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Assessing Net Returns to Blueberry Production Using a Decision Support Tool

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Abstract

The purpose of this study was to develop and assess the profitability of four highbush blueberry farming systems in the south: organic field production, conventional field production, organic high tunnel production and conventional high tunnel production. Four baseline budget scenarios, one for each system, are developed for a 15 year production period. The results suggest that under expected production and price conditions for Northwest Arkansas, while all four production systems generated positive present value of net returns, the conventional field production produced the highest present value of net returns across the 15 years. The breakeven years of production were 7 and 8 for the conventional field system and organic field system, respectively. Because high tunnel production systems are not expected to increase yields over that of the field systems, the present value of net returns to these high tunnel systems were lower than those from their field production counterparts and these systems broke even much later, in year 12. Sensitivity analyses were conducted around the level of yields, input prices, output prices and pesticide application rates used in the baseline scenarios. Of the ranges of values examined for the sensitivity analyses, changes in yields seemed to have the greatest impact on the changes in present values of net returns. More study is needed to determine whether the range of values examined are representative of those faced by Arkansas producers. The baseline scenarios developed in this study will be used to inform the development of a new interactive sustainable blueberry production budgeting tool that will be released in 2015.

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List of Measurement Unit Acronyms

Acre	A	Kilogram or Kilograms	kg
Centimeter or Centimeters	cm	Kilogram per Cubic Meter	$kg.m^{-3}$
Cubic Foot or Cubic Feet	ft^3	Kilogram per Hectare	$kg.ha^{-1}$
Cubic meter or Cubic meters	m^3	Meter or Meters	m
Cubic Yard or Cubic Yards	yd^3	Micrommhos per centimeter	µmhos/cm
Deci Siemens per meter	dS/m	Month or Months	Mth
Editor or Editors	Ed	Ounce or Ounces	oz
Fluid Ounce or Fluid Ounces	fl oz	Pint or Pints	pt
Foot or Feet	ft	Pints per Acre	pt/A
Gallon or Gallons	gal	Pound or Pounds	lb
Gallons per Acre	gal/A	Pounds per Acre	lb/A
Gram or Grams	g	Quart or Quarts	qt
Hectare	ha	Quart per Acre	qt/A
Hour or Hours	Hr	Square Feet	ft^2
Inch or Inches	in	Square Meters	m^2

Chapter 1 – Introduction

1.1. Introduction

Blueberries have become a favorite fruit to many American families and health conscious consumers around the world. The demand for the fresh and processed blueberries has substantially and constantly increased over the past two decades (Kaiser, 2010). Research shows that blueberries and their berry family have high levels of nutrients to supplement the growth of the brain cells (O'Driscoll, 2010). They are also rich in antioxidants and have additional nutrients to slow the aging effects and provide anti-cancer benefits (Becker 2001; Bliss 2007; Wang, He, and Li, 2010; O'Driscoll, 2010; Van Hoed et al., 2009; and Wood, 2011). The US produces more blueberries than any other nation (Huntrods, 2013). Blueberry production has increased to 474 Million lb in the US in 2012 from 275 million lb in 2006 (Huntrods, 2013; New Jersey Agricultural Statistics Service, 2007). But even at this level, current domestic production cannot meet the increasing demand. Therefore at certain times of the year, demand is met by both domestic production and partly from several nations such as Chile and Canada (Huang, 2013). However, this increase in demand is attracting many US producers to grow more blueberries. In terms of economic benefits, selecting the right production system is crucial to ensuring the profitable investments in the end. Blueberry production, even for a small crop, requires a large initial investment. However, the many fruit bearing years of the blueberry can help ensure a worthwhile investment.

1.2. Problem Statement

Several extension programs across the states have developed the blueberry production budgets to assist growers, such as high tunnel budgets developed by Heidenreich et al. (2012) and Oklahoma State University [OSU] (2014b). However, the budgets are in static (often times paper) form and are designed primarily to provide some general information; it is not easy or practical for users to modify many of these budget to suit their needs. The Division of Agriculture, Center for Agricultural and Rural Sustainability at University of Arkansas has been working on the interactive budgeting tools for a few fruit crops, such as apple, strawberry, and brambles. This thesis seeks to expand upon these previous works, by collecting data needed for the development of a new interactive sustainable high bush blueberry production tool. Information is gathered from local producers, United States Department of Agriculture (USDA) personnel, the literature, university researchers and demonstration field experiments at the University of Arkansas Agricultural Experiment Station in Fayetteville.

1.3. Overall Objectives

There are many questions raised related to the choice of production system that will suit the market's demands. Each type of production system has its advantages and disadvantages. Some support the idea of an organic system to promote environmentally friendly production (Bengtsson, Ahnström, and Weibull, 2005; Gabriel, Sait, Kunin, and Benton, 2013). Others support the conventional farming system for meeting the exponential growth of the population in the next few decades (Seufert, Ramankutty, and Foley, 2012). Recently, some growers, particularly vegetable growers, have adopted high tunnels to extend the production season, especially in longer winter regions.

The goal of this thesis is to assist high bush blueberry producers to make better informed financial decisions with regard to the use of four production systems: 1) field – organic, 2) field – conventional, 3) high tunnel – organic, and 4) high tunnel – conventional. This goal will be met through the following objectives:

- Collect production practice information for all four production systems to create four baselines scenarios to be used in a forthcoming interactive tool. There is one scenario each for
    - Organic open field production
    - Conventional open field production
    - Organic high tunnel production
    - Conventional high tunnel production
- Estimate the present value of variable costs, fixed costs, revenues and net returns for each production system, based on Northwest Arkansas production systems,
- Conduct sensitivity analyses (regarding input prices, market prices, pesticide application rates and yields),

- Use this information to contribute to the development of an interactive sustainable high bush blueberry budgeting tool which will enable producers to assess risks and returns associated with the four production systems for high bush blueberry production

1.4. Hypotheses

All of the data gathered was used to calculate the profitability of each of the four baseline scenarios, one for each production system. Based on a review of the literature and discussions with experts, the following null hypotheses were created:

1.4.1. Null Hypotheses for the Baseline Scenarios

H_o (1a): The present value of net returns over the fifteen years of production of organic blueberries is higher than the present value of net returns for conventional blueberry production over the same time period.

H_o (1b): The present value of net returns over the fifteen years of blueberry in high tunnel production is higher than the present value of net returns in the open field production system, over the same time period.

H_o (1c): Both the organic and conventional production systems will breakeven in the same year.

H_o (1d): Both the organic and conventional field production systems will breakeven after year 7.

H_o (1e): Both the organic and conventional high tunnel production systems will breakeven in the same year.

H_o (1f): Both the organic and conventional high tunnel production systems will break even after year 10.

Sensitivity analyses will be conducted to determine how the results of the baselines changed when certain factors changed. These factors included input price levels, output price levels, yield levels and levels of the use of pesticides.

1.5. Road Map for Remaining Chapters

The structure of the thesis consists of five chapters. Chapter 2 presents a review of previous studies that serve as guidance for the budget development and data collection. Chapter 3 presents the data collected, development of the interactive budget and economic methodologies. Chapter 4 describes an analysis of the costs and returns associated with four base case scenarios, one for each production system. The information used in these case studies will also be the foundation of the budget template to be placed in the interactive tool. Chapter 5 presents conclusions and recommendations for future research.

Chapter 2 – Literature Review

One of the objectives of this research is to collect production input, cost, yield and output information that can be used as the basis for an interactive sustainable highbush blueberry budgeting tool. This tool will have the ability to assess the profitability of the four different production systems mentioned in Chapter 1. The profitability analysis will comprise of the present value of costs and revenues and net revenues over time as well as breakeven sensitivity, and risk analyses. The literature will provide information important for the final compilation of the budgeting tool. Overall, the review will contain five sections: 1) the nature of the highbush blueberry production practices and its markets; 2) blueberry budget development based on different production systems; 3) comparison and overview of the individual production system ranging from organic, conventional, and high tunnel systems; and 4) farm sensitivity analysis.

2.1. Highbush Blueberries

The highbush blueberry, a perennial plant, has approximately 30 or more years of productive life, according to Moore, Brown, and Bordelon (1993). Highbush blueberries are the most popular cultivars among the five types (lowbush, high bush (Northern and Southern), half-high, and rabbiteye) of blueberries due to favorable yields, cultivar adaptability, and harvest period advantages, (Carter, Clark, and Striegler, 2002; Clark, Moore, and Drapper, 1996; Jimenez, Carpenter, Molinar, Wright, and Day, 2005; NeSmith, 2014; Strang, Jones, Masabni, Wolfe, Hartman, and Bessin 2003). Highbush blueberries are believed to remain productive for between 15 and 20 years under well-managed production conditions (Fonsah, Krewer, Smith, and Stanaland, 2013; Kuepper and Diver, 2010; Harrington and Good, 2000; Schooley and Huffman, 1998). After this period, the highbush blueberry plants should be replanted.

2.1.1. An Overview of Farming Systems

2.1.1.1. Organic Farming System

There is extensive literature associated with the guides, practices, and techniques for growing organic blueberries. Published articles and guides provided comprehensive information and results from researches and trials showing miscellaneous applications for various stages of the organic blueberry production. Overall, some available organic blueberry production documents which interested growers can consult are from Cornell University (Carroll, Pritts, and Heidenreich, 2013); University of Maine (Drummond, Smagula, Yarborough, and Annis, 2012);University of Georgia (Krewer and Walker, 2006); Oklahoma State University (OSU, 2014b; Stafne, 2006); and National Sustainable Agriculture Information Service (Kuepper and Diver, 2004). Some blueberry production research has specifically focused on organic highbush blueberries including publications from Rutgers University (Sciarappa et al., 2008), Oregon State University (Julian, Strik, Pond, and Yang, 2011b), Nova Scotia Agricultural College (Burkhard, Lynch, Percival, and Sharifi, 2009), as well as the blueberry research and breeding program currently being conducted at University of Arkansas. Overall, the organic blueberry production practices recommended include obtaining organic certification, organic farm planning fruit marketing. Specific recommendations may vary by region and by available agricultural materials. Carroll et al. (2013) stated blueberries were commonly the most manageable crop in organic production because less pest issues occurred compared to other fruit plants. Organic blueberries production costs are higher than conventional blueberries according to studies by Julian et al. (2011a, 2011b), however they further reported that in their study organic production had a higher net profit than conventional production.

Krewer and Walker (2006) reported the organic blueberries were often sold at a price premium that could reach up to 20% more than the price of conventional blueberries. Sciarappa et al. (2008) noted that three features created the opportunity for certified organic growers to successfully grow highbush blueberries. First the existence of the national organic standard led to fair competition and clarity via the labels on the crop. Second, sales of organic produce have increased, brought about in part by their nutritional or health benefits. Third, the availability of pest control practices and improved cultivation management practices have improved overall production and profitability. For example, Julian, Strik, Larco, Bryla, and Sullivan (2012) studied the northern highbush blueberry mulch types, fertilization and planting practices in the organic culture. The trials showed that net returns depend on fertilizer sources, rates of application, mulch types, and cultivars. The greatest yields were obtained in plants fertilized with the low rate of fish emulsion in combination with growing on raised beds and covered by compost and sawdust mulch. However, there was no specific evidence to prove that the organic production system significantly surpassed the returns from the conventional system as performance results depended on growers and regions.

2.1.1.2. Conventional Farming System

Conventional farming includes a wide variety of acceptable production practices. One of the main differences between organic and conventional production systems is that conventional production allows a broad array of synthetic fertilizers and pesticides to be used within the production system. The details of conventional blueberry production systems have been widely published (Cline and Fernandez, 1998; Demchak, Harper and Kime, 2009; Fonsah, Krewer, Harrison, and Bruorton, 2010; Garcia, 2009; Gauthier and Kaiser, 2013; Johnson, Striegler, Lewis, and Vann, 2003; Mainland and Cline, 2007; Pritts, Hancock, Strik, Eames-Sheavly, and Celentano, 1992; Schooley and Huffman, 1998). Conventional blueberry production is less labor intensive than organic blueberry production. Another major difference from organic production is that conventional blueberry production does not have specific standards (like the organic standards) that need to be followed in terms of input use. Most of the research provided the steps to grow blueberries. These details are provided beginning in section 2.2 below.

2.1.2. Conventional, Organic, High Tunnel and Field Production Strategies

Highbush blueberries can be grown in both high tunnels or in the field. While highbush blueberries were traditionally grown in field systems, the uses of high tunnels for highbush blueberry production are currently being researched. A high tunnel is sometimes called hoop house; its structure is a proven agricultural cropping technique to extend cropping season (Pool and Stone, 2014). It is passively heated, low cost in constructing, using metal structure with a plastic rain cover attached by either a plastic door or a simple polyester net closure. According to Blomgren and Frisch, (2007), there are several types of high tunnel structures including four-season high tunnels (hoop houses or passive solar greenhouses), three-season high tunnels (such as Haygroves) of single bay tunnels (called "solo") or multi-bay tunnels, low tunnels, and walk-in tunnels (called "caterpillars"). However, low tunnels and caterpillars are more suitable for small bushes and vegetables. Multi-bay tunnels like Haygroves are used for growing dwarf trees such as sweet cherries, or vegetables. The traditional high tunnels are used to produce high value crops such as fresh market tomatoes, strawberries, raspberries, salad mix, and others (Blomgren and Frisch, 2007). The primary use of high tunnels is to change the crop environment, such as to raise the temperature to be able to plant earlier during spring, to expedite the ripening period and prolong the fall harvest (Knewtson, Carey, and Kirkham, 2010; Santos, and Salame-Donoso, 2012). High tunnels are beneficial for protecting against wind and rain, reducing some diseases and insects, reducing fruit damage for freeze protection, and thus reducing sprinkler irrigation and fuel or electricity costs, as well as improving yield and quality (Lamont, 2005; Wells and Loy, 1993, Demchak, 2009). It is reported as an estimated figure of high tunnel area for blueberry is small (10 to 20 hectares or equivalent to 24.70 to 49.40 acres) compared to other types of berries, (strawberries and Primocane raspberries), (Demchak and Hanson, 2013).

2.2. Highbush Blueberry Cultivars

Blueberry cultivars are grouped by ripening periods ranging from early-season, early mid-season, mid-season to late season cultivars (Mainland and Cline, 2007). Highbush cultivars ripen early, starting in mid-May or early July varying by regions. Southern highbush cultivars are intermediate, between highbush and rabbiteye, in soil and climate adaptation (Mainland and Cline, 2007). Generally, highbush blueberries include Northern highbush grown mostly in Northern and Central Arkansas areas, and Southern highbush produced in Central and Southern Arkansas. The cultivars of Northern highbush blueberries recommended for Arkansas include Bluecrop, Bluejay, Blueray, Duke, and Elliot; recommended southern highbush blueberry cultivars include Legacy, Ozarkblue, and Summit (Garcia, 2009).

2.3. Site Selection and Preparation

When choosing a site to produce blueberries, soil condition is an important factor. Appropriate soil conditions for blueberry plants include an acid pH of 4.5, sandy loam greater than 3 percent organic matter that is well drained with low soil calcium (less than 2,240 $kg.ha^{-1}$ [2000 lb/A]), (Carroll et al., 2013; Hancock and Hanson, 1986). According to Carroll et al. (2013), blueberry producers should avoid clay soils and abandoned sites because blueberries require well drained soil. Wet soils like clay soils restrain root growth and can lead to reduced plant sizes and lower yields. Thus site selection should be based on these attributes rather than to attempt to costly acidify the soil pH to meet the favorable soil quality conditions required by the highbush blueberries. Soil tests should be conducted for nematode analysis, nitrogen and pH adequacy. A minimum of 6 subsamples/A was recommended by Carroll et al. (2013) for soil test. The guide stated that soil tests at every three years are considered good observation to monitor soil acidity (Carroll et al., 2013; Hancock and Hanson, 1986).

2.3.1. Production Site Preparation

Even though most of the organic practices are applicable to conventional production techniques, with the selective pricing availability, conventional producers have extensive choices whereas organic producers need to follow the national organic program. The practice described in this section applicable to both organic and conventional production system. Mainland and Cline (2007) suggested employing peat moss or pine sawdust or bark of four to six inch if organic matter is less than 2%. If the soil pH for growing highbush blueberries is 5.0, Mainland and Cline (2007) suggested applying sulfur at 1 lb/100 sq^2 around three or four months before planting until reaching a good pH level. Similarly, Mainland and Cline (2007) suggested 0.1 lb of sulfur per plant to reduce pH by 1.0.

2.3.2. Organic Production Site Preparation and Certification

Specifically for the organic system, Kuepper and Diver (2004) argued that other applications could be used for soil modification including sphagnum peat moss of five to ten gal/plant, or vinegar or citric acid solutions via drip lines, lime or sulfur of two hundred lb/A for two applications.

For organic certification purposes, sites are supposed to be National Organic Programm (NOP) approved for three years prior to harvesting of certified organic crop. Additionally, buffer zones of the same plant cultivars or different crops are required for contamination drift prevention, according to Carroll et al. (2013). Soil preparation must begin one year minimum ahead of planting, including planting cover crops one or two seasons prior to growing blueberries (Carroll et al., 2013).

2.3.2.1. Cover Crops

Cover crops are often introduced in the site preparation year for conventional production. However, Carroll et al. (2013) reported a cover crop is necessary for organic farming. They state it is important to incorporate it once or twice into the soil at the planting site ahead of the planting period. Cover crops are useful for providing supplemental nutrients to blueberry plants, for weed suppression, for soil erosion prevention and for soil moisture maintenance. Carroll et al. (2013) suggested fescues or ryegrass. Sciarappa et al. (2008) also suggested the use of fescue (turf grass) as a row middle. Krewer and Walker (2006) recommended ryegrass and that it be mowed off to the shortest length before the blueberry bloom. Kuepper and Diver (2004) reported three-to-five-time mowing the ground cover per year can prevent weed growth.

2.4. Planting

2.4.1. Spacing/Density

Planting takes place the year after the site preparation. The nursery blueberry bushes that are two to three years old are recommended and the bushes' roots are to be kept moist at all-time until planted (Mainland and Cline, 2007). Plant spacing is an important consideration as it can impact plant health and yields. Highbush blueberry spacing varies across different regions and practices. These ranges include 1.2 to 1.5 m (3.9 to 5 ft) between plants and 2.7 to 3.7 meters (8.9 to 12 ft) between rows, (Carroll et al., 2013; Kuepper and Diver, 2004; Mainland and Cline, 2007; Sciarappa et al., 2008). Moore et al. (1993) showed that using 0.61-m (2-ft) space within the row within the first five years of harvest can increase yields and not affect fruit size compared to other distances. However, when plants are placed at high density rates, more irrigation, pruning methods, and fertilization were suggested to care for the plots. This closely spaced cultivating resulted in lower yield during the last two years of the harvest. Similarly, Kuepper and Diver (2004) reported in a study conducted by University of Arkansas that double the number of plants per acre for the first five years of planting would increase the yields remarkably to compensate the high expenses of drip irrigation and bird netting. However, they recommended removing every other plant in the row in year five and replanting them in a different new.

2.4.2. Mulching

Mulch is used in blueberry production to improve water retention and reduce weeds. Depending on whether conventional or organic production is being pursued, as well as if the system exists in the field or in a high tunnel, different types of mulching practices are recommended.

2.4.3. Conventional Production Mulching

Odneal and Kaps (1990) recommended planting highbush blueberry by incorporating fresh or aged pine bark as a replacement for sphagnum peat in the planting hole as soil modification. Applying the pine bark treatments for soil aeration can solve the plants' root rot problems. However, Wilber and Williamson (2008) study showed that applying pine bark system to containerized Southern highbush blueberry appeared to be based on cultivar and similar to fertilizer requirements in soil culture.

2.4.4. Organic Production Mulching

In conventional production, weed control can be managed by pesticides and mulching. In organic agriculture, much of the burden of weed control falls to the mulching practices. Organic mulch types can be woodchips, pine bark, wheat straw, pine straw, pine needles, sawdust, or bark, pinewood, hardwood, coffee grinds, composted, and leaf compost, cocoa grinds of 3 to 5 in by 4-to-6-in wide strip under the plants. Studies by Kuepper and Diver (2004); Krewer and Walker (2006); Sciarappa et al. (2008) suggested that mulch be replenish by 2.54 to 5.08 cm (1 to 2 in) each year. These same studies suggested other mulch choices could be fabric or plastic mulch to be depreciated by 10-12 years and 5 years respectively and be removed once rotten by the end of the life span. De Silva, Patterson, Rothrock, and Moore (2000); and Burkhard, Lynch, Percival, and Sharifi (2009) reported pine needles as the most effective organic mulches to suppress weed in highbush blueberries compared to manure–sawdust compost and seafood waste compost. Besides, organic mulches also improve soil quality and nutrients.

2.4.5. High Tunnel Production Mulching

High tunnels can be even more appealing to rodents and birds than open field production systems. The research by Lamont et al. (2003) found that using plastic mulch with drip irrigation embedded under the soil to be a suitable approach to reduce the rodent and nest built up for large sheet protection the entire tunnel inside the structure.

2.5. Fertilization

Fertilization is an important part of blueberry production management. Fertilization strategies will vary across organic and conventional production systems as well as different soils. Some blueberry nutrient research has been compiled by Hayden (2001) and Strik (2013). Examples of fertilization strategies for conventional, organic and high tunnel systems are presented below.

2.5.1. Conventional Production Fertilization

Synthetic fertilizers are commonly applied in many conventional agricultural production systems. However, Townsend (1973) discovered that use of ammonium sulfate over time (seven years) on ‘Bluecrop’ plants, a popular highbush blueberry variety, would reduce yields compared to the non-fertilized plants. As a result, the author recommended applying little fertilizer to highbush blueberries. Additionally, according to Clark, Maples, and McNew, (1999), Arkansas conventional blueberry growers use ammonium sulfate if the pH level is 5.3 or above, and use urea if the pH is 5.2 or below soil modifiers.

2.5.2. Organic Production Fertilization

Organic blueberry producers usually employ fertigation, injecting soluble nutrients via drip lines. For organic growers, blood meal was found to clog the drip lines, but researchers found that fish and poultry protein meal were fine via drip irrigation (Kuepper and Diver, 2004). Also, other nutrients can be used, such as fish emulsion, seeds, kelp, or seaweed. To develop ideal soil quality for organic blueberry plants, green manure can be used during the soil preparation. The nitrogen level that is considered sufficient ranges from 112 to 134.4 $kg.ha^{-1}$ (100 to 120 lb/A) with a mulch application of 67 to 73 $kg.ha^{-1}$ (50 to 60 lb/A) for non-mulch plants (Pritts et al., 1992). This same amount is needed for both conventional and organic blueberry cultivation. However, there is no straight rule for optimal nutrient management; real conditions at actual farm sites will determine the actual needs and quantity required of fertilization. But Ferguson and Ziegler (2004) as well as Mainland and Cline (2007) noted that excessive nitrogen applications could reduce yields because blueberry demands less nitrogen than other fruit plants.

2.5.3. High Tunnel Production Fertilization

Demchak (2009) found that the practices used under high tunnel production were similar to the open field practices with fairly small adjustments in irrigation, fertilization, and pruning methods as reported by Heidenreich et al. (2012), Jett (2008), Lamont et al. (2006). Therefore it is expected that while fertilization practices will vary across organic and conventional practices, they will not vary within field and high tunnel systems for organic or conventional systems.

2.6. Pruning

Carroll et al. (2013) suggested pruning to promote plant health, for example, removing the dead and diseased canes to reduce the infection to other canes and bushes, or removing some canes to facilitate the harvest as indicated by Gauthier and Kaiser (2013). Mainland and Cline (2007) recommended removing all flower buds in year two after the planting year, and 50% of the flower buds when plants are matured, usually in year four. According to Barney (1999) and Gauthier et al. (2013), the highbush blueberry plant can grow from 1.5 to 3 m (5 to 10 ft) high. It should be trimmed to around 1.5 to 2.13 meters (5 to 7 ft) tall after pruning to ease harvest. Generally, approximately 20% maximum of wood is pruned without affecting yields of blueberries (Gauthier and Kaiser, 2013). Before establishing the bushes, Mainland and Cline (2007) suggested removing half of the shoots and keeping just a few healthy shoots.

2.7. Irrigation

Blueberries can be irrigated using three different techniques. Sprinkler irrigation is an irrigation method that sprays water into the air via sprinklers in a form similar to rainfall by pumping through a water pipe system (Brouwer, Prins, Kay, and Heibloem, 1988). It can be used for winter frost protection. Micro-spray or micro sprinkler irrigation is a hybrid irrigation method between drip and sprinkler irrigation. The water is slowly discharged on soil surface via sprinkler nozzles using low pressure through the buried pipe lines under soil. It is a suitable watering method for fruit trees, and saves water volume, and reduces labor costs to apply fertilizer (which can be injected via the micro irrigation pipes) (Godin and Broner, 2013). As for drip irrigation, it is a type of plant watering method known as trickle or micro irrigation, in which water is slowly dripped onto the plants' roots under or just above the soil surface by tube openings connected to buried water pipe system (Wilson and Bauer, 2014). According to Bryla, Gartung and Strik (2011) among the three methods, drip irrigation was the best and most efficient method for establishing the highbush blueberry plants. Ehret, Frey, Forge, Helmer, and Bryla (2012) reported higher drip irrigation volume increased fruit size and water content but reduced fruit firmness and soluble solids. Irrigation reduced fruit water loss during storage and thereby promoted longer shelf life.

Blueberry plants need 2,055 to 2,569.75 m^3 (20 to 25 in) of rainfall per season (Pritts et al.,1992). Irrigation water should contain less than 1.0 or 2.0 dS/m of salt and less than 5.5 of pH (Carroll et al., 2013). The quality of irrigation water is one necessary factor to maintain crop growth; a level of salt of an EC (salinity or electrical conductivity) of 1.0 µmhos/cm (or dS/m), is appropriate for most crop irrigation, (Grattan, 2002). He noted that salinity in irrigation water can be based on sources of irrigation water. For instance, snow water has less salt levels compared to groundwater or wastewater. However, other factors also cause the salinity water problems on crops, such as poor irrigation and drainage structure or excessive watering (Umali, 1993). The Holzapfel, Hepp, and Mariño (2004) study showed a positive relationship between yields of highbush blueberry and microjet irrigation. Microjet irrigation is similar to microspray/microsprinkler irrigation except its nozzle is designed to focus spray at one direction (Bryla, Trout, Ayars, and Johnson, 2003). As a result of a seven-year study at Chile's experiment station, microjet irrigation was shown to be superior method to have good impact on highest yield increase with the water volume in a season of 6,200 $m^3.ha^{-1}$, equivalent to 662,823.4 gal/A, compared to a similar water level of drip irrigation of 6000 $m^3.ha^{-1}$, equivalent to 641,442 gal/A. Even though it was shown a similar result with a different study of ten years on grapefruit; economic perspective showed drip irrigation was more cost effective to offset the lower yield when drip irrigation was used, (Nelson, Young, Enciso, Klose, and Sétamou, 2011; Young, Klose, Kaase, Nelson, and Enciso, 2008). Despite the outcome of the case study, exact costs tended to vary by irrigation system designed on water capacity and fuel or other operation costs (Nelson et al., 2008).

A North Carolina study (Mainland and Cline, 2007)) stated watering one time every two days was adequate. 0.2-m (8-in) depth drip irrigation installation was suggested by Krewer and Walker (2006). Mainland and Cline (2007) recommended employing micro sprinkler irrigation which is more efficient watering method for blueberry than the drip irrigation. It was reported that drip irrigation did not supply adequate water volume despite installed two drippers for each plant. To supply adequate water, a rate of approximately 37.85 liters per hour (10 gal of water per hour) was suggested if employing micro sprinkler irrigation method and one to two gal/hour if using drip irrigation (Mainland and Cline, 2007). Santos and Salame-Donoso (2012) reported other significant finding that 10 times lower of water level were used under the high tunnel system compared to open field system which used 635 $m^3.ha^{-1}$ (2.5 acre-in/A) in eight hours to prevent frost in blueberry plants.

2.8. Pest Management (Organic and Conventional Production)

Some common factors shared by both conventional and organic highbush blueberry production are the importance of careful site selection, virus-free nursery blueberry bushes and supportive applications of soil amendment nutrients as reported by Demchak et al. (2009). Blueberries are generally known to be less susceptible to pests and thus less pest control is needed in both conventional and organic systems compared to other fruits. However, when diseases and pests become unavoidable, the most effective control used in conventional management is synthetic pesticides. The exact quantity, frequency, and types vary by actual situations and thus growers should consult various publications available via sources of agricultural extension programs across the United States. Some applications for pest management and weed control were reported by Smith et al. (2014). For example, the authors indicated the case of the most common types of pest occurred in Arkansas blueberry farms summarized in Table 2.1 below, the pest treatment in organic and conventional production. Pritts, et al. (1992) detailed the pest and disease control measurements where growers can consult to detect the problems once occur in the conventional blueberry bushes. Other university research programs including Demchark and Kristen (2013), Gauthier and Kaiser (2013), Johnson et al. (2003), Krewer et al. (2010), Mulder and Smith (2011), Oudemans et al. (2014), Puls, (1999), and Strang et al. (2003) also discussed the action to cope with blueberry diseases conventionally. As for organic practices, some publications are available as sources of support to the organic blueberry pest control including Carroll et al. (2013), Hazelrigg and Kingsley-Richards (2006), Krewer and Walker (2006), and Kuepper and Diver (2004). While herbicides are commonly used in conventional production; for weed control in organic production system, if planting without mulch, frequent hoeing as many as every two weeks would keep weeds away, (Mainland and Cline, 2007).

Table 2. 1 Selected Pest Treatments for Blueberry Plants

Blueberry Production Stage	Pest Problems	Recommended Pest Treatments (Pesticides Used)
Dormant Growth	▪ Bacterial Blight (BB) ▪ Mumyberry (MB) ▪ Phomopsis (P) ▪ Phytophthora Root Rot (PRR) ▪ Scale (S) ▪ Stem Canker (SC)	**To control [BB], choices include** ▪ Copper Oxychloride [Kocide 3000 (1-2.5 lb/A)] **To control [MB, P, SC], choices include** ▪ Lime Sulfur (Lime Sulfur: 5 gallons per acre: for [MB] and 5 gallons per acre for [P, and SC]) ▪ Sulforix (1 gallon per acre) **To control [PRR], choices include** ▪ Fosetyl Al [Aliette 80WDG (5 lb/A)] ▪ Fosphite [Phosphorous Acid (1-4 qt/A)] ▪ Mefenoxam [Ridomil Gold SL (3.6 pt/A)] ▪ Dormant Oil (to control [S])
Fruiting Season/Harvest Period	▪ Anthracnose (A) ▪ Japanese Beetle (JB) ▪ Green June Beetle (GJB) ▪ Bagworms (BW) ▪ Stem Blight (SB) ▪ Stem Canker (SC) ▪ Spotted Wing Drosophila (SWD)	**To control [A, SC, SB, and SWD], choices include** ▪ Delegate (3-6 ounces per acre) ▪ Fenpropathrin [Danitol 2.4 EC (16-21.3 oz/A)] ▪ Malathion (1-4 pints per acre: Malathion 8EC) ▪ Phosmet [Imidan (1.3 lb/A)] ▪ Tame [Danitol 2.4 EC (13-16 fl oz/A] ▪ Zeta-cypermethrin [Mustang Max (4 oz/A)] ▪ Spinosad [Entrust (4-6 oz/A (Entrust EC); 1.25-2 oz/A (Entrust))] (OMRI) ▪ Pyrethrins [PyGanic: 1-2 pt/A] (OMRI) **To control [JB, GJB], choices includes** ▪ Acetamiprid [Assail 30SC (4-6.9 oz/A)] ▪ Aphids [Actara (4 oz/A) ▪ Admire Pro (2.1-2.8 fl oz/A)] ▪ Cabaryl [Sevin 80S (1.8-2.5 lb/A), Sevin XLR (1.5-2 qt/A)] ▪ Esfenvalerate [Asana (9.6 oz/A)] ▪ Imidacloprid [Provado (4-8 oz/A] ▪ Phosmet [Imidan (1.3 lb/A)] ▪ Azadirechtin [Aza-Direct(4-8 oz/A)] (OMRI) ▪ Azidirachtin [Neemix (7-16 fl oz/A)] (OMRI) ▪ Kaolin clay [Surround (25-50 lb/A)] (OMRI) ▪ Pyrethrins [PyGanic: 1-2 pt/A] (OMRI) **To control [BW, or other fruit feeding insects], choices include** ▪ Bacillus thuringiensis kurstaki [Javelin (0.5-4.0 lb/A), Deliver (0.25-1.5 lb/A)] (OMRI) ▪ Spinosad [Entrust 2SC (4-6 oz/A)] (OMRI)
Weed Control	Pre-emergence	**Choices of herbicides which can be used:** ▪ Dichlobenil [Casoron 4G (100 to 150 lb/A); Casoron CS (1.4 to 2.8 gal/A)] ▪ Diuron [Karmex 80DF (1.5 to 2 lb/A)] ▪ Isoxaben [Gallery 75DF (0.66 to 1.33 lb/A)]

Blueberry Production Stage	Pest Problems	Recommended Pest Treatments (Pesticides Used)
		▪ Napropamide [Devrinol 50 DF (8 lb/A)] ▪ Oryzalin [Sulflan 4AS (2 to 4 qt/A)] ▪ Pronamide [Kerb 50WP (2 to 4 lb/A)] ▪ Simazine [Princep 4L (2 to 4 qt/A)] ▪ Terbacil [Sinbar 80W (2 to 3 lb/A)] ▪ Trifluralin-Isoxaben-Oxyfluorfen [Showcase G (100 to 200 lb/A)]
Weed Control	Post-emergence	**Choices of herbicides which can be used:** ▪ Flauzifop [Fusilade DX 2EC (16-24 fl oz/A)] ▪ Glyphosate [Roundup Ultra] and Glyphosate (41%) (1 pt to 5 qt/A) ▪ Glufosinate [Rely 200 (3.6 pt to 3.6 qt/A)] ▪ Mesotrione [Callisto 4L (3-6 fl oz/A)] ▪ Paraquat [Gramoxone Inteon] (2-4 pt/A)] ▪ Sethoxydim [Poast 1.5 EC (1.5-2.5 pt/A)]

Note: “OMRI” refers to Organic Materials Review Institute (for organic production practice).
Sources: Content is partially adopted from Oudemans et al. (2014), Scott et al. (2014), Smith (2014), and Studebaker (2014).

2.8.1. <u>High Tunnel Production Pest Management</u>

Demchak (2009) reported the presence of powdery mildew (Sphaerotheca macularis) in the berry high tunnel production. The main difference was the applications of pesticide was notably lower than field applications but the management of pest can possibly be control out of biological or cultural methods (Heidenreich et al., 2012; Lamont et al., 2006).

2.9. Harvest and Post-harvest Management

2.9.1. <u>Pollination</u>

Kuepper and Diver (2004) reported using bee pollinators to increase yields because blueberries are insect-crossed pollinated. Small native bees and bumble bees are the most effective pollinators in blueberry fields, honey bees can be effective pollinators of highbush blueberries if they bloom during warm climate (Burrack, 2013; and Agriculture Research Service [USDA-ARS], 2009). Honey bees are most plentiful in North Carolina (NC), and are generally seen in NC commercial blueberry fields and recommended to stock at rates up to four hives per acre (North Carolina State University

Entomology Extension Portal [NC State]. 2013). Fostering more than one bee species to have good blueberry crossed pollination (Burrack, 2013; and Kuepper and Diver, 2004).

2.9.2. Blueberry Harvest Machinery and Equipment

Pritts et al. (1992) listed various kinds of sprayers and purposes of usage as well as formula to calculate spray requirements including air-blast sprayers, backpack sprayers to small truck- or all-terrain vehicle (ATV)-mounted machines. The requirement to purchase or rent the machinery needed for the blueberry fields is based on the farm size, available budget, or economic benefits offered the farm owners.

2.9.3. Harvest Labor

Kuepper and Diver (2004) indicated “blueberry U-Pick” was a popular method for a small farm around five to fifteen acres. U-Pick is a kind of client’s labor base where a producer allows customers to pick the blueberry by themselves in the farm during the harvest season by charging a certain weight measurement unit so that producer can minimize expensive harvest labor charges. However, U-pick method becomes less effective if the farm size is too big to be accessed by self-pick clients. The authors suggested that hand labor of 10 to 15 people per acre are essential once the blueberry farm surpassed 2 ha (5 A). Jimenez, Klonsky, and De Moura (2009) examined the costs of fresh market blueberry production and estimated that the picking rate is around 10 lb/hour). It was stated a full production required around 350 to 400 labor hours in Kentucky (Strang, 2014) As for a hand pick harvest charge, $0.72/lb was reported by Morgan et al. (2011).

2.9.4. Prices and Yields

Blueberry harvest takes place in many of the production years but the extent of the harvest varies by production year. Furthermore, the first production year can vary by production location. In the United States, highbush blueberry production can begin as early as the third season (Kuepper and Diver, 2010; Harrington and Good, 2000). Overall, blueberries produce a first crop at the rate of 448 to 896 kg.ha^{-1} (400 to 800 lb/A) (Harrington and Good, 2000); or 225 g (0.5 lb) per plant of highbush blueberries in year three (Schooley and Huffman, 1998).

Harrington and Good (2000) reported blueberry yield of 1,568 to 2,240 kg.ha^{-1} (1,400 to 2,000 lb/A) in year four; and 4,480 to 6,720 kg.ha^{-1} (4000 to 6000 lb/A) in full production which is after six to eight years of planting and further indicated a possible yield to be exceed 11,200 kg.ha^{-1} (10,000 lb/A) for a mature blueberry bushes under ideal circumstances.

Particularly, highbush blueberries are found to produce about 450 to 900 grams (0.99 to 1.98 lb) per bush in year four and 2.5 to 3.5 kg (5.5 to 7.7 lb) per bush in around year 6 to year 8 of full crop, (Schooley and Huffman, 1998). Highbush blueberries yields gradually increase until year 7 where matured plants yield about three tons per acre (Kuepper and Diver, 2010).

Certain types of highbush blueberries reach maximum production in around year four or five. Ozarkblue was the first breeding cultivar of southern highbush blueberry released by the University of Arkansas (Clark, Moore, and Draper, 1996). When grown up to four or five years, its yield can reach 6.8 kg per plant (15 lb/plant) while on the trial planting. As for Summit, having the same period of full production, and a second release of breeding cultivar from the university was reported to have a yield of up to 3.6 to 4.5 kg/plant (8 to 10 lb/plant) in the research trial (E. Garcia, personal communication, May 19, 2014).

Picking frequency is around 5 to 7 days based on weather conditions to obtain the best quality for Highbush blueberries (Mainland and Cline, 2007). At harvest, depending on the region, birds can completely destroy the harvest quality and quantity expectations.

Fresh market blueberries were reported by Economic Research Service [USDA-ERS] (Perez and Plattner, 2013b) to be $30 to $35 per 12 cups with lids of 1 pint quantity (about $2.5 to $2.9 per lb at free on board (F.O.B) prices in Georgia in May 2013). Prices were lower in June 2013, $19 to $21 per

12 cups of 1 pt. The fresh market blueberry average prices per lb across the states is $2.14 and $0.95 for processed price in 2012 (USDA-ERS, 2013, Table D2) compared to average price of fresh market $2.14 and processed price $1.28 in 2011 (USDA-NASS, 2013, Table 8).

Studies have shown a range of expected yield values for conventional production. Demchack (2009) stated that in the third year after planting, the initial yield can reach about 1,680 $kg.ha^{-1}$ (2,000 pt/A [1500 lb/A]). Yields continued growing to approximately 5,040 $kg.ha^{-1}$ (6,000 pt/A [4,500 lb/A]) for the optimum condition in the fifth year (Demchak, 2009). A study by Fonsah et al. (2010) reported the best yields in 2000 of 4,625.60 $kg.ha^{-1}$ (4,130 lb/A) in Georgia. These yields were roughly 10% higher than the national level and earned a high price of $5.00 per lb.

According Ogden and van Iersel (2009), previous findings suggested that high tunnels extended the blueberry harvest time from one week to one month. Further, tunnels changed the microenvironment and plant growth, increased yields compared with the in-field yield, increased the quality and fruit cleanliness, suppressed diseases, and improved fertilizer and water use efficiency. However, it cannot protect the frost during winter except using the propane heater as assistance. The authors had neither found the effect of different closing dates in high tunnels on the season extension as a result of the growth under the high tunnels nor the effect of high tunnels on blueberry fruit quality. The authors expressed the biggest drawback of high tunnel production of southern highbush blueberries seemed to be a lack of adequate pollination and cost effective winter frost protection. Santos and Salame-Donoso (2012) worked on the experiment to compare the southern highbush blueberry's fruit weight between high tunnel grown blueberry fruit and open field cultivated blueberry in Florida. The results specified that there were major difference in fruit weights of almost 10 times higher in year one for high tunnel fruit and twice to four times higher for year two than the weight of open field fruit which prove the high tunnel system effectively influenced flowers and fruit sets of blueberry plants grown under this structure. The study by Lamont (2005) found out 7 to 21-day early crop production, two to three- time high yields per measurement unit, and advanced-quality and cleaner products. Despite the previous research into season extension of blueberries, questions remain regarding the effects of different tunnel closure dates. Previous studies, such as Bal, (1997) and Hicklenton, Forney, and Domytrak (2004) mentioned that harvest period was prolong by the effect of high tunnel production up to one month; however, Baptista, Oliveira, Lopes da Fonseca, and Oliveira (2006) found that the plant growth varied from plants to plants while cultivated inside the high tunnels.

The US Highbush Blueberry Council reported increasing growth of blueberry industry over the past decades and noticed exceptional high demand and available blueberry out of the past four years (2008 – 2011), Perezand Plattner (2013a) report on organic fruit and berries, when more consumers come to know the health benefits of blueberry consumptions. Now, there are thrice fresh blueberries eaten today more than ten years ago. Blueberries are now marketed as a healthy product. Scientific studies revealed subsequent findings about the possibility to cure diseases in human relevant to breast and cervical cancer, anti-aging of brain and memory decline as well as cardiovascular related health retention. Blueberry is known to have fewer calories and high vitamin C as well as the rich antioxidants, (Becker, 2001; Bliss, 2007; O'Driscoll, 2010; Wang et al., 2010; Wood, 2011). To date, as previous literature revealed, there are no clear results to conclude whether conventional or organic food products are superior to the other, and thus, more research is needed. Overall, subsequent research has shown different attributes in organic and conventional produce; however, to have more available food products with various niche values in the market to meet diverse tastes and preferences and income levels of consumers seem the core tasks of marketers.

2.10. Generic Budgeting for Highbush Blueberries

2.10.1. Existing Budgeting

To date, enterprise budgets related to conventional and organic blueberry production have been abundantly available for growers who are interested in become involved in the blueberry industry (Table 2.1). Many university extension programs across the states still place efforts in developing the most useful tools to assist producers in making good investment decisions. These tools can assist producers in addressing questions related to expanding the acreage of the current blueberry operation, to transforming the operation into an organic blueberry production system, to adding a high tunnel structure to the existing blueberry open field, to determining the number of years to recover the initial investment of establishing the blueberry production, to developing financial plans for requesting credit or even for selling the operation. Most of these questions can be answered via the interpretation of budget analyses by examining economic costs, revenues, profits, breakeven points, opportunity costs, sensitivity analyses and risk. The majorities of the existing blueberry budgets are static guides with assumptions based on farm locations and growing practices and conditions and are not easily changed to better reflect an individual grower's situation. Some blueberry production budgets (Mississippi State University (MSU), 2010, Pritts et al., 1992; and Yarborough, 2011) just showed the calculation of variable costs, fixed costs, total costs of soil preparation year, establishment year, and full harvest year. Some other budgets (Bervejillo, Jimenez, and Klonsky, 2002; British Columbia Ministry of Agriculture [BCMA], 2007, 2008; Demchak et al., 2009; Demchak et al., 2013; Fonsah et al., 2010; Fonsah, Krewer, Harrison, and Stanaland, 2005; Jimenez et al., 2009; Julian et al., 2011b; Julian et al., 2012; OSU, 2014b; Safley, Cline, and Mainland, 2013; and Woods, 2014) showed the brief calculation of either breakeven and sensitivity analysis, or sensitivity and risk assessment, or a combination among the three components (breakeven, sensitivity, and risk assessment). However, the majority of the studies did not include economics of the high tunnel structure or comparisons of organic and conventional production. Additionally the calculation of machinery investment and loan calculations were briefly guided in some existing budgets (Carroll et al., 2013; Demchak et al., 2013; Fonsah et al., 2010; Julian et al., 2011b; Kuepper and Diver, 2004; OSU, 2014b; Pritts et al., 1992; Puls, 1999; and Yarborough, 2011). A review of the literature revealed no production budget that addresses the use of blueberry high tunnels except presented the vegetable or other fruit production using high tunnels (Rodriguez, Popp, Thomsen, Friedrich, and Rom, 2012; Blomgren and Frisch, 2007; Bomford, 2011; Everhart, Lewis, Naeve, and Taber, 2010; Galinato and Walters, 2012; Hanson and Vonweihe, 2008; Heidenreich et al., 2012; and Iowa State University [ISU], 2012).

2.10.2. <u>High Tunnel Subsidies and Other Supports to Farm Business Entries</u>

USDA provides financial assistance, for one high tunnel per producer covering up to 5 percent (%) of an acre or 202 m (2,178 ft^2). The program is called "Seasonal High Tunnel System for Crops Program" and was started in 2010 for a trial period of 3 years to test the effectiveness of the high tunnel uses. At present, the program is still active. Growers can apply for other grants, such as organic certification cost share program provide organic certification cost of up to $750; farm loans, and other kinds of assistance.

Table 2. 2 Summary of Existing Budgets

Budget	Cultivars/Crops	Production			Economic Analysis				
		Conven-tional	Organic	High Tunnel	Profit	Break-even	Sensitivity	Risk Assess-ment	Others
BCMA (2007, 2008)	Blueberry, and other crops	X			X	X	X		X
Bervejillo et al. (2002)	Blueberry	X			X		X		
Blomgren and Frisch (2007)	Vegetables	X		X	X				
Bomford (2011)	Vegetables		X	X	X				
Demchak et al. (2009)	Highbush		X	X	X	X			
Demchak et al. (2013)	Berries	X			X	X	X		
Everhart, et al. (2010)	Vegetables	X		X	X				
Fonsah et al. (2005)	Rabbiteye	X			X	X	X	X	
Fonsah et al. (2007)	Highbush	X			X	X		X	
Fonsah et al. (2010)	Highbush	X			X	X	X		
Galinato and Walters (2012)	Strawberry			X	X	X	X		
Hanson and Vonweihe (2008)	Raspberry	X		X	X	X			
Heidenreich et al. (2012)	Raspberry and Blackberry	X		X	X				X
ISU (2012)	Vegetables	X		X	X	X			
Jimenez et al. (2009)	Blueberry	X			X	X	X		
Julian et al. (2011a)	Blueberry	X			X	X	X		
Julian et al. (2011b)	Blueberry		X		X	X	X		
Julian et al. (2012)	Highbush		X		X	X	X		X
MSU (2010)	Blueberry	X			X				X
OSU (2014b)	Blueberry and other crops	X			X	X			
Pritts, et al. (1992)	Highbush	X			X	X			X
Rodriguez et al. (2012)	Blackberry		X	X	X	X	X	X	
Safley et al. (2013)	Blueberry	X			X	X	X		X
Woods (2014)	Blueberry	X			X	X	X		X
Yarborough (2011)	Blueberry	X			X				

2.10.3. Profitability/Net Present Value and Other Investment Decision Methods

When taking into consideration the investment decision tools, the time value of money concept comes into effect because it is believed that the dollar today is worth more than the same dollar amount tomorrow or the future time. Furthermore, inflation will reduce the value of the future dollar amount, (Kay and Edwards, 1999). Producers can use investment decision rules in order to help with their decision-making process. One such rule is the net present value (NPV) decision rule which has been expressed by Kay et al. (1999) as in equation 2.1 (Eq 2.1):

$$\mathbf{NPV} = \frac{P_1}{(1+i)^1} + \frac{P_2}{(1+i)^2} + \ldots + \frac{P_n}{(1+i)^n} - C \qquad \text{(Eq. 2. 1)}$$

where "P_n" is the n^{th} net cashflow and "i" is the discount rate; C is the initial investment. Discount rate is the chosen interest rate used in calculating present values of cash-flows.

Ross (1995) explained that the NPV rule was to accept all projects with NPVs greater than zero and to reject projects with NPVs less than zero. He conveyed that it is worthwhile to accept all projects after calculating the risk associated with those projects via probability and expected value of those projects and result showed no interference with other projects. Safley et al. (2013) further interpret the useful information related to the NPV calculation. The authors indicated that the NPV rule is useful in planning whether to proceed with the blueberry production project when inspecting the expected future incomes from this project by converting the future cash-flows into current net value via the discount factor ($\frac{1}{(1+i)^n}$). One possible drawback of the NPV method is the NPV result heavily depends on the selected discount rate. A very high discount rate can result in zero or negative NPV and thus the appropriate discount rate must be selected with care (Kay and Edwards, 1999).

2.10.4. Breakeven Analysis

The breakeven points in the farm enterprise include breakeven yield (total costs divided by market price) and breakeven price (total costs divided by yield). Hilker, Black, and Hesterman (1987) showed that comparative breakeven analysis can answer to questions, such as what the minimum prices or yields of new or multiple product line expansion having to share the same amount of fixed cost. The authors viewed that the breakeven yield concept is helpful particularly to a new crop producer to prudently define the harvest target (Hilker et al., 1987). Breakeven analysis could be defined as a more sophisticated quantitative management guide. It contributed to the net return planning and forecasting by embracing the volatilities in demand in place of setting fixed output for the entire investment or production period, Manes (1966). In addition of taking output factor into consideration in the breakeven analysis, input factor also affect the analysis result. Johnson and Simik (1971) suggested that the breakeven analysis could be misleading for a number of reasons. The method failed to take into consideration the risk of uncertainty in product demand (assumed constant variable costs) while choosing additional product lines or making decision to enter a new market employing the existing product lines.

2.10.5. Sensitivity Analysis

Sensitivity analysis is an analytical method to define the variation in output while taking into account the fluctuation states of the input uncertainty, such as prices and yield volatilities in agriculture. This method can help a business manager to prioritize activities and set strategic management, (Romero and Rehman, 2003). Future uncertainty is unavoidable when one wants to plan efficiently and thus estimating sensitivity is helpful to assess the trustworthiness of a forecast (Ahamad and Scott, 1972). In the farming enterprise budgeting process, researchers of various universities across the United States performed sensitivity analysis as part of the farm budgeting to cope with the irreducible uncertainty in the farming profit management due to weather uncertainties that can cause extensive price and yield fluctuations (Fonsah et al., 2010; Julian et al., 2011b; BCMA, 2007, 2008; Galinato and Walters, 2012, Rodriguez et al., 2012). A study by Schurle and Erven (1979) emphasized that employing the sensitivity of the efficient frontier model was not a conclusive manner to predict a farmer's choice of the least-risk farm plan. They suggested further investigation into more appropriate data and time series information. Every event can be expected to change its plan in any circumstances, and from the report of Hong and Vonderohe (2014) suggested that a simulation method was a preferred analytical method to analyze the uncertainty and sensitivity because of its ability and flexibility that input data could be detected for positional errors.

The next chapter, Chapter 3 describes the practices and mathematical relationships needed to develop a template for an interactive budget for different blueberry production systems. It also indicates the similarities and differences among production systems of organic blueberry bushes grown in open fields, conventional blueberry bushes grown in open fields, organic blueberry bushes grown high tunnels, and conventional blueberry bushes grown in high tunnels.

Chapter 3 – Building a Blueberry Budget

3.1. Background of the study

3.1.1. Budget Basics

In the coming months, an Interactive Sustainable Blueberry Budget will be developed in Microsoft Excel with a Visual Basic interface and will allow for the creation of budgets for four different highbush blueberry production systems: organic/field, conventional/field, organic/high tunnel, conventional/high tunnel. Budgets will be generated for 15 years of production. Like other budgets, this tool will generate values associated with gross revenues, variable costs, fixed costs, total costs and net revenues. However, this tool will differ from most other blueberry budgets in three ways. First, the tool will be interactive. A user can use the production activity and cost information provided in the tool or he/she can change any/all information to better reflect the information on his/her operation. The tool will then automatically recalculate the economic data. Second the tool will allow a user to view breakeven information for both price and yield. Further the user can make changes in prices/activities and view how those changes impact breakeven yields and prices. Third the tool will allow for a risk analysis to be conducted regarding the operation by assessing the probability that the operation will earn a given net revenue value. Finally unlike other budgets developed at University of Arkansas, this tool will include detailed information regarding depreciation, insurance, taxes etc., that can be manipulated by the user to better reflect the true fixed costs of the operation. The next sections discuss the development of the pieces that will be used in the sustainable blueberry budgeting tool.

3.2. Overall Budget Development

Farm enterprise budget development generally consists of three main components: revenue, fixed costs, and variable costs. The budgeting statement is a financial planning tool that estimates revenues and costs for the commodity. For perennial commodities, like blueberries, the budget estimates these values annually beginning with the soil preparation year until the last useful year of production. In the case of blueberries for the south, the interactive budget begins with the pre-plant/soil preparation year, continues with planting and runs for 15 years. It is important to note that while blueberries may produce berries beyond year 15 this is considered to be a reasonable economic planning period for the grower (E. Garcia, personal communication, April 18, 2013). Because this is a multiyear budget, strong consideration must be given to the choice of the appropriate inflation rate, interest rate and discount rate. The individual parts of the budget, as well as these other important considerations, are discussed below.

3.2.1. Variable Costs

Variable cost refers to all expenses which occur in a given production year and can vary in units used. Examples of variable costs include operating labor, fertilizer, pesticides, harvest containers, and so forth.

3.2.1.1. Labor

Labor is required for a variety of activities in any given production year. Those activities can involve land clearing, cover crop seeding, blueberry planting, pruning, fertilization, pesticide application, irrigation management, and harvesting among others. Labor costs (*L*) in any given year *t* are calculated as equation 3.1 (Kay and Edwards, 1999):

$$\mathbf{L_t = \sum_i^n (P_{L,t} * Q_{L_i t})} \qquad \text{(Eq. 3. 1)}$$

where *P* represents the price of labor, *Q* is the quantity of labor in hours and *i* represents the i^{th} labor activity (pruning, planting, etc.).

3.2.1.2. Other Materials Costs

In addition to labor, variable costs can include the use of fertilizers and pesticides as well as purchases of materials such as plant, mulch and harvest containers and the rental of equipment by the day or hour. Similar to labor, they are priced on a per unit basis but unlike labor that was always measured in hours and priced at a fixed value per hour, in this case the unit and the cost per unit can vary per item. As such, the other material costs (OMC) in a given year *t* are calculated as follows (equation 3.2):

$$\mathbf{OMC_t = \sum_j^m (P_{j,t} * Q_{j,t})} \qquad \text{(Eq. 3. 2)}$$

where other materials can range from *j* through *m* in any given year.

3.2.1.3. Other Expenses

The cost of farm machinery operation is classified as other expense cost category. Generally, machinery operating cost is part of the variable costs; and it can be measured by days, acres, or hours. It covers the cost of repair and maintenance, fuel consumption, lubricant/oil and filter, and machine operating labor. The unallocated expenses occurred along farm operating activities namely, miscellaneous expenses, and opportunity costs shall be listed under other expenses. Opportunity costs may include the interest on operating capital of investing in other investment project outside the farming.

3.2.1.3.1. Repair and Maintenance Costs

According to the American Society of Agricultural Engineers (ASAE) - D. 497.7 (2011), the formula in equations 3.3a through 3.3c can be used to calculate the cost of machinery repair and maintenance:

$$\mathbf{C_{rm} = PP * RF1 \left[\frac{H}{1000}\right]^{RF2}} \qquad \text{(Eq. 3. 3a)}$$

where C_{rm} is the accumulated repair and maintenance costs in dollars, *H* is the accumulated use in hours; *RF1* and *RF2* are the repair factors which can be retrieved from table 15.1 of Srivastava, Goering, Rohrbach, and Buckmaster (2006) and *PP* is the purchased price.

Another simplified way to find the total accumulated repair and maintenance costs is to locate the repair and maintenance factor (*RM%*) as indicated in table 3 by Edwards(2010) or in table 3 by American Society of Agricultural Engineers [ASAE] - D497.7 (2011) and then use the factor to multiply the new list price (LP).

$$\mathbf{C_{rm} = LP * RM\%} \qquad \text{(Eq.3. 3b)}$$

Then, from equation 3.3 b, average repair and maintenance hour is derived by equation 3.3 c below

$$\mathbf{C_{rm}\ Per\ Hour = \frac{C_{rm}}{AHr}} \qquad \text{(Eq.3. 3c)}$$

where *AHr* stands for accumulated total hours used.

3.2.1.3.2. Fuel Consumption and Oil/Lubricant and Filters

The formula to calculate cost of fuel consumption and oil/lubricant and filters per acre is based on the Srivastava et al. (2006). Equation 3.4 is then used to convert the cost to an acre base:

$$\mathbf{C_s = \frac{P_f Q_f}{C_a}} \qquad \text{(Eq. 3. 4)}$$

where C_s is fuel cost per hectare \$/ha, P_f is fuel price \$/liter, Q_f is fuel consumption by engine liter/hour, C_a is effective field capacity during the operation ha/hour.

If diesel is used, the measurement of quantity of diesel fuel is specified in equation 3.5:

$$\mathbf{Q_f = \frac{21.69+0.59\ EP}{1000}} \qquad \text{(Eq. 3. 5)}$$

where Q_f is oil consumption liter/hour, *EP* is kW (Kilowatt) engine power rate.

The total cost of lubricants is estimated to be equivalent to 10 to 15% of fuel costs according to Srivastava et al. (2006). However, in practice, average diesel machinery annual consumption can be calculated by the formula in equation 3.6:

$$\mathbf{C_{ds}(Avg) = PTO\ hp * 0.044 * P_G * AMH} \qquad \text{(Eq. 3. 6)}$$

where C_{ds} *(Avg)* is the average diesel cost in gallons, *\$/gal, hp* is the engine capacity in power take off (PTO) horse power, and P_G is fuel price in dollars per gallon and *AMH* is annual work hours. The above formula in equation 3.6 can also be used to calculate gasoline average consumption cost by changing the fuel factor from 0.044 to 0.60. PTO horse power is generally assumed to be known at purchase by the specification of machine engine in horse power; otherwise, it can be calculated using a string of formulas and coefficients specified in ASAE - EP496.3 (2011).

3.2.1.3.3. Machine operating labor

The formula to find the labor charge for machinery operation is shown in (equation 3.1) above. It is assumed the fertilization and pest control as well as the soil clearance and cover crop activities are performed by farm equipment either by rented or owned equipment. If these activities are operated by rented equipment, the rental cost category shall also list these hours spent in addition to the equipment rental charges on a daily base.

3.2.1.3.4. Interest Expenses on Operating Capital

The expense of interest (I_{Exp}) on operating capital should not be neglected because it represents the value of investment diverted current farm business to other outside source of fund generation. This expense can be calculated using equation 3.7 as follows:

$$\mathbf{I_{Exp} = C_i * TCap} \qquad \text{(Eq. 3. 7)}$$

where *TCap* is the total operating capital at the initial year (soil preparation) including the investment in land purchase, new set of machinery, blueberry bush total purchasing prices, and so forth. C_i can be I_R (real interest rate on capital loan) or other interest rates of other investment projects.

3.2.2. Fixed Costs

Unlike variable costs, fixed costs do not vary by the farm size once the beginning expenditure was set. Fixed costs include machinery depreciation, rent, interest expenses, insurance, taxes, office administration and general utility charges, as well as the salary and management costs. The idea of including the either equal or unequal portion of lump-sum amount of initial purchase of machinery and equipment, loan installment, and initial investment including the site preparation investment cost into fixed cost is to account for the opportunity cost and income tax reduction and accrual accounting concept of having expense at the time the revenue occurs. There is more than one way to calculate the depreciation for farm machinery and equipment and amortization for the land investment to adjust to the market value of the real estate property value. However, for simplicity, it is assumed to use straight-line method which divides the initial cost of asset purchased into equal payment according to its life span.

For the blueberry budget, the categories of fixed costs will be similar across conventional and organic production ranging from irrigation, annual operating fixed cost, and high tunnel if included. These costs are explained below.

3.2.2.1. Annual Operating Fixed Costs

Operating costs can include office administration (phone calls, utilities, paper work and stationery, etc.), annual organic certification, insurance, taxes, and annual marketing fees payable to blueberry association or cooperative membership and so forth. For purposes of this budget we will focus only on those fixed costs that are directly attributable to blueberry production such as items related to machinery and land usage. These fixed costs are explained below.

3.2.2.2. Machinery and Equipment.

The fixed machinery cost contains depreciation, interest, insurance, taxes, and housing cost. The initial part of the fixed machinery cost's formula used in various agricultural production tend to be either capital recovery charge or depreciation plus interest expenses.

Depreciation is a cost of doing business to be deducted from income when calculating income tax. There are four types of depreciation which growers can use to calculate the depreciation: straight line, activity, accelerated and declining balance methods. The interactive sustainable blueberry budget uses the straight line method primarily because it is the easiest method and therefore likely the most user friendly method. Straight line depreciation for the k^{th} piece of machinery is calculated in equation 3.8 (Pritts et al., 1992):

$$\mathbf{Machinery\ Depreciation}_{\mathbf{k,t}} = \frac{(\mathbf{PP_k} - \mathbf{SV_k})}{\mathbf{YT_k} * \mathbf{AMH_k}} \qquad \text{(Eq. 3. 8)}$$

where *PP* is purchase price, *SV* is salvage value, and *YT* is years to trade.

To find the salvage value of a machine as a percentage of the purchase price, the American Society of Agricultural and Biological Engineers (ASAE - D497.7, 2011) Standard recommendation is presented in equation 3.9:

$$\mathbf{SV_n = 100\left[C_1 - C_2\left(n^{0.5}\right) - C_3\left(h^{0.5}\right)\right]^2} \qquad \text{(Eq. 3. 9)}$$

where *n* is the expected machine life, *h* is the average hour use per year, and SV_n is the n^{th} year of the salvage value in percentage of purchased price, and C_1, C_2 and C_3 are the remaining value coefficients which can be found in Table 4.3 of ASAE - D497.7, 2011.

There is an alternative simpler method to estimate the salvage value of the machinery or farm equipment which is based on the varying percentage of the total list price of the machinery or farm equipment depending on the machinery category, or remaining usage periods. The percentages are listed in both ASAE (1996) and Edwards (2011). The list price is the factory assigned price, and generally evaluated to be lower to 85% of the original list price once the asset is purchased based on negotiation.

3.2.2.2.1. Interest

There are two ways to obtain the interest rate. The Farm Service Agency (USDA-FSA) (2014) suggests a 40-year farm capital loan's interest rate of 2.13%. Alternatively the U.S. Federal Reserve (2014) suggests the risk-free rate (3.23% - 30-year maturity). The choice can be made based on the condition of the machinery investment; that is whether it was purchased on loan or with equity.

ASAE-EP496.3 (2011) uses a complex formula to calculate the capital cost of ownership. However, because this method is a bit complex, it may not be the best option for an agricultural production budget that targets non-academics as the primary users. There is another way to find the real interest rate which is found in equation 3.10a:

$$\mathbf{I_R = \frac{1 + I_N}{1 + I_F} - 1} \qquad \text{(Eq. 3. 10a)}$$

where I_R refers to real interest rate, I_N is nominal interest rate, and I_F is the inflation rate.

or equivalently, as simplified in equation 3. 10b:

$$\mathbf{I_R = I_N - I_F} \qquad \text{(Eq. 3. 10b)}$$

Then, the concept of compounding the interest rate can be taken into account later after the capital recover cost is calculated if to take into account the time value of money.

3.2.2.2.2. Taxes, Housing, and Insurance

These costs can be calculated from the estimate in percentage of the average between the purchase price and salvage value. The idea of using the average value is surrounding by the concept of machine erosion and reducing its value to nearly zero at the last period of its life, and thus, assessing its value based on the average price is equivalently balanced. It was recommended by ASAE-EP496.3 (2011) to use the following rate 2% of purchase when the actual data were unknown.

1. Taxes at 1%
2. Insurance at 0.25%
3. Housing at 0.75%

3.2.2.2.3. Capital Recovery Factor (CRF)

The capital recovery factor (CRF) formula can be taken from Luening, Klemme, and Mortenson (1991) is specified in equation 3.11a:

$$\mathbf{CRF = \frac{C_i(1+C_i)^n}{(1+C_i)^n - 1}} \qquad \text{(Eq. 3. 11a)}$$

or to simplify the formula for calculation ease, equation 3.11b may be used:

$$\mathbf{CRF = \frac{C_i}{1-(1+C_i)^{-n}}} \qquad \text{(Eq. 3.11b)}$$

where C_i: opportunity cost of capital; n: length of planning horizon (economic life of machine).

From the capital recovery factor, grower can use the formula above (called “amortization factor”) to find the annual capital recovery charges (ACRC) which is equivalent to (equation 3.12).

$$\mathbf{ACRC = (PP - SV) * CRF + (SV * I_R)} \qquad \text{(Eq. 3. 12)}$$

where PP is the purchased price.

The result is higher than the depreciation + interest costs because of the time value of money, (Leuning et al., 1991).

The list of available machinery and equipment and materials depreciable for the blueberry production will be partly adapted from the machinery listed in the budget development section of the highbush blueberry production guide of Pritts et al. (1992) with additional items actually used on northwest Arkansas blueberry farms such as pneumatic pruner, hand pruner, bed layer, irrigation, high tunnel and landscape fabric.

3.2.2.3. Important Fixed Cost Considerations

3.2.2.3.1. Irrigation

The irrigation structure was set up during the soil preparation year. The specific structure used for the blueberry budget was representative of the system. The materials, quantities and prices are partially adopted from the blackberry budget (Rodriguez, et al., 2014a) with adjustment for the size of the drip tubing to fit the practice by local producers. Details are presented in Chapter 4.

3.2.2.3.2. High Tunnels

High tunnels, like irrigation systems are comprised of multiple materials. However, instead of pricing these materials individually, the system is priced on a per square foot basis as this is the cost unit most commonly used in Arkansas currently (J. Lee, personal communication, October 25, 2014; S. Foster, personal communication, October 25, 2014). It is important to note that some producers may qualify for cost-share from the USDA Natural Resource Conservation Service (NRCS) for tunnel construction (USDA-NRCS, 2014). This new interactive sustainable blueberry budget will allow the users to account for the cost-share provided by the NRCS. The cost of high tunnels per square foot is used in the budget calculation based on information provided by NRCS (Lee, 2014) and local blackberry producer, Foster (2014).

3.2.3. Revenues

Revenue from berry production can come from two sources: berries being sold in the fresh market or berries being sold in processed market. Prices per unit sold will likely vary based on the market in which they are sold. Revenue can be represented in equation 3.13 as

$$\mathbf{Rev_t = P_{BM,t} * \ Q_{BM,t}} \qquad \text{(Eq. 3. 13)}$$

where Rev is revenue and BM represents the market in which the product is sold.

The revenue signifies harvest amount times the berry selling price based on the conventional or organic production system. With the theoretical information provided above, the budget can now be populated with information specific to blueberry production.

3.2.4. Future Value and Present Value Analyses

The interactive sustainable blueberry budget will track costs and revenues over a 15 year production period for the user. It is expected that a producer would want to estimate these costs and revenues as part of the decision making process of determining whether or not to begin a blueberry operation. In year one, the values of future costs and revenues are not known. However, these values can be estimated using equation 3.14 (Callan and Thomas, 2010):

$$\mathbf{FV = PV(1 + I)} \qquad \text{(Eq. 3. 14)}$$

where FV represents the future value and PV represents the present value of the cost or revenue, and I is the inflation rate.

Present value is a procedure that discounts a future value for a cost or a revenue into the value it would hold today (present value). Equation 3.15 illustrates how this is handled:

$$\mathbf{PV = \frac{FV}{(1+r)^t}} \qquad \text{(Eq. 3.15)}$$

where r represents the discount rate. It is important to note that the discount rate is different from the inflation rate. The inflation rate adjusts for changes in the price level whereas the discount rate accounts for the opportunity cost of money.

3.3. Blueberry Production from Year 1 to Year 15

The following describes in general terms the annual blueberry production practices that will be incorporated in this budget. The specific practices, by year and by type of production system used for our case study, are discussed in Chapter 4. Many of the activities, applications, and quantities applied follow procedures described by Pritts et al. (1992). Remaining information has been gathered from university researchers and local producers.

3.3.1. Year 1 - Site Preparation Stage

In this first year of the blueberry operation, the planting site is selected and cleared with machinery and/or pesticides. Soil testing is conducted to determine the need for soil amendments and relevant nutrients approved for the conventional or organic system. Drip irrigation is set up in year one of production across all open field and high tunnel structures for both the organic and conventional production systems.

3.3.2. Year 2 – Blueberry Plant Establishment Stage

Two-year old blueberry plants are established in this year at a rate of 1,250 plants/A applying a space of 0.9 m (3 ft) within row and 3 m (10 ft) between the rows. These plants are established with peat moss and then covered with mulch. One third of the initial mulch is replaced every year. Landscape fabric is placed in the planting beds with holes left for planting and nutrients injection or mulch added later years. Appropriate nutrients are applied in each system and irrigation rates are set to obtain 20% of water volume used in open field per year (because tunnels are covered, the irrigation water use will be higher inside the tunnel than outside). Labor needs including planting, weeding, pruning/flower removal among others.

3.3.3. Year 3 – Vegetative Stage

In year three, the plants have been established for a year. Pesticides are applied where allowable to control for weeds and fungus. Nutrient applications continue to help ensure plant growth. Soil testing is repeated and leaf analysis begins. Primary labor costs include fertilizer/pesticide application, and pruning.

3.3.4. Years 4 to 6 – Beginning Production Stage

In year four, bees are introduced to the production system. Honey bees are used for field production while bumble bees are placed in the high tunnel systems. Pesticide, nutrient and management practices continue, as does leaf analysis. Labor is charged for each of those activities. Harvesting begins and can be handled through hired labor when the product is taken to market. Or it can be done by customers when it is a U-Pick operation. In addition to harvest labor, harvesting materials including packaging materials and perhaps a grading table may be purchased. Yields begin and increase each year through year 6.

3.3.5. Year 7 to 15 – Full Production Stage

In year seven, the blueberries reach full harvest. This full harvest yield is expected to continue through the remaining years of the 15 year time frame. Each plant is expected to yield approximately one gal of berries at full production if healthy plants are managed properly. The activities of nutrient applications and pest control and plant care of pruning, mulching, and folia and soil test are maintained.

3.4. Yields and Prices

Based on the Arkansas blueberry production history, almost all berries harvested have been sold in the fresh market; only a small quantity was reported sold for processed market (USDA, NASS, 2013). In recent years, all blueberries produced in Northwest Arkansas have been sold on the fresh market (L. Dozier, personal communication, October 09, 2014). Thus, one hundred percent of harvest is assumed to be sold to vendors the same day without needing to use the cooler storage except grading tables, and harvest containers.

Chapter 4 describes the economic analysis that is conducted for the blueberry budget case study.

Chapter 4 – Blueberry Production Budget and Economic Analysis

4.1. Comparison among Budgets of Different Blueberry Production Systems

4.1.1. Development of the Blueberry Production Budgets

As indicated in Chapter 3, the economic life of the blueberry production system is assumed to be fifteen (15) years for the current budget development. The budget begins with at the soil preparation state which is called year one (1). Blueberry plants are established in year two (2). Year three (3) is expected to be the vegetative stage where, pending no unexpected problems, no major applications of fertilizer or pesticide are applied. Years four (4) through six (6) are known as the beginning production years. In year seven (7), blueberry reaches full production stage. From year seven (7) to year fifteen (15), the production stage is maintained through routine management practices.

This interactive sustainable blueberry budget can be used to examine four production systems: organic open field, conventional open field, organic high tunnel, and conventional high tunnel. In order to look at these systems, four baseline scenarios (one for each system) comprised of production activities, their levels and prices and associated yields are developed.

A review of the literature (Table 4.1) identified a range of practices that could be relevant in southern systems. Often times when systems were compared, the outcomes (in terms of yield, quality of fruit, prices, profits and other considerations) showed varying, and sometimes contradictory, results. Therefore, the literature information was coupled with local expert opinion (Garcia, 2014; C. Rom, September 18, 2014; Dozier, 2014; Lee, 2014; Foster, 2014) to develop the default scenarios used in this analysis.

Tables A.1 through A.9 in the Appendix A present the practices, levels, prices and sources for the information that was used in the development of the baseline scenarios. Some practices/assumptions were the same across all four systems while others differed.

Table 4. 1 Summary of Conventional and Organic Production Practices Effects on Yields, prices, Quality and Profits

	Production System	Yields	Profits	Prices	Other Factors	Results/ Conclusion
Bonti-Ankomah and Yiridoe (2006) Demand in organic produce	Organic			Price premium and consumer behavior study	Demand driven factor for organic produce: health and safety	
Brumfield, Rimal, and Reiners (2000) Crops: Tomato, sweet corn, and pumpkin Location: New Jersey	Organic		Organic production had the lowest profit; however, still very closed to conventional production due to price premium		ICM is the most profitable (Integrated Crop management)	
Dalgaard, Halberg, and Porter (2001) Study on 8 crops on different soil types. Location: Denmark	Conventional				Energy used lower in organic cultivation	
de Ponti, Rijk, and van Ittersum (2012) Study: meta-analysis (362 comparative crop yields)	Conventional and Organic	Average organic yields: 80% of conventional counterpart (standard deviation 21%) by groups of crops and zones				Organic facing pest and disease. Further studies on nutrient availability in both organic and conventional cultivation systems are recommended

	Production System	Yields	Profits	Prices	Other Factors	Results/ Conclusion
Fonsah et al. (2013)	Organic Rabbiteye Blueberries		It is still questionable if price premium will be able to offset the higher cost and lower yield	Blueberry is usually received a price premium for organic fruit. (Some years, 100% above conventional counterpart), based on the study reported from Krewer and Walker, 2006. However, Without price premium, studies by Fonsah et al. (2013) showed profitability in organic soybean and grain.	No market for Georgia organic blueberry growers – So it is still not known until the price is set. However, uncertainty in crop loss due to weak pest control in organic cultivation and higher cost of production make it a fear to ensure organic producers a promising net returns in growing organic blueberries	
Gabriel, Sait, Kunin, and Benton(2013) Study: Crop yields and species density Location: England	Organic	Grain 54% yield lower in organic fields compared to conventional counterpart				Increase in biodiversity proportionally reduce yields
Ierna and Parisi (2014)	Conventional and Organic	Organic: less productive (3		-	Cropping: Season dependence	Need further studies on

	Production System	Yields	Profits	Prices	Other Factors	Results/ Conclusion
Early crop: Potato. Study: Compare growth and yields (conventional and organic cultivation) Location: Italy		seasons) – New organic cultivar showed highest yield				environmental impact on organic cultivation
Julian et al. (2011a, 2011b) 25 years of blueberry production Location: Oregon	Conventional and Organic		Smaller than 5-acre blueberry cultivation: Net Loss (conventional)	Grower price (20% to 100%) higher than conventional fruits		
Krewer and Walker, (2006) Crop: blueberry	Organic			Price premium 20% or more on organic produce above the conventional counterpart	Authors suggested growing rabbiteye blueberry organically, easier grown than highbush cultivars	
Maguire, Owens and Simon (2004) Study: organic babyfood price premium Location: California, North Carolina	Organic			Price premium for organic babyfood to compensate the reduced pesticide use	Consumer willingness to pay for organic price premium	
Nemes (2009) Study: Profitability of organic and conventional productions in developed countries	Organic	Lower yields	Profitability in organic system is possible if attaining price premium, cost reduction, and demand		To succeed in organic cultivation in developing countries, a need of development of main crop market for organic soybean, wheat,	Profitability depends on varieties of crop selection; thus, it is not comparable between the two systems

	Production System	Yields	Profits	Prices	Other Factors	Results/ Conclusion
					chili, etc. which has potential to obtain a price premium	
Pimentel, Hepperly, Hanson, Douds, and Seidel (2005) Legume (soybean, corn) Location: Pennsylvania	Conventional and Organic	Yield are found to be similar to conventional counterparts	Organic had lower profit over 10-year study		Organic cultivation is advantageous in water preserving condition compared to conventional counterpart	Conventional can be more sustainable if partly adopted organic technology into cultivation
Seufert et al. (2012) Meta-analysis	Conventional and Organic	Compared to conventional counterpart, organic yields are ▪ 5% lower (legumes and perennials/low-alkaline soils), ▪ 13% lower (best cultivation practice is applied) ▪ 34% lower (when both systems are comparable)				Organic yields are lower than conventional yields
Stanhill (1990) Studies of 205 cases of organic and conventional yield comparison	Conventional and Organic	Milk and bean have higher yields than conventional counterparts (the greater ratio, more than 1.0)				Yield is not attestable affected by organic cultivation practice due to climate, and cultivation system interim effects

4.1.1.1. Harvest Yields and Materials

As described in Chapter 3 measurable blueberry yields for the baseline setup are expected to begin in year four at a small quantity. Baseline yield is estimated to double annually in years five and six until reaching full production in year seven (Dozier, 2014). Full production yields for blueberry base case are expected to be in year seven at one gallon (6 lb) per plant (equivalent to 2,720 g or 2.72 kg) or equivalent to roughly 8,400 $kg.ha^{-1}$ (7500 lb/A) if blueberries are chosen to be grown 1250 plants/A.

For these baseline scenarios, the farm is assumed to use the baseline yields described earlier were from the operation known as “U-Pick,” where fruit is sold directly to customers who personally pick the berries by themselves at the farm. This type of operation was chosen as it is typical of the farms that exist in Northwest Arkansas. Growers can save money on costly harvesting labor and avoid long distance shipping problems, including quality maintenance. Kuepper and Diver (2004) suggest the U-Pick system is suitable for small family sized farm businesses of up to 15 acres.

Based on previous studies on organic and conventional production as presented in Table 4.1, and personal communications with Dr. Rom (2014) and Mr. Dozier (2014), baseline yields across all four systems are assumed to be the same, and 100% of all berries are picked and sold through the U-Pick operation. Detailed information on baseline scenarios are presented in Appendix A, Table A1 to A8. Across four systems, berry price is assumed to be the same for the baseline organic high tunnel and organic open field budget which are assumed to be 10% higher than the baseline conventional high tunnel and conventional open field budget, owing to the studies on prices of organic produce and willingness to pay by consumers (Table 4.1). Conventional berries are expected to be sold at $13.00 a gal which is the 2014 price in Northwest Arkansas (Dozier, 2014). Organic fruit premium price is closely examined in the sensitivity section.

Harvesting materials and preparation are expected to follow the schedule of the harvesting years starting from year four (Beginning Production Stage). To boost the yield, three bumble bee hives costing $35 per hive are placed across the blueberry farm beginning in year four and removed every year. Further, one (1) grating table and blueberry containers (170 pails and 4 cases of 1000 plastic bags) are purchased. No container lids are used for the budgeting original base.

A one-gallon-pail is used in the U-Pick operation and common white plastic bags with dimensions of 11 ½ in wide by 6-in depth by 21-in length are also needed to pack the harvested fruits for customers. A purchase of 4-case plastic bags containing 1000 bags is repeating every year from year four. It is adequate to serve the one-acre U-Pick operation opening twice per week with an average of 700 customers (per 3 A) of a maximum 8-week harvest (Dozier, 2014).

To calculate a number of pails needed at the start of the first harvest business, a gathering of information of seasonal yields, harvest periods, and also the custom U-Pick operation is used as a supporting reference. The harvest season for blueberry generally runs from mid-May to mid-August in the United States depending on blueberry cultivars, (Boyette, Estes, Mainland, and Cline, 1993; Strang, Jones, and Brown, 1989). Mostly, ripening periods take two to five weeks for each blueberry cultivar, (Polomski and Reighard, 1999). For commercial purposes, generally, growers tend to plant more than one cultivar to provide longer productivity periods lengthening a wide range of ripening periods of different cultivars; and different kinds of cultivars can provide better cross pollination, as indicated by Strang et al. (1989), which results in fruit size increase. As for U-Pick operation, it requires about 100 to 200 customers each week to pick an average of 10-lb blueberry (Foulk, 2013); 450 U-Pick customers can harvest an acre of 6000-lb blueberries with an average of 11.7 lb (Kindhart and Holcomb, 1994; Strang et al., 1989).

For the budgeting base case scenarios, the assumption is to have mixed cultivars of blueberry plants purchased at the price averaging by all cultivar prices, $5.00 per plant for both organic and conventional systems, as demonstrated in the Appendix A; and assumed overall-cultivar harvest period of 8 weeks. According to Dozier (2014)'s experience of growing blueberry since 1987 at his farm in Tontitown, Arkansas, a mixture of cultivars yield for approximately 6 to 8 weeks with a picking frequency of twice per week. The selling price of berries are assumed the average rate across all cultivars in the baseline case following the practice that Mr Dozier charged the average rate of $13.00 per gal across all cultivars even though in reality it is based on fruit sizes and cultivars. Nonetheless, practical experience shows a higher quantity requirement of packaging materials. Based on experience of local producer (Dozier, 2014), he needs 500 pails to serve around 700 customers twice per weeks on the three-acre blueberry farm. For the budget baseline case, it is followed the concrete experience of the local grower; totally, for an acre operation, about170 pails of one-gallon volume are purchased in year four (the first harvest operation) and repurchased every ten years.

During the harvest season, food safety rules require the availability of a porta-potty and a hand washing station (S.C. Seideman, personal communication, September 22, 2014). In this budget, a porta potty is rented at a cost of $150 per month (Zters, personal communication, September 22, 2014) and hand washing station at a cost of $25 per month for the duration of the harvest season.

4.1.1.2. Soil/folia Test

It is important to start the blueberry production with soil testing in the soil preparation year and again in the establishment year to oversee the necessity of soil pH modification applications. After this stage, soil testing is recommended just every other year (Garcia, 2014) unless problems are detected that require repeated observation (Dozier, 2014). Leaf (folia) analysis, is expected to start in year three (vegetative stage) and continue for all remaining years so that the fertilization application will follow the result of the leaf analysis.

The leaf analysis is priced at $20.00 (Dozier, 2014) to $25.00 (Garcia, 2014) per test annual analysis is recommended (Garcia, 2014). In this study, the price used ($20.00) is that charged to the local farmer. Regionally, the price of routine soil testing ranges from $0 in Arkansas, (Arkansas Agricultural Experiment Station, “Soil Test Analyses,” 2014) to $6.00 in Mississippi (Mississippi State University [MSU] Extension, 2002) to $10 in Missouri and Oklahoma (University of Missouri [MU] Extension, 2012; and OSU, 2014a). These baseline scenarios have been developed for Arkansas and therefore the assumption is that the soil test is free. Soil test is done in year one, year two and then once every other year which are year four, year six, year eight, and so forth until the full cycle of the production.

For the budgeting purpose, soil modification is assumed required and soil condition is assumed sandy loam with a high pH; 6.2 pH for open field organic plot and 6.7 pH for organic blueberry plot inside the high tunnel structure, (L. Freeman, personal communication, May 29, 2013); and thus the active treatment is elemental sulfur for organic production system and ammonium sulfate for conventional production system followed by other applications describing in the planting materials' section below.

4.1.1.3. Planting Materials (Blueberry Farm Supplies, and Hand Tools)

In year two, approximately 1250 two-year old blueberry plants are planted on the one acre site, assuming plant spacing of 0.9m (3 ft) in rows by 3m (10 ft) between rows leaving a cross-walk of about every 61m (200 ft) for a turn-around space as stated by Kindhart and Holcomb (1994). The design of the planting area of Dozier's farm is to leave the ending both sizes of the field of about 3 to 5 m (10 to 15 ft). The estimated price for the two-year old conventional blueberry bush is $3.05 in Arkansas (Arkansas Berry and Plant Farm, 2014); however, to ensure a virus-free bush, the certified source should be consulted. Following Dozier (2014)'s experience, growers may pay a higher price of up to an average of $5.00 per conventional bush to obtain the high quality blueberry, such as from Oregon nursery farm (Fall Creek Farm and Nursery, 2014). The price of conventional blueberry plant, $5.00 per plant, is used also for organic production base case due to the fact that it takes three years in farming practice organically.

Other materials needed in only the year for planting include peat moss at 1.89 l/plant [half a gal/plant] (5,843.75 $l.ha^{-1}$ or 625 gal per 1250 plants/A), Garcia (2014), is applied to the soil for the organic and conventional system. Peat moss is suggested at a rate of one lb/plant (Kindhart and Holcomb, 1994), mixing soil with wet peat moss of one gal/hole in the bottom while preparing the planting, or applying at a rate of a bale of 0.17m^3 (6 ft^3) of peat moss per 45 plants, (Strang et al., 1989), or 0.04 to 0.06 m^3 [1.5 to 2 ft^3/plant] (Foulk et al., 2013). A compressed bale of 6 ft^3 of peat moss is equivalent to 0.3 m^3

(10 ft^3) of peat moss, and about 10% to 15% shrink during the mixture of soil, (Boodley and Sheldrake, 1982). Polomski, (1999) and Mainland and Cline (2002) suggested applying the equal amount of sand and peat moss of 1 ft^3/plant. According to Jasinski, Milanovich, and Coleman (1999) a bulk of peat moss (sphangnum moss) contains 219 $kg.m^{-3}$ which is equivalent to 369 $lb.yd^{-3}$ (multiply by 1.685 to convert from $kg.m^{-3}$ to $lb.yd^{-3}$) or 13.67 $lb.ft^{-3}$. If peat moss is measured in packaging unit rather than in bulk, it contained 169 $kg.m^{-3}$ (10.14 $lb.ft^{-3}$); 210 $kg.m^{-3}$ (12.6 $lb.ft^{-3}$) in bulk and package.

Sphangnum moss, hypnum moss, reed-sedge, and humus, all are classified as peat moss category, (Jasinski et al., 1999). For budgeting case, Sphangnum moss is used and different types of peat moss are considered for other scenarios analysis for economical reason. According to Carroll (2013), soil amendment of peat, compost, and sand is more appropriate for a small scale of farm operation because peat is costly. Based on Garcia (2014)'s recommendation of applying peat moss 0.5 gal/plant, assuming used peat moss of 3 lb at equivalence to half a gal/plant, so total quantity of peat moss is used at 4,200 $kg.ha^{-1}$ (3,750 lb/A) and cost $1,311.82/A (equivalent to $3.69.$ft^{-3}$ multiplied by1250 plants/A multiplied by 10.55 $lb.ft^{-3}$ multiplied by 3 lb/plant).

Wood chips or other types of wood mulch, like shredded hardwood or sawdust mulch are needed at 5,600 $kg.ha^{-1}$ (5000 lb/A), according to Pritts et al. (1992), for the first time of application in year two followed by 1/3 of quantity for subsequent years (Garcia, 2014). At Mr Dozier's (2014) U-Pick operation mulch applied at a semi-load (2.47 $tons.ha^{-1}$ [or one ton]) per acre once every four years. In the budget development, following Dr. Garcia's suggestion, expense on mulch occurs in year two followed by next applications repeated at 1/3 from year three. Furthermore, hand tools of five (5) hand hoes are purchased in year two and it is assumed they will last for six years and new replacement is expected to repurchase in year eight (8) to be used for the rest of the production cycle. While chippers are used for some commercial operations, in Northwest Arkansas producers do not chip their branches and use as mulch for fear of spreading disease to healthy plants (Dozier, 2014). Instead, pruned branches are assumed burned.

Prices associated with these items can vary by time, of the quantity needed, and location, among other things. A summary of selected suppliers and prices of materials in 2014 prices is available in the Appendix A. For the baseline case, materials pricing is estimated and used the average ranges. Sensitivity analyses will be conducted later in this chapter to address volatility in prices.

Specifically for organic high tunnels and organic field production, additional plastic film (38 x 1,219m [125 x 4000 ft]) is needed. Adopting the similar prices and units needed from Rodriguez et al. (2014b) 6.75 rolls.ha^{-1}/3 rolls are assumed adequate for an acre based blueberry farm. Every season, manual labor of four (4) hours is employed to set up and remove the plastic mulch to reduce soil heat. The rolls of fabric are expected to last for five years. Therefore, while the labor for set up and removal must be charged every year, the cost of the fabric is only charged in years two (2), seven (7) and twelve (12). Overall, it is assumed no plant replacement is needed for a well maintained production during the total fifteen years.

4.1.1.4. Fertilizer, Cover Crops and Soil Modifiers

Fertilization practices will vary between the conventional and organic systems. For the conventional production system, soil modifier of ammonium sulfate (34 kg [75 lb]) listed in Pritts at al. (1992) is used from the soil preparation stage (year one) followed by 91 kg (200 lb) every year and maintained that level, (Garcia, 2014).

During year one for the baseline organic production system, a soil modifier like sulfur and a soil nutrient booster like pelleted poultry manure are used (Garcia, 2014). While poultry manure is readily available in northwest Arkansas, its use is not a common practice by local blueberry growers (Dozier, 2014). Further the U.S. Highbush Blueberry Council (2002) suggested avoiding fresh manure application. This base case uses the scenarios at Dozier’s farm operation as a main guide in combination with recommendations by Garcia (2014) and Pritts at al. (1992)’s when Dozier’s activities are not applicable.

Legume seeds cover crop used as soil nutrient booster during the soil preparation and Orchardgrass seeds used as row cover to resist weeds are recommended by Garcia (2014) across all production systems; and the quantity applied is based on the label of each application. There are several types of legume, for the baseline budget, cowpeas are selected to fit the southern region.

Beginning year two in organic baseline production, fish meal (contained 9% nitrogen) is applied every year repeatedly at the similar actual nitrogen quantity (17 kg [41 lb]) as used in the conventional production.

From year four and subsequent years, actual micronutrients are needed based on the result of the folia analysis. As for the baseline budget, the assumption on the quantity of micronutrients is applied by the average label reported explicitly in the Appendix A.

4.1.1.5. Labor

Table 4.2 below summarizes the estimated machinery operation hours used. Machinery needs and estimated use time are partly adopted from Pritts et al. (1992) as well as the personal conversation with Mr. Dozier (2014). The miscellaneous hand tools' hours include hours to prune, to backpacked spray, and to maintain irrigation, etc. Other activities with no specific purposes other than the category listed are registered under the miscellaneous tools are assumed to be additional two hours each year.

Based on a local producer (Dozier, 2014), when hand pruners are used, it takes about 1 minute/plant for the first two year after planting and after that stage, it takes the average 2.5 minutes/plant. The hours to prune are assumed to be based on pneumatic pruner usage, which takes 30% less than hours used by hand pruners (Dozier, 2014). Totally, for an acre of 1,250 plants; it takes 16 hours for year three and year four; and 40 hours from year five of production stage. Pruning this way (as opposed to hand pruning) is the assumption used in the base case as it is the most common practice in Northwest Arkansas. Pritts (2004) states that removing about 20% of the aging branches, does not interfere with yields at all. Also, Pritts further stated that constant pruning should be maintained to have a consistency in yields from year to year. Pritts recommends light pruning is done during the early years and more pruning should begin when canes reach mature stage.

Practically, for a small farm operation (one to fifteen acres), producers tend to have at least one tractor to perform multi functions using attachments. For example, Mr. Dozier owns 30-hp and 24-hp tractors and other machinery and implements. However, for an acre operation budgeting, one 30-hp tractor in the baseline reflects those used by the small farm producers; its hours include more hours associated with multi-tasks in the soil clearance and tilling/plowing, bed shaping, mowing, spreading mulch and fertilizer, spraying pesticides, and cleaning up after harvest (U-Pick service). The spreader's and sprayer's hours are assumed to follow the annual applications of fertilizer spreading and pesticide sprays, respectively. The use of mulcher is expected to occur from year two; its machinery hours are assumed 6 hours by quantifying the hours used in Pritts et al. (1992). Within year two, a bed shaper's (bed layer/turn blade) operating hours are assumed 0.80 hour per acre adopted from MSU (2010) in addition to manual labor hours used in planting and plastic mulching. The average hours are defined to be used in the machinery annual ownership cost as a constant rate every year without changes; such as variation of hours used each year, replacement of machinery implements, or tractors out of life; over the entire life of the 15-year blueberry farm. However for simplicity in the interactive tool, the calculation will match the way to calculate in this thesis, applying an average constant rate. Hence, the machinery operating labor across four production systems is also adopted the average hours used per annum based on machinery hours.

The hand labor and management schedules are summarized in Appendix A. Labor hours for machinery operation are calculated as machinery time times 1.2. This extra 20 percent is used to account for traveling to the field, oil or filter changes, fuel refill, repair, and so forth (Kay and Edwards, 1999). Machinery operating hours for baseline organic production both inside the high tunnels and in the open field are assumed extra 10% of the conventional production machinery operating hours to accountable for the extra load of fertilizer, Strang (2014).

Table 4. 2 Summary of Tractors and Machinery's Hours Used

Machinery Description	Annual Hours							Total Hours (15 Years)	Average Hours per Annum
	Y1	Y2	Y3	Y4	Y5	Y6	Y7-15		
30 hp Tractor	3.55	4.95	4.35	7.75	7.75	7.75	7.75	105.85	7.06
Mower	0.50	1.00	1.00	2.00	2.00	2.00	2.00	26.50	1.77
Air Blast Sprayer				2.00	2.00	2.00	2.00	24.00	1.60
Bed Shaper		0.80						0.80	0.05
Boom Sprayer	0.80	0.80	1.20	2.40	2.40	2.40	2.40	31.60	2.11
Disc	0.55							0.55	0.04
Mulcher		2.00	1.00	1.00	1.00	1.00	1.00	15.00	1.00
Plow	1.10							1.10	0.07
Spreader	0.60	0.35	0.35	0.35	0.35	0.35	0.35	5.50	0.37
Tiller - 5 feet		1.00						1.00	0.07
Miscella-neous Hand Tools	2.00	2.00	18.00	18.00	42.00	42.00	42.00	502.00	33.47
Total Hours Used	9.10	12.90	25.90	33.50	57.50	57.50	57.50	713.90	47.59

Source: activity hours listed in Table 4.6 above are partially taken from Pritts et al. (1992), Dozier (2014), and MSU (2010).

Mulching is done primarily with the machinery (and hand labor is included in the miscellaneous category) and takes approximately two (2) hours per acre (Pritts, et al., 1992). No harvest labor hours for the operation are needed when the operation is a pick-your-own or U-Pick system. A small number of labor hours however are relegated to pre harvest and post-harvest cleanup activities. Other labor hours are logged for the remaining activities of soil and folia test sample collection, and management oversight hours, both based on Pritts et al. (1992) at one hour for each activity. Extra 18 hours are added for the baseline organic field and high tunnel budgeting for weeding by hands, synthesizing the number of hours from Jimenez, et al. (2009); Julian et al., (2011b); and Woods (2014). Additional 10 hours are assumed for baseline high tunnel production budgeting both organic and conventional system, adopted the hours from Galinato, and Walters (2012); and Wright (2014).

4.1.1.6. Tractors and Machinery

In the baseline budget, 100% ownership of needed equipment is assumed as this follows the practices of the blueberry producers in Northwest Arkansas The machinery list was based on the equipment used on the Dozier Farm as well as Pritts et al. (1992) and assumed to be brand new at the start of the operation. Useful life, average annual hours used, and hours used in operation for this equipment was taken from both Pritts et al. (1992) and Dozier (2014). Salvage values were needed to calculate machinery costs. Salvage value for the machinery was calculated using the equations in Chapter 3 as well as the salvage value coefficients listed in Table 3 of ASAE D497.7 (ASAE Standards, 2011). Those used in this study are presented in Table 4.3.

Table 4. 3 Summary of Assumed Salvage Value for the Machinery List

Machinery List	Estimated SV % of List Price
Tractors	24%
Air Blast Sprayer	34%
Bed Shaper	22%
Boom Sprayer	34%
Disc	22%
Mulcher	22%
Plow	29%
Spreader	34%
Tiller (five feet)	22%
Miscellaneous Tools	26%

Tables 4.4 below summarizes some of the important characteristics of the machinery used in this analysis. Details on the pricing of this equipment can be found in Appendix A (Table A.9). Using the information in Tables 4.3 and 4.4 as well as the information in the Appendix, the annual fixed costs for the machinery were calculated and are presented in Table 4.5.

Table 4. 4 **Selected Characteristics of Tractors and Machinery**

Equipment Description	List Price[1]	Purchase Price[1]	Salvage Value (SV) [1]	Average Value[1]	Ownership Life (Years)	Estimated Annual Hour Use	Average Hour Allocated to Blueberry
30 hp Tractor	$23,690.00	$20,600.00	$5,591.69	$13,095.84	15	250.00	7.12
Mower	$1,840.00	$1600.00	$451.64	$1,025.82	15	100.00	1.77
Air Blast Sprayer	$1,380.00	$1,200.00	$465.69	$832.84	15	150.00	1.60
Bed Shaper	$534.75	$465.00	$115.61	$290.31	15	160.00	0.05
Boom Sprayer	$690.00	$600.00	$232.84	$416.42	15	100.00	2.11
Disc	$948.75	$825.00	$205.12	$515.06	15	20.00	0.04
Mulcher	$4,600.00	$4,000.00	$994.51	$2,497.26	15	100.00	1.00
Plow	$575.00	$500.00	$168.09	$334.05	15	60.00	0.07
Spreader	$390.94	$339.95	$131.92	$235.94	15	40.00	0.37
Tiller - 5 ft	$1,782.49	$1,549.99	$385.37	$967.68	15	50.00	0.07
Miscellaneous Tools. (Pneumatic pruner, backpacked spot sprayer, etc.)	$1,006.25	$875.00	$264.92	$569.96	15	100.00	33.47
Total	$37,438.18	$32,554.94	$9,007.41	$20,781.17			$47.66

[1] dollars are nominal 2014 dollars

Source: purchased prices are selected from the price list presented in the Appendix A except mulcher which is based on information by local grower (Dozier, 2014). Some machinery items are partially adopted from Pritts et al. (1992) and local producer (Dozier, 2014).

Table 4. 5 Summary of Tractor and Machinery Annual Fixed Costs in Nominal 2014 Prices

Equipment Description	Ownership Costs per Hour	Ownership Costs Per Annum	Annual Capital Recovery Charge (ACRC)	Annual Capital Recovery Factor	Annual Taxes	Annual Housing	Annual Insurance
30 HP Tractor	$7.51	$53.48	$46.02	9%	$3.73	$2.80	$0.93
Mower	$1.45	$2.56	$2.20	9%	$0.18	$0.14	$0.05
Air Blast Sprayer	$0.69	$1.11	$0.93		$0.09	$0.07	$0.02
Bed Shaper/Turn Blade	$0.27	$0.01	$0.01	9%	$0.00	$0.00	$0.00
Boom Sprayer	$0.52	$1.09	$0.92	9%	$0.09	$0.07	$0.02
Disc	$3.80	$0.14	$0.12	9%	$0.01	$0.01	$0.00
Mulcher	$3.68	$3.68	$3.18	9%	$0.25	$0.19	$0.06
Plow	$0.74	$0.05	$0.05	9%	$0.00	$0.00	$0.00
Spreader - 350-lb capacity	$0.74	$0.27	$0.23	9%	$0.02	$0.02	$0.01
Tiller - 5 ft	$2.85	$0.19	$0.16	9%	$0.01	$0.01	$0.00
Miscellaneous Tools. (Pneumatic pruner, backpack spot sprayer, etc.)	$0.79	$26.32	$22.51	9%	$1.91	$1.43	$0.48
Total	**$23.03**	**$88.92**	**$76.33**		**$6.30**	**$4.72**	**$1.57**

4.1.1.7. Pest Control

There are several types of pest control applications. The practices and the quantities recommended differ by actual farm conditions. Here, the pesticide assumption is that the same quantity of the pest control ingredient is used in both open field and high tunnel production systems; and “pesticides” here in this budget specifically is referred to all treatment applications including for herbicides (in conventional production), fungicides and insecticides. For the conventional field and all other production systems, the current base case will use the medium applications of the maximum dose indicated on the label. The estimated prices and average quantity of pesticides used for the baseline budgeting are obtained from a survey of some local suppliers in Arkansas by Dr. C. Lewis (personal communication, August 14, 2014) and other online sources which are listed in Appendix A (Table A.9).

The flat-headed borer and Spotted Wing Drosophila fly are troublesome for growers to manage without treatment. According to Studebaker et al. (2014), for Arkansas area, Sevin XLR, Sevin 80s, Imidan 70W will be able to control the situation for conventional production and Entrust is applied for the organic production. As for the budget scenario, Sevin XLR is applied for the conventional production system both in the open field and in high tunnels. Traps and baits are used in both organic and conventional production as recommended by Garcia (2014).

4.1.1.8. Irrigation

In this budget, the drip irrigation system developed by Rodriguez et al. (2014a) is used; the detail can be referred to in Table. 4.6 below. The total cost of the design per acre is $2,498.00 in 2014 nominal dollars. The annual fixed costs of irrigation (amortization rate), containing annual insurance and tax (the same calculation method for tractor and machinery’s) and annual depreciation (amortization) and interest expenses, uses the total irrigation setup cost times capital recovery factor of 9%, equivalent to $229.01/A per annum (for interest plus the irrigation depreciation). The capital recovery method is used at the nominal interest rate of 4.28%, the average interest rate for farm credit for Arkansas (D. Keeton, personal communication, October 16, 2014) in Northwest Arkansas. It is assumed that the irrigation system has a useful life of at least 15 years with no remaining salvage value, and the system is connected to a city water supply. During the harvest season, it is assumed that plants need 1 gal of water per day for those eight weeks and one gallon per week for thirteen (13) weeks continuing from the end of harvest period ending until the freeze time arrives in October (Dozier, 2014). No watering is applied during the winter freezing period (assumed 16 weeks). During spring time, watering resumes for about 15 weeks at a rate of one gallon per week. Gluck and Hanson (2011) recommended removing the high tunnel structure (if used) during the off-season to receive more rain water that can wash the soil and reduce salinity of soil.

Because of the establishment of a cover crop in year one (soil preparation stage), watering starts in year one applying at the quantity of 4 $l.m^{-2}$ (4,276.74 gal/A), as recommended by the Department of Agriculture, Forestry and Fishery of South Africa (2013). From year two, the baseline open field production budget uses the water application at an extra 20% on the water volume used by Mr. Dozier to account for watering the row cover Orchard grass planting between the rows of blueberry plants, (Critchley and Siegert, 1991).The high tunnel systems are assumed to use a higher (20% more) water level than used in the open field systems.

Table 4. 6 Drip Irrigation Details in Nominal 2014 Prices

Materials and Labor	Unit	Quantity	Unit Price	Total Cost
1" Drip tube	Ft	4000	$0.385	**$1,540**
1"x10' PVC schedule 40 pipe	Unit	40	$3.40	**$136**
Miscellaneous adapters, elbows, and couplers	Unit	140	$1.00	**$140**
Pressure reducers 1" inline	Unit	12	$15.00	**$180**
Purple primer	Unit	4	$10.00	**$40**
PVC cement	Unit	4	$6.00	**$24**
Solenoid valve	Unit	4	$50.00	**$200**
Y strainers	Unit	12	$9.00	**$108**
Labor	Hr	10	$9.00	**$90**
Total Cost				**$2,498**

Source: list of irrigation installation items are partially adopted from Rodriguez et al. (2014a).

4.1.1.9. High Tunnels

When grown in high tunnels, Renquist (2005) showed that highbush blueberry (Toro, Nui, Legacy, and Misty) yields increased from one to four times compared to the open field grown. As for season extension, result shown in the study proved the early ripening period ranges from one to three weeks compared to the field grown blueberry. However, it is noted that by the author that the result was based on cultivar selected and the experiment was tested using blueberry plants grown in the pot. As indicated in literature review section 2.9.4 of Chapter 2, Santos and Salame-Donoso (2012) also found yields increased for blueberries grown inside the high tunnels compared to yields of open field production. However, study by Ogden and van Iersel (2009) reported low yields and crop loss during two years of high tunnel production trials due to freeze damage and low flower set. The problems of pest, climate, soil salinity, and pollination found in high tunnel production were reported by Bal (1997). To date, there is no result related to blueberry production in Arkansas regions. Personal communications with Dr. Rom (October 18, 2014) and Dr. Garcia (November 10, 2014) suggested no yields of blueberry production in high tunnels to be higher than yield of field production Therefore yields in both tunnels and fields are assumed to be the same for the baseline scenarios which are summarized in Appendix A.

The cost of small (much less than one acre) tunnels can range from \$2.17 to \$3.14/ft^2 excluding labor costs (Foster, 2014; Lee, 2014); this rate also varies by the height of the high tunnel selected. However, for construction of a tunnel that will cover an entire acre the multibay high tunnel type is more commonly used as it is cheaper. Therefore, the baseline high tunnel is based on the price \$0.96/ft^2 excluding labor costs (Haygrove company, 2014). The additional cost of labor to construct the high tunnels is estimated at 250 hours per acre (Blomgren, and Frisch, 2007; Goldy and Francis, 2005) times the labor wage of \$9.00 per hour. So in total, an acre of tunnel will cost \$44,067.60 and assumed to last for 15 years with no salvage value by the end of its useful life. The calculation for annual fixed costs for high tunnels (depreciation and interest) is the same as calculation method used for irrigation fixed costs, capital recovery method. Detailed costs of high tunnel per annum are listed in Appendix B

(Table B.3 and B.4, Fixed Cost section). The subsidy on the high tunnel installation is excluded from the baseline budgeting.

4.1.1.10. Additional Expenses

Besides the actual applications needed for plant management, the budget also considers the opportunity cost of capital (interest for short-term loan). Short-term loan refers to one-year period or less of variable costs. An interest rate of 4.28 percent per year was used based on the quoted average interest rate for a farm operating loan in Arkansas (Keeton, 2014).

Miscellaneous expenses are estimated at $200 per annum to account for unforeseen activities not covered in the budget. The remaining activities registered in the miscellaneous variable costs include machinery operating costs, such as tractors and machinery's fuel, oil and filter changes, and repairs where the formulas to calculate each item specified in Chapter 3. The below Table 4.7 provide a summary of tractors and machinery annual operating costs. The actual annual equipment operating cost per acre is allocated to blueberry farm with the assumption that The producer owns more than just one acre of blueberry, so the equipment costs per acre for the blueberry farm is calculated by multiplying the average cost per hour (annual total costs divided by estimated annual hours used listed in the Table. 4.4) by the average actual hours used for blueberry farm which can also be found via Table. 4.4. All figures presented are in nominal values and land charge, tractors/machinery rental option and income taxes are not included in the budget calculation. The organic certification fee is categorized into other expenses. Cost and schedule of spending are summarized in Appendix A, Table A.1, which shows the cost occur from year three due to the organic program standards (3 years).

Table 4. 7 Summary of Tractors and Machinery Annual Operating Costs per Acre in Nominal 2014 Prices

Equipment Description	Annual RM Allocated to Blueberry	Annual Fuel Allocated to Blueberry	Annual Lubricant (Oil) and filters Allocated to Blueberry	Average Operating Costs of Equipment based on Unallocated Hours						
				Average RM Cost	**Average RM per Hour**	**Estimate Life in Hours**	**RM % of List Price**	**Diesel Per Hour**	**Diesel Fuel**	**Oil and filters**
30 hp Tractor	$8.44	$35.10	$5.27	$18,952	$1.18	16,000	80	$4.93	$1,232	$185
Mower	$2.84			$3,220	$1.61	2,000	175			
Air Blast Sprayer	$0.66			$828	$0.41	2,000	60			
Bedder Layer	$0.01			$428	$0.21	2,000	80			
Boom Sprayer	$0.68			$483	$0.32	1,500	70			
Disc	$0.01			$569	$0.28	2,000	60			
Mulcher	$0.92			$1,840	$0.92	2,000	40			
Plow	$0.02			$431	$0.22	2,000	75			
Spreader	$0.10			$313	$0.26	1,200	80			
Tiller - 5 feet	$0.06			$1,426	$0.95	1,500	80			
Miscellaneous Tools.	$9.82			$352	$0.29	1,200	35			
Total	**$23.56**	**$28.28**	**$4.24**	**$28,842**	**$6.67**			**$4.93**	**$1,232**	**$333**

Note. "RM" refers to Repairs and Maintenance

4.1.2. Null Hypotheses for the Baseline Scenarios

Using this information, the following null hypotheses have been developed for the four baseline scenarios:

H_o (1a): The present value of net returns over the fifteen years of production of organic blueberries is higher than the present value of net returns for conventional blueberry production, over the same time period.

H_o (1b): The present value of net returns over the fifteen years of blueberry in high tunnel production is higher than the present value of net returns in the open field production system, over the same time period.

H_o (1c): Both the organic and conventional production systems will breakeven at the same year.

H_o (1d): Both the organic and conventional field production systems will breakeven after year 7.

H_o (1e): Both the organic and conventional high tunnel production systems will breakeven at the same year.

H_o (1f): Both the organic and conventional high tunnel production systems will break even after year 10.

4.1.3. Results and Discussion

Table 4.8 provides a summary of the results from the baseline cases. Details of the present value of revenues, variable costs, fixed costs and net returns for each of the four baseline scenarios over the fifteen years can be found Appendix B, Tables B.1 to B.4. The open field conventional production system showed the highest present value of net returns at $82,869.19, followed by the open field organic production system at $79,314.72. Given the large investment associated with the high tunnels, returns to those systems were much lower, at $24,337.78 and $20,783.32, for the high tunnel conventional high tunnel production system and high tunnel organic production system, respectively. Figure 4.1 below provides a snap shot of present value of annual returns of each production system.

Table 4. 8 Summary Results from the Baseline Scenarios

Results (in Present Values)	Open Field Organic	Open Field Conventional	High Tunnel Organic	High Tunnel Conventional
Net Returns for 15 Years	$79,314.72	$82,869.19	$20,783.32	$24,337.78
Average Annual Net Returns	$5,287.65	$5,524.61	$1,385.55	$1,622.52
Average Annual Total Costs	$4,269.78	3,163.96	$8,171.87	$7,066.05
Average Annual Yields (Gallon)	822.92	822.92	822.92	822.92
Breakeven Costs	$38,314.78	$26,432.76	$101,768.95	$88,260.58
Breakeven Year	8	7	12	12
Breakeven Price ($/gallon)	$5.19	$3.84	$9.93	$8.59
Breakeven Yields (Gallon)	4,478.79	3,650.72	8,571.90	8,153.14
Total Yields for 15 Years (Gallon)	12,343.75	12,343.75	12,343.75	12,343.75

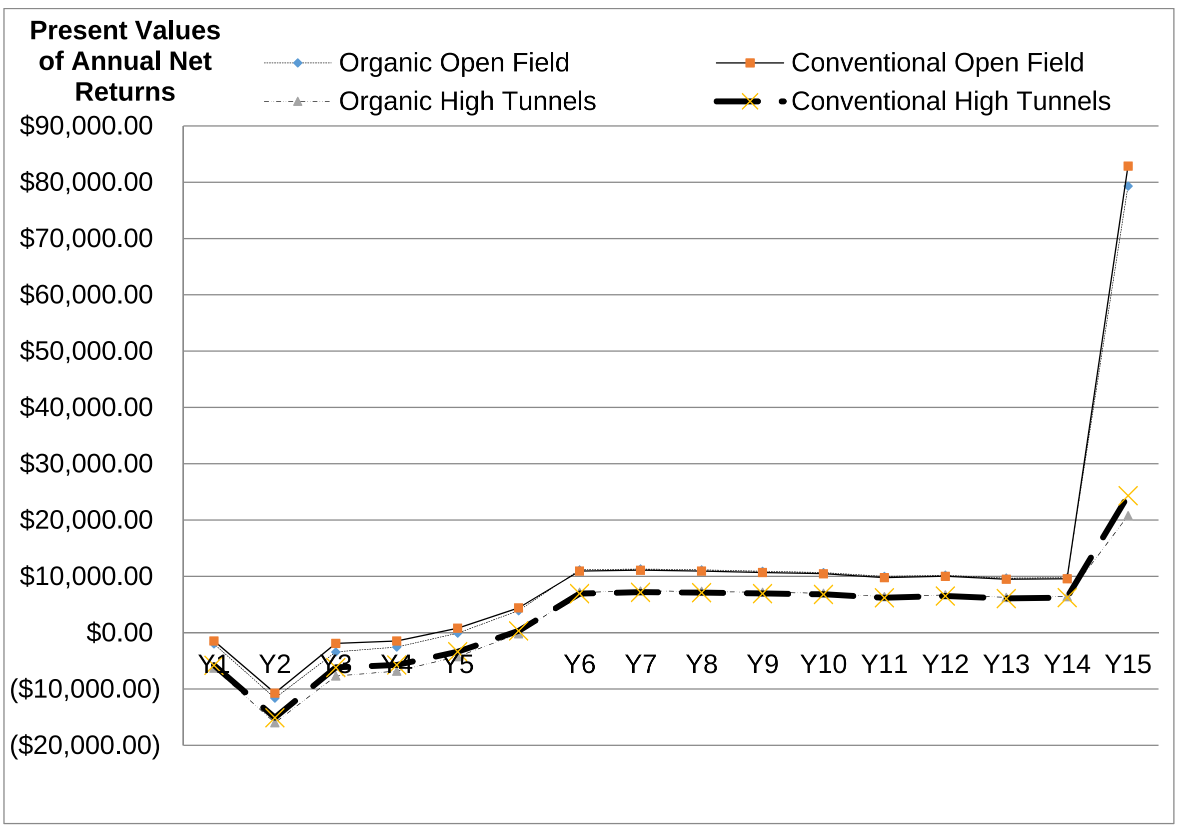

Figure 4. 1 Present Values of Annual Net Returns for Each of the Baseline Production Systems

Figures 4.2 to 4.5 provide a graphical illustration of cost categories in each of the production systems. Without high tunnel investment expenses, the cost structures for both open field operations tends to fall heavily on the variable costs, mainly planting materials (26% versus 19%) followed by labor charges (19% versus 18%), water charges (17% versus 13%), and fertilizer (2% versus 16%) for conventional and organic production, respectively. However, in the high tunnel systems, the total costs are substantially weighed by the large investments associated with the high tunnel system. Under the baseline scenarios for the high tunnel conventional production system, these tunnels provide no additional yield or price benefit, mainly additional costs, (53% versus 46%) followed by materials (12% versus 10%), labor charges (9% versus 10%), and water charges (9% versus 8%) for high tunnel conventional and organic production, respectively. The present value of net returns associated with conventional high tunnel system is much lower than with the conventional field system. Even with the price premium associated with the organic production systems, because there is no yield benefit to using the high tunnel for blueberries in Arkansas, the present value of net returns for the organic high tunnel system is less than that for the organic field system. The sensitivity analyses will below revisit some of these price/yield assumptions.

Under the assumptions used in these baseline analyses, overall, the open field conventional blueberry production system provides the highest present value of net returns. In fact both field production systems secured positive present values of net returns. However, in addition to net returns, there are other important considerations when deciding whether or not to invest in a blueberry production. Some of those important considerations include the level of operating capital needed before the operation can cover those costs, the year that breakeven occurs and yields and prices that lead to breakeven.

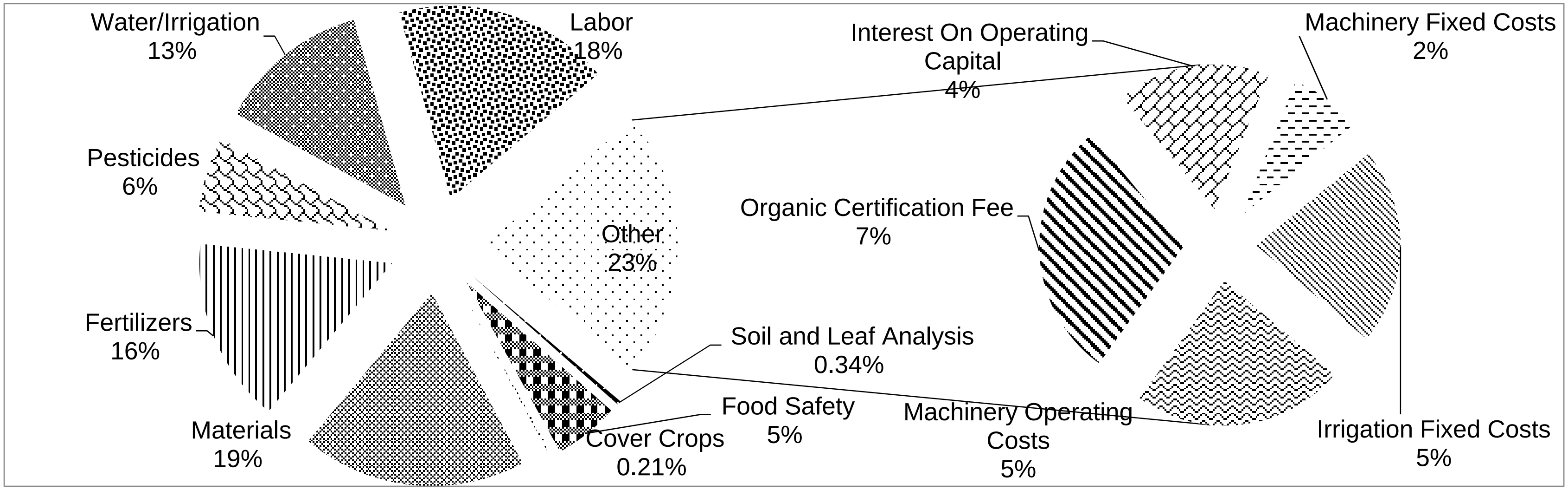

Figure 4. 2 **Percentage of Total Costs per Production Cycle (15 Years) - Open Field Organic Production System**

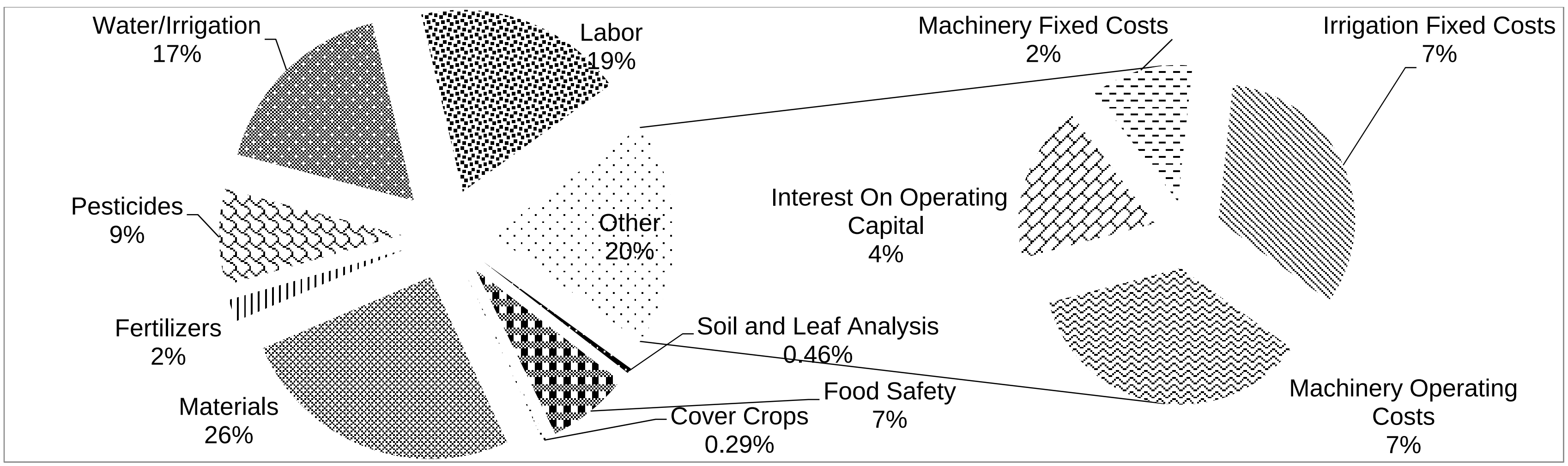

Figure 4. 3 Percentage of Total Costs per Production Cycle (15 Years) - Open Field Conventional Production System

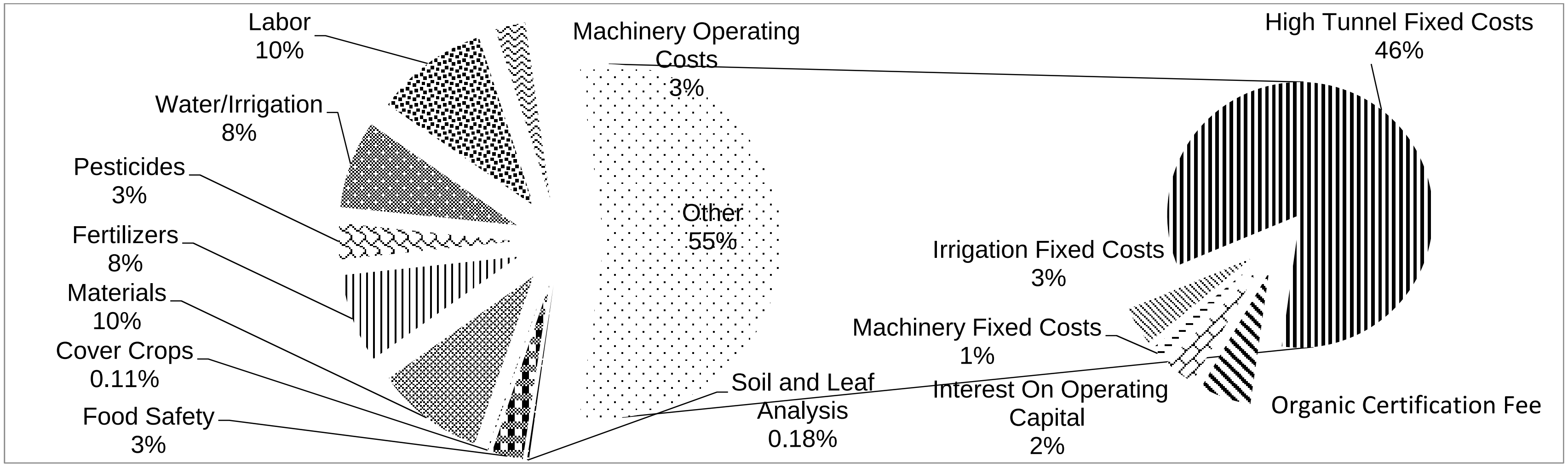

Figure 4. 4 **Percentage of Total Costs per Production Cycle (15 Years) - High Tunnel Organic Production System**

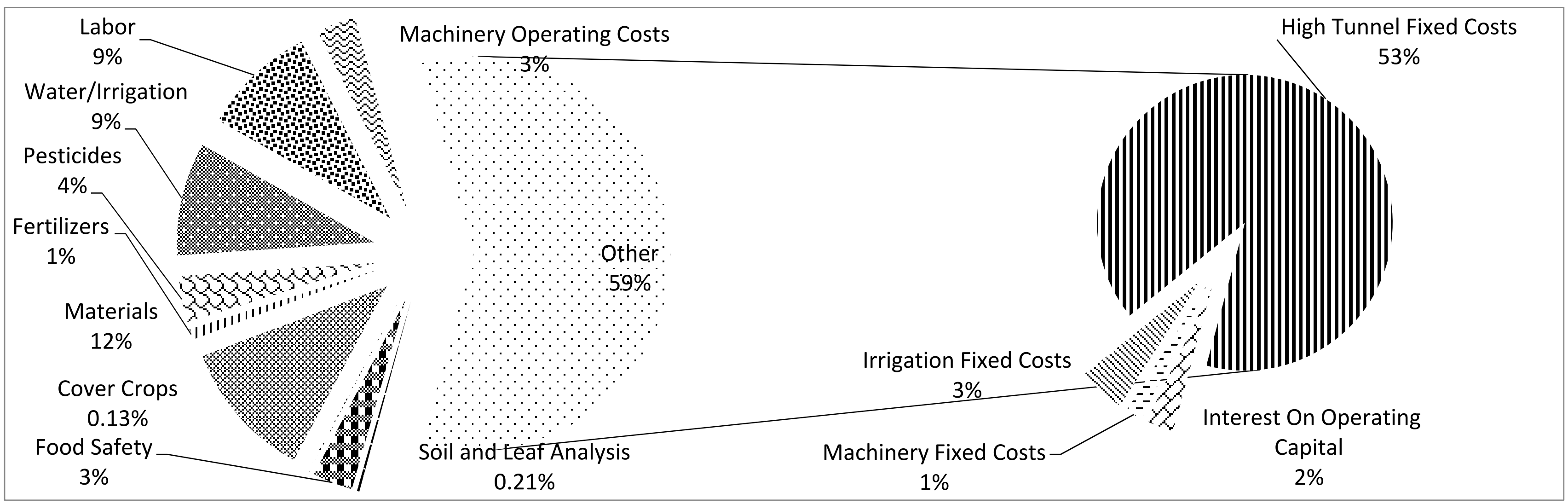

Figure 4. 5 Percentage of Total Costs per Production Cycle (15 Years) - High Tunnel Conventional Production System

4.1.4. <u>Breakeven Analysis</u>

A summary of the results from the breakeven analysis is also included in Table 4.8 For this farm operation, the calculation is based on total costs. The number of years to breakeven occurs when the accumulated total revenues equal total costs accumulated over a certain number of years. The breakeven year is found by comparing the accumulated revenues (accumulated yield times the selling price per gallon) with accumulated total costs of each year. As indicated in Table 4.8, total accumulated revenues and costs are equal in the open field conventional system in year 7 and in year 8 for the organic open field production system. The breakeven costs levels for the organic and conventional open field systems are $38,314.78, and $26,432.76 respectively. The breakeven prices for the organic and conventional field systems are $0.86 per lb (or $5.19/gal) and $0.64/lb (or $3.84/gal) respectively.

In the baseline scenarios, the high tunnel systems both show a positive present value of net returns. However, the additional costs associated with the high tunnels delay the breakeven year to year 12 for both organic and conventional high tunnel systems. Breakeven costs for organic and conventional high tunnel production are $101,768.95 and $88,260.58 respectively. The breakeven prices for organic and conventional high tunnels are $1.66/lb ($9.93/gal) and $1.43/lb ($8.59/gal), respectively.

4.1.5. <u>Baseline Hypothesis Testing Results</u>

Based on the analysis above the following conclusions are drawn regarding the hypotheses:

Ho (1a): The present value of net returns over the fifteen years of production of organic blueberries is higher than the present value of net returns for conventional blueberry production, over the same time period.

Reject: the detailed results in Appendix B show that the conventional systems have a higher present value of net returns than their organic system counterparts.

Ho (1b): The present value of net returns over the fifteen years of blueberry in high tunnel production is higher than the present value of net returns over the same time period in the open field production system, over the same time period.

Reject: results in Appendix B show that high tunnels fail to earn more than the open field systems

Ho (1c): Both organic and conventional field production will breakeven at in the same year.

Reject: The conventional field production breaks even in year seven (7), while the organic field production system breaks even one year later, year eight (8), (Table 4.8).

Ho (1d): Both organic and conventional field production will breakeven after year 7.

Mixed: the conventional field production breaks even in year 7. This result mirrors the experience of the local producer (Dozier, 2014). However, organic field production breaks even in year 8, (Table 4.8).

Ho (1e): Both the organic and conventional high tunnel production systems will breakeven at in the same year.

Fail to Reject: Conventional and organic high tunnels breakeven in year 12.

Ho (1f): Both the organic and conventional high tunnel production systems will break even after year 10.

Fail to Reject $H_{o.}$ It is true that it takes more than 10 years provided the baseline's net return conditions are maintained.

4.2. Additional Blueberry Economic Analyses

There are several uncertainties within budget planning regarding the quantity of inputs applied, including pesticides, fertilizer, labor or machinery replacement hours; yields, and prices of input and output; interest rate (for present value calculation, interest on loan, and opportunity costs); plant density; irrigation system; numbers of high tunnels in combination with open field, production system mixture of organic and conventional system, etc. All of these factors could change net earnings from those resulting from the assumed prices, practices and levels used in the baseline scenarios. Therefore, sensitivity analyses are conducted to evaluate how the results of the baseline may change when yields and prices change as well as the pesticide application rate changes.

4.2.1.1. Changes to Yields and Input Prices

As described in Chapter 2, different studies have reported different yield levels for the four types of production systems evaluated here. For example, weather can negatively impact yields as was seen in Arkansas In 2011, when blueberry yields fell by 50% due to drought (McCarthy, 2011). Additionally, the selection of cultivar can also influence the yield levels. As indicated in Chapter 2 section 2.9.4, yields of some cultivars studied in Arkansas reached 10 to 15 lb/plant (Clark et al., 2006). In general the studies presented in Chapter 2 suggest that yields can be influenced by a number of factors and can be half to one and a half times those used in the baseline scenarios. Therefore, in the sensitivity analysis, the range of yields explicitly evaluated are selected to be from 50% to 150% that of the baseline scenarios. Yields are evaluated at 50%, 60%, 70%, 80%, and 90% of the baseline, as in Arkansas those factors are expected to lessen yields more than increase yields. However yields are also evaluated at 150% of the baseline in order to represent the best possible scenario (optimal growing conditions) every year.

Additionally, it is possible that the input costs used here are not those faced by growers. The reasons for this are many but most likely include these two reasons. First, discussions with local experts and review of USDA reports for consumer and producer price indices suggests that the input prices could change but likely not reach more than 20% of current levels over the life of the budget. Second, because some of the prices used here were only gathered from one source, it is possible that lower prices are available in some areas. Results are summarized below in Tables 4.9 through 4.12.

Table 4. 9 Sensitivity Analysis (Yield and Input Price Changes) - Organic Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Input Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	$18,929	$13,281	$7,634	$1,987	($3,661)
	Year	11	12	13	15	
60%	Total 15 Years	$33,265	$27,617	$21,970	$16,323	$10,676
	Year	9	10	11	12	13
70%	Total 15 Years	$47,601	$41,954	$36,306	$30,659	$25,012
	Year	8	9	10	10	11
80%	Total 15 Years	$61,937	$56,290	$50,642	$44,995	$39,348
	Year	8	8	9	9	10

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Input Prices				
		80%	90%	100%	110%	120%
90%	Total 15 Years	$76,273	$70,626	$64,979	$59,331	$53,684
	Year	8	8	8	9	9
100%	Total 15 Years	$90,609	$84,962	**$79,315**	$73,667	$68,020
	Year	7	8	**8**	8	8
150%	Total 15 Years	$162,290	$156,643	$150,995	$145,348	$139,701
	Year	7	7	7	7	7

Table 4. 10 Sensitivity Analysis (Yield and Input Price Changes) - Conventional Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Input Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	$26,550	$22,127	$17,705	$13,283	$8,860
	Year	9	10	11	12	13
60%	Total 15 Years	$39,583	$35,160	$30,738	$26,315	$21,893
	Year	8	9	9	10	11
70%	Total 15 Years	$52,615	$48,193	$43,771	$39,348	$34,926
	Year	8	8	9	9	9
80%	Total 15 Years	$65,648	$61,226	$56,803	$52,381	$47,959
	Year	7	8	8	8	9
90%	Total 15 Years	$78,681	$74,259	$69,836	$65,414	$60,992
	Year	7	7	8	8	8
100%	Total 15 Years	$91,714	$87,292	**$82,869**	$78,447	$74,024
	Year	7	7	**7**	8	8
150%	Total 15 Years	$156,878	$152,456	$148,033	$143,611	$139,189
	Year	6	7	7	7	7

In the field production systems, of the 35 new possible input price/yield combinations, only 7 of these (rows of 90 to 100% of baseline yields) are at least as possible as the baseline organic and conventional field systems. The level of profitability was never as high as the baselines if yields were allow to fall from baseline levels. However, in some cases, even when all input price increased, so did present value of net returns (as long as yields were higher than those in the baseline).

Table 4. 11 Sensitivity Analysis (Yield and Input Price Changes) - Organic High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Input Prices				
		80%	**90%**	**100%**	**110%**	**120%**
50%	Total 15 Years	($27,897)	($39,397)	($50,897)	($62,398)	($73,898)
	Year					
60%	Total 15 Years	($13,560)	($25,061)	($36,561)	($48,062)	($59,562)
	Year					
70%	Total 15 Years	$776	($10,725)	($22,225)	($33,726)	($45,226)
	Year	15				
80%	Total 15 Years	$15,112	$3,611	($7,889)	($19,389)	($30,890)
	Year	13	15			
90%	Total 15 Years	$29,448	$17,948	$6,447	($5,053)	($16,554)
	Year	11	12	14		
100%	Total 15 Years	$43,784	$32,284	**$20,783**	$9,283	($2,218)
	Year	10	11	**12**	14	
150%	Total 15 Years	$115,465	$103,964	$92,464	$80,964	$69,463
	Year	8	8	9	9	10

Table 4. 12 Sensitivity Analysis (Yield and Input Price Changes) – Conventional High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Input Prices				
		80%	**90%**	**100%**	**110%**	**120%**
50%	Total 15 Years	($20,275)	($30,551)	($40,827)	($51,102)	($61,378)
	Year					
60%	Total 15 Years	($7,243)	($17,518)	($27,794)	($38,069)	($48,345)
	Year					
70%	Total 15 Years	$5,790	($4,485)	($14,761)	($25,036)	($35,312)
	Year	14				
80%	Total 15 Years	$18,823	$8,548	($1,728)	($12,003)	($22,279)
	Year	12	14			
90%	Total 15 Years	$31,856	$21,580	$11,305	$1,029	($9,246)
	Year	10	12	13	15	
100%	Total 15 Years	$44,889	$34,613	**$24,338**	$14,062	$3,787
	Year	10	11	**12**	13	15
150%	Total 15 Years	$110,053	$99,778	$89,502	$79,227	$68,951
	Year	8	8	9	9	10

Under most of the examined combinations for the organic and conventional high tunnel systems, present value of net returns were negative for about half of the yield-input cost combinations. Positive returns generally occurred when input prices were reduced below the baseline levels and yields remained at or above the baseline level.

4.2.1.2. Changes to Yields and Output Prices

Similar to the sensitivity analysis above, this one examined various combinations of changes to yields and output prices. Once again, yields were allowed to change from 50 to 150% of baseline yields. Here prices for blueberries in the fresh market were allowed to change from 80 to 120% of those baseline output prices. Yield ranges examined here are based on those same reasons used in the section above. The reasons for using the chosen range of output prices are as follows. First, as described in Chapter 2, organic fruit can capture a higher premium – the high end of prices used here captures that highest level of premium found in the literature. Second, prices could actually fall if increases in production in the area saturate demand. The results of this sensitivity analysis are presented in Tables 4.13 through 4.16.

Assuming still the baseline output prices, the open field organic production system remains profitable even if yields fall by 50% (Table 4.13). In fact positive net returns are earned in every case except where the output price declined to 80% of baseline and yields fell to 50% of the baseline. Again, only 7 cases are more profitable than the baseline and require (compared to the baseline) either increases in output prices, increases in yields or both. Similar results (except that no case has negative net returns) are found in the conventional open field system as show in Table 4.14.

Table 4. 13 Sensitivity Analysis (Yield and Output Price Changes) - Organic Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Output Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	($6,702)	$466	$7,634	$14,802	$21,970
	Year		15	13	12	11
60%	Total 15 Years	$4,767	$13,368	$21,970	$30,572	$39,174
	Year	14	12	11	10	9
70%	Total 15 Years	$16,236	$26,271	$36,306	$46,342	$56,377
	Year	11	10	10	9	9
80%	Total 15 Years	$27,705	$39,174	$50,642	$62,111	$73,580

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Output Prices				
		80%	90%	100%	110%	120%
	Year	10	9	9	8	8
90%	Total 15 Years	$39,174	$52,076	$64,979	$77,881	$90,784
	Year	9	9	8	8	8
100%	Total 15 Years	$50,642	$64,979	**$79,315**	$93,651	$107,987
	Year	9	8	**8**	8	7
150%	Total 15 Years	$107,987	$129,491	$150,995	$172,500	$194,004
	Year	7	7	7	7	7

Table 4. 14 Sensitivity Analysis (Yield and Output Price Changes) - Conventional Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Output Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	$4,672	$11,188	$17,705	$24,221	$30,738
	Year	13	12	11	10	9
60%	Total 15 Years	$15,098	$22,918	$30,738	$38,557	$46,377
	Year	11	10	9	9	8
70%	Total 15 Years	$25,525	$34,648	$43,771	$52,894	$62,017
	Year	10	9	9	8	8
80%	Total 15 Years	$35,951	$46,377	$56,803	$67,230	$77,656
	Year	9	8	8	8	8
90%	Total 15 Years	$46,377	$58,107	$69,836	$81,566	$93,295
	Year	8	8	8	7	7
100%	Total 15 Years	$56,803	$69,836	**$82,869**	$95,902	$108,935
	Year	8	8	**7**	7	7
150%	Total 15 Years	$108,935	$128,484	$148,033	$167,583	$187,132
	Year	7	7	7	7	6

For the organic high tunnel system, over half of the output price-yield combinations produce negative net returns. Profit levels are higher than those of the baseline only in seven cases where output-yield combinations are equal to or greater than those of the baseline (Table 4.15). This also held true in the conventional high tunnel systems as well (Table 4.16).

Table 4. 15 Sensitivity Analysis (Yield and Output Price Changes) – Organic High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Output Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	($65,234)	($58,065)	($50,897)	($43,729)	($36,561)
	Year					
60%	Total 15 Years	($53,765)	($45,163)	($36,561)	($27,960)	($19,358)
	Year					
70%	Total 15 Years	($42,296)	($32,260)	($22,225)	($12,190)	($2,155)
	Year					
80%	Total 15 Years	($30,827)	($19,358)	($7,889)	$3,580	$15,049
	Year				15	13
90%	Total 15 Years	($19,358)	($6,455)	$6,447	$19,350	$32,252
	Year			14	12	11
100%	Total 15 Years	($7,889)	$6,447	**$20,783**	$35,119	$49,456
	Year		14	**12**	11	10
150%	Total 15 Years	$49,456	$70,960	$92,464	$113,968	$135,472
	Year	10	9	9	8	8

Table 4. 16 Sensitivity Analysis (Yield and Output Price Changes) – Conventional High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Percentage (%) of Baseline Output Prices				
		80%	90%	100%	110%	120%
50%	Total 15 Years	($53,859)	($47,343)	($40,827)	($34,310)	($27,794)
	Year					
60%	Total 15 Years	($43,433)	($35,613)	($27,794)	($19,974)	($12,154)
	Year					
70%	Total 15 Years	($33,007)	($23,884)	($14,761)	($5,638)	$3,485
	Year					15
80%	Total 15 Years	($22,581)	($12,154)	($1,728)	$8,698	$19,125
	Year				14	12
90%	Total 15 Years	($12,154)	($425)	$11,305	$23,034	$34,764
	Year			13	12	11
100%	Total 15 Years	($1,728)	$11,305	**$24,338**	$37,371	$50,403
	Year		13	**12**	11	10
150%	Total 15 Years	$50,403	$69,953	$89,502	$109,051	$128,601
	Year	10	9	9	8	8

4.2.1.3. Changes to Pesticide Application Rates

This sensitivity analysis explores how net returns change when the level of pesticide application changes. Using pesticides can have two types of impacts. First, adding or reducing pesticide use will change input costs. Some pesticides, particularly for the organic production systems, are quite costly. However, failure to apply pesticides in some circumstances can result in a partial or complete loss in yield for the year. Therefore this sensitivity analysis examines changes in net returns when pesticide levels are changed from the baseline (mixed use from the local producer) to four other levels of zero, as well as the minimum, average and maximum recommended rates. The pesticide levels examined are presented in Tables 4.17 through 4.19. The analysis is conducted assuming the following additional assumptions about yield based on the literature (Knutson, Hall, Smith, Cotner, and Miller, 1994) and the experience of the local producer:

- Zero or minimum pesticide use will reduce yields by 50% or more
- Average pesticide use could reduce yields by up to 20%
- Maximum pesticide use may actually increase yields by up to 10% over the baseline.

Table 4. 17 Summary of Different Level of Pesticide Applications in Nominal 2014 Prices

Pesticide	Unit	Minimum	Average	Maximum	Unit Price	Y1	Y2	Y3	Y4	Y5	Y6	Y7 - 15	System
Captan (Captan 50 WP)	lb	5	15	35	$6.59				x	x	x	x	Conventional
Lime sulfur	gal	8	13	30	$8.30			x	x	x	x	x	Organic and Conventional
Malathion	pt	2	4	6	$4.74				x	x	x	x	Conventional
Zeta-cypermethrin (Mustang Max)	oz	4	12	24	$1.17				x	x	x	x	Conventional
Glyphosate (Roundup WeatherMax 5.5 EC)	qt	0.5	3.5	7	$9.75	x	x	x	x	x	x	x	Conventional
Paraquat (Gramoxone Inteon 2 L)	pt	2	9	20	$3.13	x	x	x	x	x	x	x	Conventional
Carbaryl (Sevin XLR Plus)	qt	1.5	4.5	10	$11.52			x	x	x	x	x	Conventional
Spinosad (Entrust 2SC)	oz	4	15	29	$11.22				x	x	x	x	Organic
Pyrethrins (Pyganic 1.4% EC)	oz	16	64	112	$1.56				x	x	x	x	Organic
Traps (Spotted Wing Drosophila)	Trap	1.00	5	9	$2.75				x	x	x	x	Organic and Conventional
Baits (Spotted Wing Drosophila)	Bait	8.00	40	72	$0.10				x	x	x	x	Organic and Conventional

Note. "Minimum" refers to one application listed by labels, "Maximum" refers to the upper limit per annum per acre by its label, "Average" is the average between Minimum and Maximum. Local Producer refers to applications from Dozier (2014) for the conventional and partial organic except the Pyganic (adapted from Blackberry budget developed by Rodriguez et al. (2014a), and traps and lures also listed in the blackberry budgets with quantifying the amount for minimum and maximum following Studebaker et al. (2014) who recommend replacing lures every month. The maximum number of traps is not specifically mentioned by Studebaker et al. (2014), so the estimation is made for the number of traps (upper limit).

Table 4. 18 Present Values of Total Costs of Pesticides by Application Rates, Years 1 through 8

Present Values of Pesticide Costs	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Conventional Production								
Average Application Rate	$62.25	$60.89	$212.39	$347.76	$340.16	$332.72	$325.44	$318.33
Minimum Application Rate	$11.13	$10.88	$90.70	$136.14	$133.16	$130.25	$127.40	$124.62
Maximum Application Rate	$130.75	$127.89	$473.54	$761.85	$745.20	$728.90	$712.97	$697.38
Organic Production								
Average Application Rate	$0.00	$0.00	$103.23	$368.52	$360.46	$352.58	$344.87	$337.33
Minimum Application Rate	$0.00	$0.00	$63.53	$130.82	$127.96	$125.16	$122.43	$119.75
Maximum Application Rate	$0.00	$0.00	$238.23	$730.93	$714.95	$699.32	$684.03	$669.07

Table 4. 19 Present Values of Total Costs of Pesticides by Application Rates, Years 9 through 15

Present Values of Pesticide Costs	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Conventional Production								
Average Application Rate	$311.37	$304.56	$297.90	$291.39	$285.02	$278.79	$272.69	$4,041.65
Minimum Application Rate	$121.89	$119.23	$116.62	$114.07	$111.58	$109.14	$106.75	$1,563.55
Maximum Application Rate	$682.13	$667.22	$652.63	$638.36	$624.40	$610.75	$597.40	$8,851.35
Organic Production								
Average Application Rate	$329.96	$322.74	$315.69	$308.78	$302.03	$295.43	$288.97	$4,030.61
Minimum Application Rate	$117.13	$114.57	$112.06	$109.61	$107.22	$104.87	$102.58	$1,457.69
Maximum Application Rate	$654.44	$640.13	$626.14	$612.45	$599.06	$585.96	$573.15	$8,027.86

The results of the various combinations of pesticide level and yield changes are presented below in Tables 4.20 through 4.23. In the open field systems, neither organic nor conventional production is profitable when yields fall to 25% of those in the baseline. Both systems are profitable once yields reach 50%, however only when yields are 150% baseline and maximum application rates are used do the net returns exceed those from the baseline. In reality, it is hard to maintain yields to the level of the baseline (100%) when no pesticide or just minimum pesticide levels are applied to the blueberry fields. For the high tunnel systems, net returns remain negative under about half of the scenarios examined. However positive net returns are achieved under the 90% yield or above, and 80% baseline yields, no pesticide and minimum application rate scenario.

The shaded cells in the tables below indicate the scenarios which, based on expert opinion, are likely in Arkansas. These results show the importance of pesticides to the profitability of the open field (and to some extent even the high tunnel) systems. As shown in the earlier sensitivity analyses, yields seem to have a larger impact on returns than input prices (including pesticide prices) do. Therefore reducing input costs that have large negative impacts on yields can lead to extensively lower (or even negative) present value of net returns.

Table 4. 20 Sensitivity Analysis (Yield and Pesticide Application Changes) – Organic Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
25%	Total 15 Years	($24,003)	($25,523)	($28,206)	($32,375)
	Year				
50%	Total 15 Years	$11,837	$10,317	$7,634	$3,466
	Year	12	12	13	14
75%	Total 15 Years	$47,677	$46,157	$43,474	$39,306
	Year	9	9	9	9
80%	Total 15 Years	$54,846	$53,325	$50,642	$46,474
	Year	9	9	9	9
90%	Total 15 Years	$69,182	$67,662	$64,979	$60,810
	Year	8	8	8	8
100%	Total 15 Years	$83,518	$81,998	**$79,315**	$75,146
	Year	8	8	**8**	8

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
150%	Total 15 Years	$155,199	$153,678	$150,995	$146,827
	Year	7	7	7	7

Note: shading indicates those yield-pesticide rate combinations that are expected to be possible in most cases.

Table 4. 21 Sensitivity Analysis (Yield and Pesticide Application Changes) – Conventional Open Field Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
25%	Total 15 Years	($10,663)	($12,293)	($14,877)	($19,893)
	Year				
50%	Total 15 Years	$21,920	$20,289	$17,705	$12,689
	Year	10	10	11	12
75%	Total 15 Years	$54,502	$52,871	$50,287	$45,271
	Year	8	8	8	9
80%	Total 15 Years	$61,018	$59,388	$56,803	$51,788
	Year	8	8	8	8
90%	Total 15 Years	$74,051	$72,420	$69,836	$64,821
	Year	8	8	8	8
100%	Total 15 Years	$87,084	$85,453	**$82,869**	$77,854
	Year	7	7	**7**	8
150%	Total 15 Years	$152,248	$150,618	$148,033	$143,018
	Year	7	7	7	7

Note: shading indicates those yield-pesticide rate combinations that are expected to be possible in most cases.

Table 4. 22 Sensitivity Analysis (Yield and Pesticide Application Changes) – Organic High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
25%	Total 15 Years	($82,535)	($84,055)	($86,738)	($90,906)
	Year				
50%	Total 15 Years	($46,694)	($48,214)	($50,897)	($55,066)
	Year				
75%	Total 15 Years	($10,854)	($12,374)	($15,057)	($19,225)
	Year				
80%	Total 15 Years	($3,686)	($5,206)	($7,889)	($12,057)

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
	Year				
90%	Total 15 Years	$10,650	$9,130	$6,447	$2,279
	Year	14	14	14	15
100%	Total 15 Years	$24,986	$23,466	**$20,783**	$16,615
	Year	12	12	**12**	13
150%	Total 15 Years	$96,667	$95,147	$92,464	$88,296
	Year	9	9	9	9

Note: shading indicates those yield-pesticide rate combinations that are expected to be possible in most cases.

Table 4. 23 Sensitivity Analysis (Yield and Pesticide Application Changes) – Conventional High Tunnel Production

% of Baseline Yield	Present Values of Net Returns and Breakeven	Pesticides Application Rates			
		None	Minimum	Average (Baseline)	Maximum
25%	Total 15 Years	($69,194)	($70,824)	($73,409)	($78,424)
	Year				
50%	Total 15 Years	($36,612)	($38,242)	($40,827)	($45,842)
	Year				
75%	Total 15 Years	($4,030)	($5,660)	($8,244)	($13,260)
	Year				
80%	Total 15 Years	$2,487	$856	($1,728)	($6,743)
	Year	15	15		
90%	Total 15 Years	$15,520	$13,889	$11,305	$6,289
	Year	13	13	13	14
100%	Total 15 Years	$28,552	$26,922	**$24,338**	$19,322
	Year	11	11	**12**	12
150%	Total 15 Years	$93,717	$92,086	$89,502	$84,487
	Year	8	8	9	9

Note: shading indicates those yield-pesticide rate combinations that are expected to be possible in most cases.

4.2.1.3.1. The Sensitivity Analysis Hypothesis Testing

Table 4.24 below provides a snapshot of results of hypotheses tests with a comparison between baseline and other cases where input prices, yields, output prices, and pesticide applications varied from the baseline.

Table 4. 24 Hypothesis Testing Results from Sensitivity Analyses

Hypotheses	Baseline Results
H_o (1a): The present value of net returns over the fifteen years of production of organic blueberries is higher than the present value of net returns for conventional blueberry production, over the same time period. *Sensitivity analyses lead to **failure to reject H_o** because there are multiple cases that when yields/prices change (not at the same percentage changed), present value of net returns in the organic systems exceed those in the relevant conventional system*.	Reject H_o
H_o (1b): The present value of net returns over the fifteen years of blueberry in high tunnel production is higher than the present value of net returns in the open field production system over the same time period. *Sensitivity analyses lead to **failure to reject H_o**. In the output price/yield scenarios when yield increased to 150% and output prices to at least equal to or above the baseline, the present value of net returns to the high tunnel systems were higher than those of the baseline field systems.*	Reject H_o
H_o (1c): Both the organic and conventional production systems will breakeven at the same year. *Sensitivity analyses lead to **failure to reject H_o**. There are cases where the breakeven years are the same in both the input price/ yield and output price/yield scenarios*	Reject H_o
H_o (1d): Both the organic and conventional field production systems will breakeven after year 7. *Sensitivity analyses lead to **failure to reject H_o** for both organic and conventional field production because there are cases in both organic and conventional systems where breakeven before year 7.*	Reject H_o
H_o (1e): Both the organic and conventional high tunnel production systems will breakeven at the same year. *Sensitivity analyses lead to **reject H_o**. as there are some cases that do not break even in the same time frame. Though in some cases there were breakeven that occurred in same year for both tunnel systems.*	Fail to Reject H_o
H_o (1f): Both the organic and conventional high tunnel production systems will break even after year 10. *Sensitivity analysis leads to a **H_o rejection** for some cases only.*	Fail to Reject H_o

4.3. Results Summary

In this chapter, baseline scenarios were created for each of the four production systems: organic open field, conventional open field, organic high tunnel and conventional high tunnel. Six null hypotheses were tested and the results of that testing were presented in section 4.1.5. In short, the baseline scenarios showed that both the organic field and conventional field systems yielded positive present value of net returns and that returns to the conventional open field system were higher than those of the organic open field system. In the baseline, the high tunnel systems for both organic and conventional production had positive present value of net returns. High tunnel systems took more years to break even than the field systems.

Sensitivity analyses were conducted to determine how these baseline scenario results changed when input prices, output prices, yields, and levels of pesticide use changed. These sensitivity analyses revealed that changes in yields (or changes in input use that produced changes in yields) had the greatest impacts on the baseline results. Examination of hypotheses during yield-input price, yield-output price sensitivity analyses showed that level of profitability is highly dependent on the yields, input prices and output prices examined. Also ability to reject the hypothesis changed with changes in these yields and prices. Therefore baseline results cannot assume to hold for all producers as they face different yields, input prices and output prices.

Chapter 5 – Conclusion

5.1. Introduction

As stated in Chapter 1, the goal of this thesis is to assist high bush blueberry producers to make more informed financial decisions with regard to the use of four production systems: 1) high tunnel – conventional, 2) high tunnel – organic, 3) field – conventional, and 4) field – organic. This goal was met through four objectives.

- Collect production practice information for all four production systems,
- Estimate variable costs, fixed costs, revenues and net returns for each production system, based on Northwest Arkansas production systems,
- Conduct sensitivity analyses (market price , yield and pesticide rates),
- Use this information to contribute to the development of an interactive sustainable high bush blueberry budgeting tool which will enable producers to assess risks and returns associated with the four production systems for high bush blueberry production

An extensive review of the literature, experimental plot data, as well as personal communications with horticultural research specialists, producers and USDA personnel was used to develop a list of production activities for highbush blueberry production in Northwest Arkansas. Baseline scenarios were created to estimate present values of variable costs, fixed costs, revenues and net revenues over time for each of the systems. These baseline analyses suggested that while high tunnel production systems produced positive present values of net returns, the open field systems generated even higher present values of net returns. Similarly, both organic and conventional systems were profitable, but even with a price premium assigned to organic production, the conventional systems were more profitable than their organic counterparts. Sensitivity analyses were conducted to evaluate how those results might change when prices, yields and pesticide levels varied and these results showed that profitability is strongly influenced by the levels of pesticide application, input prices, output prices and yields examined. But in general, the conventional systems outperformed their organic counterparts in like yield-price or yield-pesticide rate scenarios and field systems outperformed the high tunnel systems.

Therefore, in general, conventional field production for blueberries appears to be the most profitable system for growers who experience the situations examined in the baseline and sensitivity analyses.

5.2. Limitations and Future Research

There are a number of limitations associated with this study. First, much of the conventional scenarios used here were developed based on experiences at an experimental farm (small plot conditions) and personal communications with one local blueberry grower. Furthermore scenarios created for the organic systems relied on no Arkansas based data as no organic producers were identified and the organic studies at the University of Arkansas Agricultural Experiment Station have not yet generated results. Therefore, more data through future research studies are needed to be more representative of Arkansas growing conditions.

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Appendix A Summary of Baseline Practices

Table A. 1 Summary of Baseline Scenario Practices Used in the Organic Open Field System Baseline Scenario, Years 1- 7

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Soil/Leaf Analysis									
Leaf analysis	$20.00	Sample			1	1	1	1	1
Soil analysis	$0.00	Sample	1	1		1		1	
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)	$1.15	lb	100						
Orchard Grass Seeds	$4.39	lb	6						
Planting									
Blueberry plants - Price	$5.00	Plant		1,250					
Bumblebees	$35.00	Hive				3	3	3	3
Grading table	$100.00	Unit				1			
Hand hoe	$17.95	Unit		5					
Peat moss	$0.35	lb		3,750					
Wood Mulch	$0.03	lb		5,000	1,667	1,667	1,667	1,667	1,667
Landscape fabric (125 by 4000 feet)	$182.60	Roll		3					3
Irrigation Water	$0.01	gal	4,277	54,000	54,0000	126,000	126,000	126,000	126,000
Organic Certification Fees	$700.00	A			1	0.5	0.5	0.5	0.5
Harvest									
Harvest - fresh market	$14.30	gal				156.25	312.50	625	1,250
Harvest containers (one gallon size)	$1.66	Pail				170			
Harvest containers (1000 plastic bags/case)	$17.95	Case				4	4	4	4
Hand Washing Station	$150.00	Mth				2	2	2	2
Porta potty	$25.00	Mth				2	2	2	2
Fertilizer									
Pelleted dry poultry litter	$124.00	Ton	0.68						
Sulfur	$0.29	lb	1,000						
Fish Meal	$1.72	lb		450	450	450	450	450	450
Copper Chelate	$5.12	qt				2.50	2.50	2.50	2.50
Iron Chelate	$8.74	qt				1.25	1.25	1.25	1.25
Solubor	$0.65	lb				1.50	1.50	1.50	1.50

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Zinc Chelade	$6.70	qt				1.50	1.50	1.50	1.50
Pesticides									
Lime sulfur	$8.30	gal			13	13	13	13	13
Pyrethrins (Pyganic 1.4% EC)	$1.56	oz				64	64	64	64
Spinosad (Entrust 2SC)	$11.22	gal				15	15	15	15
Traps (SWD)	$2.75	Unit				5	5	5	5
Baits (SWD)	$0.10	Unit				40	40	40	40
Labor									
Leaf sample collection	$9.00	Hour			1	1	1	1	1
Soil sample collection	$9.00	Hour	1	1		1		1	
Landscape fabric removel / set up	$9.00	Hour		4	4	4	4	4	4
Machinery operation	$15.00	Hour	62.91	62.91	62.91	62.91	62.91	62.91	62.91
Management	$9.00	Hour	1	1	1	1	1	1	1
Planting	$9.00	Hour		60					
Pre-harvest	$9.00	Hour				1	1	1	1
Post harvest	$9.00	Hour				1	1	1	1
IPM Scouting	$9.00	Hour				5	5	5	5
Weed control Labor	$9.00	Hour	18	18	18	18	18	18	18
Unallocated Activities	$9.00	Hour	2	2	2	2	2	2	2

Table A. 2 Summary of Baseline Scenario Practices Used in the Organic Open Field System Baseline Scenario, Years 8 -15

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Soil/Leaf Analysis									
Leaf analysis	1	1	1	1	1	1	1	1	**13**
Soil analysis	1		1		1		1		**8**
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)									**100**
Orchard Grass Seeds									**6**
Planting									**-**
Blueberry plants - Price									**1,250**
Bumblebees	3	3	3	3	3	3	3	3	**36**
Grading table									**1**
Hand hoe	5								**10**
Peat moss									**3,750**
Wood Mulch	1,667	1,667	1,667	1,667	1,667	1,667	1,667	1,667	**26,671**
Landscape fabric (125 by 4000 feet)					3				**9**
Irrigation Water	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	**1,624,277**
Organic Certification Fees	1	1	1	1	1	1	1	1	**7**
Harvest									**-**
Harvest - fresh market	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	**12,343.75**
Harvest containers (one gallon size)							170		**340**
Harvest containers (1000 plastic bags per case)	4	4	4	4	4	4	4	4	**48**
Hand Washing Station	2	2	2	2	2	2	2	2	**24**
Porta potty	2	2	2	2	2	2	2	2	**24**
Fertilizer									**-**
Pelleted dry poultry litter									**1**
Sulfur									**1,000**
Fish Meal	450	450	450	450	450	450	450	450	**6,300**
Copper Chelate	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	**30**
Iron Chelate	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	**15**
Solubor	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18**
Zinc Chelade	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18**
Pesticides									**-**

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Lime sulfur	13	13	13	13	13	13	13	13	**169**
Pyrethrins (Pyganic 1.4% EC)	64	64	64	64	64	64	64	64	**768**
Spinosad (Entrust 2SC)	15	15	15	15	15	15	15	15	**180**
Traps (SWD)	5	5	5	5	5	5	5	5	**60**
Baits (SWD)	40	40	40	40	40	40	40	40	**480**
Labor									**-**
Leaf sample collection	1	1	1	1	1	1	1	1	**13**
Soil sample collection	1		1		1		1		**8**
Landscape fabric removel / set up	4	4	4	4	4	4	4	4	**56**
Machinery operation	62.91	62.91	62.91	62.91	62.91	62.91	62.91	62.91	**943.67**
Management	1	1	1	1	1	1	1	1	**15**
Planting									**60**
Pre-harvest	1	1	1	1	1	1	1	1	**12**
Post harvest	1	1	1	1	1	1	1	1	**12**
IPM Scouting	5	5	5	5	5	5	5	5	**60**
Weed control Labor	18	18	18	18	18	18	18	18	**270**
Unallocated Activities	2	2	2	2	2	2	2	2	**30**

Table A. 3 Summary of Baseline Scenario Practices Used in the Conventional Open Field System Baseline Scenario, Years 1-7

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Soil/Leaf Analysis									
Leaf analysis	$20.00	Sample			1	1	1	1	1
Soil analysis	$0.00	Sample	1	1		1		1	
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)	$1.15	lb	100						
Orchard Grass Seeds	$4.39	lb	6						
Planting									
Blueberry plants	$5.00	Plant		1,250					
Bumblebees	$35.00	Hive				3	3	3	3
Grading table	$100.00	Unit				1			
Hand hoe	$17.95	Unit		5					
Peat moss	$0.35	lb		3,750					
Wood Mulch	$0.03	lb		5,000	1,667	1,667	1,667	1,667	1,667
Landscape fabric (125 by 4000 feet)		Roll		3					3
Irrigation Water	$0.01	gal	4,277	54,000	54,000	126,000	126,000	126,000	126,000
Harvest									
Harvest - fresh market	13.00	gal				156.25	312.50	625.00	1,250.00
Harvest containers (one gallon size)	$1.66	Pail				170			
Harvest containers (1000 plastic bags per case)	$17.95	Case				4	4	4	4
Hand Washing Station	$150.00	Mth				2	2	2	2
Porta potty	$25.00	Mth				2	2	2	2
Fertilizer									
Ammonium Sulfate	$0.24	lb	75	200	200	200	200	200	200
Copper Chelate	5.12	qt				2.50	2.50	2.50	2.50
Iron Chelate	8.74	qt				1.25	1.25	1.25	1.25
Solubor	0.65	lb				1.50	1.50	1.50	1.50
Zinc Chelade	6.70	qt				1.50	1.50	1.50	1.50
Pesticides									
Captan (Captan 50 WP)	$6.59	lb				15	15	15	15
Carbaryl (Sevin XLR Plus)	11.5	qt			4.5	4.5	4.5	4.5	4.5
Glyphosate (Roundup WeatherMax 5.5 EC)	9.8	qt	3.5	3.5	3.5	3.5	3.5	3.5	3.5
Lime sulfur	8	gal			13	13	13	13	13

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Malathion	5	pt				4	4	4	4
Paraquat (Gramoxone Inteon 2 L)	3	pt	9	9	9	9	9	9	9
Zeta-cypermethrin (Mustang Max)	1	oz				12	12	12	12
Traps (SWD)	$2.75	Unit				5	5	5	5
Baits (SWD)	$0.10	Unit				40	40	40	40
Labor									
Leaf sample collection	$9.00	Hr			1	1	1	1	1
Soil sample collection	$9.00	Hr	1	1		1		1	
Landscape fabric removel / set up	$9.00	Hr		4	4	4	4	4	4
Machinery operation	9.00	Hr	57.19	57.19	57.19	57.19	57.19	57.19	57.19
Management	$15.00	Hr	1	1	1	1	1	1	1
Planting	$9.00	Hr		60					
Pre-harvest	$9.00	Hr				1	1	1	1
Post harvest	$9.00	Hr				1	1	1	1
IPM Scouting	$9.00	Hr				5	5	5	5
Unallocated Activities	$9.00	Hr	2	2	2	2	2	2	2

Table A. 4 Summary of Baseline Scenario Practices Used in the Conventional Open Field System Baseline Scenario, Years 8-15

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Soil/Leaf Analysis									
Leaf analysis	1	1	1	1	1	1	1	1	**13**
Soil analysis	1		1		1		1		**8**
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)									**100**
Orchard Grass Seeds									**6**
Planting									**-**
Blueberry plants - Price									**1,250**
Bumblebees	3	3	3	3	3	3	3	3	**36**
Grading table									**1**
Hand hoe	5								**10**
Peat moss									**3,750**
Wood Mulch	1,667	1,667	1,667	1,667	1,667	1,667	1,667	1,667	**26,671**
Landscape fabric (125 by 4000 feet)					3				**9**
Irrigation Water	126,000	126,000	126,000	126,000	126,000	126,000	126,000	126,000	**1,624,277**
Harvest									**-**
Harvest - fresh market	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	**12,343.75**
Harvest containers (one gallon size)							170		**340**
Harvest containers (1000 plastic bags per case)	4	4	4	4	4	4	4	4	**48**
Hand Washing Station	2	2	2	2	2	2	2	2	**24**
Porta potty	2	2	2	2	2	2	2	2	**24**
Fertilizer									**-**
Ammonium Sulfate	200	200	200	200	200	200	200	200	**2,875**
Copper Chelate	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	**30.00**
Iron Chelate	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	**15.00**
Solubor	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**
Zinc Chelade	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**
Pesticides									**-**
Captan (Captan 50 WP)	15	15	15	15	15	15	15	15	**180**
Carbaryl (Sevin XLR Plus)	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	**58.5**
Glyphosate (Roundup WeatherMax 5.5 EC)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	**52.5**

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Lime sulfur	13	13	13	13	13	13	13	13	**169**
Malathion	4	4	4	4	4	4	4	4	**48**
Paraquat (Gramoxone Inteon 2 L)	9	9	9	9	9	9	9	9	**135**
Zeta-cypermethrin (Mustang Max)	12	12	12	12	12	12	12	12	**144**
Traps (SWD)	5	5	5	5	5	5	5	5	**60**
Baits (SWD)	40	40	40	40	40	40	40	40	**480**
Labor									**-**
Leaf sample collection	1	1	1	1	1	1	1	1	**13**
Soil sample collection	1		1		1		1		**8**
Landscape fabric removel / set up	4	4	4	4	4	4	4	4	**56**
Machinery operation	57.19	57.19	57.19	57.19	57.19	57.19	57.19	57.19	**857.85**
Management	1	1	1	1	1	1	1	1	**15**
Planting									**60**
Pre-harvest	1	1	1	1	1	1	1	1	**12**
Post harvest	1	1	1	1	1	1	1	1	**12**
IPM Scouting	5	5	5	5	5	5	5	5	**60**
Unallocated Activities	2	2	2	2	2	2	2	2	**30**

Table A. 5 Summary of Baseline Scenario Practices Used in the Organic High Tunnel System Baseline Scenario, Years 1- 7

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Soil/Leaf Analysis									
Leaf analysis	$20.00	Sample			1	1	1	1	1
Soil analysis	$0.00	Sample	1	1		1		1	
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)	$1.15	lb	100						
Orchard Grass Seeds	$4.39	lb	6						
Planting									
Blueberry plants - Price	$5.00	Plant		1,250					
Bumblebees	$35.00	Hive				3	3	3	3
Grading table	$100.00	Unit				1			
Hand hoe	$17.95	Unit		5					
Peat moss	$0.35	lb		3,750					
Wood Mulch	$0.03	lb		5,000	1,667	1,667	1,667	1,667	1,667
Landscape fabric (125 by 4000 feet)		Roll		3					3
Irrigation Water	$0.01	gal	5,132	64,800	64,800	151,200	151,200	151,200	151,200
Organic Certification Fees	$700.00	A			1	1	1	1	1
Harvest									
Harvest - fresh market	14.30	gal				156.25	312.50	625.00	1,250.00
Harvest containers (one gallon size)	$1.66	Pail				170			
Harvest containers (1000 plastic bags per case)	$17.95	Case				4	4	4	4
Hand Washing Station	$150.00	Mth				2	2	2	2
Porta potty	$25.00	Mth				2	2	2	2
Fertilizer									
Pelleted dry poultry litter	$124.00	Ton	1						
Sulfur	$0.29	lb	1,000						
Fish Meal	$1.72	lb		450	450	450	450	450	450
Copper Chelate	5.12	qt				2.50	2.50	2.50	2.50
Iron Chelate	8.74	qt				1.25	1.25	1.25	1.25
Solubor	0.65	lb				1.50	1.50	1.50	1.50
Zinc Chelade	6.70	qt				1.50	1.50	1.50	1.50
Pesticides									

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Lime sulfur	$8.30	gal			13	13	13	13	13
Pyrethrins (Pyganic 1.4% EC)	2	oz				64	64	64	64
Spinosad (Entrust 2SC)	11	gal				15	15	15	15
Traps (SWD)	$2.75	Unit				5	5	5	5
Baits (SWD)	$0.10	Unit				40	40	40	40
Labor									
Leaf sample collection	$9.00	Hr			1	1	1	1	1
Soil sample collection	$9.00	Hr	1	1		1		1	
Landscape fabric removel / set up	$9.00	Hr		4	4	4	4	4	4
Machinery operation	9.00	Hr	62.91	62.91	62.91	62.91	62.91	62.91	62.91
Management	$15.00	Hr	1	1	1	1	1	1	1
Planting	$9.00	Hr		60					
Pre-harvest	$9.00	Hr				1	1	1	1
Post harvest	$9.00	Hr				1	1	1	1
IPM Scouting	$9.00	Hr				5	5	5	5
Weed control Labor	$9.00	Hr	18	18	18	18	18	18	18
High Tunnel Management	$9.00	Hr		10	10	10	10	10	10
Unallocated Activities	$9.00	Hr	2	2	2	2	2	2	2

Table A. 6 Summary of Baseline Scenario Practices Used in the Organic High Tunnel System Baseline Scenario, Years 8-15

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Soil/Leaf Analysis									
Leaf analysis	1	1	1	1	1	1	1	1	**13**
Soil analysis	1		1		1		1		**8**
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)									**100**
Orchard Grass Seeds									**6**
Planting									**-**
Blueberry plants - Price									**1,250**
Bumblebees	3	3	3	3	3	3	3	3	**36**
Grading table									**1**
Hand hoe	5								**10**
Peat moss									**3,750**
Wood Mulch	1,667	1,667	1,667	1,667	1,667	1,667	1,667	1,667	**26,671**
Landscape fabric (125 by 4000 feet)					3				**9**
Irrigation Water	151,200	151,200	151,200	151,200	151,200	151,200	151,200	151,200	**1,949,132**
Organic Certification Fees	1	1	1	1	1	1	1	1	**7**
Harvest									**-**
Harvest - fresh market	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	**12,343.75**
Harvest containers (one gallon size)							170		**340**
Harvest containers (1000 plastic bags per case)	4	4	4	4	4	4	4	4	**48**
Hand Washing Station	2	2	2	2	2	2	2	2	**24**
Porta potty	2	2	2	2	2	2	2	2	**24**
Fertilizer									**-**
Pelleted dry poultry litter									**1**
Sulfur									**1,000**
Fish Meal	450	450	450	450	450	450	450	450	**6,300**
Copper Chelate	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	**30.00**
Iron Chelate	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	**15.00**
Solubor	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**
Zinc Chelade	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Pesticides									**-**
Lime sulfur	13	13	13	13	13	13	13	13	**169**
Pyrethrins (Pyganic 1.4% EC)	64	64	64	64	64	64	64	64	**768**
Spinosad (Entrust 2SC)	15	15	15	15	15	15	15	15	**180**
Traps (SWD)	5	5	5	5	5	5	5	5	**60**
Baits (SWD)	40	40	40	40	40	40	40	40	**480**
Labor									**-**
Leaf sample collection	1	1	1	1	1	1	1	1	**13**
Soil sample collection	1		1		1		1		**8**
Landscape fabric removel / set up	4	4	4	4	4	4	4	4	**56**
Machinery operation	62.91	62.91	62.91	62.91	62.91	62.91	62.91	62.91	**943.67**
Management	1	1	1	1	1	1	1	1	**15**
Planting									**60**
Pre-harvest	1	1	1	1	1	1	1	1	**12**
Post harvest	1	1	1	1	1	1	1	1	**12**
IPM Scouting	5	5	5	5	5	5	5	5	**60**
Weed control Labor	18	18	18	18	18	18	18	18	**270**
High Tunnel Management	10	10	10	10	10	10	10	10	**140**
Unallocated Activities	2	2	2	2	2	2	2	2	**30**

Table A. 7 Summary of Baseline Scenario Practices Used in the Conventional High Tunnel System Baseline Scenario, Year 1- 7

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Soil/Leaf Analysis									
Leaf analysis	$20.00	Sample			1	1	1	1	1
Soil analysis	$0.00	Sample	1	1		1		1	
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)	$1.15	lb	100						
Orchard Grass Seeds	$4.39	lb	6						
Planting									
Blueberry plants - Price	$5.00	Plant		1,250					
Bumblebees	$35.00	Hive				3	3	3	3
Grading table	$100.00	Unit				1			
Hand hoe	$17.95	Unit		5					
Peat moss	$0.35	lb		3,750					
Wood Mulch	$0.03	lb		5,000	1,667	1,667	1,667	1,667	1,667
Landscape fabric (125 by 4000 feet)		Roll		3					3
Irrigation Water	$0.01	gal	5,132	64,800	64,800	151,200	151,200	151,200	151,200
Harvest									
Harvest - fresh market	13.00	gal				156.25	312.50	625.00	1,250.00
Harvest containers (one gallon size)	$1.66	Pail				170			
Harvest containers (1000 plastic bags per case)	$17.95	Case				4	4	4	4
Hand Washing Station	$150.00	Mth				2	2	2	2
Porta potty	$25.00	Mth				2	2	2	2
Fertilizer									
Ammonium Sulfate	$0.24	lb	75	200	200	200	200	200	200
Copper Chelate	5.12	qt				2.50	2.50	2.50	2.50
Iron Chelate	8.74	qt				1.25	1.25	1.25	1.25
Solubor	0.65	lb				1.50	1.50	1.50	1.50
Zinc Chelade	6.70	qt				1.50	1.50	1.50	1.50
Pesticides									
Captan (Captan 50 WP)	7	lb				15	15	15	15
Carbaryl (Sevin XLR Plus)	11.52	qt			4.50	4.50	4.50	4.50	4.50
Glyphosate (Roundup WeatherMax 5.5 EC)	9.75	qt	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Lime sulfur	8	gal			13	13	13	13	13

Activity/Year (Y)	Unit Price	Unit	Y1	Y2	Y3	Y4	Y5	Y6	Y7
Malathion	5	pt				4	4	4	4
Paraquat (Gramoxone Inteon 2 L)	3	pt	9	9	9	9	9	9	9
Zeta-cypermethrin (Mustang Max)	1	oz				12	12	12	12
Traps (SWD)	$2.75	Unit				5	5	5	5
Baits (SWD)	$0.10	Unit				40	40	40	40
Labor									
Leaf sample collection	$9.00	Hr			1	1	1	1	1
Soil sample collection	$9.00	Hr	1	1		1		1	
Landscape fabric removel / set up	$9.00	Hr		4	4	4	4	4	4
Machinery operation	$9.00	Hr	57	57	57	57	57	57	57
Management	$15.00	Hr	1	1	1	1	1	1	1
Planting	$9.00	Hr		60					
Pre-harvest	$9.00	Hr				1	1	1	1
Post harvest	$9.00	Hr				1	1	1	1
IPM Scouting	$9.00	Hr				5	5	5	5
High Tunnel Management	$9.00	Hr		10	10	10	10	10	10
Unallocated Activities	$9.00	Hr	2	2	2	2	2	2	2

Table A. 8 Summary of Baseline Scenario Practices Used in the Conventional High Tunnel System Baseline Scenario, Years 8-15

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Soil/Leaf Analysis									
Leaf analysis	1	1	1	1	1	1	1	1	**13**
Soil analysis	1		1		1		1		**8**
Cover Crops & Row Cover									
Legume Seeds (Cowpeas)									**100**
Orchard Grass Seeds									**6**
Planting									**-**
Blueberry plants - Price									**1,250**
Bumblebees	3	3	3	3	3	3	3	3	**36**
Grading table									**1**
Hand hoe	5								**10**
Peat moss									**3,750**
Wood Mulch	1,667	1,667	1,667	1,667	1,667	1,667	1,667	1,667	**26,671**
Landscape fabric (125 by 4000 feet)					3				**9**
Irrigation Water	151,200	151,200	151,200	151,200	151,200	151,200	151,200	151,200	**1,949,132**
Harvest									**-**
Harvest - fresh market	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	1,250.00	**12,343.75**
Harvest containers (one gallon size)							170		**340**
Harvest containers (1000 plastic bags per case)	4	4	4	4	4	4	4	4	**48**
Hand Washing Station	2	2	2	2	2	2	2	2	**24**
Porta potty	2	2	2	2	2	2	2	2	**24**
Fertilizer									**-**
Ammonium Sulfate	200	200	200	200	200	200	200	200	**2,875**
Copper Chelate	2.50	2.50	2.50	2.50	2.50	2.50	2.50	2.50	**30.00**
Iron Chelate	1.25	1.25	1.25	1.25	1.25	1.25	1.25	1.25	**15.00**
Solubor	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**
Zinc Chelade	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	**18.00**
Pesticides									**-**
Captan (Captan 50 WP)	15	15	15	15	15	15	15	15	**180**

Activity/Year (Y)	Y8	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Carbaryl (Sevin XLR Plus)	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	**58.50**
Glyphosate (Roundup WeatherMax 5.5 EC)	3.50	3.50	3.50	3.50	3.50	3.50	3.50	3.50	**52.50**
Lime sulfur	13	13	13	13	13	13	13	13	**169**
Malathion	4	4	4	4	4	4	4	4	**48**
Paraquat (Gramoxone Inteon 2 L)	9	9	9	9	9	9	9	9	**135**
Zeta-cypermethrin (Mustang Max)	12	12	12	12	12	12	12	12	**144**
Traps (SWD)	5	5	5	5	5	5	5	5	**60**
Baits (SWD)	40	40	40	40	40	40	40	40	**480**
Labor									**-**
Leaf sample collection	1	1	1	1	1	1	1	1	**13**
Soil sample collection	1		1		1		1		**8**
Landscape fabric removel / set up	4	4	4	4	4	4	4	4	**56**
Machinery operation	57	57	57	57	57	57	57	57	**858**
Management	1	1	1	1	1	1	1	1	**15**
Planting									**60**
Pre-harvest	1	1	1	1	1	1	1	1	**12**
Post harvest	1	1	1	1	1	1	1	1	**12**
IPM Scouting	5	5	5	5	5	5	5	5	**60**
High Tunnel Management	10	10	10	10	10	10	10	10	**140**
Unallocated Activities	2	2	2	2	2	2	2	2	**30**

Table A. 9 Sources for Practices and Prices used in Baseline Scenarios

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
Soil and Leaf Analysis/Organic Certification Fee						
Soil analysis	$0.00	Sample	Arkansas Agricultural Experiment Station	http://www.uark.edu/depts/soiltest/NewSoilTest/available_analyses.htm	Accessed 11/19/2014	Garcia (2014)
Leaf analysis	$20.00	Sample	Mr. L. Dozier	Personal Communication	10/09/2014	Garcia (2014)
Organic Certification Fee	$700.00	Annum	California Certified Organic Farmers	http://www.ccof.org/certification/fees	Accessed 11/11/2014	Garcia (2014)
Cover Crops						
Legume Seeds (Cowpeas)	$1.15	lb	Harmony Organics Garden And Farm Supply	http://harmonyorganics.net/catalog.html#SoilAme	Accessed 11/19/2014	http://www.sare.org/Learning-Center/Books/Managing-Cover-Crops-Profitably-3rd-Edition/Text-Version/Legume-Cover-Crops/Cowpeas
Orchardgrass Seeds (Row Cover)	$3.66	lb	Southern States Cooperative	http://www.southernstates.com/catalog/c-1109-orchardgrass.aspx	Accessed 11/19/2014	http://extension.missouri.edu/p/g4511
Planting						
Blueberry plants	$5.00	Plant	Fall Creek Farm and Nursery, Inc.	http://www.fallcreeknursery.com/nursery/landing/nurseries	Accessed 11/19/2014	Dozier (2014)
Bumblebees	$35.00	Hive	Rodriguez et al. (2014b)	Strawberry Unpublished Budget	2014	Garcia (2014)
Hand hoe	$17.95	Unit	Territorial Seed Company	http://www.territorialseed.com/product/Ko_Gamma_Hoe	Accessed 11/19/2014	Pritts et al. (1992)
Peat moss	$0.35	lb	The Tool Workshop	http://www.thetoolworkshop.com/premierbrands38cufts	Accessed 11/19/2014	Garcia (2014) and Literature review

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
				phagpeatmoss0082p.aspx		
Wood mulch	$0.03	lb	City of Bentonville, Arkansas	http://www.bentonvillear.com/departments/compost-facility/	Accessed 11/19/2014	Garcia (2014)
Landscape Fabric (125x4000 feet)	$182.60	Roll	Rodriguez et al. (2014b)	Strawberry Unpublished Budget	2014	Rodriguez et al. (2014b)
Harvest						
Harvest - fresh market	$13.00	gal	Mr. L. Dozier	Personal Communication	10/09/2014	Dozier (2014)
Harvest containers (1 gal pail)	$1.66	Unit	Container and Packaging Supply Inc.	http://www.containerandpackaging.com/item/P009	Accessed 11/19/2014	Dozier (2014)
Plastic Bags	$17.95	case	Store Supply Warehouse, LLC	http://www.storesupply.com/pc-13204-623-plastic-thank-you-bags-white-90109.aspx?zmam=66923263&zmas=1&zmac=1&zmap=90109.00&gclid=CPWTpsXWpMECFQqGaQodPrIA2g	Accessed 11/19/2014	Assumption
Grading table	$100.00	Unit	Rodriguez et al. (2014b)	Strawberry Unpublished Budget	2014	Assumption and Rodriguez et al. (2014b)
Food Safety						
Porta potty	$150.00	Mth	Zters, Inc.	Personal communication	September 22, 2014	S.C. Seideman (2014) (2014), personal communication
Handwashing station	$25.00	Mth	Dr. J Popp	Personal Communication	September 22, 2014	Assumption, J. Popp (2014)
Fertilizer						
Ammonium sulfate	$0.24	lb	Rural King Supply	http://www.ruralking.com/agriculture/agricultural-sprayers-	Accessed 11/19/2014	E. Garcia (2014), personal communication and

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
				chemicals/agricultural-chemicals-fertilizers/fertilizers/dsm-ammonium-sulfate-51lb-bag.html		Pritts et al. (1992)
Copper Chelate	$5.12	qt	Arizona Biological Control, Inc.	http://www.arbico-organics.com/product/3442/organic-soil-conditioners?kpid=1810568&gclid=COvD8PyX9MECFYdzMgodrVQAsw	Accessed 11/19/2014	Product Label
Fish Meal	$1.72	lb	Nitron Industries, Inc.	http://www.gardeniq.com/fish-meal?ReturnUrl=LwBwAHIAbwBkAHUAYwB0AHMA	Accessed 11/19/2014	Carroll et al. (2013)
Iron Chelate	$8.74	qt	Seed Ranch	http://www.seedranch.com/Chelated-Liquid-Iron-1-Gal-p/Liquid-Iron-Gal.htm?gclid=COnr-LekhsICFaPyMgodSQkAaQ	Accessed 11/19/2014	Product Label
Pelleted Poultry Litter	$124.00	Ton	Herbruck's Poultry Ranch, Inc.	http://www.herbrucks.com/index.php/products-and-services/dried-fertilizer	Accessed 11/19/2014	The Royal Horticultural Society (https://www.rhs.org.uk/advice/profile?PID=297)
Solubor (Boron)	$0.65	lb	Harmony Organics Garden and Farm Supply	http://harmonyorganics.net/catalog.html#SoilAme	Accessed 11/19/2014	Pritts et al. (1992)
Sulfur	$0.29	lb	University of Arkansas, Division of Agriculture, Research & Extension, 2014 Crop Enterprise Budgets	http://www.uaex.edu/farm-ranch/economics-marketing/docs/Budgets%202014.pdf	Accessed 11/19/2014	Pritts et al. (1992)
Zinc chelate	$6.70	qt	KORUSA Pest	http://www.pestrong.com/8	Accessed	Product Label

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
			Control., Inc.	72-dyna-gold-chelated-zinc-7-liquid-fertilizer-25-gallons.html	11/19/2014	
Pesticides						
Captan (Captan 50 WP)	$6.59	lb	Keystone PestSolutions LLC	http://www.keystonepestsolutions.com/captan-fungicide-50wp-5-pounds-295.html	Accessed 11/19/2014	Product Label
Carbaryl (Sevin XLR Plus)	$11.52	qt	Winfield Solutions	Dr. C. Lewis (Personal Communication, August 14, 2014)	2014	Product Label
Glyphosate (Roundup WeatherMax 5.5 EC)	$9.75	qt	Dorsett Bros., Inc.	http://www.dorsettbrosinc.com/index.cfm?show=10&mid=15	Posted 3/26/2014	Product Label
Lime sulfur	$8.30	gal	Peaceful Valley Farm & Garden Supply	http://www.groworganic.com/bsp-lime-sulfur-fungicide-30-gallon.html	Accessed 11/19/2014	Product Label
Malathion	$4.74	pt	Dorsett Bros., Inc.	http://www.dorsettbrosinc.com/index.cfm?show=10&mid=15	Posted 3/26/2014	Product Label
Paraquat (Gramoxone Inteon 2 L)	$3.13	pt	EzBuyAg.com	http://www.ezbuyag.com/farm-chemical-details.cfm/60	Accessed 11/19/2014	Product Label
Pyrethrins (Pyganic 1.4% EC)	$1.56	oz	P&M Solutions, LLC	http://www.domyownpestcontrol.com/pyganic-crop-protection-ec-14-ii-p-2711.html	Accessed 11/19/2014	Product Label
Spinosad (Entrust 2SC)	$11.22	oz	Winfield Solutions	Dr. C. Lewis (Personal Communication, August 14, 2014)	2014	Product Label
Zeta-cypermethrin (Mustang Max)	$1.17	oz	Kentucky Farm Bureau	https://www.kyfb.com/media/files/fed/member-benefits/2014%20Chemical%20Prices%20corrected.pdf	Posted 2/28/2014	Product Label

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
Traps (Spotted Wing Drosophila)	$2.75	Trap	Contech Enterprises, Inc.	http://www.oregonblueberry.com/update/new.html	Accessed 11/19/2014	Contech Enterprises Inc. (http://www.oregonblueberry.com/update/new.html)
Baits (Spotted Wing Drosophila)	$0.10	Bait	University of Connecticut, Plant Science and Landscape Architecture Extension	http://ipm.uconn.edu/documents/raw2/html/588.php?display=print	Posted 6/16/2014	University of Connecticut, Plant Science and Landscape Architecture Extension (http://ipm.uconn.edu/documents/raw2/html/588.php?display=print)
Labor						
Blueberry Farm Management	$15.00	Hr	Dr C. Rom	Personal Communication	September 18, 2014	J. Popp (2014), personal communication and Pritts et al. (1992)
Machinery and Manual Operation	$9.00	Hr	Dr C. Rom	Personal Communication	September 18, 2014	Assumptions, J. Popp (2014) and Pritts et al. (1992) and Liturature review
Irrigation and High Tunnels						
1" Drip tube	$0.39	ft	DripWorks, Inc.	http://www.dripworks.com/product/Q_F	Accessed 11/19/2014	Rodriguez et al. (2014a)
Irrigation Water	$0.006	gal	City of Springdale, Arkansas	http://www.springdalewater.com/?page_id=193	Accessed 11/19/2014	FAO (http://www.fao.org/docrep/u3160e/u3160e04.htm; http://www.nda.agric.za/docs/Brochures/Cowpea2013.pdf)

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
High Tunnel Installation	$0.96	ft^2	Haygrove, Inc.	https://www.uaex.edu/farm-ranch/crops-commercial-horticulture/docs/High%20Tunnel%20Construction.pdf	Accessed 11/19/2014	Assumptions and Literature review
			Machinery			
30 HP Tractor	$20,600.00	Unit	USDA - Agricultural Prices	http://www.usda.gov/nass/PUBS/TODAYRPT/agpr0414.pdf	Posted April 30, 2014	E. Garcia (2014) and Dozier (2014)
Mower	$1,600.00	Unit	Tractor Supply Co.	http://www.tractorsupply.com/en/store/countylinereg%3B-6-ft-rear-discharge-finish-mower-with-a-40-hp-gearbox	Accessed 11/19/2014	Dozier (2014)
Airblast Sprayer	$1,200.00	Unit	Legacy Equipment	Personal Communication	October 02, 2014	Dozier (2014) and Pritts et al. (1992)
Bed Shaper	$465.00	Unit	Everything Attachments.com	http://www.everythingattachments.com/Tractor-3-Point-Hitch-Garden-Bedder-48-GB50-p/eta-bedder-50-gb50.htm	Accessed 11/19/2014	Garcia (2014) and Dozier (2014)
Boom Sprayer	$600.00	Unit	Tractor Supply Co.	http://www.tractorsupply.com/en/store/fimco-40-gallon-trailer-sprayer?cm_vc=-10005	Accessed 11/19/2014	Dozier (2014) and Pritts et al. (1992)
Disc	$825.00	Unit	Equipment Trader	http://www.equipmenttraderonline.com/listing/-AGRI-3pt-4--foot-tandem-disc-112952018	Accessed 11/19/2014	Dozier (2014) and Pritts et al. (1992)
Mulcher	$4,000.00	Unit	Mr. L. Dozier	Personal Communication	10/09/2014	Dozier (2014) and Pritts et al. (1992)
Plow	$500.00	Unit	Tractor Supply Co.	http://www.tractorsupply.com/en/store/countylinereg%3B-1-bottom-plow	Accessed 11/19/2014	Dozier (2014) and Pritts et al. (1992)
Spreader	$339.95	Unit	Agri Supply	http://www.agrisupply.com/fertilizer-	Accessed 11/19/2014	Dozier (2014) and Pritts et al. (1992)

Activities	Unit Price	Unit	Sources	Links	Date	Quantity Sources
				spreaders/c/2000011/		
Tiller - 5 ft	$1,549.99	Unit	Tractor Supply Co.	http://www.tractorsupply.com/en/store/countylinereg%3B-5-ft-all-gear-driven-tiller	Accessed 11/19/2014	Dozier (2014) and Pritts et al. (1992)
Pnuematic pruner	$795.00	Unit	OESCO., Inc.	http://www.oescoinc.com/campagnola-se-4-pneumatic-pruner-hand-held-or-extended.html	Accessed 11/19/2014	Dozier (2014) and Garcia (2014)
backpack spot sprayer	$80.00	Unit	Tractor Supply Co.	http://www.tractorsupply.com/en/store/soloreg%3B-backpack-sprayer-4-gal	Accessed 11/19/2014	Dozier (2014)
Diesel	$3.73	gal	Ycharts	https://ycharts.com/indicators/us_diesel_price	Posted 10/06/2014	ASAE D.497.7 (2011)
Inflation	2%	Annum	Bureau of Labor Statistics	http://www.bls.gov/cpi/ or http://www.bls.gov/ppi/ or http://www.clevelandfed.org/research/Data/us-inflation/revmcpi.pdf	Accessed 09/01/2014	

Appendix B Summary of Baseline Results

Table B. 1 Organic Open Field Production Present Values, Years 1-7

Activity	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
				Revenues				
Revenues	-	-	-	2,091	4,091	8,002	15,655	15,312
				Variable Costs				
	-	-	-	-	-	-	-	-
Soil and Leaf Analysis	-	-	19	19	18	18	18	17
Food Safety	-	-	-	328	320	313	307	300
Cover Crops	137	-	-	-	-	-	-	-
Materials	-	8,167	48	570	208	203	678	271
Fertilizers	374	757	741	757	740	724	708	693
Pesticides	-	-	103	369	360	353	345	337
Water/Irrigation	26	317	310	707	692	677	662	648
Labor	770	1,317	814	822	796	786	761	752
				Additional Expenses				
Fuel	35	34	34	33	32	31	31	30
Machinery Repairs	24	23	23	22	22	21	21	20
Miscellaneous	200	196	191	187	183	179	175	171
Oil and Filter	5	5	5	5	5	5	5	5
Organic Certification Fee	-	-	670	328	320	313	307	300
Interest on Operating Capital	67	463	127	177	158	155	172	152
Total Variable Costs	**1,638**	**11,279**	**3,084**	**4,323**	**3,855**	**3,779**	**4,188**	**3,696**
				Fixed Costs				
Machinery Depreciation and Interest	76	75	73	71	70	68	67	65
Machinery Insurance	2	2	2	1	1	1	1	1
Machinery Tax	6	6	6	6	6	6	6	5
Machinery Housing	5	5	5	4	4	4	4	4
Irrigation Depreciation and Interest	229	224	219	214	210	205	201	196
Irrigation Insurance	3	3	3	3	3	3	3	3
Irrigation Tax	12	12	12	12	11	11	11	11
Total Fixed Costs	**334**	**326**	**319**	**312**	**305**	**299**	**292**	**286**
Total Costs	1,972	11,605	3,403	4,635	4,160	4,078	4,481	3,981
Net Return	**(1,972)**	**(11,605)**	**(3,403)**	**(2,544)**	**(70)**	**3,925**	**11,174**	**11,331**

Table B. 2 Organic Open Field Production Present Values, Years 8-15

Activity	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Revenues								
Revenues	14,977	14,650	14,330	14,016	13,710	13,410	13,117	143,361
Variable Costs								
Soil and Leaf Analysis	17	16	16	16	15	15	15	219
Food Safety	293	287	281	274	268	263	257	3,491
Cover Crops	-	-	-	-	-	-	-	137
Materials	190	186	182	607	174	449	166	12,100
Fertilizers	678	663	648	634	620	607	593	9,938
Pesticides	330	323	316	309	302	295	289	4,031
Water/Irrigation	633	620	606	593	580	567	555	8,192
Labor	728	720	697	689	667	659	638	11,616
Additional Expenses								
Fuel	29	29	28	28	27	26	26	453
Machinery Repairs	20	19	19	18	18	18	17	304
Miscellaneous	168	164	160	157	153	150	147	2,582
Oil and Filter	4	4	4	4	4	4	4	68
Organic Certification Fee	293	287	281	274	268	263	257	4,160
Interest on Operating Capital	145	142	139	154	133	142	127	2,452
Total Variable Costs	**3,529**	**3,459**	**3,376**	**3,758**	**3,230**	**3,457**	**3,090**	**59,741**
Fixed Costs								
Machinery Depreciation and Interest	64	63	61	60	59	57	56	985
Machinery Insurance	1	1	1	1	1	1	1	20
Machinery Tax	5	5	5	5	5	5	5	81
Machinery Housing	4	4	4	4	4	4	3	61
Irrigation Depreciation and Interest	192	188	184	180	176	172	168	2,956
Irrigation Insurance	3	3	3	2	2	2	2	40
Irrigation Tax	10	10	10	10	10	9	9	161
Total Fixed Costs	**279**	**273**	**267**	**262**	**256**	**250**	**245**	**4,305**
Total Costs	3,808	3,733	3,643	4,019	3,486	3,708	3,335	**64,047**
Net Return	**11,169**	**10,917**	**10,686**	**9,997**	**10,224**	**9,703**	**9,782**	**79,315**

Table B. 3 Conventional Open Field Production Present Values, Years 1-7

Activity	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Revenues								
Revenues	-	-	-	1,901	3,719	7,275	14,231	13,920
Variable Costs								
Soil and Leaf Analysis	-	-	19	19	18	18	18	17
Food Safety	-	-	-	328	320	313	307	300
Cover Crops	137	-	-	-	-	-	-	-
Materials	-	8,167	48	570	208	203	678	271
Fertilizers	18	47	46	77	76	74	72	71
Pesticides	62	61	212	348	340	333	325	318
Water/Irrigation	26	317	310	707	692	677	662	648
Labor	557	1,108	610	622	600	595	574	569
Additional Expenses								
Fuel	35	34	34	33	32	31	31	30
Machinery Repairs	24	23	23	22	22	21	21	20
Miscellaneous	200	196	191	187	183	179	175	171
Oil and Filter	5	5	5	5	5	5	5	5
Interest on Operating Capital	46	426	64	125	107	105	123	104
Total Variable Costs	**1,109**	**10,384**	**1,562**	**3,043**	**2,603**	**2,554**	**2,991**	**2,524**
Fixed Costs								
Machinery Depreciation and Interest	76	75	73	71	70	68	67	65
Machinery Insurance	2	2	2	1	1	1	1	1
Machinery Tax	6	6	6	6	6	6	6	5
Machinery Housing	5	5	5	4	4	4	4	4
Irrigation Depreciation and Interest	229	224	219	214	210	205	201	196
Irrigation Insurance	3	3	3	3	3	3	3	3
Irrigation Tax	12	12	12	12	11	11	11	11
Total Fixed Costs	**334**	**326**	**319**	**312**	**305**	**299**	**292**	**286**
Total Costs	1,443	10,710	1,881	3,355	2,908	2,853	3,283	2,810
Net Return	**(1,443)**	**(10,710)**	**(1,881)**	**(1,454)**	**810**	**4,422**	**10,949**	**11,110**

Table B. 4 Conventional Open Field Production Present Values, Years 8-15

Activity	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Revenues								
Revenues	13,616	13,318	13,027	12,742	12,464	12,191	11,925	130,329
Variable Costs								
Soil and Leaf Analysis	17	16	16	16	15	15	15	219
Food Safety	293	287	281	274	268	263	257	3,491
Cover Crops	-	-	-	-	-	-	-	137
Materials	190	186	182	607	174	449	166	12,100
Fertilizers	69	68	66	65	63	62	61	936
Pesticides	311	305	298	291	285	279	273	4,042
Water/Irrigation	633	620	606	593	580	567	555	8,192
Labor	549	545	526	521	503	499	481	8,860
Additional Expenses								
Fuel	29	29	28	28	27	26	26	453
Machinery Repairs	20	19	19	18	18	18	17	304
Miscellaneous	168	164	160	157	153	150	147	2,582
Oil and Filter	4	4	4	4	4	4	4	68
Interest on Operating Capital	98	96	94	110	90	100	86	1,771
Total Variable Costs	**2,383**	**2,338**	**2,280**	**2,685**	**2,181**	**2,431**	**2,087**	**43,154**
Fixed Costs								
Machinery Depreciation and Interest	64	63	61	60	59	57	56	985
Machinery Insurance	1	1	1	1	1	1	1	20
Machinery Tax	5	5	5	5	5	5	5	81
Machinery Housing	4	4	4	4	4	4	3	61
Irrigation Depreciation and Interest	192	188	184	180	176	172	168	2,956
Irrigation Insurance	3	3	3	2	2	2	2	40
Irrigation Tax	10	10	10	10	10	9	9	161
Total Fixed Costs	**279**	**273**	**267**	**262**	**256**	**250**	**245**	**4,305**
Total Costs	2,662	2,612	2,547	2,947	2,437	2,682	2,331	**47,459**
Net Return	**10,954**	**10,707**	**10,480**	**9,796**	**10,027**	**9,510**	**9,593**	**82,869**

Table B. 5 Organic High Tunnel Production Present Values, Years 1-7

Activity	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Revenues								
Revenues	-	-	-	2,091	4,091	8,002	15,655	15,312
Variable Costs								
Soil and Leaf Analysis	-	-	19	19	18	18	18	17
Food Safety	-	-	-	328	320	313	307	300
Cover Crops	137	-	-	-	-	-	-	-
Materials	-	8,167	48	570	208	203	678	271
Fertilizers	374	757	741	757	740	724	708	693
Pesticides	-	-	103	369	360	353	345	337
Water/Irrigation	31	380	372	849	830	812	795	777
Labor	770	1,405	900	906	878	867	840	829
Additional Expenses								
Fuel	35	34	34	33	32	31	31	30
Machinery Repairs	24	23	23	22	22	21	21	20
Miscellaneous	200	196	191	187	183	179	175	171
Oil and Filter	5	5	5	5	5	5	5	5
Organic Certification Fee	-	-	670	328	320	313	307	300
Interest on Operating Capital	67	469	133	187	168	164	181	161
Total Variable Costs	**1,644**	**11,437**	**3,238**	**4,558**	**4,085**	**4,004**	**4,409**	**3,911**
Fixed Costs								
Machinery Depreciation and Interest	76	75	73	71	70	68	67	65
Machinery Insurance	2	2	2	1	1	1	1	1
Machinery Tax	6	6	6	6	6	6	6	5
Machinery Housing	5	5	5	4	4	4	4	4
Irrigation Depreciation and Interest	229	224	219	214	210	205	201	196
Irrigation Insurance	3	3	3	3	3	3	3	3
Irrigation Tax	12	12	12	12	11	11	11	11
High Tunnels Depreciation and Interest	4,040	3,952	3,865	3,781	3,698	3,617	3,538	3,461
High Tunnel Insurance	55	54	53	52	50	49	48	47
High Tunnel Tax	220	216	211	206	202	197	193	189
Total Fixed Costs	**4,649**	**4,547**	**4,448**	**4,351**	**4,256**	**4,163**	**4,072**	**3,983**
Total Costs	6,293	15,984	7,686	8,909	8,341	8,167	8,480	7,894
Net Return	**(6,293)**	**(15,984)**	**(7,686)**	**(6,818)**	**(4,250)**	**(165)**	**7,174**	**7,419**

Table B. 6 Organic High Tunnel Production Present Values, Years 8-15

Activity	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Revenues								
Revenues	14,977	14,650	14,330	14,016	13,710	13,410	13,117	143,361
Variable Costs								
Soil and Leaf Analysis	17	16	16	16	15	15	15	219
Food Safety	293	287	281	274	268	263	257	3,491
Cover Crops	-	-	-	-	-	-	-	137
Materials	190	186	182	607	174	449	166	12,100
Fertilizers	678	663	648	634	620	607	593	9,938
Pesticides	330	323	316	309	302	295	289	4,031
Water/Irrigation	760	744	727	711	696	681	666	9,831
Labor	804	794	769	759	736	726	704	12,687
Additional Expenses								
Fuel	29	29	28	28	27	26	26	453
Machinery Repairs	20	19	19	18	18	18	17	304
Miscellaneous	168	164	160	157	153	150	147	2,582
Oil and Filter	4	4	4	4	4	4	4	68
Organic Certification Fee	293	287	281	274	268	263	257	4,160
Interest on Operating Capital	153	150	147	162	140	150	134	2,568
Total Variable Costs	**3,739**	**3,665**	**3,578**	**3,955**	**3,423**	**3,646**	**3,275**	**62,567**
Fixed Costs								
Machinery Depreciation and Interest	64	63	61	60	59	57	56	985
Machinery Insurance	1	1	1	1	1	1	1	20
Machinery Tax	5	5	5	5	5	5	5	81
Machinery Housing	4	4	4	4	4	4	3	61
Irrigation Depreciation and Interest	192	188	184	180	176	172	168	2,956
Irrigation Insurance	3	3	3	2	2	2	2	40
Irrigation Tax	10	10	10	10	10	9	9	161
High Tunnels Depreciation and Interest	3,385	3,311	3,239	3,168	3,099	3,031	2,965	52,150
High Tunnel Insurance	46	45	44	43	42	41	40	711
High Tunnel Tax	185	181	177	173	169	165	162	2,844
Total Fixed Costs	**3,895**	**3,810**	**3,727**	**3,645**	**3,566**	**3,488**	**3,412**	**60,011**
Total Costs	7,635	7,476	7,305	7,600	6,989	7,134	6,686	**122,578**
Net Return	**7,343**	**7,174**	**7,025**	**6,416**	**6,721**	**6,276**	**6,431**	**20,783**

Table B. 7 Conventional High Tunnel Production Present Values, Years 1-7

Activity	Y1	Y2	Y3	Y4	Y5	Y6	Y7	Y8
Revenues								
Revenues	-	-	-	1,901	3,719	7,275	14,231	13,920
Variable Costs								
Soil and Leaf Analysis	-	-	19	19	18	18	18	17
Food Safety	-	-	-	328	320	313	307	300
Cover Crops	137	-	-	-	-	-	-	-
Materials	-	8,167	48	570	208	203	678	271
Fertilizers	18	47	46	77	76	74	72	71
Pesticides	62	61	212	348	340	333	325	318
Water/Irrigation	31	380	372	849	830	812	795	777
Labor	557	1,196	696	706	683	676	653	647
Additional Expenses								
Fuel	35	34	34	33	32	31	31	30
Machinery Repairs	24	23	23	22	22	21	21	20
Miscellaneous	200	196	191	187	183	179	175	171
Oil and Filter	5	5	5	5	5	5	5	5
Interest on Operating Capital	46	433	70	135	116	114	132	112
Total Variable Costs	**1,114**	**10,542**	**1,716**	**3,278**	**2,833**	**2,780**	**3,211**	**2,740**
Fixed Costs								
Machinery Depreciation and Interest	76	75	73	71	70	68	67	65
Machinery Insurance	2	2	2	1	1	1	1	1
Machinery Tax	6	6	6	6	6	6	6	5
Machinery Housing	5	5	5	4	4	4	4	4
Irrigation Depreciation and Interest	229	224	219	214	210	205	201	196
Irrigation Insurance	3	3	3	3	3	3	3	3
Irrigation Tax	12	12	12	12	11	11	11	11
High Tunnels Depreciation and Interest	4,040	3,952	3,865	3,781	3,698	3,617	3,538	3,461
High Tunnel Insurance	55	54	53	52	50	49	48	47
High Tunnel Tax	220	216	211	206	202	197	193	189
Total Fixed Costs	**4,649**	**4,547**	**4,448**	**4,351**	**4,256**	**4,163**	**4,072**	**3,983**
Total Costs	5,763	15,089	6,164	7,629	7,089	6,942	7,282	6,722
Net Return	**(5,763)**	**(15,089)**	**(6,164)**	**(5,728)**	**(3,370)**	**333**	**6,949**	**7,198**

Table B. 8 Conventional High Tunnel Production Present Values Years 8-15

Activity	Y9	Y10	Y11	Y12	Y13	Y14	Y15	Total
Revenues								
Revenues	13,616	13,318	13,027	12,742	12,464	12,191	11,925	130,329
Variable Costs								
Soil and Leaf Analysis	17	16	16	16	15	15	15	219
Food Safety	293	287	281	274	268	263	257	3,491
Cover Crops	-	-	-	-	-	-	-	137
Materials	190	186	182	607	174	449	166	12,100
Fertilizers	69	68	66	65	63	62	61	936
Pesticides	311	305	298	291	285	279	273	4,042
Water/Irrigation	760	744	727	711	696	681	666	9,831
Labor	625	619	598	592	572	566	547	9,932
Additional Expenses								
Fuel	29	29	28	28	27	26	26	453
Machinery Repairs	20	19	19	18	18	18	17	304
Miscellaneous	168	164	160	157	153	150	147	2,582
Oil and Filter	4	4	4	4	4	4	4	68
Interest on Operating Capital	106	104	102	118	97	108	93	1,887
Total Variable Costs	**2,593**	**2,544**	**2,481**	**2,882**	**2,374**	**2,620**	**2,271**	**45,980**
Fixed Costs								
Machinery Depreciation and Interest	64	63	61	60	59	57	56	985
Machinery Insurance	1	1	1	1	1	1	1	20
Machinery Tax	5	5	5	5	5	5	5	81
Machinery Housing	4	4	4	4	4	4	3	61
Irrigation Depreciation and Interest	192	188	184	180	176	172	168	2,956
Irrigation Insurance	3	3	3	2	2	2	2	40
Irrigation Tax	10	10	10	10	10	9	9	161
High Tunnels Depreciation and Interest	3,385	3,311	3,239	3,168	3,099	3,031	2,965	52,150
High Tunnel Insurance	46	45	44	43	42	41	40	711
High Tunnel Tax	185	181	177	173	169	165	162	2,844
Total Fixed Costs	**3,895**	**3,810**	**3,727**	**3,645**	**3,566**	**3,488**	**3,412**	**60,011**
Total Costs	6,489	6,355	6,208	6,528	5,940	6,108	5,683	**105,991**
Net Return	**7,127**	**6,964**	**6,819**	**6,214**	**6,524**	**6,083**	**6,242**	**24,338**