A COST-BENEFIT ANALYSIS OF A FERTILIZER LAB ON A PRODUCE FARM IN SANTA BARBARA COUNTY, CALIFORNIA

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ABSTRACT

The purpose of this study was to determine if a fertilizer lab would be a cost beneficial way of reducing nitrogen costs and consumption for a medium-sized produce farm (The Farm) in Santa Barbara County, California. A cost benefit analysis was performed to determine if the lab, installed in 2011, would provide a net positive benefit. The analysis compares the costs of the lab to the benefits of the lab. The costs of the lab are the annualized initial investment costs (based on costs incurred in 2011), the operating costs, and the opportunity costs of the lab. The benefit of the lab was measured by the decrease in fertilizer costs assuming constant yields. If the benefits less the costs are positive and the use of nitrogen, potassium and phosphorus are decreased for The Farm, then the lab would be a cost beneficial way to decrease nutrient costs and usage for The Farm. A sensitivity analysis was also performed to determine how sensitive the results of this study were to the assumption of unchanged yields for The Farm.

The analysis suggests that the benefits of the lab greatly outweigh its costs when no change in yields is assumed. This occurs because fertilizer use was reduced significantly with no change in production yield (based on information provided by farm managers). Annual lab costs in 2011 ($58,825) were only about one-tenth of the amount of the cost savings from reduced fertilizer use ($535,222). Thus, under the assumption of unchanged yields, the lab appears to be a highly cost beneficial way for The Farm to reduce its nitrogen costs and consumption.

However, the sensitivity analysis indicates that the results depend markedly on assumed yields. If yields were to decrease by more than 1.8% in 2011 due to reductions in fertilizer application attributed to the information provided by the lab, then the costs would outweigh the benefits. This suggests that if the manager's perception about yields being unchanged is even

mildly inaccurate, the basic conclusion of this study is altered. Future studies of this investment can therefore provide more accurate results if they are based on data about actual production yields. Similarly, the findings for this one medium-scale produce farm may not be applicable to other farms with different production patterns or cost structures.

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CHAPTER 1

INTRODUCTION

Nitrogen is one of the most widely used fertilizers in the United States. Potassium and phosphorus are the other two widely used fertilizers, but these are applied in much smaller quantities than nitrogen fertilizers. In 2009, the U.S. agricultural industry consumed 11,434,000 tons of nitrogen, 3,192,000 ton of phosphate, and 3,090,000 tons of potassium (USDA, 2009). Nearly all of the nitrogen fertilizer used in agriculture "originates form a process that uses natural gas to convert" the nitrogen from the atmosphere "into a form" that can be used by crops (Erickson and Miller, 2009). The price of natural gas has risen significantly in the past decade and, as a result, so has the price of nitrogen fertilizer. Even with the increasing cost of nitrogen, farmers still sometimes apply more fertilizer than the crops can utilize. It is estimated that "only about 30% to 70% of nitrogen fertilizer used in U.S. agriculture is recovered in crops" which means that, at best, 30% is being wasted (Bosch and Fuglie 1995). This abundant use of synthetic nitrogen fertilizer is becoming an increasingly important problem on farms. Many farmers do not realize that this is not only causing an unnecessary increase in fertilizer costs, but also contributing to environmental pollution.

There are two main ways in which synthetic nitrogen fertilizers lead to pollution. The pollution of surface and ground water is the most commonly discussed. Synthetic nitrogen, mainly nitrate (NO_3), in the ground can contaminate aquifers. It is not uncommon to find dangerously high levels of nitrate in aquifers near rural areas, which if consumed can lead to lethal health complications (Altieri, 2000). The other form of nitrogen pollution is its contribution to greenhouse gases. Nitrate is not only harmful to humans, but it is also harmful to the ozone layer. This form of pollution starts with nitrate-contaminated surface water, and as it evaporates the nitrate enters the atmosphere. The constant evaporation of nitrate-contaminated water over the years has contributed to the build up of greenhouse gases and ozone depletion. Nitrate-contaminated water can also find its way to lakes and other bodies of water where it promotes unwanted algae growth. Over-application is a primary reason chemical fertilizers pollute the environment (Altieri, 2000). Excessive use of synthetic nitrogen is not only detrimental to the environment, but it can also be a financial burden to farmers.

Farmers, as with most business owners, are often looking for ways to lower their costs in order to become more profitable. As the cost of nitrogen continues to rise, it is becoming more obvious that a good way to increase a farm's profitability is to practice better nutrient management. Nitrogen fertilizers have what is referred to as diminishing marginal returns. Diminishing marginal returns means that as more and more nitrogen gets applied there comes a point at which the excess nitrogen will become harmful to the crop and result in a decrease in yield (Johnson, 1994). The best way to resolve these negative environmental effects and unnecessary fertilizer costs is to use nitrogen fertilizer efficiently, and one way to do this is to frequently test for nitrogen levels in the field using laboratory analyses. The analyses can be done either though contracting with a separate testing company or establishing an on-site laboratory also operated by the farm.

This study examines the financial impacts of the establishment of an on-site laboratory to test plant nitrogen levels and use this information to determine appropriate fertilizer applications. It is a case study of the application of this approach on a single produce operation located in Santa Barbara County, California, herein referred to as "The Farm." The Farm has established a fertilizer testing facility with the objectives of lowering its fertilizer applications and costs while maintaining or increasing profitability. This medium-sized produce farm grows celery, iceberg lettuce, romaine lettuce, broccoli, cauliflower, and strawberries. In the fall of 2010, The Farm established a lab that tests plant matter to determine how much nitrogen, and other nutrients, the plant contains, and to estimate fertilization needs.

The Farm uses a proprietary variation of one of the most common methods of testing plant matter for nutrients, the photometric method. The photometric method is an extremely accurate way of testing for not only nitrogen, but many other nutrients as well. Prior to 1944 there was only an extremely time-consuming photometric method, but there is now a much speedier method called the rapid photometric method (Wolf, 1944). The original, 'non-rapid' method is more time consuming than the 'rapid' method because it requires the plant to be "dried at 70 degrees Celsius for several days", whereas the rapid photometric method can be done in one day (Hickman and Pitelka, 1975). The rapid method can be done in a more timely manner by taking a finely ground 0.2-gram sample of the plant and mixing it with sulfuric acid and hydrogen peroxide instead of drying it for several days (Wolf, 1944). This solution is mixed, heated, and allowed to settle. Once this has been done, it is then mixed with an extracting agent, ".5 acetic acid buffered at pH 4.8 with sodium nitrate", and then placed in to a photometric colorimeter which will measure the levels of nitrogen, potassium, and phosphorus based on its absorption of different light wavelengths (Wolf, 1944). A fairly inexpensive way to properly dispose of this solution is to mix it with the proper amount of lime and allow it to sit for at least one day (Faust and Orford, 1958). Once this has been done, the solution is neutral and can be poured down the sink.

Problem Statement

Will starting and operating a nitrogen fertilizer lab allow a reduction in fertilizer use and costs while maintaining profitability for a specific medium-sized produce farm? That is, will the benefits of a testing facility outweigh the costs?

Hypothesis

A fertilizer lab will prove to be cost-beneficial because it enables The Farm to use nitrogen more efficiently and therefore reduce their nitrogen fertilizer use and cost while maintaining or increasing their yields.

Objectives

Given the foregoing, the specific objectives of this study are:

1. Determine the annualized establishment and operating costs for the testing laboratory;
2. Determine the impact of the information provided by the testing laboratory on fertilizer application levels and fertilizer costs for The Farm;
3. Determine the impact of the information provided by the fertilizer laboratory on the yields of produce grown by The Farm, and associated revenues in 2011;
4. Determine if the benefits of the laboratory outweigh the costs for establishing and operating the laboratory by combining the cost savings in fertilizer application and any changes in revenues (from yield changes);

Significance of the Study

The continuous rise in population is resulting in an increased demand for food. To meet this increased demand, farmers have been increasing the amount of fertilizer they apply per acre in order to increase their yields per acre. Although the increase in yields is needed to supply food to the growing world population, sometimes farmers apply excessive amounts of fertilizer. The overuse of synthetic nitrogen fertilizer has contributed to environmental pollution and an unnecessary increase in fertilizer costs for farmers. To resolve both issues, more efficient use of fertilizers is required.

This study will shed light on the detrimental affects of inefficient nitrogen use to both the environment and the farmer. Information will be provided about efficient nitrogen fertilizer use. The results will provide The Farm with information as to whether or not the installation of a fertilizer lab is a cost-beneficial way of managing its nitrogen fertilizer use. Finally, other produce farmers can use this study as a staring point when trying to determine if it is cost-beneficial to add a fertilizer lab on their own farms.

CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

Synthetic and organic nitrogen fertilizers are an integral part of agricultural production, universally applied to increase crop yields and quality. However, these fertilizers also have a downside. The downside to nitrogen fertilizer is that the nitrogen not used by a crop ends up contributing to environmental pollution by contaminating waters and contributing to greenhouse gas concentrations. The utilization of a fertilizer lab can provide information about nitrogen levels that can be used to make better-informed decisions about appropriate and profitable nitrogen application. Although the setup and operating costs of a fertilizer lab may make it impractical for small-scale farms, larger farms may be able to decrease their costs and consumption of nitrogen by keeping better track of nitrogen levels in the fields.

Nutrient Management and Profitability

Nutrient management is an important part of all large farms because an excessive application of nutrients can be toxic to plants and an insufficient application of nutrients can leave the crop 'hungry'. In both of these instances the crop's yield and quality will suffer and, therefore, so will the farm's overall profit. Nutrient management is aimed at helping "farmers manage fertilizer use more efficiently, while obtaining desired crop yields" (Caswell, et al., 2001). The three most common nutrients, or fertilizers, used on farms are nitrogen, phosphorus and potassium with nitrogen being "the key element of increased yields and is usually used in the largest quantity" (Caswell, et al., 2001). Nitrogen not only helps to increase a crop's yield, but also growth rate, quality and aesthetic appearance, which is why farmers tend to focus more on the nitrogen aspect of nutrient management. The two main ways in which nutrient management can help increase profitability are by decreasing excessive nutrient use, especially nitrogen, and by ensuring that the crop is getting the right combination of nutrients when it needs them.

Nitrogen prices have been increasing rapidly in recent years, causing farmers to look for ways to cut their nitrogen consumption. The price of nitrogen has quadrupled from 1999 to 2008 (Williamson, 2011). There are many farmers that are using nitrogen inefficiently by applying more than is needed by the crop. One of the main reasons for this inefficient nitrogen use is the fact that many fertilizer recommendations are based on a farm's estimated production function (Babcock, 1992). An estimated production function means that the exact amount of inputs needed for a specific farm, in this case fertilizer, is only approximated. For many farmers, this causes uncertainty about whether or not the recommended application rate of nitrogen will be enough for their crops, so they tend to apply a higher rate than what is recommended to reduce the risk of not achieving desired yields. Although some farmers may be correct in applying higher than recommended rates, it is likely that many are applying more nitrogen than the crops can utilize. This wasteful use of nitrogen causes an unnecessary increase in fertilizer costs. The only way to be certain about what application rate is optimal for the crop, and keep fertilizer costs to a minimum is to practice proper nutrient management.

Nutrient imbalance also can cause crops to show deficiency signs of nutrients that are plentiful in the soil. Nutrient imbalance means that the crop is not getting a proper balance of all nutrients needed for growth, which can inhibit the crop's ability to absorb nutrients that are in the soil. One of the most common, and problematic, nutrient imbalance is low amounts of potassium that lead to crops not being able to absorb nitrogen as efficiently as possible. Potassium has been proven to help in "raising the concentration of nitrogen in the crop" (Albrecht et. al., 1948). Potassium also plays a major role in root development, and has been "associated with movement of water, nutrients, and carbohydrates in plant tissue." Thus, it is not surprising that low potassium levels can make it harder for the crop to utilize other nutrients (Rehm and Schmitt, 2002). When the crop is unable to utilize nutrients or efficiently move them through its tissues, it will not grow properly. Nutrient imbalance will often result in a decrease in a crops growth rate and, therefore, a decrease in yields as well. This ultimately means that the farmer will lose revenue, but often this can be avoided by utilizing proper nutrient management. Proper nutrient management will ensure that the crop is getting the nutrients it needs when it needs them and that there is not an excessive amount of nitrogen being applied, which should both help a farm's profits and benefit the environment.

Excessive Nitrogen Use

Not only are there financial reasons to test for nitrogen, but there are also ethical reasons. Nitrogen is mobile in the soil, and, therefore, excess nitrogen can find its way into groundwater and eventually to rivers, lakes and the ocean. Since 1960, researchers have found excess levels of nitrogen from the overuse of synthetic nitrogen fertilizers (Moffat, 1998). The excess nitrogen in waterways is causing algae to grow more rapidly, and when this excess algae dies it sinks to the bottom where it begins to decay. Decaying algae uses oxygen and when there is an abundance of this decaying algae it can cause deep-dwelling fish to die of oxygen deprivation (Moffat, 1998).

This form of nitrogen pollution is the most known and talked about, but nitrogen in waterways can also lead to health problems among people.

Excess nitrogen in waterways can contaminate drinking water. Nitrogen in drinking water is usually not a problem, but if an excess of nitrogen were to contaminate drinking water, it can be deadly. According to the Woods Hole Research Center, nitrate levels in drinking water must not exceed 45 milligrams per liter of water. Even though some researchers argue that it is too restrictive, the United States Environmental Protection Agency's (EPA) Drinking Water Regulations state that no more than ten milligrams of nitrate per liter of drinking water is acceptable. People who drink water that surpasses this allowable nitrate concentration may be more susceptible to methemoglobinemia, a potentially fatal type of blood disorder that prevents red blood cells from binding to oxygen molecules and distributing them throughout the body (Self and Waskom, 2008). The Woods Hole Research Center's 2007 article claims that this is extremely rare in the United States and other developed countries because nearly all drinking water supplies in these countries have sufficient water treatment standards to ensure the nitrate concentration stays below the acceptable threshold. Although modern technology has helped to limit nitrate contaminations in drinking water, even small amounts of nitrate can be harmful to some people.

Ingesting levels of nitrate within the EPA's regulatory range are not harmful to the average person; it is what a person's body does with this ingested nitrate that can cause health complications. The Woods Hole Research Center sheds some light onto this new discovery in their 2007 article "Reactive Nitrogen in the Environment." Once the body has ingested nitrate, it has the capability of converting this nitrate into much more harmful forms of nitrogen that are potent animal carcinogens: N-nitroso-compounds (NOC). NOCs can cause an increased risk of colon cancer and neural tube defects. The numerous variables that play a role in health make it difficult to study the relationship between methemoglobinemia or NOC-induced cancer and excessive nitrate intake, but the health complications that may come from excessive nitrate intake are too severe to ignore (The Woods Hole Research Center, 2007).

One of the most common ways to help prevent nitrogen pollution in waterways is to limit runoff by not tilling the land. Although this may decrease waterway pollution, this process results in a different type of pollution: greenhouse gases (Reay, 2004). Nitrogen that is not taken up by the crop or lost to leaching can be trapped in water runoff. Reduced tillage practices can cause this water to accumulate and makes it subject to evaporation. As this water evaporates, so does the potentially harmful nitrogen trapped in the water. The elemental form of Nitrogen does not contribute to greenhouse gases, but if the nitrogen goes through the denitrification process it can be transformed into nitrous oxide, which is a "powerful greenhouse gas" (Reay, 2004). Reay goes on to explain how the only way to combat this increasing nitrogen pollution problem is to "use less fertilizer, but more efficiently".

Efficiency is something that more farmers can relate to because it addresses the financial impact of excessive nitrogen use. A farmer using nitrogen fertilizer inefficiently, applying either excessive or insufficient amounts, is throwing away money by either purchasing and using excess fertilizer or having a loss in yield due to lack of nitrogen. Efficient nitrogen use is imperative for farmers trying to increase profits, therefore, it may be cost beneficial for some farmers to setup and use a fertilizer lab to test for efficient fertilizer use.

Cost-Benefit Analysis

Businesses are continuously making crucial financial decisions on a day-to-day basis. Deciding what to invest in is an important financial decision that can make or break a business. The best way to avoid making a bad investment is to analyze the investment using a financial analysis tool that fits the situation or investment. One of the most widely used financial analysis tools is a cost-benefit analysis. A cost-benefit analysis consists of five steps: 1) defining the program or investment to be studied; 2) defining the alternatives to the program or investment being studied; 3) determining the cash flows of the program or investment; 4) quantification and monetization of benefits and costs; and 5) Analyzing the benefits vis-à-vis the costs (Rogers, 1997). Having this information clearly laid out will help the business make an educated decision on whether or not the program or investment will be beneficial or detrimental to their company.

Determining the investment to be analyzed is the fist step, and, once this has been done, the alternatives to that investment must be examined. In some instances, the alternative to the investment is to not invest, but if there are two or more investments being analyzed then the costs and benefits of each must be obtained. The next step of the cost-benefit analysis is to determine the lifespan and all expected cash flows, or the costs and revenues, over the lifespan of the investment. The costs and benefits must be presented in nominal, or monetary, values and deflated using the discount rate to adjust for inflation that will occur during the lifespan of the investment (Rodrigue and Slack, 1998). The discount rate is the difference, in value, between receiving a dollar today and receiving a dollar at some time in the future (Kahn and Nelling, 2010). John Whitehead, an economics professor at Appalachian State University, says that the appropriate discount rate is equal to the real rate of interest. He goes on to explain that the real rate of interest, or discount rate, is equal to the market interest rate minus the expected inflation rate (Whitehead, 2005). After determining the discount rate, lifespan, and cash flows of the investment, the data can be analyzed using the three different measures of a cost- benefit analysis: net present value (NPV), cost-benefit ratio, and internal rate of return (IRR).

The NPV is a way to help the investor determine whether or not an investment is worth the money spent on it by showing how much the initial investment will be worth at the end of its expected lifespan (Business Dictionary). Dividing the benefits and costs by the discount rate and "subtracting the discounted costs from the discounted benefits" is generally how to obtain the NPV (Rodrigue and Slack, 1998). A negative NPV means that the investment is not cost beneficial, but a positive NPV implies that the investment is cost beneficial. Determining the net present value will not only show the expected value of the lab at the end of its lifespan, but also the current value of the lab in comparison to its initial cost.

The cost-benefit ratio is another measurement that helps to assess the decision. A cost-benefit ratio "is derived by dividing the discounted costs by the discounted benefits" (Rodrigue and Slack, 1998). Cost-benefit ratios with a value greater than one are considered to be cost beneficial. The cost-benefit ratio and NPV are "broadly similar", but if a high cost-benefit ratio and a small NPV is found then this means that some of the costs and benefits may have been predicted incorrectly and the data need to be reevaluated (Rodrigue and Slack, 1998).

The last measurement that needs to be calculated is the IRR. The IRR is usually compared to the cost of capital, or the cost of not investing the money and allowing it to accrue interest, to determine if the investment will be worth the money spent on it (Magni, 2010). The IRR is calculated using the formula:

$$\text{-Initial Investment} + \sum_{i=1}^{n} \frac{CF_i}{(1+IRR)^i} = 0$$

and solving for IRR, where CF_i is the cash flow for each year and n is the number of years past the base year (Grayson, 2010). This value will show the average return per unit of time that is used in the calculation. The IRR is considered cost beneficial if it is greater than the determined discount rate. A downside to calculating the IRR is that the discount rate is assumed to be constant during the entire lifespan of the investment. If there is a substantial change in the discount rate, the results of the IRR will not be completely accurate. The investment is considered to be beneficial if the NPV is positive, the cost-benefit ratio is greater than one, and the IRR is greater than the discount rate; but if just one of the measurements is not a desirable value, then the investment is considered to be detrimental.

This study will utilize a cost-benefit analysis to determine whether or not a fertilizer laboratory will be a cost effective way to manage nutrients for The Farm. Nutrient management is usually done in one of two ways, testing the soil or testing the plant's leaves. Nutrient management, when done properly, can "help protect the long-term sustainability and profitability of the farm" by maximize yields while minimizing their nutrient costs (Abnee, et al., 2001). This can help maximize yields because, "a properly implemented nutrient management plan can assure the farmer that the correct amounts of nutrients are being utilized in the most efficient manner" (Abnee, et al., 2001). Nutrient use efficiency can help decrease nutrient costs and therefore increase profits, because nitrogen fertilizer alone is typically ten to twenty percent of a farm's variable costs (Dobermann and Fairhurst, 2000). With the cost of nutrients being a large part of a farm's variable costs, it is important to maximize every dollar spent on fertilizer, but "without soil tests (or other forms of nutrient management) it is impossible to determine which nutrients are in short supply and which ones are adequate for the crop" (Penn State). This study looks at a form of nutrient management, plant nutrient testing, to see if it is a cost effective way to decrease nutrient costs while maintaining yields.

CHAPTER 3

METHODOLOGY

Procedures for Data Collection

In order to determine if a fertilizer lab is a cost beneficial way of cutting nitrogen fertilizer cost and consumption for The Farm there are numerous data that must be collected. As noted in the objectives, the data must allow an assessment of the changes in costs and revenues due to the establishment of the on-site testing facility. The cost changes include those for fertilizer use and costs due to the information provided by the lab, changes in harvesting costs and revenues due to any yield changes arising from changes in application of fertilizer due to the information provided by the laboratory, costs establishment and operation of the laboratory (Table 1). For this study, information from The Farm for both 2010 and 2011 is used to estimate these cost and revenue changes. These data are primarily from records maintained by the farm managers.

Table 1: Summary Table of Data to be Collected for Study

Variable	Units	Year(s) Data is From	Source
Fertilizer Use	Pounds	2010 and 2011	The Farm's Accountant via Ranch Manager B
Crop Prices	Dollars/Carton	2011	The Farm's Accountant and ThePacker.com
Fertilizer Prices	Dollars/Pound	2011	Ranch Manager A via Fertilizer Provider
Acres Farmed for Each Crop	Acres/Crop	2010 and 2011	Ranch Manager A
Total Yields for Each Crop	Cartons	2010 and 2011	Ranch Manager A
Changes in Harvesting Costs	Dollars	Difference of 2010 and 2011	Ranch Manager A
Changes in Labor Costs (Excluding Lab Tech Salary)	Dollars	Difference of 2010 and 2011	Ranch Manager A
Initial Investment of Lab	Dollars	2011	Owner B
Opportunity Cost of Lab (based on interest rate on Line of Credit)	Percent	2011	Owner B
Operating Costs of Lab	Dollars	2011	Owner B
Useful life of lab	Years	2011	Owner B
Salvage Value of Lab Equipment	Dollars	2021	Owner B
Changes in Management Practices	Dollars	Difference between 2010 and 2011	Owner A

Data on Fertilizer Use

The Farm grows six different crops: broccoli, cauliflower, celery, iceberg lettuce, romaine lettuce and strawberries. The strawberries are a fairly new addition and are a very small portion of the revenues for The Farm. Therefore all data collected will pertain only to the other five crops. The first data to be collected are the consumption of nitrogen fertilizer for one year both before, 2010, and after, 2011, the installation of the lab. It is important to obtain data for a full year because fertilizer consumption changes during different growing seasons throughout the year. Data for the consumption of nitrogen fertilizer was provided by one of the accountants and a ranch manager, Ranch Manager B, of The Farm. The Farm's accountant has Microsoft Excel Spreadsheet records of their nitrogen fertilizer consumption based on information provided by Ranch Manager B after each application of nitrogen fertilizer. Ranch Manager B records the total amount of nitrogen, phosphorus and potassium applied after each fertilizer application. The installation of the lab has probably resulted not only in a change in the amount of nitrogen fertilizer used, but also a change in the amount of phosphorus and potassium fertilizer used. To account for these variables, The Farm's accountant provided information on the use of these fertilizers as well. Changes in fertilizer applications between 2010 and 2011 are assumed to be due primarily to the information provided by the laboratory. This is a reasonable assumption because The Farm has been following a fertilizer application schedule prior to the installment of the lab that if fairly consistent from year to year. The purpose of the lab is to change this schedule so that The Farm is only applying fertilizer when the crop needs it instead of just when the schedule says it is time to apply more fertilizer.

Data on Fertilizer and Crop Prices

Data on fertilizer and crop prices are also required to estimate cost savings and revenues differences. The accountant for The Farm recorded the crop prices received by The Farm for its produce sales throughout the 2011 growing year. The accountant then calculates the average price received for each crop that The Farm grows during the growing year, which were used to calculate the revenues for crops examined in this study. Because some of these calculated average prices appeared inconsistent, a price data from The Packer (thepacker.com) were used to determine the average crop price for celery. Fertilizer prices were obtained from one of The Farm's ranch managers, Ranch Manager A. Ranch Manager A contacted The Farm's fertilizer provider to determine the average price paid for nitrogen, phosphorus, and potassium fertilizers throughout the 2011 growing season.

Data on Yields, Labor and Harvesting

Other data required are the acres farmed per crop, yields per crop, and changes to the labor and harvesting costs as a result of the lab. The acres farmed and yields were obtained for both the 2010 and 2011 growing seasons. After each planting, Ranch Manager A records the crop that was planted as well as the total acres that were planted. Ranch Manager A tracks the yields in a similar way; after each harvest the crop and the total yields harvested are recorded, which were reported to him by the crew chiefs. For each harvest, The Farm has a crew chief that supervises the harvest and keeps track of each carton that is harvested by his crew, he then relays the total amount harvested back to Ranch Manager A. The yields for 2010 are much higher than the yields for 2011. However, discussions with Ranch Manager A indicated that this was a result of market conditions and not the information provided by the lab. Theses market conditions (lower prices) resulted in a decrease in harvested quantities (less harvesting per field and sometimes not harvesting entire fields) for The Farm, but Ranch Manager insists that the actual yields (production, rather than sales) were unchanged from 2010 to 2011.

The changes in labor and harvesting costs due to the lab were not tracked directly so this study uses estimates from Ranch Manager A and B to determine this. Ranch Manager A and B are involved in all aspects of The Farm's production, which includes labor and harvesting, and have been for years. Due to their expertise, they are able determine reasonably accurately whether or not the information provided by the lab has influenced these costs. Although 2010 harvesting costs are greater than 2011 because of larger quantities actually harvested, the question is if the lab itself has caused a change in harvesting or labor costs. Ranch Manager A and B agree that there is no reason to believe that harvesting costs have changed due to the lab and the only change in labor due to the lab is the cost of the lab technician and the assistant lab technician, which is accounted for in the lab's operating costs.

Data on Establishment and Operations Costs for the Laboratory

Data on the costs of the lab itself are also required and can be collected from Owner A. Owner A was in charge of managing the installation of the fertilizer lab. She kept records of all the costs of the installation, maintenance, and operation of the lab. The first piece of information required is the cost of the initial investment. The initial investment consists of four different costs that were incurred in 2011 prior to the growing season. The first cost incurred by The Farm was hiring a lab consultant who helped instruct The Farm about how to properly setup and run the fertilizer lab. The consultant supplied a manual that described, in detail, how the lab should be set up and operated. The consultant also trained the analyst that operates the lab. The cost of the manual and the cost of the training both are included in this study.

The second cost was for equipment, including sampling equipment and chemicals used to test the samples. The third cost incurred was the labor required to properly set up the fertilizer lab. The fourth cost incurred was the opportunity cost of spending this money on the lab instead of investing it. In order to determine the opportunity cost, the interest rate associated with The Farm's line of credit was used. Another common initial cost is the building required for the laboratory, or cost of office space lost due to the installation of the lab. In this case, The Farm already owned the lab room and it was not being used so there are no costs included for this.

In order to properly analyze investment costs for the lab, given that the information on cost and yield changes are for a single year, the initial costs need to be annualized. Thus, properly calculating these annualized costs involves using the expected useful life of the lab and the salvage value of the lab's equipment. Owner A provided both of these numbers. These four initial costs, as well as the expected useful life and the salvage value of the equipment, were entered into a Microsoft Excel spreadsheet.

There are five different costs that determine the total operating costs of the lab. Each of these costs is recorded as the total amount spent during the 2011 growing season. The largest operating cost is the salary paid to the lab technician. There is also a lab assistant who is paid an hourly wage. The next two operating costs components are for maintenance. The first is the cost of maintaining the lab, which includes cleaning/servicing the equipment and cleaning the lab itself. The second maintenance cost is the vehicle maintenance for the vehicle used to collect the samples for testing. The vehicle maintenance includes the gas used to do the collecting and the actual maintenance, such as oil changes, of the vehicle. The final operating cost of the lab is the cost of the chemicals used to perform the necessary tests. All of these costs were obtained from

Owner A based on the bookkeeping system for The Farm. These data also were compiled in a Microsoft Excel spreadsheet and summed to calculate the total operating costs.

The final cost that was determined was the change in management costs as a result of the lab. These management costs include things such as the way The Farm plants its crops, applies the fertilizer, waters its crops, markets its produce, etc. This cost is not straightforward. Similar to the approach used by Ranch Manager A and B for the harvesting and labor costs, Owner B used his intuition to determine if there was a change in management costs. There are numerous variables that could change the management costs of a farm from year to year. The hardest part of determining this cost was figuring out what costs have changed as a direct result of the lab. After discussing the management costs with Owner B, he determined that there was no change in the management costs from 2010 to 2011 that directly relate to the lab. Owner B came to this conclusion because he said that the lab does not change the way they do things, it mainly changes the amount of fertilizer they apply which is not a management cost. Moreover, Owner B also stated that there is no additional time spent on using and processing the information provided by the lab because the lab technician is the one that determines which crops need fertilization and how much is needed. Owner B said that before the lab's installation managers would spend time deciding how much fertilizer to apply before each scheduled application, but now that time is spent discussing, with the lab technician, the optimum amount of fertilizer to apply.

Procedures for Data Analysis

Numerous calculations are required to compare the costs and benefits of the lab. Because there are many factors that can change prices from year to year it is not possible to look at the total costs and revenues from 2010 and 2011 and attribute any differences entirely to the establishment of the lab. Thus, the basic approach here is to use data from 2011 when the lab was operational and construct an estimate of the costs and returns for 2011 if the lab had not been in operation. To keep the data comparable, the prices, both crop and fertilizer prices, used in the calculations will be solely from 2011. Other adjustments are as described below.

Although the crop prices per unit are straightforward, the fertilizer cost data are modified so that it can be properly determined how much was spent on each nutrient. The fertilizer costs include the application costs and the cost of the actual nutrients, but the cost of the actual nutrients is the only cost that needs to be considered for this study because the application costs do not change. Even though they are applying less fertilizer, it does not affect the application costs because they are applying less fertilizer per application and not changing their number of applications. Because The Farm applies fertilizer through their drip tape while irrigating, it does not matter if they are applying 50 pounds or 75 pounds of nutrients; the application cost is unchanged. The price of phosphorus and potassium are on a per pound basis whereas the price for nitrogen is on a per gallon basis. The price of nitrogen can easily be changed to a per pound basis by multiplying the total pounds per gallon of the fertilizer by the price per gallon. Ranch Manager B has said that the nitrogen fertilizer used by The Farm is 2.12 pounds per gallon; so, in this case, multiplying 2.12 by the price per gallon will result in the price per pound. There is another calculation that needs to be made with the fertilizer prices of phosphorus and potassium.

The phosphorus fertilizer used by The Farm has both phosphorus and potassium in it, which means that the price of phosphorus fertilizer needs to be split between phosphorus and potassium. Fertilizers have a grade that tells the consumer what percent of each nutrient the fertilizer contains. For example, if a fertilizer has a grade of 0-30-40 this means that the fertilizer contains 0% nitrogen, 30% phosphorus, 40% potassium and the remaining 30% is filler with no nutrient value. This means that by multiplying the price of the phosphorus fertilizer by the percent of phosphorus it contains will result in the price spent on just the phosphorus and the remainder will be the price spent on the potassium. The calculated amount spent on the potassium will be added to the price of the potassium fertilizer to give the total amount spent, per pound, on potassium. After these calculations are made, the fertilizer prices will be in a form that is useful for this study.

The next calculations that need to be made involve the acres farmed, yields and fertilizer use. The Farm rarely farms the same number of acres from one year to the next. Because the total acres farmed and the acres farmed per crop has changed from 2010 to 2011, the yields and fertilizer use were calculated on a per acre basis. To do this the total yields for each crop were divided by the total amount of acres planted for each respective crop. For example, if broccoli yields for 2010 were 1,000 cartons and the acres of broccoli planted in 2010 were 100 acres then the yields per acre would be 1,000 cartons/100 acres, or 10 cartons/acre. This calculation was done for each crop in 2010 and 2011 so that the 2010 yields per acre could be compared to the 2011 yields per acre. The fertilizer use must also be calculated on a per acre basis, or pounds/acre, for each fertilizer used in 2010 and 2011. Nitrogen use per acre was calculated by taking the total pounds of nitrogen used and dividing by the total acres farmed. Next, the phosphorus and potassium use were calculated on a per acre basis. As previously stated, the phosphorus fertilizer has potassium in it as well. Multiplying the percent of potassium that is in the phosphorus fertilizer by the total amount of phosphorus fertilizer used and adding that to the amount of potassium fertilizer used resulted in the total amount of potassium used by The Farm. Subtracting the amount of potassium in the phosphorus fertilizer from the total amount of phosphorus fertilizer indicates the total amount of phosphorus used by The Farm. The phosphorus and potassium use per acre can now be calculated the same way in which the nitrogen use per acre was calculated.

Two additional costs that must be estimated the opportunity costs and the annualized cost of the initial investment of the lab. The opportunity costs are the benefits that are forgone by The Farm in order to make the initial investment in the lab. It is important to account for these costs because, even though accountants may not consider these costs, they are actual costs, or money lost, to a business looking to make an investment. The opportunity costs of the lab can be calculated by multiplying the interest rate from The Farm's line of credit (in percent), by the sum of the initial investment (which represents the initial asset value in the first year). The result will be the interest given up by investing the money in the lab instead of allowing it to earn the interest. The annualized cost is used to spread out the initial investment costs over the useful life of the lab so that it is consistent with the single-year information available for impacts on fertilizer costs and yields. According to Monke and Pearson (1989), a simplified formula to calculate annualized costs is given by:

$$AC = (IC - PVSV) \cdot \left[\frac{(1+i)^n \cdot i}{(1+i)^n - 1} \right]$$

$$PVSV = \frac{SV}{(1+i)^n}$$

The first formula is the formula used to calculate the annualized costs where IC is the initial cost, PVSV is the present value of the salvage value, i is the interest rate (or line of credit), and n is the useful life of the lab in years. The second formula is used to calculate the PVSV where SV is the salvage value.

After all these calculations have been made, the costs and benefits of the lab can be compared to determine if the lab is a cost beneficial way of reducing nitrogen costs and consumption for The Farm. The cost of the lab itself is the first cost that needs to be determined. The annualized costs, operating costs, and opportunity cost of the lab need to be summed and recorded as a cost. After this, the changes in harvesting costs, labor costs, and management practices (represented as dollars) need to be summed. Because the costs associated with the lab are zero in the absence of the lab, the 2011 costs with the lab indicate the change.

The next benefit (or possibly cost) to be determined is the change in fertilizer costs with and without the lab for 2011. To approximate the changes in fertilizer application with the lab, changes in fertilizer usage per acre in 2010 to 2011 were calculated. For example, if the 2010 nitrogen use was 100 pounds per acre and the 2011 nitrogen use was 80 pounds per acre then the difference would be 20 pounds per acre. Because the farm manager believes that applications would have been the same in 2011 as in 2010 in the absence of the information from the lab, any difference here is attributed to the information from the laboratory. A similar calculation was made for phosphorus and potassium usage. This information was used to determine how much the total amount of each fertilizer usage changed by taking the change in each fertilizer usage per acre and multiplying by the total acres farmed in 2011. For example, if the change in nitrogen was 20 pounds/acre and the total acres farmed was 1000 acres in 2011 then The Farmed saved

20,000 pounds of nitrogen in 2011 with the lab compared to without it. This calculation was also done for phosphorus and potassium. These total differences in fertilizer use were converted to values using fertilizer price information from 2011. For example, if the nitrogen usage changed by 20,000 pounds and the price of nitrogen is $5 per pound then The Farm saved $100,000 on nitrogen fertilizer with the laboratory information available in 2011. A similar calculation was done for phosphorus and potassium. The fourth and final step is to calculate the sum of the value difference for all of the fertilizers. A positive is a benefit and a negative value is recorded as a cost.

Similarly, adjustments to yield to account for the lab must also be determined. As noted earlier, the harvested yields per acre recorded in 2011 were much lower than the harvested yields recorded in 2010. Ranch Manager A indicated that the harvested yields in 2011 were not a proper representation of the actual production yields in 2011. Because the 2011 harvested yields are not accurate as indicators of production yields, and existing records do not allow accurate estimation of the production yields in 2011, it will be assumed that the 2011 yields are equal to the 2010 yields. This is considered reasonable because Ranch Manager A was certain that the 2011 harvested yields were lower due only to market conditions.

Because the yields for 2011 are assumed to be the same as 2010, a sensitivity analysis was performed to assess the importance of this assumption. This sensitivity analysis determined by how much the 2011 yields would need to have decreased by to make the lab breakeven based on costs an prices in 2011. The sensitivity analysis was calculated by decreasing the 2010 total yield revenues (in dollars) by different percentages until the decrease in yield revenue was equal to the benefits minus the costs of the lab. The percent change in yields was calculated in four steps. The first step was to get the total yields for 2011 assuming that the 2011 and 2010 yields per acre are equal. The total yields for 2011 were calculated by taking the 2010 yields per acre and multiplying by the total acres farmed in 2011 for each corresponding crop. The second step was to take these total yields and multiply by the corresponding crop price from 2011, which resulted in the gross revenue of each crop. The third step was to take the sum of all the crop's gross revenue to get the total gross revenue from the crops. The fourth step was to multiply the total gross revenue by different percentages until the result was equal to the decrease in fertilizer costs minus the lab costs. A low percentage means that this study is greatly affected by the change in yields and the opposite is true for a larger percentage. After all these calculations have been made, there is sufficient information to determine if the fertilizer lab is a cost beneficial way of reducing nitrogen costs and consumption.

Once the benefits and detriments have been accounted for and calculated as monetary values, the sum of the detriments can be subtracted from the sum of the benefits. If the difference is positive then the fertilizer lab will prove to be cost beneficial, but if the difference is negative then the fertilizer lab will not prove to be cost beneficial.

Assumptions

A key assumption is that any differences in fertilizer used from 2010 to 2011 are due entirely to the information from the lab. It is also assumed that there was no change in yields although less fertilizer was used. In economic terms, this suggests that the marginal product of the combined applied nutrients was zero, which is not commonly observed for crop responses, but can occur. However, it could have been the case that The Farm was over-applying fertilizer, and that the lab increased fertilizer use efficiency. Since it is assumed that yields are the same in

2011 and 2010. Another assumption is that there are no external variables that greatly changed the need for fertilizer in 2011 versus 2010.

Limitations

This cost-benefit analysis is based on a medium-sized produce farm with fertilizer costs comprising a large portion of their variable costs. The results of this study may not apply to a smaller produce farm that has relatively low fertilizer costs. This study may also not apply to farms growing varieties of crops that differ from those grown at The Farm. For this particular farm, there were no costs incurred for the room in which the lab was setup, but the cost of the room or building is typically a large cost for many farms considering this investment. Most cost benefit analysis include NPV and IRR calculations, but due to the difficulty of determining the data used in this study, these other calculations are beyond the scope of this study. The NPV and IRR calculations are typically used for longer-term investment analyses than what was performed for this study. Another reason that NPV and IRR were not calculated is because the future prices of fertilizers and crops are required, but would be very difficult to predict accurately. A key assumption for this study is that both fertilizer applications and yields would have been the same in 2011 as in 2010 without the information from the laboratory. The limitation here is that although this may be appropriate based on the opinion of the managers, a more sophisticated analysis would examine this empirically. One approach to this is to use crop simulation models to show how yields would be affected by application amounts and timing and would have been able to more explicitly attribute the changes to the lab.

CHAPTER 4

DEVELOPMENT OF THE STUDY

Introduction

The purpose of this study is to determine if a fertilizer lab is a cost beneficial way of reducing fertilizer costs and consumption for The Farm. This portion of the study is the actual testing of the hypothesis. The first component of the analysis was to determine how the total amount of fertilizer applied differed from 2010 to 2011, specifically to see if there was a decrease in fertilizer applications. Because there was a decrease in consumption based on this analysis, the total costs saved by The Farm based on this reduced fertilizer consumption was calculated. After this, the total costs of the lab were determined and the costs of the lab were compared to the total amount saved on fertilizer. It was determined that the fertilizer lab was a cost beneficial way of reducing fertilizer costs and consumption for The Farm, but only if the 2011 yields are actually the same or greater than the 2010 yields.

Yield Data and Assumptions

As noted previously, changes in yields due to changes in fertilization practices due to the information from the lab is one of the factors considered in this analysis. The reported per acre harvested yield was lower in 2011 than in 2010 for each crop except iceberg. Although this decrease in yields could be consistent with the information from the lab if fertilizer was systematically over-applied in 2010, additional information suggests this was not the case. . Ranch Manager A indicated that the decrease in reported (harvested) yields was a result of market conditions in 2011. Heavy rain early in the season restricted when many farmers were able to plant. Thus, farmers were unable to stagger their plantings and they ended up harvesting many crops around the same time, causing a significant price drop. As a result, The Farm decided to not harvest entire fields because the expected revenue would be less than the harvesting costs. The Farm only records harvested yields, and, therefore, the yields from 2011 do not accurately depict the total production yields. Ranch Manager A is confident that the 2011 production yields per acre would have been the same or higher than the 2010 production yields per acre if not for the market conditions. For this analysis 2010 and 2011 yields per acre were assumed to be the same for each crop, but the importance of this assumption is tested with sensitivity analysis. There was also an issue with the celery price reported by The Farm for 2011. The celery price was a contracted price reported to be $.07 per pound, which, when calculated on a per carton basis, was much lower than the 2010 price. Although crop prices tend to fluctuate frequently, this price was too low to consider it a good representation of what most farmers were getting in the study area. To get a better representation, this study used the average celery price for Santa Barbara County from a website called The Packer (thepacker.com). The Packer supplies average produce prices for numerous cities and counties all over the United States.

Analysis

One component of the analysis is fertilizer use per acre for each crop. This calculation requires the acres farmed of each crop in 2010 and 2011 (Table 2). Total acres farmed increased from 2010 to 2011 and the proportions of crops grown change, which it is one reason why fertilizer use per acre is needed. One key result is that The Farm decreased per-acre use of each nutrient from 2010 to 2011 (Table 3), while apparently maintaining yields. This implies that The Farm reduced fertilizer costs and consumption compared to the situation without the lab.

Table 2: Acres Farmed per Crop, Total Acres Farmed in 2010 and 2011 and the Difference

Crop	2010	2011	Difference
Broccoli	755	872	117
Cauliflower	478	747	269
Celery	122	147	25
Iceberg	376	462	86
Romaine	630	903	273
TOTAL	2361	3131	770

Table 3: Pounds of Nutrients Used per Acre and the Difference from 2010 to 2011

Nutrient	2010	2011	Difference/Acre
Nitrogen	247.78	206.38	- 41.40
Phosphorus	30.60	15.37	- 15.23
Potassium	85.12	50.27	- 34.85

The fertilizer used is shown as an average for all crops (Table 3). Although it would have been more fitting to show the fertilizer use per crop, this information was not readily available. The Farm was able to reduce their potassium use by 41%, which suggests that The Farm was greatly over applying potassium in 2010 and, most likely, years before that. Fertilizer expenses were reduced by $535,223 due to the information provided by the lab (Table 4). Nearly 80% of the reduction in expenses was for changes in use of nitrogen fertilizer, because it was the most expensive nutrient and the one used in the largest quantity.

Table 4: The Total Difference in Fertilizer Used and Reduction in Fertilizer Expenses With and Without the Lab, 2011

Nutrient	**Difference/ Acre (Lbs.)**	**Total Difference (Lbs.)**	**2011 Price (Dollars/Lb.)**	**Total Difference (Dollars)**
Nitrogen	41.4	129,635	$3.16	$409,490
Phosphorus	15.23	47,686	$0.60	$28,516
Potassium	34.85	109,110	$0.89	$97,217
TOTAL		286,431		$535,223

The initial investment in the lab consisted of six different costs with the equipment and the manual accounting for the largest proportion, approximately 71% (Table 5). It was determined that the only initial investment with a non-zero salvage value was the equipment. This is mainly because the equipment is the only initial investment that is in physical form and could be sold after ten years. Although the total initial investment of the lab totaled just over $44,000, the annualized investment costs were relatively low for 2011, $5,220 (Table 5). The total costs of the lab consisted of annualized, operating, and opportunity costs. Of these three costs, the operating costs were the largest comprising 88% of the lab's costs in 2011. The salary paid to the lab technician was the greatest operating cost at $40,000 (Table 6). Even though the salary paid to the lab technician was $40,000, the total costs of the lab only amounted to just over $58,000 making the lab relatively inexpensive for a medium-sized produce farm.

Table 5: Calculation of Total Asset Values and 2011 Annualized Costs of Fertilizer Lab

Cost Category	Initial Investment	Salvage Value	Line of Credit	Useful Life	Annualized Value
Manual	$10,625.00	-	4%	10 yrs.	$1,309.97
Training	$4,660.00	-	4%	10 yrs.	$574.54
Modifications to Room	$2,000.00	-	4%	10 yrs.	$246.58
Equipment	$21,000.00	$2,000.00	4%	10 yrs.	$2,342.53
Lab Tech (Labor Set Up)	$4,950.00	-	4%	10 yrs.	$610.29
Shop (Labor Set Up)	$1,100.00	-	4%	10 yrs.	$135.62
TOTAL	**$44,335.00**	**$2,000.00**			**$5,219.53**

Table 6: Annualized Investment, Operating and Opportunity Costs for the Fertilizer Lab, 2011

Cost Category	Annualized Cost Value
Annualized Initial Investment	
Manual (Consultant)	$1,309.97
Training (Consultant)	$574.54
Modifications to Room	$246.58
Equipment	$2,342.53
Lab Tech (Labor Set Up)	$610.29
Shop (Labor Set Up)	$135.62
Operating Costs	
Lab Tech Salary	$40,000.00
Lab Assistant	$5,000.00
Gas and Vehicle Maintenance	$858.00
Lab Maintenance	$5,000.00
Chemicals	$975.00
Opportunity Costs	
Line of Credit at 4%	$1,773.40
TOTAL Lab Costs for 2011	**$58,825.92**

The Farm saved $535,223 on fertilizer costs and spent $58,826 on the lab in 2011, which means that The Farm reduced expenses by $476,397 in 2011 with the installation of the lab (Table 7). These results show that the lab not only reduced fertilizer use and costs, but provided net financial benefits. The cost-benefit ratio of this investment is 9.1, and, in a typical cost-benefit analysis, an investment is considered to be cost-beneficial if the ratio is greater than one. Since the ratio is much greater than one, this investment appears to be highly cost beneficial. This makes sense because, as discussed in the literature review, proper nutrient management can be a good way to help increase nutrient use efficiency and, in turn, increase profits. In this case, proper nutrient management has proven to increase profits for The Farm. However, the previous analysis assumes that the 2010 and 2011 yields were the same. To determine by how much the results were affected by that assumption, a sensitivity analysis was performed. This sensitivity analysis assess by how much yields would have to decrease for the costs of the lab to equal to the benefits. If the percentage change required to offset the benefits of reduced fertilization is small, this suggests the result that the lab is cost beneficial is sensitive to the assumption that yields were unchanged.

Table 7: Estimated Costs and Benefits of The Farm's Fertilizer Lab in 2011

Costs	Amount	Benefits	Amount
Manual (Consultant)	$1,309.97	Reduction in Nitrogen	$409,489.65
Training (Consultant)	$574.54	Reduction in Phosphorus	$28,515.94
Modifications to Room	$246.58	Reduction in Potassium	$97,217.38
Equipment	$2,342.53		
Lab Tech (Labor Set Up)	$610.29		
Shop (Labor Set Up)	$135.62		
Lab Tech Salary	$40,000.00		
Lab Assistant	$5,000.00		
Gas and Vehicle Maintenance	$858.00		
Lab Maintenance	$5,000.00		
Chemicals	$975.00		
Opportunity Cost	$1,773.40		
TOTALS	$58,825.92		$535,222.98

The effect of the lab on yields is uncertain because there are numerous factors that can affect yields, including prices, demand, weather, pests, etc. Ideally, the effect of fertilizer application on production yields would be measured for the purposes of assessing the impact of the lab, also assuming that any change in fertilizer applications was due to the information provided by the lab. Although Ranch Manager A was certain that the 2011 yields were at least equal to the 2010 yields, the sensitivity analysis indicates that if the yields were to decrease by just 1.8% as a result of the reduced fertilization with the lab, then the lab will not provide The Farm a net financial benefit. This small percentage suggests that the results of this study are highly sensitive to the assumption that the yields are unchanged. Ranch Manager A's assertion that yields stayed the same even with lower fertilization would have to be absolutely accurate for the initial results of this study to hold true.

Table 8: The Total Crop Revenues Used for Breakeven Analysis

Crop	2010 Cartons /Acre	2011 Acres Farmed	2011 Crop Price/Carton	Total Crop Revenue
Broccoli	841.63	872	$8.90	$6,531,695.58
Cauliflower	756.50	747	$10.01	$5,656,716.07
Celery	1,292.05	147	$11.40	$2,165,210.52
Iceberg	1,610.53	462	$9.02	$6,711,473.02
Romaine	597.45	903	$9.51	$5,130,587.77
TOTAL Crop Revenue				**$26,195,682.95**

Interpretation of the Results

Under the assumption of unchanged yields with decreased fertilization, the benefits of The Farm's fertilizer lab turned out to be greater than the costs of the lab, therefore supporting the hypothesis. As mentioned above, the results of this study are highly sensitive to the assumption that yields did not change. Although Ranch Manager A is fairly confident that the yields did not decrease in 2011, just a 2% decrease in yields as a result of the lab would make the lab a cost-detrimental investment. Assuming that the 2011 yields did not decrease from the 2010 yields, the fertilizer lab is a cost beneficial way to reduce nitrogen costs and consumption for The Farm. The lab was actually able to decrease fertilizer costs by enough to pay for its entire initial investment cost in the first year of operation.

CHAPTER 5

SUMMARY, CONCLUSION, AND RECOMMENDATIONS

Summary

The rising nitrogen fertilizer costs have been driving farmers to try different ways of managing their nitrogen use. There are two reasons that farms focus more on managing their nitrogen levels above other nutrients. The first reason is that nitrogen fertilizer is the most expensive and abundantly used fertilizer. The second is that nitrogen's detrimental effects on the environment are becoming more clearly recognized and regulated in the agricultural community. A fertilizer lab can provide information useful to improve management of not just nitrogen fertilizers, but all fertilizers. A fertilizer lab could help farms use nitrogen more efficiently, resulting in a reduction of fertilizer costs and consumption.

The purpose of this study was to determine if a fertilizer lab was a cost beneficial way to reduce nitrogen costs and consumption for The Farm. The value of changes in The Farm's fertilizer consumption and crop yields with and without the lab and the costs of the lab, were estimated to determine if the benefits outweighed the costs. The benefits greatly outweighed the costs of the fertilizer lab as long as yields did not decrease by more than 1.8%, In this case, the lab proved to be a cost beneficial way for The Farm to reduce their nitrogen costs and consumption. On the other hand, if the assumption is incorrect and the yields dropped by only a small percentage, then the lab is not a cost beneficial way for The Farm to reduce their nitrogen costs and consumption, although it may have other benefits for the management not accounted for here.

Conclusion

This study examined changes in the costs of fertilizer purchased by The Farm, the costs of the lab, and the changes in yields and revenues from production of the crops. This study analyzed these aspects of The Farm using a cost-benefit analysis to help determine if the fertilizer lab was a cost-beneficial way of reducing The Farm's nitrogen costs and consumption. The results of this study suggest that by utilizing the fertilizer lab The Farm was able to save $535,223 on fertilizer costs in 2011, with the lab, compared to 2010, without the lab. The costs of the lab incurred in 2011 were only $58,826 proving to The Farm that the investment made in the lab was cost beneficial.

A key assumption of the initial analysis was that yields did not change despite lower amounts of fertilizer applied. This may be a reasonable assumption because, as stated in the literature review, many farms use more fertilizer than their plants can effectively utilize, and it appears this could be true for The Farm. Under this assumption, the benefits outweigh the costs to such a significant degree that even if the initial investment costs were not annualized the lab would have still been cost beneficial in the first year of operation. In other words, the lab pays for itself by more than four fold in the first year of operation. The importance of the assumption of constant yields was examined through sensitivity analysis. If the yields decreased by more than 1.8% based on the information from the lab, the investment in the lab facility would not have been cost beneficial. This suggests that if the manager's perception about yields being unchanged is even mildly inaccurate, the basic conclusion of this study is altered.

Recommendations

Based on the results of this study, comparing the benefits of the lab to the costs of the lab, it was determined that The Farm's lab is a cost beneficial way of reducing their nitrogen costs and consumption. The lab results in a positive cash flow for The Farm within its first year of operation.

It is recommended that other produce farms looking for ways to reduce their nitrogen costs and consumption look into the utilization of their own fertilizer lab. Although the costs of getting a fertilizer lab up and running may be a bit pricy, it is well worth the investment because it allows for a large reduction in fertilizer costs and consumption year after year.

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