COMPARISON AND COST ANALYSIS OF GROWING HOPS IN A GREENHOUSE VERSUS AN OUTSIDE ENVIRONMENT

By

Preston Way

Agricultural Systems Management

BioResource and Agricultural Engineering Department

California Polytechnic State University

San Luis Obispo

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AUTHOR : Preston Way

DATE SUBMITTED : December 12, 2014

GREGORY SCHWARTZ

Senior Project Advisor

Signature

12/12/14

Date

ART MACCARLEY

Department Head

Signature

1/5/15

Date

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ABSTRACT

This project conducted an experiment testing the beneficial effects of growing hops in a greenhouse versus outside. The experiment consisted of four total plants; two varieties with one of each inside the greenhouse and one outside. The research scale experiment was able to show that for the first year of growth, hood hops grown in a greenhouse were able to grow taller and produce more cones. Hood hops in the greenhouse produced 25% more cones than its counterpart while the centennial did not see a significant difference. Based on a one acre hop farm, the increase in growth from the greenhouse did not justify the cost that it would take to construct a greenhouse. More experimentation along a longer period of time would be needed to more closely portray the effects that a greenhouse has on producing hops.

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INTRODUCTION

Background. Home gardening has been around for hundreds of years and has been maintained as a hobby or resource for many individuals throughout the years. Home gardens can be decorative with plants such as roses, tulips, and petunias or they can be used to grow foods such as lettuce, tomatoes, and carrots. Both types of gardens have their advantages providing the gardener with lush resources or a decorative backyard to entertain. One such crop that has been used commercially for many years has only recently found its way into the backyard of homes across the globe. Hops have been used as a flavoring agent in beer production ever since the 11^{th} century (Northwest Hops) and has also been used for medicinal purposes including a sleep aid. Hops are used for their antibacterial effect which balances the sweetness of malt with bitterness. The hop plant not only gives the beer a wide range of flavor possibilities but also can add beautiful aromas. Known as a perennial, a plant that lives for more than two years, the hop is much like a vine that grows vertically usually climbing a fence or wire. Often hop plants are grown together and the collection of these vines are considered by various names including hop fields, hop gardens, and hop yards.

As true of many plant species there is an assortment of different varieties of hops which each have their own unique qualities that work well in different aspects. In general different varieties of hops bring diverse flavors that make for differing tastes in beer. However, in addition to adding tastes, there are hops which are grown for an aesthetic value that will liven up a garden. As seen in Figure 1, the centennial hop will bloom into an aesthetic vine in addition to its use in beer as an aroma and citrus flavoring.

Figure 1. A centennial hop plant used for aromatic and aesthetic values.

Like most plants, hops utilize a photosynthetic process to grow which means they need a warm environment with plenty of sunlight to convert light radiant energy into chemical energy used to fuel the growth. Typically hops are grown outside where they can receive the most sun and convert the most energy, so this project is aimed to test whether growing hops in a greenhouse will have any effect on productivity and yield.

<u>Justification</u>. The purpose of this project is to compare the growth of a variety of hop plants in a greenhouse and in an outside environment. Greenhouses on a large scale can be very expensive and require a lot of maintenance to regulate the temperature and humidity, but they have the potential to increase the quality and the quantity of the crop. This project will look to determine whether the greenhouse will increase productivity enough to offset the cost of purchasing and maintaining the greenhouse.

<u>Objective</u>. The objective of this project is to plant and grow two different types of hop plants and compare the growth and number of buds per plant produced in the greenhouse verses the outside environment. An evaluation will be performed determining if an increase in production from hops grown in the greenhouse will offset the cost of purchasing that greenhouse. To conclude whether or not there was a significant difference between the greenhouse and outside, a statistical T-test will be performed comparing the two sets of data.

LITERATURE REVIEW

Hops as a raw product can have many benefits across a large assortment of aspects. Where hops have been used in the past are medical considerations, some soda beverages and herbal teas, and most notably hops are used in beer brewing (Burgress 1964). The aroma, bitterness, and tanginess that the many varieties of hops can provide make the plant a desirable commodity on a variety of levels.

Over time dating back to Native American history, hops have been used as a medical aid often providing healing properties to sick patients. "There are three ways that hops can be used in medical practices: as a sedative, to aid digestion, and as an antibiotic"(Dunbar 2010). Hops have commonly been prescribed as a sedative often in the form of pillows for people experiencing restlessness and anxiety. This is due to the fact that hops contains chemicals found to be sedative in nature though it is inconclusive if the concentration of this sedative chemical is enough to be effective. In other medical departments, there has been research looking in to the possibility that hops could be used as a digestive aid helping to break down food and ease the digestion process. The chemicals that comprise hops are thought to stimulate the appetite and aid in relief of the colic by simulating secretions of the stomach.

Throughout the existence of hops what it has become most known for is its use in the brewing process. In the beer making industry there are many components that give beer the delicious and refreshing taste that a lot of us are used to, but what stands out as the most important ingredient is hops. Hops, or Humulus lupulus (Herb Gardening, 2012) is a female flower of a hop plant. They give the beer a bitter and tangy taste depending on how much and which varieties are added to a specific brew of beer. The way that hops effects the flavor of the beer is by producing an antibacterial effect that when intertwined with the yeast brings out the more favorable microorganisms (Burgress 1964). Over the years "brew masters" have perfected the art of growing, harvesting and utilizing hops to make beer taste the way we want it. As seen on the next page in Figure 2, a fully bloomed hop plant can contain multiple buds per chute.

Figure 2. The hop plant fully bloomed and ready to be harvested.

What may be one of the most important aspects of growing your own hops is acquiring it. Though it can be bought, it is also very common to find breweries growing their own varieties and strains of hops to get the exact flavors they are looking for. The hop plant can be either bought as a rhizome that is then planted and maintained or bought as a pre-potted plant that has already started growth. Retail stores such as Northwest Hops offer a number of different varieties of the hop rhizomes or pre-potted hops. As seen in Figure 3, the pre-potted hops comes packaged with soil to maintain the health of the plant during shipping.

Figure 3. A specific variety of hops used for aromatic and bittering qualities.

First time growers will be more attracted to the pre-potted plants due to the much higher survival rate as compared to the rhizomes (Northwest Hops 2014). The hop rhizomes are very sensitive and require a lot of attention to detail for the survival of the plant. The rhizomes as well as pre-potted plants need to be planted in a well-drained soil that has a pH value ranging anywhere from 6.0-8.0 and typically 3 feet apart from any other plant (Garden Guides 2007). The reason being is that Hop plants are a vine that can either grow horizontally or vertically so they need a lot of space to grow properly. As the hop plant is a bine, it is often best to reinforce your hop plant with a wire or a wooden post for the plant to climb up making harvesting easier and more efficient. The hop plant initially sprouts and begins to search for a means to grow onto which is where a trellis or post will aid hops to climb and continue growing. Typical hop plants can grow in excess of 20 feet so it is important to block out enough space for a fully mature hop plant (Smith 1914). As seen in Figure 4, the hop plant latches on to wires and support posts to continue its growth in a vertical manner.

Figure 4. The hop plant as it begins to climb up the support post.

To optimize the productivity of the hop plant, it is desirable to plant with a southern exposure however an east of west exposure will work fine (Growing Your Own Hops, 2005). The recommended sun light exposure for hops should be 6-8 hours per day in order for the hops to grow to their maximum potential cone size. As far as watering of the hops, during the first year the hops have a very small root system which factors into the watering patterns during that time. Due to the minimal root system, you don't want the soil to remain dry for extended period (Herb Gardening 2012). The watering during the first year of planting is the most crucial time to be as precise as possible because this is when the plant is establishing its foundation. Hop rhizomes are very sensitive to rot and disease and overwatering is often a common mistake made by first time growers. The soil should remain moist if possible but never should puddle. "A Good Watering Rule of thumb is: (Water with 1/3 or 33% of container size). 1 gallon size container = 1 quart or 32 oz of water once a week" (Northwest Hops).

The design of a hop field is largely dependent on what the desired production size is, so fields can vary in magnitudes from as small as a few plants in a backyard to commercial growing with hundreds of acres. When planning a hop field that will be machine harvested, there are some special considerations that need to be thought of such as row spacing, maneuverability, and cost effectiveness. The row spacing is primarily to allow for tractors to go up and down rows being able to prune, cut and harvest the hops throughout the different parts of the year. Having a field that is well designed with room for maneuverability enables the entire process of planting, maintenance, and harvesting to run smoothly eliminating wasted time. Lastly, fields are designed to be cost effective so as to maximize the production per acre and yield the highest possible profits. Figure 5 is a field designed and constructed by The Hop Yard. They used the following specifications to layout and plant their field, (The Hop Yard).

- Row Spacing: 14’
- Plant Spacing: 3.5’
- Pole Spacing: 42’
- Pole Height: 18’ above ground, 3’ below
- Cable Pattern: Perpendicular to row weight bearing cable, with parallel to row cable to support twine and plant growth
- Anchorage: 4’ deep with 4’ disc anchors

Figure 5. A newly planted hop field with accompanying trellis system.

Depending on any certain geographical location the growing period for any particular crop or flower will greatly vary. For instance the number of days above 85 degrees Fahrenheit in Arizona will be much greater than that of Washington for any given year. This being said, certain plant varieties have become known to grow better in different climates. Based on numerous factors including temperature, amount of sunshine, and external factors including wind and frost, individual plants have a certain growing niche that they prefer. Due to the environmental restraints only certain plants were able to be grown in specific areas. This made gardening and even small scale agriculture very difficult in many areas up until the creation of the greenhouse. The idea for greenhouses was conceived a long time ago but didn’t start really making a name for itself until it “appeared in Netherlands and then England in the 17th century”(Wiki Greenhouse). The idea was to close up a contained area at night and “winterize” it during the winter. There was a lot of problems trying to maintain an adequate amount of heat in the controlled environment rendering it nearly useless. The problem was heat was escaping through cracks and holes and there was simply no effective way to keep the heat in. One of the most important aspects and the main advantage of greenhouses are the ability to control an environment and be able to manipulate the climate to fit the plant or crop that you are growing so without this element the greenhouse is no longer beneficial.

Greenhouses are useful for a variety of reasons including extending the growing season to produce more product. With the ability to produce for a longer period of time the effectiveness of each plant dramatically increases. By increasing the effectiveness of the plant the harvest will similarly see an increase which increases yield values. The yield values are important for crops that are commercially sold and will dictate how successful a particular plant may be. According to Garden Guides, "greenhouses are used to grow more varieties of vegetation because of the ability to precisely control climate and soil" (Garden Guides, 2007). Having a diverse garden or diverse greenhouse minimizes the potential of low yield because with a variety of plants the probability of all of them failing dramatically decreases. A potential reason for a low crop yield could result from pests and diseases. In a greenhouse environment, the inside atmosphere is controlled by the user and is protected from outside factors so there is a great reduction in pests and disease. Properly maintaining and operating a greenhouse will not only extend growing and harvesting periods but also increase crop quality and productivity.

The hop cones will be ready to harvest in late August but it is important that the cones are 100% ready to be picked before cutting and using them. To make sure that a cone is ready, a simple squeeze with the hand can test the hardiness of the cone. If the cone stays compressed when squeezed and has a damp feel to it, the hop bud is not ready to harvest. A ready hop bud will be springy, sticky to the touch, and dry signifying that it is ready to harvest (Northwest Hops 2014). And once ready to harvest, the procedure is to cut down the bine and lay them on the ground so that the plant will not die and will sprout next year. You are then free to dry and preserve the hops.

Breweries such as the Russian River Brewery in Santa Rosa, CA. grow their own hops to get the irresistible flavor that many beer connoisseurs are looking for. The uniqueness of home grown hops mixed with the intellect of world renowned brew master's has really sparked the mirco-brewing industry. The Russian River Brewing Company holds an annual release of a beer that draws consumers from all around the United State and even the world. The beer requires very precise and tedious labor to produce the "perfect" hop that is exclusively chosen to make this one in a lifetime beer. The beer is released in only one location and for only two weeks at the brewery in Santa Rosa. Over the years it has been rated the best beer in the world and won many prestigious awards only adding to the small brewery's success.

PROCEDURES AND METHODS

Design Procedure

Choose a location that will receive 6-8 hours of sunlight per day to maximize the growth of the hop plants. The location chosen for this experiment was deck with a southeast exposure to the sun. As mentioned before, hop plants can grow very quickly and very vigorously so it is important to allocate enough space for the plant to reach its full potential. Each hop plant was potted with no less than 3 feet of space from the adjacent plant to provide enough room for a full root structure.

To purchase the hop plants, contact a local or large distributer of hop rhizomes or pre-potted plants to make an order. Hop rhizomes are the stem of the plant that are put underground to grow roots and shoots from its nodes. When deciding what to buy, it is suggested that first time growers use pre-potted plants that already have growth started so that the success rate is much higher. In this experiment pre-potted plants were used and planted to ensure the best quality. Once the hop plant arrives it is very important to plant as soon as possible to reduce disease and contamination. To plant them, dig a hole 6 inches deep, (as seen in Figure 6) and place the hop plant into the hole with the roots on the bottom.

Figure 6. Hops placed in a hole as it begins to grow.

Once the hops have been planted it is very important to add a structural guide to the hop so that the bine has something that it can climb. This project included a small bamboo stick to the hop plants acting as a rigid structural support so that they could start with a solid form. Depicted in Figure 7 is how the hop plants for this project were setup.

Figure 7. The hop plant circularly climbing up the support post.

Hops are a very hardy plant and prone to disease and rot with excess watering, so to maintain a healthy and fruitful plant check on the soil every 2-3 days making sure that it moist rather than wet.

Measurement Procedure

To accurately track the growth of the plants, the recordings were broken into two separate time frames, the primary growth which was observed from weeks 1 to week 6, and secondary growth grow week 7 to the final week 14. Due to the rapid growth, the recordings in the primary growth stage were noted every three days. After the sixth week the growth began to significantly slow down and there was no need to continue recording every three days, so the readings dropped down to once a week. There were two variables to be measured during the course of this experiment and those are the plant height and the number of hop cones that each plant produced.

To properly measure the height of each plant, a standard tape measurer was used and recorded the height in inches. As shown with Figure 8, the proper way to measure the height would be to place the end of the tape measure at the base of the plant and extend the tape along the length of the plant. Making sure the keep the end of the tape at the base of the plant, read the tape measure to the nearest half inch always rounding up. It does not matter whether you round up or down as long as you are consistent over the course of the experiment.

Figure 8. Measuring the height of each hop plant with a tape measure.

The earliest that the cones started to appear was in week 6 so the data for cone counts does not begin until then. To make the data easier to interpret and easy to compare each plant to the next, the number of cones was recorded as a summation of each plant. This being the total number of cones on the plant during that specific observation. The total number of cones was counted and recorded for the weeks that they did appear and put into Table 2 in Appendix C. After the experiment concluded the cones were collected and separated based on which plant they came from and prepared for drying.

Data Processing

There are numerous ways to dry home brewed hops, but most of them can be expensive and require additional appliances so being cost efficient, this project air dried the hop cones. According to Freshops, with dry weather and enough sunlight, the hops will be completely dry in three days. It is also important to turn and stir the hops to ensure that every cone is dry.

To accurately record the weights a digital scale was used that measured to the nearest hundredths place. This way the user can be sure to record enough data to see a significant difference between the plant's productions. To use the scale I place a plastic weigh boat on top and pressed the tare button to reset the scales reading to 0. What this does is account for the weight of the weigh boat while allowing me to add my hops while the scale begins its count at 0. This way I am only recording the total weight of the hops.

RESULTS

Production Data

After completing a 20 week growing period for the four individual hop plants, some very valuable data was collected. Figure 9 shows the height of each plant measured across the months of May to October. Figure 10 shows the plants as they were observed over the same time frame but instead indicates the number of hop cones per vine that were produced.

Figure 9. Growth in inches of each hop plant across the 20 measured weeks.

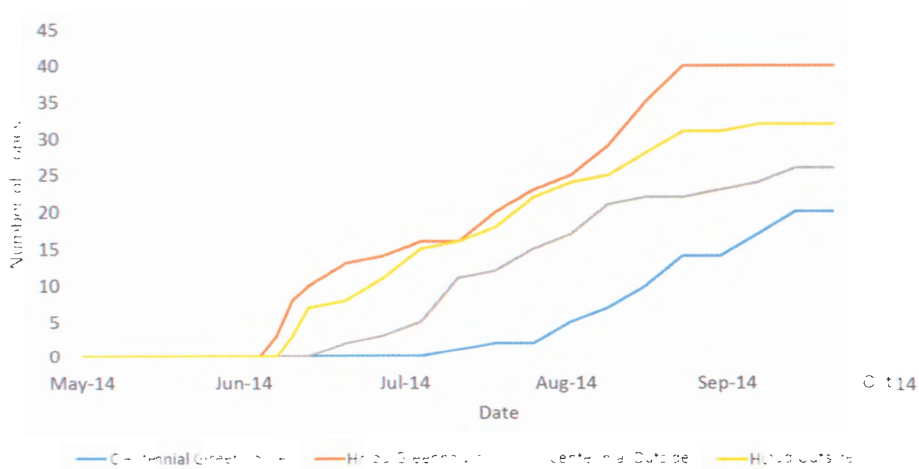

Figure 10. Cumulative cone production over the duration of the study.

A statistical analysis was performed to compare the significance of the data. Shown in Table 1 are the statistical readouts that compare each variety to its counterpart.

Table 1. Statistical analysis of the centennial and hood hop heights comparing the greenhouse to the outside plant.

	Centennial	Hood
Mean	23.41	62.45
Variance	157.13	716.83
Observations	29.00	29.00
Hypothesized Mean Difference	0.00	0.00
df	28.00	28.00
P(T<=t) one-tail	0.28	0.00
P(T<=t) two-tail	0.56	0.00

The greenhouse was able to aid the growth of the hood variety protecting it in an enclosed environment. Figure 11 shows the hood plant growing in the greenhouse.

Figure 11. An inside look at the greenhouse hood plant beginning to grow.

Cost Analysis

The objective of this experiment was to test whether the cost of growing hops in a greenhouse will produce enough extra crop to offset the cost of installing and maintaining the greenhouse. Table 2 shows the cost analysis projection based on the data collected

from this experiment and a price per pound value $3.59, taken from the United States of Department of Agriculture.

Table 2. Cost breakdown given the amount of harvested hops in ounces.

	Greenhouse		Outside	
	Centennial	Hood	Centennial	Hood
oz	2.75	4.25	3.50	3.25
lbs.	0.17	0.27	0.22	0.20
lbs/acre	1222	1889	1556	1445
$/acre	$ 4,388	$ 6,782	$ 5,585	$ 5,186

After the cones were collected and dried, the weights were taken and recorded in ounces. The USDA reports for the United States hop production record the weights as lbs. per acre. To go from ounces per plant to pounds per acre there is a simple formula shown below that outlines the steps needed to make this conversion:

$$\frac{Lbs.}{Acre} = \frac{Ounces}{Plant} * \frac{1lb}{16\ Ounces} * \frac{1\ Plant}{4\ Vines} * \frac{2\ Vines}{1\ String} * \frac{1778\ Strings}{Acre} \qquad (1)$$

Collected data was converted from ounces per plant to pounds per acre using equation 1.

DISCUSSION

Statistical Comparison

The experiment conducted for this report used only four different plants and two different varieties. The results in this experiment were based upon a very small sample size and the discussion will be based on the assumption that these values would hold true over a much larger population sample. The method used to test whether there was a significant difference between the greenhouse plants and their counterparts, a statistical "T-test". The student's t-test is a statistical method that is used to see if two sets of data differ significantly (Explorable 2010). The T-test uses a hypothesis called a null hypothesis which is set at p=.05 and compares each set of data points against it. This test assumes that the results are normally distributed and is a comparison to determine whether the means, or averages, are significantly different. This test cannot be used to prove any claims as there is always a chance of experimental error and errors in data collection, but it can be used to support a hypothesis.

After running the T-test with the hypothesis: if the hops are grown in a greenhouse, then they will grow taller and produce more cones; the results revealed that the centennial hop plant in the greenhouse and the centennial plant outside showed no significant difference. However, the hood hop plants did have a significant difference. As seen above in Table 1, the p-value statistic is the value that will either reject or fail to reject the claim that the two data sets are different. The p-value recorded in the two tailed T-test for the centennial hops was 0.56 indicating that the null hypothesis would be rejected. By rejecting the null hypothesis it is concluded that the means of the centennial plants when compared to each other were not significantly different. However, despite the centennial plants having no difference, the hood plants did show an interesting result where the p-value was 0.00 which leads to a failure to reject the null hypothesis indicating that there was a significant difference between the means. Because the p-value was 0.00, we can support the claim that for the hood hops only, growing in a greenhouse will produce taller bines and more cones. The positive results show that it is possible to produce more with the use a greenhouse, so a cost analysis will be provided based upon a 1 acre farm. The farm will be constructed on 1.1 acres of land that needs to be prepared and installed with a drip irrigation system to water the hops.

Cost Analysis

The cost of establishing and producing a 1 acre hop field will be largely based upon a similar study conducted by Washington State where a newly planted hop field was broken down into capital costs, variable costs, and fixed costs. The establishment cost is a cost that will only been seen in year 1 because after the field has been prepared with disking and plowing, the irrigation can be installed and will not have to be re-installed in following years. The layout of field will be 1.1 acres as it takes 1.1 acres of land to grow 1 acre of hops after all of the roads and buildings have been accounted for (Galinato and George and Hinman). Using a similar setup to the study conducted in Washington, the total land preparation costs will be $149 while the capital costs for the trellis system and the irrigation will be $5,724 for a total establishment cost of $5,873 (Galinato and George

and Hinman). The next costs that will be considered are the fixed costs that will be present in each year which include operating costs such as licenses, parts and repairs, fuel and oil, and packaging costs. Taken from the Washington State study conducted by Galinto, George, and Hinman, the yearly total for operating costs will be $7,875 and this cost will be seen as the cash outflow which appears in every year of operation. The following equation will demonstrate the costs associated with growing hops and payback period using a national average Lbs./Acre of 2,383 acquired from the USDA. In equation 1 below the cash inflow will be the product of the national average in Lbs./acre and the price per pound of hops ($3.59) referenced from the USDA website.

$$Payback = \frac{Initial\ Payment}{(Cash\ Inflow - Cash\ Outflow)} = \frac{\$5{,}873}{(\$8{,}554 - \$7{,}875)} = 8.6\ years \qquad (2)$$

This calculation shows the amount of time that it will take in order for the hops to return the initial investment that was needed to establish the field. With this being considered, the hops only become profitable after year 9. The greenhouse used in this experiment was able to increase the productivity for the hood variety hops 34% more than the average of the other three plants. This number will be applied to the national average yield per acre and another payback period will be generated taking into consideration the price of installing a greenhouse.

$$Payback = \frac{Initial\ Payment + (\frac{\$}{sq.ft.} * \frac{Number\ of\ sq.ft.}{acre})}{(Cash\ Inflow - Cash\ Outflow)} = \ years \qquad (3)$$

$$Payback = \frac{\$5{,}873 + (\frac{\$2.5}{sq.ft.} * \frac{43{,}560\ sq.ft.}{acre})}{(\$11{,}463 - \$7{,}875)} = 33\ years \qquad (4)$$

The greenhouse will cost $2.5 per square foot (Ranger Series Greenhouse), so the total cost of the greenhouse will be $109,771 to completely cover one acre of hops. The abnormally large cost of the greenhouse will not be fully paid back until year 33 of operation which poses many problems. The lifespan of hops will not exceed 15 years of regrowth so through the course of paying back the greenhouse, the hops would need to be re-planted only adding to the cost of production (Northwest Hops 2014).

RECOMMENDATIONS

Growing a plant of any type will always be a challenge due to the high number of variables that go into growing and sustaining the health. With thousands of different diseases and hundreds of different growing climates, no two experiments are going to be alike, however they can be closely replicated or reproduced to try and bring about similar results. Taking into consideration that no two plants will behave in the same way, it is advised to recreate this experiment but on a much larger scale. Due to the confined space of a backyard experiment, the number of plants that were able to be used was much smaller than an ideal sample size that could yield more consistent results. Instead of using only one of each variety, it is recommended that at least 20 of each plant be used in its respective growing habitat that is to say 20 centennial hops in a greenhouse and 20 hood hops in a greenhouse with 20 of each also growing outside. This larger population would decrease the possibility of any outliers that could potentially skew the data.

Based on the results, the use of a greenhouse was able to aid the growth of the hood hops, but it was not substantial enough to take the experimental to a larger scale. The price of the greenhouse was far greater than that of the extra product that it was able to produce and so it is not recommended to proceed to with design of a full scale hop field with a greenhouse until more small scale experiments have been performed.

The results displayed in Figure 8 show an interesting relationship between the centennial plant in the greenhouse and the centennial plant outside. The centennial plant in the greenhouse begins to grow more rapidly than the centennial plant outside, however when it reaches week 13, the outside centennial passes it and in fact continues to increase growth while the greenhouse plant does not. The recommendation based on this finding is to plant the centennial plant in the greenhouse and transplant it outside after 13 weeks in order maximize the growing cycle as seen in this experiment.

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APPENDIX A

HOW PROJECT MEETS REQUIREMNETS FOR THE ASM MAJOR

HOW PROJECT MEETS ASM REQUIREMENTS

ASM Project Requirements

The ASM senior project must include a problem solving experience that incorporates the application of technology and the organizational skills of business and management, and quantitative, analytical problem solving. This project addresses the issues as follows.

Application of Agricultural Technology. The project involves the application of design and construction of Agricultural buildings and structures

Application of Business and Management Skills. The project involves a cost analysis and payback period as well as statistical inference to compare data sets. The project also incorporates cost and productivity analyses as they relate to a feasible business

Quantitative, Analytical Problem Solving. Quantitative problem solving techniques include the cost analysis, payback period calculations, and statistical inference as it relates to means and hypothesis testing

Capstone Project Experience

The ASM senior project must incorporate knowledge and skill acquired in earlier coursework (Major and Support courses). This project incorporates knowledge and skills from these key courses.

- BRAE 129 Lab Skills/Safety
- BRAE 142 Machinery Management
- BRAE 203 Agricultural Systems Analysis
- BRAE 321 Ag Safety
- BRAE 340 Principals of Irrigation
- BRAE 342 Agricultural Materials
- BRAE 418/419 Ag Systems Management
- BRAE 432 Agricultural Buildings
- AGB 212 Agricultural Economics
- AGB 214 Financial Accounting
- ENGL 148 Tech Writing for Engineers
- MATH 251 Statistical Inference and Business Management

ASM Approach

Agricultural Systems Management involves the development of solutions to technological, business or management problems associated with agriculture or related industries. A systems approach, interdisciplinary experience, and agricultural training in specialized areas are common features of this type of problem solving. This project addresses these issues as follow.

Systems Approach. The project involves the integration of managing and designing systems to optimize the growth potential of hops for hop farmers.

Interdisciplinary Features. The project touches on agricultural safety and the management of production in the field of agriculture.

Specialized Agricultural Knowledge. The project applies specialized knowledge in the field of growing, harvesting, and processing of hops as well as the use of statistical inference to compare data sets as they relate to production value

APPENDIX B

CONTRACT

California Polytechnic State University	November 14, 2013
BioResource and Agricultural Engineering Department	Way, Preston ASM
ASM Senior Project Contract	

Project Title

Research and Implementation of Growing Hops

Background Information

The hop plant or Humulus Lupulus, produces a bud that can be used to brew beer. The hop cone adds a bitterness to beer giving it a unique but desirable flavor. They are many varieties of hops and they can be used in large or small amounts. Hops are a major component of beer and essential to provide a smooth taste.

Statement of Work

The purpose of this senior project will be to research different ways to grow and mature hops. The research will be based on determining whether hops grows better in a natural environment or under a controlled environment such as a greenhouse. The project will also provide information so that a document can be outline each step in the hop growing process. The project will also include purchase and planting of the hop rhizomes with an accompanying support structure for which the plant to grow onto.

How Project Meets Requirements for the ASM Major

ASM Project Requirements - The ASM senior project must include a problem solving experience that incorporates the application of technology and the organizational skills of business and management, and quantitative, analytical problem solving.

Application of agricultural technology	The project will include design and construction of a free standing structure that the vine will grow on
Application of business and/or management skills	The project will involve business/management skills in the area of communication with small microbreweries and managing of the crop
Quantitative, analytical problem solving	Quantitative data will be recorded and documented outlining the various processes and procedures to grow hops

Capstone Project Experience - The ASM senior project must incorporate knowledge and skills acquired in earlier coursework (Major, Support and/or GE courses).

Incorporates knowledge/ skills from these key courses	151/152 Autocad and Solid Works modeling programs, 321 Ag Safety, 418/419 Ag Systems Management, As well as ASM support courses such as AGB 202 Sales, and AGB 301 Marketing

ASM Approach - Agricultural Systems Management involves the development of solutions to technological, business or management problems associated with agricultural or related industries. A systems approach, interdisciplinary experience, and agricultural training in specialized areas are common features of this type of problem solving.

Systems approach	
Interdisciplinary features	The project will involve intensive research and exploration of different ways to grow and manage hop plants
Specialized agricultural knowledge	The project applies specialized knowledge in the irrigation and management of a specialty crop

Project Parameters

1. The project must involve extensive research on the various ways to grow hops
2. A hop rhizome seedling must be purchased and planted
3. A support structure must be built for the hop vine to grow onto

List of Tasks and Time Estimate

TASK	Hours
Research in library on various hop growing techniques	15
Visitation to local micro brewing facilities	20
Materials procurement	8
Construction of support structure	30
Field Work (collection)	20
Final evaluation	4
Preparation of written report	30
TOTAL	127

Financial Responsibility

Preliminary estimate of project costs: $ *300*

Finances approved by (signature of Project Sponsor): ____________

Final Report Due: June 4, 2013

Approval Signatures		**Date**
Student:	____________	________
Proj. Supervisor:	____________	________
Department Head:	____________	________

APPENDIX C

DATA SHEETS

HOPS GROWTH DATA SHEET

	Greenhouse		Outside	
	Centennial Height	Hood Height	Centennial Height	Hood Height
Date				
5/18/2014	3.5	4	3.75	4.25
5/21/2014	3.5	10	11.5	8
5/24/2014	5	16	14.5	10
5/27/2014	6	26	14.5	15
5/30/2014	7	31	14.75	16.25
6/2/2014	11	37	14.75	17
6/5/2014	13	38	15	17.75
6/8/2014	13	43	15	18
6/11/2014	13.5	50	15	18.5
6/14/2014	15	52	15.25	19.25
6/17/2014	17.5	55	15.25	21
6/20/2014	18	61	15.25	21
6/23/2014	19.75	66	15.5	21.5
6/26/2014	21	66	15.5	23
6/29/2014	23.25	69	15.5	23
7/6/2014	26	74	16	23.25
7/13/2014	31	78	16.5	23.5
7/20/2014	31	79	16.25	24
7/27/2014	32	79	22.5	24
8/3/2014	32	80	24	24
8/10/2014	35	85	28	25
8/17/2014	35	86	36	26
8/24/2014	36	86	38	27
8/31/2014	37	88	43	28
9/7/2014	37	88	47	33
9/14/2014	38	91	51	37
9/21/2014	39	91	52	41
9/28/2014	40	91	52	43
10/5/2014	40	91	52	50

NUMBER OF CONES PER PLANT DATA SHEET

Greenhouse		Outside	
Centennial # cones	Hood # cones	Centennial # cones	Hood # cones
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0
0	3	0	0
0	8	0	3
0	10	0	7
0	13	2	8
0	14	3	11
0	16	5	15
1	16	11	16
2	20	12	18
2	23	15	22
5	25	17	24
7	29	21	25
10	35	22	28
14	40	22	31
14	40	23	31
17	40	24	32
20	40	26	32
20	40	26	32