used	
Percent of mulch used	***f***	**%**	***f***	**%**	***f***	**%**
22	1	16.7	-	-	-	-
25	-	-	-	-	1	50
50	1	16.7	1	50	1	50
70	1	16.7	-	-	-	-
75	1	16.7	1	50	-	-
100	2	33.3	-	-	-	-

Survey participants were asked to provide the percentage of seeds versus transplants planted in relation to vegetable production. Ten respondents report using a combination of transplants and seeds and the remaining two use only seeds. Four respondents report that 50 percent to 100 percent of tomato plants are started from seed and five respondents report 50 percent to 100 percent of pepper plants are planted as seeds, and 100 percent of sweet corn is planted as seeds. Other crops, including squash and salad greens, are also started as seeds (Table 35).

Table 35. Percent of vegetable production started from seeds versus transplants (n=8; 6; 1; 8).

	Tomato Seeds		Pepper Seeds		Sweet Corn Seeds		Other Seeds	
Percent of seeds used	*f*	%	*f*	%	*f*	%	*f*	%
8	1	12.5	-	-	-	-	-	-
18	1	-	-	-	-	-	-	-
20	-	-	1	16.7	-	-	-	-
31	1	12.5	-	-	-	-	-	-
36	1	12.5	-	-	-	-	-	-
50	2	25	3	50.0	-	-	-	-
56	-	-	-	-	-	-	1	12.5
62	-	-	-	-	-	-	1	12.5
100	2	25.0	2	33.3	1	100	6	75.0

Survey respondents were asked the approximate self-labor hours spent on different aspects of production during one growing season. Additionally, participants were asked if they hired additional laborers and the approximate hours hired employees spent completing the same activities. Nine respondents report utilizing self-labor during vegetable production. For each production season, hours spent planting range from zero to 200 with an average of 33 hours. Growing season activities, including pesticide application and weed control, range from zero to 200 hours with an average 38.33 hours. Harvesting hours range from zero to 200 hours with an average of 61.83 hours. Hours for repairs and maintenance range from zero to 80 hours with an average of 14.56 hours. Marketing hours range from zero to 100 hours with an average of 16.11 hours and hours spent on vegetable sales range from zero to 100 hours with an average of 20.33 hours (Table 36).

Table 36. Distribution of self-labor hours during a single growing season (n= 9).

	Planting	Growing Season Activities	Harvest	Repairs & Maintenance	Marketing	Sales
Maximum	200	200	200	80	100	100
Minimum	0	0	0	0	0	0
Mean (±SD)	33.00 (±64.92)	38.33 (±62.24)	61.83 (±66.90)	14.56 (±25.24)	16.11 (±32.38)	20.33 (±34.74)

Two participants report hiring additional labor to assist with the vegetable enterprise. Seasonal, part-time, and full-time employees are utilized by survey participants and range from one to 10 employees. Hired employees are assigned responsibilities in planting, harvesting, and repairs and maintenance. Hours for each of activity range from zero to 100 with an average of 50 hours.

Survey participants were asked if they purchased any new or used equipment specifically for vegetable production, 50 percent of respondents report purchasing equipment. Common equipment purchases include tractors, tillers, mulch layers, and transplanters. Three respondents report purchasing tillers which range in price from $200 to $3,200 with an average of $1,900. Two respondents indicate purchasing transplanters for $2,000 and $10,000, with an average of $6,000. One participant report purchasing a mulch layer for $1,500 and one indicates purchasing a tractor for $10,000.

Producers were asked to provide the production per pound obtained for each vegetable they produced. Production weight is not specific to the type of production system (i.e. high tunnel, greenhouse, or open field); or production practice, (i.e. organic or conventionally grown). Eleven responses are given for tomato production and range from zero to 10,000 pounds with an average of 1,351.82 pounds in a single season. Equal responses (11) are reported for pepper production, ranging from zero to 400 pounds with an average of 56.09 pounds. No responses are reported for sweet corn production (Table 37). Other high producing crops include squash at 370 pounds, radishes at 200 pound, and lettuce mix at 360 pounds.

Table 37. Distribution of tomato and pepper production in pounds (n=11).

	Tomato Production	Pepper Production
Maximum	10,000	400
Minimum	0	0
Mean (±SD)	1,351.82 (±3101.84)	56.09 (±119.11)

The final economic questions asked survey takers to provide information regarding the outlets in which vegetables are sold and the prices per pound received. As with reported production, price information is not specific to the production system or practice. Eight respondents sell vegetables at a farmer's market, four sell through home or truck sales, herein referred to as "home sales", and three sell to local restaurants. No respondents sell vegetables to grocery stores.

Prices vary by marketing outlet and vegetable. Tomatoes sold at a farmer's market receive prices between $0.00 and $8.00 per pound with an average of $2.63 per pound. Peppers sold at farmer's market receive a range of $0.00 to $8.00 per pound with an average of $2.06 per pound. Tomatoes sold through home sales receive prices between $0.00 and $4.00 per pound with an average of $2.13 per pound. Home sold peppers receive prices between $0.00 and $1.50 per pound with an average of $0.63 per pound. Tomatoes sold to local restaurants receive prices between $0.00 and $6.00 per pound with an average of $1.75 per pound. Restaurants purchase peppers for $0.00 to $3.00 per pound with an average of $0.75 per pound (Table 38). Respondents did not report prices received for sweet corn through any marketing outlets.

Table 38. Distribution of tomato and pepper prices received from farmer's markets, home sales, and restaurant sales, in dollars per pound (n=8; 8; 4; 4; 4; 4).

	Farmer's Market Sales		Home/Truck Sales		Restaurant Sales	
	Tomato Price	**Pepper Price**	**Tomato Price**	**Pepper Price**	**Tomato Price**	**Pepper Price**
Maximum	8	8	4	1.5	6	3
Minimum	0	0	0	0.0	0	0
Mean (±SD)	2.63 (±2.72)	2.06 (±2.86)	2.13 (±1.75)	0.63 (±0.75)	1.75 (±2.87)	0.75 (±1.50)

The last section of the survey asked producers what influenced their decision to produce vegetables and where they obtain vegetable production information. All respondents report that higher revenue possibilities in vegetable markets are the leading decision factor. One participant reports implementing vegetable production because of the decreasing water availability for field crops. Participants were given the option to provide a response if their reason was not listed. Reasons for producing vegetables include personal consumption, personal enjoyment, and needing to use available land (Table 39). Most participants (10) report receiving production information via the internet. Seven respondents use Texas A&M AgriLife Extension and Research resources and six refer to other vegetable producers. Other sources of information include the USDA, out of state conferences, and books (Table 40).

Table 39. Reasons for making the decision to implement vegetable production (n=12).

Reason	*f*	%
Higher revenue potential in vegetable markets	7	58.3
Decreased water availability for field crops	1	8.3
Land Availability	1	8.3
Personal Consumption	2	16.7
Personal Enjoyment	1	8.3

Table 40. Resources used to obtain vegetable production information (n=12).

Resource	*f*	%
Internet source(s)	3	25.0
Internet source(s), Other producers, books, USDA	1	8.3
Other producers	1	8.3
Texas A&M AgriLife Research	1	8.3
Texas A&M AgriLife Research, Internet source(s)	2	16.7
Texas A&M AgriLife Research, Internet source(s), Other producers	3	25.0
Texas A&M AgriLife Research, Internet source(s),Other producers, conferences	1	8.3

CHAPTER 5

SUMMARY AND DISCUSSION

The semiarid nature of the Texas High Plains, paired with the depleting Ogallala Aquifer, forces agricultural producers to consider innovative farming practices to improve their farm profitability in these unsatisfactory environmental conditions. While there is limited research on the economic feasibility of vegetable production in the region, the idea is not foreign to producers as vegetable production accounted for 1.5 percent of all Texas agricultural production and agribusinesses in 2017 (Grahame and Robinson, 2018). The overall objective of this study was to determine the economic feasibility of producing tomatoes, jalapeño peppers, and sweet corn with and without the use of black plastic mulch in the Texas High Plains. Specifically, enterprise budgets were developed and used to determine return on investment for each vegetable and compare to that for traditionally irrigated field crops produced in the region and determine which crop generates higher profit per acre-inch of irrigation water. The final objective was to identify current vegetable production methods and marketing outlets utilized by area producers.

Tomatoes produced with and without black plastic mulch can provide agricultural producers in the Texas High Plains a viable alternative to supplement total farm profitability with the changing conditions in the Southern portion of the Ogallala Aquifer. Tomato production has the highest profit, $4,998.28 per acre with black plastic mulch and \$2,073.75 per acre without black plastic mulch, in this study. When compared to irrigated corn, cotton, and wheat, vegetables result in higher production costs per acre but tomatoes are the only vegetable that results in a higher positive profit per acre than traditionally irrigated field crops. Jalapeño peppers and sweet corn, grown under drip irrigation with and without black plastic mulch, are not economically feasible unless sold through alternative marketing outlets in which a higher price per unit is received.

The use of black plastic mulch was effective in increasing crop yield in tomatoes and jalapeño peppers but not sweet corn. The increase in yield could be due to the localization of water application to the plant and reduced water loss from evaporation. Additionally, research with plastic mulch indicated a reduction in the presence of weeds, therefore decreasing the competitiveness for water between vegetables and weeds (Lamont, 1993). Overall, the use of black plastic mulch is a beneficial management practice for producers with a higher return on investment in plants grown with the cover. Despite the increased cost to install the mulch, vegetables yield higher and require fewer labor hours throughout the growing season with fewer hand weeding hours.

While this study indicates a higher profit per acre-inch of irrigation water applied to vegetables when compared to traditionally irrigated field crops, increased levels of irrigation may be necessary for producers implementing vegetable production practices. The field experiment utilized tools measuring the soil water content prior to each irrigation event, therefore precise amounts of irrigation water were applied to the vegetables. Producers may not have access to this type of equipment and may choose to follow recommendations from other producers or Texas A&M AgriLife Extension Service. Vegetable production is regarded as water-intensive and needs approximately 20 to 35 acre-inches of water, dependent on each crop throughout the growing season (Masabni, 2011a; 2011b; 2011c). Thus, a sensitivity analysis was conducted to determine to profit per-acre inch of irrigation water applied given the reported upper limits. However, the analysis of various levels of irrigation only evaluated the effect on profit, not yield, as water levels were adjusted. Tomatoes utilizing the reported upper limited of irrigation water still maintain higher profit per acre when compared to irrigated field crops.

Reducing labor hours in hand weeding results in increased profit for each crop and treatment combination. With proper land preparation and herbicide treatments, weeding can be reduced to minimal hours, especially after crops are well established. Transplanted vegetables will likely require fewer hand weeding hours because established plants will outcompete most weeds (Gianessi and Sankula, 2003). Eliminating hand weeding hours increases profit in tomatoes and jalapeño peppers, however, these changes are not enough to return a positive profit in jalapeño pepper production.

Additional adjustments can be made to variable and fixed costs of production. Survey results indicate that 37 percent of respondents who use surface or subsurface drip irrigation replace drip tape after four or more growing seasons. Producers may consider this a fixed cost since it is not replaced every season and would then incur annual depreciation on the irrigation equipment rather than the price of the drip tape and fittings every growing season. This would reduce the variable costs of production and increase annual fixed costs. The same effect could occur with the implementation of black plastic mulch. While only one respondent reports using plastic mulch for more than one season, producers using the estimated budgets from the field experiment may choose to consider the expense fixed by using the plastic mulch for more than one year.

Hand weeding labor budgeted for this study was assumed to be a lower labor rate than machinery or irrigation labor. However, this wage could be affected as minimum wage requirements increase throughout the state. Should government regulations raise the labor rate, producers may have to consider the economic threshold of competitive weeds upon eliminating hand weeding hours in vegetable production. Increased labor wages for hand weeding could result in a barrier of entry into vegetable production and should be considered by producers utilizing hired labor for their enterprise.

Vegetable production involves several risks that should be addressed. Specialty crops such as vegetable are not covered by Agricultural Risk Loss Coverage (ARC), Price Loss Coverage (PLC) or Marketing Assistance Loans (MAL), unlike traditional field crops. However, vegetables can be covered by Whole Farm Revenue Protection (WFRP) insurance, as well as yield and revenue based insurance policies. The diversity in specialty crop production presents challenges for federal coverage, primarily because of the wide range in production practices and prices associated with producing for niche markets. Insurance is an important risk management tool in vegetable production due to the sensitivity of the crops and unpredictable conditions that exist in the region. Extensive high winds, late spring freezes, and early summer hail storms can result in reduced or complete loss of crop in open-field production systems. USDA offers alternatives to crop insurance plans in case of natural disasters. Producers of specialty crops can receive emergency and land rehabilitation loans should they chose not to incorporate insurance into their vegetable enterprise (Rosa and Johnson, 2019).

Producing vegetables in a structural production system is another method of risk management that should be considered. The economic feasibility of high tunnels is still pending and research in the region indicates benefits of using a high tunnel production system as opposed to an open field. Higher yields are obtained in a high tunnel when compared to an open field and less damage occurs to crops due to the extreme weather conditions that occur throughout the season (Ledbetter, 2017). The permanent structure offered by a greenhouse would also provide protection from the external environment.

Additional risk management tools are incorporated in the economic measures analyzed in this study. High profit can be an indicator of which vegetable or field crop to produce; however, substantial costs associated with vegetable production and the lack of production protection may cause hesitation for risk-adverse producers. Return on investment is used to determine the gain or loss from investment in vegetable production. This is important to consider because of the high variable cost of vegetable production. Return on investment for tomatoes, jalapeño peppers, and sweet corn grown with and without black plastic mulch was compared to return on investment of irrigated corn, cotton, and wheat. Tomatoes grown with black plastic mulch returned 61 percent on investment and tomatoes grown without plastic mulch returned 25 percent on investment. Traditionally irrigated corn returns four percent of investment and irrigated cotton returns 22 percent on investment. The remaining crops, jalapeño peppers, sweet corn, and irrigated wheat; have a negative return on investment due to loss of profit per acre. These percentages, however, can fluctuate with adjustments made to variable costs of production and the price received for each vegetable. Small-scale or supplemental vegetable enterprises are recommended for area producers due to the risks associated with vegetable production.

Tomato production is a viable option to enhance producer profitability in the study area based on the profitability and economic measures used to identify variations in production. Tomatoes in the field experiment result in high profit per acre, high return on investment, and high profit per acre-inch of irrigation water applied when compared to traditionally irrigated corn, cotton, and wheat. Jalapeño peppers have the potential to be considered a viable alternative if producers choose to sell through different marketing outlets and obtain a higher price for the vegetable. Alternative marketing outlets provide producers with profitable retail options for all vegetables in the study.

Results from the price sensitivity analysis indicate increased revenue potential in tomato and jalapeño pepper production. Sweet corn production also has the potential for increased profit, however, since it was not sold by area producers, it was not analyzed for price sensitivity. Higher prices at 150 percent and 200 percent of the budgeted price, result in positive profits in jalapeño pepper production with and without using black plastic mulch, respectively. Farmer's markets, home sales, and restaurant sales help provide higher margins and are beneficial to any size vegetable enterprise. However, it is important to consider the additional commitment required with these alternative markets. Producers choosing to sell through farmer's markets will need to spend their time, or hire someone, to be present at the market.

Assumptions and Limitations

There were several assumptions made and limitations in this study due to variations in agricultural production. Enterprise budgets are used to help agricultural producers make an informed decision about which crops to incorporate into their operation in the upcoming year. These budgets, similar to the budgets developed in this study, were created for planning purposes only and should not be used to predict exact expenses and revenue of a particular commodity. A wide range of variations occurs with prices, yields, and costs of production, which affects the profitability of the enterprise. Conservative estimates were made when a price or quantity range was provided. Sensitivity analyses account for some of these changes, however, producers should modify these budgets to their specific operation in order to account for differences in management practices and environmental conditions.

The equipment described in this study included self-propelled tractors, pickup trucks, and implements currently owned and operated by USDA-ARS CPRL/Texas A&M AgriLife Vegetable Production Lab in Bushland, Texas. It was understood that producers using the estimates from this study may or may not have access to similar equipment. Equipment adjustments were made to be consistent with the Texas A&M AgriLife Extension Universal Factors and Prices (Jones et al., 2018) and the Internal Spreadsheet Workbook used to calculate the budgets (Texas A&M AgriLife Extension, 2019). Exact make, model, or brand of inputs used is included in this section, however, Texas A&M AgriLife Extension and Research in no way endorsed or received funding from the manufactures listed.

The survey instrument was distributed to a targeted population of vegetable producers who were asked to self-report their information. It was assumed that respondents provided honest and complete answers regarding their vegetable production practices and economic information due to the self-reporting nature of the survey.

Furthermore, the information gained through the survey should not be generalized to the population of producers and results cannot be inferred to any other population. Additionally, due to the small sample size of responses (n=12), a reliability statistic using Cronbach's alpha was not calculated. Survey data was analyzed as non-normally distributed data and had large standard deviations in scaled data points. Minimum, maximum, and average data points were reported to control for this.

The questionnaire did not ask respondents to differentiate yield and price data collected with the type of system or production practice. Yield and price data were collected in a summation of high tunnels, greenhouses, and open-field production systems along with irrigated, organic, and conventionally grown vegetables. Yields and prices for each vegetable could be affected by each of these factors and should be differentiated to obtain more accurate producer information and analysis of vegetable profitability.

Future Research

Further research opportunities exist for fruit and vegetable production in the region. The viability of producing sweet corn should be further analyzed using center pivot irrigation and similar production practices as field corn. Sweet corn did not produce well given the methods of this study but could in other circumstances. Research involving fruit and vegetable production in high tunnels and greenhouses exist in universities around the country and should be further developed in the Texas High Plains. Greenhouse and high tunnel production can increase yields and offer protection from environmental factors. These methods should be analyzed to determine the economic feasibility, given the harsh weather in the region (Ledbetter, 2017).

Furthermore, based on the survey results, prospective research lies in a wide variety of fruit and vegetable crops in the study area. Area producers have already implemented different crops and would benefit from the research of best production practices and the economic feasibility of each crop being produced, primarily strawberries, squash, and salad greens. Organic vegetable production can also be evaluated due to the increased revenue potential that exists in various markets.

Dissemination of Research Data

Research can be disseminated through several mediums to inform fellow researchers, as well as agricultural producers. Research presented at conferences and research fairs provides the opportunity to collaborate with fellow researchers on methods that can be expanded on, additional literature to review, or geographical factors to consider. Dissemination also allows other interested researchers the opportunity to initiate and expand similar studies in their respective regions.

Field day events are an effective media used by Texas A&M AgriLife Research Centers to inform producers about current production techniques. Crop specific field days serve to “address issues and opportunities for producers throughout the region and introduce them to some of the latest applied research” (Schattenberg, 2019). Furthermore, the event teaches producers how to improve farm profitability by enhancing their production. Field days bring the community together to learn practical and applicable research information (Schattenberg, 2019). These should be considered in disseminating vegetable research to regional producers since many have already implemented several vegetables into their enterprise, according to survey results.

The information collected through the producer survey provided a target demographic and ideal method to distribute relevant information. Most current vegetable producers are 35 years and older, college educated, and self-employed. They receive their information from Texas A&M AgriLife Extension and Research Service resources, the internet, and other vegetable producers. Field days explaining the current research in vegetable production allow farmers to learn from the experts and ask questions to improve their production. Additionally, fact sheets containing all pertinent information are effective AgriLife publications that can be delivered in print or email.

Video production and observations have become more prominent in several areas of the industry, along with the presence of social media. By producing instructional videos on vegetable production in the region and highlighting current producers and their methods, new producers can feel confident in their ability to achieve the same results. These videos should be produced by Texas A&M AgriLife Extension and Research to continuously improve communication channels with local producers.

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APPENDIX A

Table A 1. Enterprise budget for tomato production with black plastic mulch.

Projections for Planning Purposes Only* -- *Not to be Used without Updating

2019 Estimated Costs and Returns per Acre

Tomato, Plastic Mulch, Drip Irrigated

Panhandle Extension District - 1

Crop Acres	1			
REVENUE	**Quantity**	**Units**	**$/Unit**	**Total**
Tomato	334.40	CWT	$39.49	$13,205.46
Total Revenue				$13,205.46
VARIABLE COSTS	**Quantity**	**Units**	**$/Unit**	**Total**
Production Costs				
Seed				
Transplants - Tomato	5796	Plants	$0.18	$1,043.28
Seed - Tomato	0	Bag	$120.00	$0.00
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Black Plastic Mulch	2.2	Roll	$177.00	$389.40
Tomato Trellis Twine, 7000ft	2.5	Roll	$7.00	$17.50
Unallocated Labor	9.7	Hour	$13.03	$126.39
Custom				
Harvest, Pack & Count Vegetables	334.4	CWT	$10.00	$3,344.00
Hand Weeding - Vegetables	90	Hour	$8.50	$765.00
Irrigation				
Energy Cost	11.00	AcreInch	$3.40	$37.40
Irrigation Labor	0.20	Hour	$13.24	$2.62
Machinery Labor				
Tractors/Self-Propelled	0.98	Hour	$13.03	$12.77
Other Labor	1.79	Hour	$13.03	$23.32
Diesel Fuel				
Tractors/Self-Propelled	2.19	Gallon	$2.33	$5.10
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$68.23	$68.23
Irrigation Equipment	1	Acre	$33.00	$33.00
Tractors/Self-Propelled	1	Acre	$3.56	$3.56
Implements	1	Acre	$1.32	$1.32
Interest on Credit Line			6.04%	$85.43
Total Variable Costs				$7,354.76
Planned Returns Above Variable Costs:				$5,850.69
Breakeven Price to Cover Variable Costs			$21.99	CWT
FIXED COSTS	**Quantity**	**Units**	**$/Unit**	**Total**
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$503.56	$503.56
Tractors/Self-Propelled	1	Acre	$2.94	$2.94
Implements	1	Acre	$1.52	$1.52
Equipment Investment				
Pickup/General Use Equipment	$3,519.70	Dollars	6.32%	$222.45
Tractors/Self-Propelled	$22.92	Dollars	6.32%	$1.45
Implements	$7.83	Dollars	6.32%	$0.49
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$852.41
Total Specified Costs				$8,207.17
Returns Above Specified Costs				$4,998.28
Breakeven Price to Cover Total Costs			$24.54	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
Mandi Boychuk, Graduate Research Assistant, West Texas A&M University

Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

Table A 2. Enterprise budget for tomato production without black plastic mulch.

Projections for Planning Purposes Only – Not to be Used without Updating
2019 Estimated Costs and Returns per Acre
Tomato, Drip Irrigated
Panhandle Extension District - 1

	Quantity	Units	$/Unit	Total
Crop Acres	1			
REVENUE	Quantity	Units	$/Unit	Total
Tomato	259.60	CWT	$39.49	$10,251.60
Total Revenue				$10,251.60
VARIABLE COSTS	Quantity	Units	$/Unit	Total
Production Costs				
Seed				
Transplants - Tomato	5796	Plants	$0.18	$1,043.28
Seed - Tomato	0	Bag	$120.00	$0.00
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Tomato Trellis Twine, 7000ft	2.5	Roll	$7.00	$17.50
Unallocated Labor	9.7	Hour	$13.03	$126.39
Custom				
Harvest, Pack & Count Vegetables	259.6	CWT	$10.00	$2,596.00
Hand Weeding - Vegetables	220	Hour	$8.50	$1,870.00
Irrigation				
Energy Cost	11.00	AcreInch	$3.40	$37.40
Irrigation Labor	0.20	Hour	$13.24	$2.62
Machinery Labor				
Tractors/Self-Propelled	0.98	Hour	$13.03	$12.77
Other Labor	1.79	Hour	$13.03	$23.32
Diesel Fuel				
Tractors/Self-Propelled	2.19	Gallon	$2.33	$5.10
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$68.23	$68.23
Irrigation Equipment	1	Acre	$33.00	$33.00
Tractors/Self-Propelled	1	Acre	$3.56	$3.56
Implements	1	Acre	$1.32	$1.32
Interest on Credit Line			6.04%	$88.51
Total Variable Costs				$7,325.45
Planned Returns Above Variable Costs:				$2,926.16
Breakeven Price to Cover Variable Costs			$28.22	CWT
FIXED COSTS	Quantity	Units	$/Unit	Total
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$503.56	$503.56
Tractors/Self-Propelled	1	Acre	$2.94	$2.94
Implements	1	Acre	$1.52	$1.52
Equipment Investment				
Pickup/General Use Equipment	$3,519.70	Dollars	6.32%	$222.45
Tractors/Self-Propelled	$22.92	Dollars	6.32%	$1.45
Implements	$7.83	Dollars	6.32%	$0.49
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$852.41
Total Specified Costs				$8,177.86
Returns Above Specified Costs				$2,073.75
Breakeven Price to Cover Total Costs			$31.50	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
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Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

Table A 3. Enterprise budget for jalapeño pepper production with black plastic mulch.

Projections for Planning Purposes Only – Not to be Used without Updating
2019 Estimated Costs and Returns per Acre
Jalapeño Pepper, Plastic Mulch, Drip Irrigated
Panhandle Extension District - 1

	Quantity	Units	$/Unit	Total
Crop Acres	1			
REVENUE	Quantity	Units	$/Unit	Total
Jalapeño Pepper	325.10	CWT	$23.12	$7,516.31
Total Revenue				$7,516.31
VARIABLE COSTS	Quantity	Units	$/Unit	Total
Production Costs				
Seed				
Transplants - Pepper	11591	Plants	$0.18	$2,086.38
Seed - Pepper	0	Bag	$186.00	$0.00
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Black Plastic Mulch	2.2	Roll	$177.00	$389.40
Custom				
Harvest, Pack & Count Vegetables	325.1	CWT	$10.00	$3,251.00
Hand Weeding - Vegetables	90	Hour	$8.50	$765.00
Irrigation				
Energy Cost	11.00	AcreInch	$3.40	$37.40
Irrigation Labor	0.20	Hour	$13.24	$2.62
Machinery Labor				
Tractors/Self-Propelled	0.98	Hour	$13.03	$12.77
Other Labor	1.79	Hour	$13.03	$23.32
Diesel Fuel				
Tractors/Self-Propelled	2.19	Gallon	$2.33	$5.10
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$61.20	$61.20
Irrigation Equipment	1	Acre	$33.00	$33.00
Tractors/Self-Propelled	1	Acre	$3.56	$3.56
Implements	1	Acre	$1.32	$1.32
Interest on Credit Line			6.04%	$102.13
Total Variable Costs				$8,170.65
Planned Returns Above Variable Costs:				($654.34)
Breakeven Price to Cover Variable Costs			$25.13	CWT
FIXED COSTS	Quantity	Units	$/Unit	Total
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$64.26	$64.26
Tractors/Self-Propelled	1	Acre	$2.94	$2.94
Implements	1	Acre	$1.52	$1.52
Equipment Investment				
Pickup/General Use Equipment	$443.70	Dollars	6.32%	$28.04
Tractors/Self-Propelled	$22.92	Dollars	6.32%	$1.45
Implements	$7.83	Dollars	6.32%	$0.49
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$218.71
Total Specified Costs				$8,389.36
Returns Above Specified Costs				($873.05)
Breakeven Price to Cover Total Costs			$25.81	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
Mandi Boychuk, Graduate Research Assistant, West Texas A&M University

Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

Table A 4. Enterprise budget for jalapeño pepper production without black plastic mulch.

Projections for Planning Purposes Only -- Not to be Used without Updating
2019 Estimated Costs and Returns per Acre
Jalapeño Pepper, Drip Irrigated
Panhandle Extension District - 1

	Quantity	Units	$/Unit	Total
Crop Acres	1			
REVENUE	Quantity	Units	$/Unit	Total
Jalapeño Pepper	235.90	CWT	$23.12	$5,454.01
Total Revenue				$5,454.01
VARIABLE COSTS	Quantity	Units	$/Unit	Total
Production Costs				
Seed				
Transplants - Pepper	11591	Plants	$0.18	$2,086.38
Seed - Pepper	0	Bag	$186.00	$0.00
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Custom				
Harvest, Pack & Count Vegetables	235.9	CWT	$10.00	$2,359.00
Hand Weeding - Vegetables	358	Hour	$8.50	$3,043.00
Irrigation				
Energy Cost	11.00	AcreInch	$3.40	$37.40
Irrigation Labor	0.20	Hour	$13.24	$2.62
Machinery Labor				
Tractors/Self-Propelled	0.98	Hour	$13.03	$12.77
Other Labor	1.79	Hour	$13.03	$23.32
Diesel Fuel				
Tractors/Self-Propelled	2.19	Gallon	$2.33	$5.10
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$61.20	$61.20
Irrigation Equipment	1	Acre	$33.00	$33.00
Tractors/Self-Propelled	1	Acre	$3.56	$3.56
Implements	1	Acre	$1.32	$1.32
Interest on Credit Line			6.04%	$123.39
Total Variable Costs				$9,188.51
Planned Returns Above Variable Costs:				($3,734.50)
Breakeven Price to Cover Variable Costs			$38.95	CWT
FIXED COSTS	Quantity	Units	$/Unit	Total
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$64.26	$64.26
Tractors/Self-Propelled	1	Acre	$2.94	$2.94
Implements	1	Acre	$1.52	$1.52
Equipment Investment				
Pickup/General Use Equipment	$443.70	Dollars	6.32%	$28.04
Tractors/Self-Propelled	$22.92	Dollars	6.32%	$1.45
Implements	$7.83	Dollars	6.32%	$0.49
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$218.71
Total Specified Costs				$9,407.22
Returns Above Specified Costs				($3,953.21)
Breakeven Price to Cover Total Costs			$39.88	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
Mandi Boychuk, Graduate Research Assistant, West Texas A&M University
Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

Table A 5. Enterprise budget for sweet corn production with black plastic mulch.

Projections for Planning Purposes Only – Not to be Used without Updating
2019 Estimated Costs and Returns per Acre
Sweet Corn, Plastic Mulch, Drip Irrigated
Panhandle Extension District - 1

	Quantity	Units	$/Unit	Total
Crop Acres	1			
REVENUE	Quantity	Units	$/Unit	Total
Sweet Corn	87.60	CWT	$10.78	$944.33
Total Revenue				$944.33
VARIABLE COSTS	Quantity	Units	$/Unit	Total
Production Costs				
Seed				
Seed - Corn, Sweet	7.47	Bag	$275.00	$2,054.25
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Black Plastic Mulch	2.2	Roll	$177.00	$389.40
Custom				
Harvest, Pack & Count Vegetables	87.6	CWT	$10.00	$876.00
Irrigation				
Energy Cost	10.22	AcreInch	$3.40	$34.74
Irrigation Labor	0.19	Hour	$13.24	$2.50
Machinery Labor				
Tractors/Self-Propelled	0.88	Hour	$13.03	$11.47
Other Labor	1.47	Hour	$13.03	$19.15
Diesel Fuel				
Tractors/Self-Propelled	2.07	Gallon	$2.33	$4.82
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$61.20	$61.20
Irrigation Equipment	1	Acre	$30.66	$30.66
Tractors/Self-Propelled	1	Acre	$3.37	$3.37
Implements	1	Acre	$2.14	$2.14
Interest on Credit Line			6.04%	$64.58
Total Variable Costs				$4,950.73
Planned Returns Above Variable Costs:				($4,006.40)
Breakeven Price to Cover Variable Costs			$56.52	CWT
FIXED COSTS	Quantity	Units	$/Unit	Total
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$64.26	$64.26
Tractors/Self-Propelled	1	Acre	$2.79	$2.79
Implements	1	Acre	$2.58	$2.58
Equipment Investment				
Pickup/General Use Equipment	$443.70	Dollars	6.32%	$28.04
Tractors/Self-Propelled	$21.71	Dollars	6.32%	$1.37
Implements	$15.28	Dollars	6.32%	$0.97
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$220.01
Total Specified Costs				$5,170.73
Returns Above Specified Costs				($4,226.41)
Breakeven Price to Cover Total Costs			$59.03	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
Mandi Boychuk, Graduate Research Assistant, West Texas A&M University

Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

Table A 6. Enterprise budget for sweet corn production without black plastic mulch.

Projections for Planning Purposes Only – Not to be Used without Updating
2019 Estimated Costs and Returns per Acre
Sweet Corn, Drip Irrigated
Panhandle Extension District - 1

	Quantity	Units	$/Unit	Total
Crop Acres	1			
REVENUE	Quantity	Units	$/Unit	Total
Sweet Corn	92.20	CWT	$10.78	$993.92
Total Revenue				$993.92
VARIABLE COSTS	Quantity	Units	$/Unit	Total
Production Costs				
Seed				
Seed - Corn, Sweet	7.47	Bag	$275.00	$2,054.25
Fertilizer				
Fertilizer (N) - Dry	150	Pound	$0.38	$57.00
Fertilizer Application	1	Acre	$5.12	$5.12
Herbicide				
Metolachlor	1.33	Pint	$5.00	$6.65
Treflan	1.33	Pint	$5.00	$6.65
Herbicide Application	2	Acre	$5.12	$10.24
Insecticide				
Sevin Insecticide - Vegetables	0.17	Gallon	$87.99	$14.96
Insecticide Application	1	Acre	$5.12	$5.12
Miscellaneous				
Toro 15mil Drip Tape - 12" drip emitter spacing	2.2	Roll	$150.00	$330.00
Drip Tape Fittings	527	Unit	$1.60	$843.20
Custom				
Harvest, Pack & Count Vegetables	92.2	CWT	$10.00	$922.00
Irrigation				
Energy Cost	10.22	AcreInch	$3.40	$34.74
Irrigation Labor	0.19	Hour	$13.24	$2.50
Machinery Labor				
Tractors/Self-Propelled	0.88	Hour	$13.03	$11.47
Other Labor	1.47	Hour	$13.03	$19.15
Diesel Fuel				
Tractors/Self-Propelled	2.07	Gallon	$2.33	$4.82
Gasoline				
Pickup/General Use Equipment	1	Acre	$117.50	$117.50
Repairs & Maintenance				
Pickup/General Use Equipment	1	Acre	$61.20	$61.20
Irrigation Equipment	1	Acre	$30.66	$30.66
Tractors/Self-Propelled	1	Acre	$3.37	$3.37
Implements	1	Acre	$2.14	$2.14
Interest on Credit Line			6.04%	$57.33
Total Variable Costs				$4,600.08
Planned Returns Above Variable Costs:				($3,606.16)
Breakeven Price to Cover Variable Costs			$49.89	CWT
FIXED COSTS	Quantity	Units	$/Unit	Total
Machinery Depreciation				
Pickup/General Use Equipment	1	Acre	$64.26	$64.26
Tractors/Self-Propelled	1	Acre	$2.79	$2.79
Implements	1	Acre	$2.58	$2.58
Equipment Investment				
Pickup/General Use Equipment	$443.70	Dollars	6.32%	$28.04
Tractors/Self-Propelled	$21.71	Dollars	6.32%	$1.37
Implements	$15.28	Dollars	6.32%	$0.97
Cash Rent - Irrigated	1	Acre	$120.00	$120.00
Total Fixed Costs				$220.01
Total Specified Costs				$4,820.09
Returns Above Specified Costs				($3,826.17)
Breakeven Price to Cover Total Costs			$52.28	CWT

Developed by DeDe Jones, Extension Risk Management Specialist III, Texas A&M AgriLife Extension, 806-677-5600.
Mandi Boychuk, Graduate Research Assistant, West Texas A&M University

Information presented is prepared solely as a general guide and not intended to recognize or predict the costs and returns from any one operation. Brand names are mentioned only as examples and imply no endorsement.

APPENDIX B

IRB Approval Letter

West Texas A&M University

Academic Research Environmental Health and Safety

WTAMU Box 60217 Canyon, Tx 79016
806.651.2270

INSTITUTIONAL REVIEW BOARD FOR HUMAN SUBJECTS
Letter of Approval

December 17, 2018

Dr. Bridget Guerrero:

The West Texas A&M University Institutional Review Board is pleased to inform you that your proposal **#12-11-18** for your study titled, **"Identification of Local Producer Practices for an Economic Analysis of High-Value Vegetable Crop Production in the Texas High Plains,"** has been reviewed. meets the requirements of the WTAMU Standard Operating Procedure (SOP) No. 15.99.05.W1.01AR Institutional Review Board (Human Subject Research). Approval is granted for one calendar year. This approval expires on **December 16, 2020**.

Principal investigators assume the following responsibilities:

1. **Continuing Review:** The protocol must be renewed on or before the expiration date if the research project requires more than one year for completion. A Continuing Review form along with required documents must be submitted on or before the stated deadline. Failure to do so will result in study termination and/or loss of funding.
2. **Completion Report:** At the conclusion of the research project (including data analysis and final written papers), a Close out form must be submitted to AR-EHS.
3. **Unanticipated Problems and Adverse Events:** Pursuant to SOP No. 15.99.05.W1.13AR, unanticipated problems and serious adverse events must be reported to AR-EHS.
4. **Reports of Potential Non-Compliance:** Pursuant to SOP No. 15.99.05.W1.05AR, potential non-compliance, including deviations from the protocol and violations, must be reported to the IRB office immediately.
5. **Amendments:** Changes to the protocol must be requested by submitting an Amendment form to AR-EHS for review by the IRB. The Amendment must be approved by the IRB before being implemented. Amendments do not extend time granted on the initial approval
6. **Consent Forms:** When using a consent form, only the IRB approved form is allowed.
7. **Audit:** Any proposal may be subject to audit by the IRB Administrator during the life of the study. Investigators are responsible for maintaining complete and accurate records for five years and making them available for inspection upon request.
8. **Recruitment**: All recruitment materials must be approved by the IRB. Recruitment materials distributed to potential participants must use the approved text and include the study's IRB number, approval date, and expiration dates in the following format: WTAMU IRB##-##-## Approved: ##/##/#### Expiration Date: ##/##/####.
9. **FERPA and PPRA:** Investigators conducting research with students must have appropriate approvals from the Family Education Rights and Privacy Act (FERPA) administrator at the institution where the research will be conducted in accordance with the Family Education Rights and Privacy Act (FERPA) if applicable to the research being proposed. The Protection of Pupil Rights Amendment (PPRA) protects the rights of parents in students ensuring that written parental consent is required for participation in surveys, analysis, or evaluation that ask questions falling into categories of protected information.

Sixty days prior to the expiration of this proposal, you will receive a notification of the approaching expiration date at which time you will need to submit an Amendment/Continuation/Close out form.

Thank you for your cooperation with the IRB and we wish you well with your research project.

Sincerely,

Dr. Gary Bigham
Chair, WTAMU IRB

Dr. Angela Spaulding
Vice President of Research and Compliance

Recruitment Email

Dear agricultural producer:

My name is Mandi Boychuk and I am a graduate research assistant currently working on a Master's with an emphasis in agricultural business and economics at West Texas A&M University. My study evaluates the economic feasibility of producing locally grown, high-value vegetables in the Texas High Plains.

I am currently working on a collaborative study in which we are collecting data on vegetable production practices currently utilized by area producers. I am hopeful you will be willing to participate in this online survey. By sharing your production practices, we will gain valuable insight to accurately analyze the viability of vegetable production in the region.

You are receiving this because you or a producer acquaintance have participated in a Texas A&M AgriLife Research vegetable field day or have worked closely with their researchers who have provided me with your email address.

There are no risks involved with completing the survey, however, you are not required to complete the survey and may exit at any time during the questionnaire. If you complete the survey, you will help create a clearer picture of vegetable production in the area.

The survey takes less than 15 minutes to complete and all responses are kept confidential. Only aggregate data will be reported in order to protect the identity of each individual respondent.

The survey is mobile-friendly and can be taken on a smartphone, mobile device, or a computer. A current internet browser is required. Simply click on the link below to participate in the survey.

Qualtrics Survey

Upon completion, I would appreciate your assistance in sending the survey link to any vegetable producers you are in contact with and may not collaborate with Texas A&M AgriLife Research.

IRB proposal has been approved by Dr. Spaulding and Dr. Guerrero (WTAMU IRB #12-11-18 Approved: 12/17/2018 Expiration Date: 12/16/2020). If you have any concerns about this study, the IRB approval., or your rights, please contact Dr. Spaulding (806-651-2730) or Dr. Guerrero (806-651-2550).

Please feel free to contact me at mlboychuk1@buffs.wtamu.edu or (806) 651-2550 if you have any questions. I sincerely appreciate your time and consideration.

Survey Consent Form

West Texas A&M UNIVERSITY

Ogallala Aquifer Program

Texas A&M AgriLife Research

OgallalaWater.org

Thank you for your participation in a research study evaluating the economic viability of producing high value vegetables in the Texas High Plains. The purpose of this research is to better reflect current vegetable production practices utilized in the region. Your participation is completely voluntary. Refusal to participate does not affect any benefits to which you are otherwise entitled.

In this survey, you will be asked a series of questions regarding your vegetable production methods, operational costs, and revenue estimates. There is no direct benefit to you, but your participation will benefit Texas A&M AgriLife Extension and Research and vegetable production in the region.

The information collected will be stored on a secure server and will be downloaded and removed from Qualtrics online survey software shortly after data collection ends. Only summarized data will be reported in order to protect the identity of each individual respondent.

Your responses herein will remain completely confidential, and your assistance is greatly appreciated.

This research has been approved by the Institutional Review Board at West Texas A&M University. If you have any concerns about this study or your rights, you can contact the dean of the graduate school and research at 806.651.2730. Should you have any questions and/or wish to review summary findings please contact us at 806.651.2550.

By clicking Yes below, you indicate that you agree to contribute in this study. By clicking No, you are free to exit the survey. In either circumstance, we sincerely thank you for your time.

Thank you very much for helping with this study.

Sincerely,
Dr. Bridget L. Guerrero, West Texas A&M University
Dr. J. Tanner Robertson, West Texas A&M University
Mandi L. Boychuk, West Texas A&M University

- ○ Yes, I am willing to participate.
- ○ No, I am not willing to participate.

Survey Instrument

What is your age?

- 18 - 34 years old
- 35-54 years old
- 55+ years old
- Prefer not to answer

What is is the highest degree of level of school you have completed? If currently enrolled, highest degree received.

- Some high school
- High school graduate, diploma or the equivalent
- Some college
- Associate degree/trade school
- Bachelor's degree
- Graduate degree
- Prefer not to answer

Are you currently....? (select all that apply)

- Employed full time
- Self-employed
- Student
- Retired
- Other (please explain)
- Prefer not to answer

What is your zip code?

How long have you been farming?

- 0-1 year
- 2-3 years
- 4-6 years
- 6+ years

Which crops do you currently produce? (select all that apply)

- Corn
- Cotton
- Wheat
- Sorghum
- Vegetables
- Fruit
- Other (please list)

Which vegetable(s) are you growing? (Select all that apply)

- Tomatoes
- Peppers
- Sweet Corn
- Other (please list)

Do you use a high tunnel production system for vegetable production?

- Yes
- No

Please indicate the number of high tunnels for each dimension listed. (Select all that apply)

0	20' x 48'
0	30' x 70'
0	30' x 96'
0	Other

What percentage of total high tunnel vegetable production does each commodity account for?

Tomatoes	0
Peppers	0
Sweet Corn	0
Other (please list)	0
Total	0

Have you received funding from the EQIP High Tunnel Initiative?

- Yes
- No

Do you use a greenhouse for vegetable production?

- Yes
- No

Please indicate the number of greenhouses for each dimension listed. (Select all that apply)

0	6' x 8'
0	8' x 20'
0	30' x 96'
0	Other

What percentage of total greenhouse vegetable production does each commodity account for?

Tomatoes	0
Peppers	0
Sweet Corn	0
Other (please list)	0
Total	0

Do you use an open field production system for vegetable production?

- Yes
- No

How many acres are being used to produce vegetables?

What percentage of total open field vegetable production does each commodity account for?

Tomatoes	0
Peppers	0
Sweet Corn	0
Other (please list)	0
Total	0

Are you using any other production system not previously given for vegetable production?

- Yes
- No

Please describe.

Do you irrigate your vegetables?

- Yes
- No

What percentage of your vegetable production is irrigated?

0	10	20	30	40	50	60	70	80	90	100

What percentage of total irrigated vegetable production does each irrigation system account for?

Surface drip	0
Subsurface drip	0
Center Pivot	0
Other	0
Total	0

How often do you irrigate your vegetable during a growing season?

- Once daily
- Once weekly
- Once every other week
- Once monthly
- One time only
- Other

For how long do you typically irrigate your vegetables?

After how many growing seasons do you replace your drip tape?

- Every season
- Two seasons
- Three seasons
- Four or more seasons

Are you using conventional vegetable production practices (i.e. utilizing necessary fertilizers, herbicides, pesticides, etc.)?

- Yes
- No

How often do you apply fertilizer to your vegetable soils during a growing season?

- Once weekly
- Once every other week
- Once monthly
- One time only
- Never
- Other

How much fertilizer do you apply to your vegetable soils per application?

How often do you apply herbicides to your vegetables during a growing season?

- Once weekly
- Once every other week
- Once monthly
- One time only
- Never
- Other

How much herbicide do you apply to your vegetables per application?

How often do you apply fungicides to your vegetables during a growing season?

- Once weekly
- Once every other week
- Once monthly
- One time only
- Never
- Other

How much fungicide do you apply to your vegetables per application?

How often do you apply pesticides to your vegetables during a growing season?

- Once weekly
- Once every other week
- Once monthly
- One time only
- Never
- Other

How much pesticide do you apply to your vegetables per application?

Are you using organic vegetable production practices?

- Yes
- No

Are your vegetables considered USDA certified organic vegetables?

- Yes
- No

Do you use mulch for vegetable production?

- Yes
- No

What percentage of your vegetable production is mulched?

0 10 20 30 40 50 60 70 80 90 100

Please select the type of mulch used for vegetable production.

- Plastic
- Natural
- Both

What percentage of total mulched vegetable production does each mulch type account for?.

Plastic	0
Natural	0
Total	0

After how many growing seasons do you replace your plastic mulch?

- Every season
- Two seasons
- Three seasons
- Four or more seasons

Do you start your vegetable crop from seed or do you transplant seedlings?

- Seeds
- Transplant seedlings
- Both

What percentage of total vegetable production was planted from seeds (not transplanted seedlings) for each commodity?

0 10 20 30 40 50 60 70 80 90 100

Tomatoes

Peppers

Sweet Corn

Other

Approximately how many hours of <u>SELF</u>, <u>not hired</u>, labor were spent on each of the following activities during a single growing season?

Planting	0
Growing season activities (i.e. fertilizing, weed control, etc.)	0
Harvest	0
Repairs/maintenance	0
Marketing	0
Sales/distribution	0
Other (please describe)	0
Total	0

Do you hire laborers to assist with vegetable production?

- Yes
- No

How many of each of the following types of laborers do you employ?

0	Part-time
0	Full-time
0	Seasonal/temporary
0	Intern
0	Other (please describe)

Approximately how many hours of <u>HIRED</u>, <u>not self</u>, labor were spent on each of the following activities during a single growing season?

Planting	0
Growing season activities (i.e. fertilizing, weed control, etc.)	0
Harvest	0
Repairs/maintenance	0
Marketing	0
Sales/distribution	0
Other (please describe)	0
Total	0

Have you purchased farm equipment, new or used, specifically for vegetable production?

- Yes
- No

Please select each equipment item purchased for vegetable production with approximate cost. (Select all that apply)

- ☐ Tractor
- ☐ Mulch layer
- ☐ Tiller
- ☐ Other (please list)

Approximately how many pounds of each vegetable do you produce in total each growing season?

0	Tomatoes
0	Peppers
0	Sweet Corn
0	Other (please list)

Do you sell vegetables at a local farmers' market?

- ○ Yes
- ○ No

What is the approximate price per pound received for each vegetable at the farmers' market?

0	Tomatoes
0	Peppers
0	Sweet Corn
0	Other (please list)

Do you sell vegetables to a local grocery store?

- ○ Yes
- ○ No

What is the approximate price per pound received for each vegetable from the local grocer?

0	Tomatoes
0	Peppers
0	Sweet Corn
0	Other (please list)

Do you sell vegetables from home and/or truck sales?

- ◉ Yes
- ○ No

What is the approximate price per pound received for each vegetable from home and/or truck sales?

0	Tomatoes
0	Peppers
0	Sweet Corn
0	Other (please list)

Do you sell vegetables through any other outlets?

- Yes
- No

Please describe the other outlet through which you sell vegetables.

What is the approximate price per pound received for each vegetable from from other outlets?

0	Tomatoes
0	Peppers
0	Sweet Corn
0	Other (please list)

What influenced your decision to implement vegetable production into your enterprise? (select all that apply)

- Higher revenue potential in vegetable markets
- Decreased water availability for field crops
- Programs available to assist vegetable producers
- Other (please list)

Where do you receive your information regarding vegetable production?

- Texas A&M AgriLife Research
- Internet source(s)
- Other producers
- Other (please list)