2001

A FARM-LEVEL ANALYSIS OF SPECIALTY CROP PRODUCTION IN KENTUCKY

Daniel C. Green
University of Kentucky, Dgreen@ca.uky.edu

ABSTRACT OF THESIS

A FARM-LEVEL ANALYSIS OF SPECIALTY CROP PRODUCTION IN KENTUCKY

Special purpose crops are those with traits designed to meet the specific demands of an end user. A mean-variance (E-V) mathematical programming model and sensitivity analysis are used to quantify and discuss the potential net returns and risk associated with the adoption of special purpose crops at the farm level. Furthermore, a spreadsheet-based decision aid is developed to assist farmers in the decision of whether or not to produce high-oil corn on their operation.

Results from this study indicate that the profitability of high-oil corn is very marginal, dependent upon the ability of the crop to yield as well as conventional corn, and gain significant premiums. The potential of marketing this crop through a producer-owned cooperative seems promising.

Daniel C. Green

October 27, 2001

A FARM-LEVEL ANALYSIS OF SPECIALTY CROP PRODUCTION IN KENTUCKY

By

Daniel C. Green

Kimberli A. Zeuli
Director of Thesis

Michael R. Reed
Director of Graduate Studies

October 27, 2001

RULES FOR USE OF THESIS

THESIS

Daniel C. Green

The Graduate School

University of Kentucky

2001

A FARM-LEVEL ANALYSIS OF SPECIALTY CROP PRODUCTION IN KENTUCKY

THESIS

A thesis submitted in partial fulfillment of the
requirements for the degree of Master of Science
at the University of Kentucky

By

Daniel C. Green

Lexington, Kentucky

Director: Kimberly A. Zeuli, Assistant Professor of Agricultural Economics

Lexington, Kentucky

2001

ACKNOWLEDGEMENTS

God has vastly blessed me through the people who have contributed to the completion of this thesis. The completion of this thesis would not have been possible without their support and patience.

I wish to extend my appreciation to my major professor and thesis director, Dr. Kim Zeuli, for her suggestions, guidance, and support in the completion of this thesis under unusual circumstances.

Special thanks to Dr. Gregg Ibendahl who exceeded his duties as a committee member by spending many hours reviewing this work and offering his suggestions. He worked diligently with Dr. Zeuli to help me in the completion of this thesis and was always willing to take time to answer any questions I had.

Likewise, I would like to thank Dr. Jerry Skees for sharing his astounding expertise though his service as committee member. He was always willing to take time to contribute his views on various topics and share his ability to explain and conceptualize complex issues.

I also wish to thank Dr. Will Snell, who I have had the opportunity to work with over the past year, for his patience and encouragement.

There are many others who have had an influence on me through their friendship and advice. I would like to thank my fellow graduate students for their friendship and the rest of the faculty and staff in the department for their assistance.

Finally, I would like to express my deepest appreciation to my family for their support and encouragement. I would like to thank my wife, Allison, for the sacrifices she has made and the support and love she has shown me through the last few years.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure

LIST OF FILES

Name	Type	Size
DCGthes	PDF	781 KB

Chapter One
Introduction

Background

Significant structural changes have transformed agriculture from an industry of homogenous products and decentralized markets to one increasingly of specialized products marketed through vertically coordinated arrangements. The proliferation of genetically modified crops exemplifies this trend. Genetically modified organisms (GMOs), in the context of crops, are those plant types that have had their genetic structure altered using accepted techniques of genetic engineering. These crops have come in two phases (Riley and Hoffman). The first phase of crops included those designed to increase farm profits by reducing production costs, increasing yields, and increasing flexibility in planting. These include pesticide, insect, and drought resistant varieties (e.g., Roundup Ready Soybeans® and Bt Corn). The next phase of crops, referred to as special purpose crops, are those with valuable output traits designed for the end user.

The focus of this study is on special purpose crops, specifically high-oil corn. The objective is to expand the limited research in this area and provide a practical tool producers could use to evaluate whether or not to add a specialty crop to their crop mix. Most of these crops are associated with biotechnological advances (i.e. genetically modified), although there are some that have been created through traditional breeding practices, such as high-oil corn.

Special purpose crops offer producers a means to enhance farm profits since they receive premiums based on the value of the crops. For example, high-oil corn contains greater oil content and provides more energy in feed than other more commonly used crops. High-oil corn can be used as a replacement for more expensive energy sources to reduce the cost of feed rations. This value is passed on to the producer of the crop through premiums based on the oil composition of the crop. The higher the percentage of oil content contained in the crop, the greater the energy value, and therefore, the higher the price premiums. The increased production of special purpose crops has important implications for agriculture, since they are not typically produced and sold using traditional methods.

Limited research has been done related to the adoption of high-oil corn, and of the existing work, the majority has been done based on data from states north of Kentucky. Most of the existing economic research consists of a general discussion of the potential benefits and negative aspects of high-oil corn without going into more specific farm-level analysis, with the exception of some partial budget and enterprise analysis. An online partial budgeting tool (Frerichs) on the Illinois Specialty Farm Products (ISFP) website allows users to enter expected production and marketing information for a comparison of high-oil corn and conventional corn. Ohio State University Extension produces high-oil corn enterprise budgets for producers to use when making production decisions. The potential profits and risks of producing high-oil corn in Kentucky has been analyzed with some discussion of contract issues (Ibendahl, Zeuli, and Pearce). However, much of the discussion related to specialty crops and biotechnology focuses on the structural changes in agriculture that is associated with these advances in technology (Kalaitzandonakes; Sofranko et al; Golan; Bender et al).

Kalaitzandonakes addresses issues related to the adoption of specialty crops and potential changes in market structure that is associated with this adoption. The adoption and market penetration of specialty crops will be slower than those of the first phase of biotech crops due to the greater investments that must take place for identity preservation such as storage and shipping. Kalaitzandonakes suggests that since producers can always choose to produce commodities, the "lower bound" of the value of these specialty crops must be at least equal to that delivered by other commodities and that producers of specialty crops should capture value at least equal to any "hike in the commodity price".

Sofranko et al look at the characteristics of producers who have contracts to produce specialty crops compared to those who do not have contracts. The results show that farmers with contracts differed from those without in the following ways; they were on average 5 years younger, had larger farms, were more dependant on farm income, and were more likely to expect a family member to take over their farm upon retirement. Additionally, they had more on farm storage capacity, which is later explained as a useful asset in specialty crop production.

Bender et al use a survey of U.S. grain handlers to examine the market channels for specialty crops. Quality control methods, characteristics of buyers, oil content, and additional costs of handling of high-oil corn are each discussed. Nearly three-fourths of high-oil corn was purchased by exporters and 23 out of the 29 firms were grain elevators. All but one of the purchasers tested the quality of the crop either upon delivery at their facilities or at the end use. In addition to the premium paid for the crop, the additional costs of handling the crop over conventional corn only amounted to 1 to 2 cents per bushel.

This research more specifically analyzes the feasibility of high-oil adoption for Kentucky farmers, although the analysis also adds to the general body of literature. Further, it provides a simple tool that producers can use as an aid in the decision of whether or not to produce high-oil corn.

Movement Toward More Specialized Crops

Popular varieties of the first phase of biotech crops include Bt Corn, designed to resist the European corn borer, and Roundup Ready soybeans, herbicide resistant soybeans that allow for greater weed control. These first phase crops were quickly adopted because they were beneficial to the producers by way of their lower production costs and/or higher yields. While these seeds had special characteristics in terms of pesticide resistance and yields, their end-use value was virtually identical to the conventional crops that were being grown. Within three years of their initial introduction in 1996, around 50 million acres of these crops were being grown (Riley and Hoffman). By 1999, approximately 60 percent of the harvested soybeans in the U.S. were herbicide resistant and around 40 percent of the harvested corn acres were some type of biotech variety (Lin, Chambers, and Harwood).

The second generation crops are also quickly being adopted, although not as fast as the initial biotech crops. These new crops require a movement away from the homogeneous bulk grain markets toward specialized grain crop markets. Promising varieties of crops have been developed in this second phase to meet the demand of processors for more quality specific attributes. Varieties include high sucrose soybeans, high oleic soybeans, low saturate soybeans, and high-oil corn. High-oil corn is currently the most important corn variety produced in terms of enhanced nutritional value (Riley and Hoffman).

The demand for these specialty crops will continue to create structural changes in agriculture since these crops require new production and marketing techniques. High-oil corn requires production methods that consist of distinct production practices suggested by the seed manufacturer.

Dupont Specialty Grains (DSG), originally formed in January 1998 as Optimum Quality Grains, a joint venture of Dupont and Pioneer, is the license holder of the Top Cross High Oil Blend®, the most popular method of producing high oil corn. This method consists of planting a blend of two types of corn. The first type is the "grain parent" and comprises about 90% of the planted seed. The remaining seed is a special pollinator that is responsible for shedding pollen that contains the gene that causes the kernel to produce a larger embryo. High-oil corn can have as much as twice the oil content of traditional varieties of corn due to its larger embryo (Riley, Hoffman and Ash). The embryo of the seed is the area where the oil and essential amino acids are contained; creating a larger embryo provides for greater value. This system of pollination is the cause of additional production risk in high oil corn production. Several production techniques are recommended by the seed vendors in order to ensure comparable yields in the high-oil corn varieties and to protect the identity of the crop from commingling with the conventional varieties that may be produced on the same land. It is recommended that the crop be planted following a soybean rotation to improve yields and decrease insect and disease pressure. This requires limitations on the number of acres of high-oil corn and soybeans that can be produced in a given year. It is also suggested that conventional or minimum tilling practices to avoid cool soil temperatures. This can help avoid decrease yield damages due to lower seed germination resulting from soil temperatures that are too cool. Since a small percentage of the seed is responsible for the primary purpose of spreading the high-oil qualities, an increased planting rate of 2,000 seeds per acre is recommended, which results in additional seed cost. The crop should also be isolated to prevent dilution of oil content at the field edges due to cross breeding with nearby conventional corn varieties.

Special purpose crops are also limited in how they can be marketed. The majority of the crop is grown for the export market and has typically been produced for a niche market during the first few years of adoption. Therefore, contracts have been typically offered in order to allow the buyers of the crop fill specific orders for high-oil corn efficiently. This system is especially beneficial in addressing the fact that the crop must be stored separately from conventional corn. The contractual arrangement have allowed the contractors to require specific varieties to be grown as well as control the number of bushels of the crop that are delivered to a specific location, in order to efficiently use storage. For these reasons, contractual arrangements have become increasingly popular among these varieties. This has created a transition from individual production units to more vertically integrated arrangements resulting in contractually determined production and marketing decisions. Alliances between producers and agribusinesses can effectively reduce price and even yield risk in some situations, but they can also put producers at a disadvantage in other aspects such as price bargaining and market information.

Although a variety of special purpose crops are grown, this research is solely concerned with high-oil corn. High-oil corn varieties are currently the most popular special purpose crop with around one million acres planted in 1999 (Lin, Chambers, and Harwood). Around half of the high-oil corn grown in the U.S. in 1998 was under contract for the export market, while the rest was used in domestic livestock production (ISFP). According to the Illinois Specialty Farm Products (ISFP) program, this additional oil increases growth performance in livestock and poultry production and is used as a replacement for more expensive sources of energy in feed rations.

The animal science literature contains numerous articles and studies related to the feed value of high-oil corn. The nutritional value and advantages of high-oil corn as a poultry feed has been tested for several years (Han, Parsons, and Alexander; Bartov and Barzur). Particular emphasis has been placed on additional energy content and digestibility of high-oil corn in poultry (Adams et al; Dudley-Cash; Saleh et al; Vieira et al; Parsons, Zhang, and Araba). The majority of the studies have found that high-oil corn has at least the same level of digestibility with some improvement in gain from additional energy content. However, there are studies that show no significant difference in high-oil corn and conventional corn or that comparable results were found in the differing varieties (Bartov and Barzur; Benitez et al).

High-oil corn has been shown to have the potential to increase milk yields in dairy cows (LaCount et al) as well as demonstrate some economic value for dairy cattle in very high production levels (Dado). Feed costs per cow per day were found to decrease around $0.10 for cows yielding 50 kg of milk per day by substituting high-oil corn for conventional corn (Dado). Efficient utilization of the nutrients in high-oil corn by pigs has been shown to result in an improvement in feed efficiency and weight gain (Adeola and Bajjalieh). The overall value of high-oil corn as feed has been estimated to range between $0.25 and $0.64 above that of conventional corn across dairy, beef, pork, and poultry (DSG).

Current high-oil corn contracts primarily increase net revenues to the producer through price premiums (typically higher than conventional corn prices), based on the oil composition of the crops. The quality of the crop and price risk is related in high-oil corn because of the premium system that is used. The premium is directly determined using a graduated system based on tested oil content of the crop. In most cases, a specific premium is paid for a certain level of oil content, and the premium decreases $0.01 for each 0.1% decrease in oil content. In most cases, oil content increases with the quality of the crop and its yield. Therefore, there is a relationship between price risk and product quality. Most high-oil corn contracts specify a predetermined number of bushels to be delivered at a specific date and priced on the basis of oil content and broken corn and foreign matter.

Issues of Vertical Coordination

Agriculture continues to move toward more specialization and greater concentration. Agriculture is an industry that is shifting away from producing commodities to one that is manufacturing goods (Boehlje and Schrader). It is rapidly changing from producing homogenous bulk commodities in a decentralized market to producing more specific products with the end-user in mind.

In the near-perfect competitive commodity market producers generally face, a new technology offers early adopters the chance to temporarily gain excess profits. However, it is not long before others also adopt the technology and the excess profits are eliminated. One way farmers can realize an advantage over others is to extend the time period that they have access to new technology. Contractual arrangements that farmers may enter to take advantage of new products or technologies create these circumstances. Many new biotech crop varieties are only offered to those farmers who enter an agreement with the firm that owns the rights to the technology. These types of contracts are prevalent in the pork industry for many years (Rhodes, Flottman, and Procter), although such requirements that reduce the free decision making opportunity for the producer have hindered many from entering contractual arrangements (Gillespie and Eidman).

Non-market coordination has become fairly common in recent years. The primary reasons behind this movement are to increase efficiency, gain market advantage, reduce uncertainty (risk), and to obtain and/or reduce the cost of financing (Mighell and Jones). Williamson (1979), following work by Coase, named three critical characteristics of transactions where contracting usually occurs: uncertainty is present; the frequency that the transactions recur is high; and permanent investments are required. Although contracts are not necessarily non-market coordination, the same reasons for non-market coordination described by Mighell and Jones can be used to describe these contract arrangements since the types of contract arrangements prevalent in high-oil corn production are considered market coordination that can achieve the same goals as non-market coordination (Schrader). The value of the next best alternative to the contract specific investments is an important aspect to determining the length of the contract desired by the producer.

In the case of special purpose crops, there is a great deal of uncertainty related to the expected value of the crop, yield expectations, and the presence of markets. Producers are unsure what oil content they can expect from the crop, since weather impacts play a significant role in determining this. However, a contract that guarantees a specific premium based on oil content can at least reduce some of the risk regarding the value of the crop. A contract also gives the producer a guaranteed delivery point for their crop, since many elevators may not be equipped to store the specialty crop. Since the producers may have to make special investments in order to produce the crop, a guaranteed market for the crop may be desired. For example, if an investment in additional storage facilities is required to store high-oil corn separately from conventional corn varieties, producers will desire a contract that could guarantee the return of their investment. Investment in additional storage space can be a common cost of producing specialty crops, since the crop must be stored separately from its conventional counterpart. However, the investment is not highly specific since it can easily be used for other purposes on the grain farm should the specialty grain no longer be produced. Nonetheless, the investment is required for the initial production of specialty grain; therefore, it is still a transaction specific cost.

Cooperatives can be used to help producers gain the benefits of risk reduction that contracting offers and also collect profits at additional stages of production. Cooperatives have been an essential part of farm marketing for decades. In 1997, 31 percent of all farm products were marketed through cooperatives, including 87% of the milk and dairy products and 42 percent of grain and soybeans (Kraenzie). According to the Kentucky Directory of Cooperatives, there are not any cooperatives currently marketing value-enhanced corn in Kentucky. However, there are several value-added cooperatives for the production of corn for ethanol.

Marketing high-oil corn through a cooperative can provide several benefits for producers. Yield and price risk can be reduced by growing crops in a more dispersed area to protect from weather impacts, and more stable premiums may be obtained by providing a more consistent and certain supply to buyers of the product. Increased profits may also be realized through economies of size and scale, by purchasing inputs in large volume, and by increasing the farms bargaining position for marketing the grain.

Problem Statement

This thesis consists of the application of expected utility theory to analyze the profitability and risk of high-oil corn. More specifically, under the appropriate assumptions, maximizing expected utility is equivalent to an E-V (expected value-variance) problem; therefore, an E-V model is used in the context of whole farm planning to analyze the profitability of high-oil corn. The model solves for an expected value or mean net returns (E) and a level of variance of net returns (V) associated with that expected value of net returns. Therefore the resulting risk adjusted net returns (or certainty equivalent (CE)) can be used to rank one crop mix over another. This allows for a comparison of crop mixes that takes into account that the risks associated with producing a given combination of crops may be greater than that of another combination with a similar monetary outcome.

E-V Programming

Expected utility (Bernoulli's Principle) theory supplies the theoretical foundation for choice under uncertainty (von Neumann and Morgenstern). The monetary payoff from an investment does not always allow us to rank one investment over another. This occurs because when individuals are risk averse, more information is needed than just the expected monetary value of an investment. Expected utility theory allows for risky alternatives to be ranked based on an individual's preferences for risky consequences or utility function.

An E-V (expected value-variance) mathematical programming model is used in this research to find the optimal enterprise mix of high-oil corn and other crops. E-V programming has proven to be very widely used in optimization problems concerning risk (Boisvert and McCarl). The decision of which mix of crops to produce is essentially a portfolio selection problem, consistent with expected utility theory. As first described by Markowitz, portfolio theory explains the diversification of investments. Further, it explains how risk averse individuals assemble portfolios that minimize the risk they face, given an expected level of returns or maximize returns for a given level of risk. The same is true in production agriculture. Producers seek to optimize the amount of risk they face by getting the best-expected return possible. Markowitz's assumption was that there existed an optimal portfolio that consisted of a maximum expected return for a given level of variance faced by the investor or vice versa.

McCarl outlines the conditions in which maximizing the E-V problem is equivalent to maximizing expected utility as when any of the following conditions are met: (1) the distribution of net returns is normal (Freund); (2) these distributions satisfy Meyer's location and scale restrictions; (3) the underlying utility function is quadratic (Markowitz, Tobin). Meyer's location and scale restrictions require that the choice of alternatives only differ by location and scale. In other words, the distributions of the alternatives differ only by changes in the mean (location) and the spread about the mean (scale) (Sandmo). Although the assumption of normality for returns is unlikely to be completely accurate, it is a reasonable assumption as long as the number of alternatives is not too small and risky prospects are diverse (Anderson, Dillon, Hardaker). Through consistency with expected utility theory, an E-V model can be used to choose one crop mix over another, given an individual's risk preferences.

The E-V mathematical programming model requires some estimate of the risk aversion level. Assuming normality of net returns, one method this parameter can be estimated is by dividing a standardized normal Z-value for a given level of significance times two by the standard deviation of net returns for the risk neutral case (McCarl and Bessler; Babcock, Choi, and Feinerman): $\lambda=2Z/\sigma$. The normality assumption allows for the number of standard deviations in the confidence interval to be equivalent to a Z-value in the standardized normal distribution of net returns. Therefore, risk preferences are quantified by setting a particular limit on the percent of the time that the mean expected level of net returns is anticipated. The likeliness of achieving this expected level of returns will be between 50% and 100% for a rational decision maker, while below 50% would denote risk-loving behavior. However, it is also unlikely that one's risk preference would be to receive the aspired level of net returns 100% of the time, as this would require a significantly large sacrifice of net returns. Likewise being very close to 50% would indicate very little risk aversion. Therefore, the majority of producers will lie somewhere in between these significance levels.

Chapter Initiatives and Expected Results

This thesis consists of a two-article format. The intention is to provide two published articles with the completion of this thesis. At the same time a thesis is produced in compliance with the requirements of the Master's degree, the research is made available through the creation of journal articles.

Chapter 2 will involve an analysis of high-oil corn varieties that are most suited to be grown in Kentucky. This chapter involves a discussion of the relevant literature, objectives, methodology, analysis, and results. The analysis is focused on determining the feasibility of specialty crop production for a typical Kentucky crop producer and includes a discussion of the costs of producing these crops and the risks involved. The overall objective is to quantify and discuss the potential benefits of the adoption of special purpose crops into a whole farm plan. Specifically, an E-V model that maximizes risk adjusted net returns will determine optimal percentage of crop acres to be planted in high oil corn to maximize risk adjusted net returns from contracting the crops. Sensitivity analysis is used to explore how changes in premiums, prices, yields, and farm size affect the optimal crop mix results.

Chapter 3 builds on the analysis of chapter 2. This chapter presents an interactive spreadsheet-based decision aid that incorporates the model from Chapter 2. The spreadsheet is designed to allow producers to easily analyze the feasibility of high-oil corn production on their operation. The spreadsheet integrates the producer's operation specific data into a mathematical programming model that maximizes risk adjusted net returns. The utility maximizing crop mix is determined and the results are organized into a simplified income statement.

This chapter also includes a discussion of the risk implications of high-oil corn and alternative marketing strategies (cooperative versus individual contracting). The relative risks associated with the specialty crops are compared to more common hybrids. An analysis of the risks the producers face under a contracting versus a cooperative arrangement is also included.

The final chapter involves a brief discussion of the previous two and the implications of the results. A discussion of the ramifications for Kentucky farmers is made. A general summary is made of the previous discussions and recommendations are proposed for future research.

Chapter Two
A Farm-Level Analysis of High-Oil Corn Production

Background

With low prices for traditional commodities, special purpose crops offer growers the opportunity to add value to their crop production and earn greater revenue. However, they must weigh these benefits against added costs and risks. Although special purpose crops have the potential to earn higher expected profits, the returns may show greater year-to-year variation than the returns for conventional corn. There may also be higher costs associated with producing the crop; specialty crops may require additional storage, transportation, and acreage for isolation. In addition, the marketing arrangements currently utilized for these crops may result in farmers losing profits to the contractors. With accurate knowledge about the potential net returns and risks of these crops, farmers will be in a position to better assess their net impact on farm profits.

The primary objective of this analysis is to quantify the net profit potential and risk associated with the adoption of special purpose crops at the farm level. Specifically, the adoption of high-oil corn into a typical Kentucky grain farm is analyzed to determine the optimal combination of high-oil corn, conventional corn, and soybeans that will maximize the risk adjusted net returns for a given producer. Sensitivity analysis explores how changes in premiums, prices, yields, costs, and other aspects of production affect the profit and risk profile of special purpose corn. Three levels of risk aversion levels (low, medium, and high), for a given producer, are used for each simulation.

The use of Kentucky production data makes the analysis presented in this thesis unique and valuable to producers in the region. Previously, the closest data previously available geographically was for regions north of Kentucky with cooler climates.

The relatively small volume of special purpose crop production limits the development of commodity markets. Thus, contractual arrangements have become increasingly popular among these varieties. Contracts for the crop are offered for a particular number of bushels to be delivered to a certain location as needed by the purchaser (ConAgra, CG&B, and Purdue Dupont contracts). This allows the grain elevator to plan ahead in order to utilize the storage space as optimally as possible, since the crop must be stored separately from conventional corn.

The expeditious development of contracting has further hindered the development of commodity markets. Since such a large percentage of the crop is produced under contract, the need for a commodity market has been reduced. Likewise, unless the oil content of the crop reaches certain levels specified in the contract, then that portion of the crop will be sold as regular yellow corn on the commodity market.

The contractual arrangements also meet the demands of end-users who desire a very specific product and wish to obtain more control over the type and quantity of crop produced and the production practices utilized. Therefore, additional incentives or specifications are offered to producers by the contractors to use certain management practices, such as particular pesticides, when producing the crop. The contracts also give the contractors the ability to price the premium at a level that allows them to make an assured profit on the added value.

There are additional risks associated with the production of high-oil corn varieties over traditional hybrid corn varieties. Because such a small percentage of the crop is responsible for pollination, and therefore the resulting yields, the impacts from bad weather, insects, and other undesirable production conditions are enhanced. This results in greater variation in yields across years. Impacts from pests that feed on pollen or silk will reduce yields more in the high-oil varieties than in traditional yellow corn varieties since there are less pollinators. These same impacts can also cause greater revenue variability. Weather can also impact the oil composition of the crop, and this will in turn reduce or raise the premium that is received on the crop.

Dupont Specialty Grains recommends certain production practices that are important when using TC Blend seed. These recommendations include the following: (1) planting the seed following a soybean rotation to improve yields and decrease insect and disease pressure; (2) using conventional or minimum tilling practices to avoid cool soil temperatures; (3) increasing planting rates by 2,000 seeds per acre; and (4) although isolation is not required, it is recommended to avoid dilution of oil content at the field edges. Typical recommendations for isolation consist of a barrier of 150-200 feet or excluding the first 30-40 rows of the high-oil corn. In addition, equipment must be cleaned prior to handling high-oil corn, the crop must be stored separately, and low temperature drying is recommended to protect quality.

Data and Methods

This study primarily uses Kentucky farm financial and production data from 255 Kentucky farms collected through the Kentucky Farm Business Management (KFBM) program in 2000 based on the 1999 crop year. Of the 255 participating farms, 177 were determined to be grain farms (their total value of feed fed was less than 40 percent of the crop returns and the value of feed fed to dairy was less than one-sixth of the crop returns). The KFBM program reports farm level financial data as well as the revenue and expenses for various crop and livestock enterprises. The data from those classified as grain farms is used to develop a stylized farm that represents an average Kentucky grain farm. Table 2.1 summarizes the data for the typical farm used in this analysis.

KFBM data were also used in the development of an enterprise budget for conventional corn (Powers, Isaacs, and Trimble). The enterprise budget for conventional corn was modified to include the additional costs associated with producing high-oil corn. A comparison of the two enterprise budgets created an estimate of returns above variable costs for high-oil corn.

High-oil corn yield data was derived from the 1998, 1999, and 2000 Kentucky Hybrid Corn Performance Tests of special purpose corn varieties in Kentucky (Pierce and Poneleit). Traditional corn hybrids were planted in the same locations from 1986 to 2000 (Poneleit and Evans; Pierce and Poneleit). High-oil corn data is available for 16 different TC High-Oil Blend® hybrids planted in 2 locations in 1998 and for 13 different hybrids in 3 locations in 1999 and 2000. The data includes 6 different hybrids that were planted in the same two locations across three years. Reported crop characteristics were yield, moisture percentage, percentage lodged, and the protein, oil, and starch content. Since the trial crop data includes spatially different locations, it provides some information to examine the impacts of weather on variability in crop chemical composition and yields.

Data was also available from the Kentucky Agricultural Statistics Service, but these data consist of averages reported by various producers for each county in Kentucky. The Kentucky Corn Performance Test data are preferred because the varieties were produced under the same management practices and same locations across years, which more closely resembles the experience an individual producer may face.

Given the limited time-series of high-oil corn yield data, a more comprehensive yield risk profile for the TC High-Oil corn varieties was simulated using traditional corn hybrid data. This was accomplished by detrending the existing traditional corn data and creating mean and standard deviation statistics for the detrended series. The high-oil corn data was expanded based on the relationships between the three-year series of the high-oil corn and the same three-year series of conventional corn. This method is further justified by the high degree of correlation between high-oil corn and conventional corn for the three-year series of 0.998 (Table 2.2). The mean was calculated for the three years of high-oil corn yield data and a ratio was calculated to find the relationship between this mean and the three-year mean for conventional corn that was produced in the same locations. This ratio was then used to create a fifteen-year mean for high-oil corn based on the fifteen-year mean for conventional corn in the same locations. The same procedure was used to provide a fifteen-year variation.

Yield data for soybean yields were gathered from the Kentucky Soybean Performance Tests (Lacefield, Tutt, and Pfeiffer) and represent conventional varieties planted in the same locations as the corn. Summary statistics for the crop yield data are presented in Table 2.3. Conventional corn has the higher yield of the corn varieties. The coefficients of variation (CVs) for conventional corn and high-oil corn are not much different for these data. The CV for high-oil corn yield is the highest at 20%, followed by corn at 19%, and soybeans at 16%. It is important to note that these CVs are perhaps lower than CVs that may be typically observed from farm data. Harwood et al show that CVs for county level data for corn have ranged from 20%-24% for the area close to Henderson and 30%-40% for areas close to Lexington. Farm-level data should have even more volatility since the county level data is aggregated across many individual farms. Therefore, consideration should be given to yield risk, given that farm level variation may differ from county level variation (this is later addressed through sensitivity analysis).

The conventional corn price for the model was derived from the December futures contract price on the Chicago Board of Trade (CBOT) when 2000 planting decisions were being made, minus the basis for Kentucky ($0.20). The soybean price data is the 2000 Loan Deficiency Payment (LDP) for soybeans. Since the futures price of soybeans was far short of the LDP when planting decisions were being made, the LDP of $5.40 is used as the only reasonable expected price. The high-oil corn premium is based on recent contract prices (Dupont Specialty Grains 2000) and the average oil content of the high-oil varieties in the 1998, 1999, and 2000 Kentucky Corn Performance Tests (7.7%). A premium of $0.30 was reported for 8% oil content for buyer's call contracts and $0.25 for harvest delivery (ISFP) and the premium decreases $0.01 for each 0.1% decrease in oil content (Table 2.7). Therefore, a premium of exactly $0.27 per bushel would be expected for an oil content level of 7.7% for buyer's call and $0.22 for harvest delivery. However, a value of $0.25 is used for the base case, while sensitivity analysis will examine higher and lower premiums in a later section. A summary of this price data is reported Table 2.3.

Volatility levels of 18% and 16% were reported by Harwood et al as a measure of corn and soybean price risk. These are based on average yearly prices from 1987-1996 and are calculated by computing the standard deviation of the logs of the ratios of each year's price to the previous year. Implied volatility measurements reported by the Chicago Board of Trade for corn futures contracts during the planning period (February 1st through March 31st) in 2000 averaged 22.9% for corn and 23.3% for soybeans.

Skees has also suggested price volatility levels of 22% for corn and 20% for soybeans may be more appropriate levels. Therefore, coefficients of variation of 22% and 20% are used as a measure of corn and soybean price risk, respectively.

While these coefficients of variation levels may be debatable, the sensitivity analysis that is included in this study allows for some small error in the estimation of price volatility. Using historical price information to estimate price volatility would be misleading due to several reasons. First, price volatility increases at planting time when the producer is making planting decisions. Therefore, using mean prices could cause problems since some of the variation could be eliminated. Second, the impact of farm programs that existed in the past tended to lower price volatility from what it may be today. Finally, using farm level historical prices might reflect more chance and when and how the crop was marketed rather than the true price risk.

A variance-covariance matrix of net returns for the three crops is shown in Table 2.4. The variance was calculated under the assumption of independence between prices and yields and a normal distribution of yields and prices (Anderson, Dillon, and Hardaker). The variance formula is simply a portfolio variance formula (equation 1) where the portfolio weights are the number of total acres of each crop produced.

(1)

$$\sum_{i=1}^{n} T_i^2 m_i + \sum_{i=1}^{n} \sum_{j=1}^{n} T_i T_j \rho_{ij} \sqrt{m_i} \sqrt{m_j}$$

where:

$m = E(P_i)^2 * V(Y_i) + E(Y_i)^2 * V(P_i) + V(P_i) * V(Y_i)$ (Anderson, Dillon, and Hardaker 6.3)

$j \neq i$

T_i= total acres of the i^{th} enterprise grown

E= expectation

V=variance

P=price

Y=yield

ρ_{ij}= the yield correlation between the i^{th} and j^{th} enterprises

Assuming independence of prices and yields is probably appropriate because even though an increase in the average yield for *all* corn producers may cause price to decrease, the yields that an individual producer receives on their operation do not affect the prices that he/she will receive. This assumption is probably more realistic in Western Kentucky than Central Illinois because Kentucky weather is different than the rest of the Corn Belt. However, this method of calculating the variance does have important implications that should be discussed. Assuming independence of prices and yields ignores the covariance portion of variance associated with price and yield. Since the price and yield for a particular crop would be expected to be negatively correlated, this assumption of yield and price independence also results in a slightly higher estimation of variance than in the case where prices and yields are not assumed to be independent.

Assuming normality of prices and yields is reasonable since the outcome is net revenue. The effect of skewness is not a substantial concern when dealing with net revenue because of the likely distributions of price and yield. Prices tend to be more skewed to the right due to LDP payments allowing for more upside potential than downside in the distribution. However, yields tend to be skewed to the left or have more downside risk. If a producer faces an expected yield of 145 bushels per acre, there is much greater probability of a natural disaster or poor weather causing 50 bushels per acre yields than the producer getting yields in excess of 200 bushels per acre. Therefore, the individual distributions of yields and prices should net a distribution somewhat close to a normal distribution. One problem that may arise with assuming a normal distribution of prices and yields is the case where yield variance is much greater than price variance. In this case there would be more downside risk unaccounted for.

<u>The Model</u>

An E-V mathematical programming model was used to determine the optimal enterprise ratio for high-oil corn, soybeans, and conventional corn for a typical Kentucky grain farm, as described above. Typically, those with adverse attitudes towards risk diversify their investments. The same is true in production agriculture.

Freund developed an E-V programming model that consisted of a risk aversion parameter that was chosen for a producer, on the basis of the size of the operation and the producer's preference between net returns and risk that was constant without dependency upon changes in the parameters. This allows for a measure of the preference toward risk that is suitable for the producer and will be relevant for various parameter values (McCarl).

McCarl outlines the conditions in which maximizing the E-V problem is equivalent to maximizing expected utility. These assumptions are when the distribution of net returns is normal (Freund), these distributions satisfy Meyer's location and scale restrictions, or the underlying utility function is quadratic (Markowitz, Tobin). Only one of the three conditions must hold for the problems to be equivalent. Although the assumption of normality for returns is unlikely to be completely accurate, it is a reasonable assumption as long as the number of alternatives is not too small and risky prospects are diverse (Anderson, Dillon, Hardaker).

Consider the general example that is adapted from Anderson, Dillon, and Hardaker that is presented in Figure 2.1. The curve represents the utility function of an individual that faces a 60 percent probability of gaining $2000 and a 40 percent probability of losing $3400. The concavity of the utility function demonstrates risk aversion. Based on the probabilities, the expected monetary value (EMV) of this situation is a loss of $160 (0.60 x $2,000 + 0.40 x -$3,400 = -$160), with an expected utility function of the form (0.40 x *U*(-$3400) + 0.60 x *U*($2000)). This utility corresponds to point B on the straight line AB. Point B corresponds to utility from getting -$1030 for certain. Therefore, since the individual is risk averse, the expected utility from the risky event (EMV=-$160) is equivalent to the utility of the certainty equivalent (-$1030 for certain). The difference between the certainty equivalent and the expected monetary value of the situation is the individual's risk premium. Therefore it can be said that this individual is "willing to pay" $830 to guarantee a loss of $1030 and give up the possibility of higher returns and totally avoid the possibility of greater loss. This type of application of expected utility theory allows for the ranking of alternatives and the quantification of a producer's risk preference.

The model, for this thesis, is specified as follows:

(2)

$$\text{Max} \quad \sum_i \overline{R}_i T_i - \lambda \sum_{i=1}^{n} T_i^2 m_i + \sum_{i=1}^{n} \sum_{j=1}^{n} T_i T_j \rho_{ij} \sqrt{m_i} \sqrt{m_j}\,,$$

$$\text{where: } m = E(P_i)^2 * V(Y_i) + E(Y_i)^2 * V(P_i) + V(P_i) * V(Y_i)$$
$$\text{and } i \neq j$$

subject to:

1) $\sum_i T_i \leq \text{ACREAVL}$
2) $T_i \geq 0$
3) $0.4(\text{ACREAVL}) \leq T_3 \leq 0.6(\text{ACREAVL})$

where:

i & j = 1, 2, and 3, where 1= conventional corn, 2=high-oil corn, and 3 = soybeans; $\overline{R}$ signifies mean net returns

R_i = net returns above variable costs per acre for the i^{th} enterprise;

T_i = total acres of the i^{th} enterprise grown; e.g. T_3 represents total acres allocated to soybeans

λ = the risk aversion parameter

ρ_{ij} = the yield correlation between the i^{th} and i^{th} enterprises

ACREAVL = total tillable acres available

E = expectation

V = variance

P = price

Y = yield

The acreage constraint (3) on soybeans was required due to the seed companies' recommendation that high-oil corn should be used in a crop rotation with soybeans. Further, this is standard agronomic practice and a realistic constraint. This constraint requires the producer to raise approximately half of his/her acres in soybeans thus ensuring that high-oil corn can be successfully grown in future periods. Also, typical rotations are near 50/50 due to the yield advantages of utilizing a crop rotation. Kentucky farmers are shown to use this type of rotation. Farm data (KFBM) for 57 Kentucky farms, and for three years, show that an average rotation of 53% soybeans and 47% corn is used (standard deviation 8.7). If they rotated significantly more or less they would be continuously cropping the same crop on some acres. The specification of a value between 40% and 60% allows for some variation in soybean acres, but also some continuous cropping.

The risk aversion parameter was chosen using the method described by McCarl and Bessler under the assumption of normality of net returns. Babcock, Choi, and Feinerman describe this method as testing to ensure that the risk aversion level is "reasonable" for the associated gamble size. The risk aversion parameter divided by two and multiplied by the standard deviation of net returns should always result in a value between .01 and .99, which is the same as the appropriate Z-value for the distribution. The assumption of normal distribution of net returns allows for the number of standard deviations in the confidence interval to be equivalent to a Z-value in the standardized normal distribution of net returns. McCarl and Bessler derive the following formula for calculating the risk aversion parameter:

(3) $\lambda = 2Z_{\alpha}/\sigma_{Y}$

where:

λ = risk aversion parameter, Z_{α} = standardized normal Z-value for a given level of significance α, and σ_{Y} = the standard deviation of the risky prospect, which is net returns in this study.

The significance level that represents the Z-value represents the percentage of the time that a producer would expect to receive the mean expected value of returns. For example, when α=50, the producer would be indifferent to the risk (risk neutral).

Half the time he/she would receive the mean expected value of returns or better and half the time would receive the mean expected value of returns or less. Three levels of risk aversion were chosen to represent low-risk aversion, medium-risk aversion, and high risk aversion. The low risk averse producer is defined as one who requires the mean expected value of returns no less than 55% of the time, while the medium and high risk averse producers are those who require a return to be 65% and 75% of the time, respectively. The low value was chosen at 55% based on the assumption that producers are at least somewhat risk averse. The high level of 75% was used because there was no change in the crop mix selection worthy of noting for risk aversion levels greater than that level.

The standard deviation that was used is that associated with the profit maximizing solution for the risk neutral case (Z=0). Risk aversion parameters (RAP) represent those particular levels resulting from looking up Z-values for the particular level of significance and applying them to the equation above. The risk aversion parameters (λ) that were calculated based on the standard deviation calculated for the Z=0 case are presented in Table 2.5.

The product of a RAP and the total variance of a crop mix is the risk premium that was discussed earlier. The risk premium represents the product of the total variance of the crop mix and the appropriate risk parameter. The total variance for the low risk aversion case (riskiest outcome) is the highest in most cases. However, since the risk aversion parameter is smaller, in many cases, the risk premium will be a smaller value than that for the medium and high-risk aversion selections. This is better understood by thinking of the risk premium as a valuation of the risk associated with the particular crop mix by the producer with that preference toward risk. Therefore, the low risk averse producer will not tend to value a given level of variance as much as a high risk averse producer. The more risk the person is willing to take on, the more he/she will discount the variance. Simply stated, the risk premium represents the amount the producer with that risk preference would be willing to pay to receive the risk adjusted net income, which is risk free. Therefore the producer is indifferent between expecting the unadjusted net income with the risk associated with it and paying the risk premium to get the risk adjusted net income.

Sensitivity analysis is conducted by changing several variables that could possibly affect the results: changes in the high-oil premium, high-oil corn yields, and the soybean price. Sensitivity analysis is essential due to shortfalls in the data. Sensitivity analysis helps address concerns due to the limited high-oil corn data and the environment that the crop was produced under. The simulations regarding the high-oil corn yields and premium prices are important to examine because the data shows lower volatility in the high-oil and conventional corn yields than has been reported in the literature for similar areas (Harwood et al). There is also substantial uncertainty regarding what the oil content of a crop may be in any given year, thus affecting premium prices. The simulation with changes in the soybean price is notable because of the substantially lower variation in net returns for soybeans than for corn. Small increases in the soybean price should provide the ability for producers to enhace their risk adjusted net returns.

Results of Model Application

The model was calculated under the three different levels of risk aversion. The results from the first model calculation (the base case), using the data presented in Table 2.2, are summarized in Table 2.6. The results show a combination of high-oil corn and soybeans at the low risk aversion level. At this level of risk aversion, a producer is willing to accept more variance in net returns in exchange for higher net returns. No high-oil corn is produced for risk aversion levels above the medium preference level. The percent of acres in soybeans is the minimum allowed under the rotation constraint for the low risk averse case and is the maximum allowed for the medium and high risk averse cases. If the constraint were relaxed, the low risk averse producer would likely grow less soybean acres while the more risk averse producers would likely produce more. The soybean constraint requires the low risk averse producer to produce at least 40% or the crop mix in soybeans, which are of low variance in net returns. Therefore, the additional 60% of the total acres are optimized in a way that is consistent with this producers risk preferences, which consists of planting the remaining acres in high-oil corn, which allow the producer higher expected returns. The high risk averse producer does not produce any high-oil corn because of the more weight that is placed on the variance due to a larger risk aversion parameter, which reflects the greater preference of this producer to avoid risk through the tradeoff with net returns.

Sensitivity Analysis

Simulation One: Impacts of High-Oil Corn Premiums

The premium for most high-oil corn production is set by a contractual-arrangement and is partially determined by oil content. Furthermore, an accurate prediction of the oil content for a given year is impossible to accurately predict, therefore sensitivity analysis on this variable is warranted. The oil content can vary due to weather impacts and the performance of different varieties. Thus, six other premium levels for high-oil corn were used in the model besides the base case of $0.25/bu to examine the impact of higher and lower premium levels due to variance in oil content levels. Higher premium levels also increase price variance since the standard deviation of the high-oil price is the mean price (expected price) times the coefficient of variation. The lower (higher) premium levels directly lower (raise) the effective high-oil corn price. Thus, if the coefficient of variation is held constant, a higher price requires the standard deviation to increase (CV = standard deviation/mean price).

At the given levels of risk aversion, it takes a minimum premium of $0.24 before any high-oil corn is produced (Table 2.8). At this level, the low risk averse producer raises as much high-oil corn as possible, the medium risk averse producer grows 25% of his/her acres in high-oil corn along with a mix of conventional corn and soybeans. The high risk averse producer plants high-oil corn when the premium reaches $0.26.

Simulation Two: Impacts of Changes in Soybean Prices

The price of soybeans was another important variable in this simulation. The coefficient of variation of net returns for soybeans (64%) is much lower than that of either hybrid corn (76%) or high-oil corn (77%). The low expected price of soybeans resulted in the minimum amount of acreage allocated to soybeans (0.4*ACREAVL or 40%) in the base case (Table 2.8). There is, however, no guarantee that the LDP payment for soybeans will be higher than the market price in future years. Simulation two allows for soybean prices to vary around the base case. The results are presented in Table 2.8. The "base case" situation is the value with a box around it ($5.40).

Raising the price of soybeans above the base case does not affect the percent of acreage allocated to soybeans by the low risk averse producer until the price reaches $6.00. The medium risk averse producer changes from 60% conventional corn and 40% soybeans to the reverse at a soybean price of $5.50. At soybean prices greater than $5.75, soybean acres are maximized at all risk aversion levels (0.6*ACREAVL or 60%). This reflects some fairly substantial sensitivity of the model results to soybean prices.

Varying the soybean price has implications on the amount of acreage devoted to high-oil corn production. For soybean prices less than $5.25 there is a substitution effect away from regular hybrid corn to high-oil corn for the high risk averse producer who is still producing high-oil corn, even though the amount of soybeans produced remains constant. This is due to the variance of net income decreasing with lower soybean prices and the producer is able to take on more risk and substitute more acres into high-oil production. When the price of soybeans rises enough for soybeans to be added into the crop mix, there is a substitution away from high-oil corn to increased production of regular hybrid corn.

Simulation Three: Tests of High-Oil Corn Yielding Ability

The simulation results for examining various yields for high-oil corn are presented in Table 2.10. High-oil corn was not planted at any of the risk aversion levels when yields were less than 138 bushels per acre. This shows extraordinary sensitivity and signifies the importance of yield expectations. The low-risk aversion producer plants the maximum amount of high-oil corn possible for all yields above 138 bushels per acre. At 139 bushels per acre, the medium-risk averse producer adds high-oil varieties into production, with the high-risk averse producer joining at 140 bushels per acre. For a yield of 146 bushels per acre, the medium risk averse producer begins to increase high-oil corn acres. This is a substitution away from soybeans to high oil corn due to the additional profit that comes with increasing high-oil acres. Eventually, at 152 bushels per acre yields, the medium risk averse producer joins the low risk averse producer in maximizing high-oil corn acres, when the added net returns more than compensates for the increased variance that must be taken on to reach these higher returns. It takes an expected yield of 188 bushels per acre for high-oil corn to get the high risk averse producer to maximize the amount of high-oil corn acres that can be planted under the rotation constraint.

Summary and Conclusions

Specialty crops continue to become increasingly popular with producers. However, novelty crops come with uncertainty and require the producer to take on additional risks which may or may not be rewarded with additional farm profits. With low prices for traditional commodities, special purpose crops offer growers the opportunity to add value to their crop production and earn greater returns. However, the risks associated with these crops can be substantial, and without accurate information regarding these risks, producers can find these crops financially devastating in some years.

The results of this study provide a reasonable estimate of the value of special purpose crop production at the farm level for a typical crop producer in Kentucky. For this data, it appears that the optimal adoption of high-oil corn is very marginal, dependent upon the producers' willingness to accept risk, and sensitive to other variables such as the premium levels, yield drag of high-oil corn, and other competing crop yields and prices. Only producers willing to take on some risk will grow high-oil corn. The analysis of varying premium levels shows that contracts that offer more protection for producers against price risk may increase the amount of high-oil corn acres produced in Kentucky. However, it is also important to consider the possible impacts of a yield drag in the high-oil corn varieties, and the possibility of increased susceptibility to depressed yields and oil content due to weather, insects, and other conditions.

Simulation 1 compared how various premium levels for high-oil corn affected the adoption of the crop. The results show that a premium of $0.24 is required to induce the low-risk averse and medium-risk averse producers to include high-oil corn production in the crop mix. A premium of $0.26 per bushel was necessary before the high risk averse producer grows any high-oil corn acres. These premiums are fairly substantial and in many cases unobtainable, when compared to the recent premiums offered to producers in 2000. In 2000, Illinois Specialty Farm Products (ISFP) reported premiums in the range of $0.25 to $0.05 per bushel for harvest delivery contracts, and $0.30 to $0.10 for buyer's call (Table 2.7). If the crop failed to reach the minimum oil content level, it would be priced as regular #2 yellow corn. While these represent a large majority of the pricing opportunities available to producers of high-oil corn, there were a few contracts that varied from these price premium levels.

Simulation 2 replicates changes in the price of soybeans, which is a crop with substantially lower variance of net returns compared to the other crops. Production of soybeans was required to remain between 40% and 60% of the total tillable acres. Changes in the soybean price had substantial impacts on the amount of high-oil corn acres planted. This was especially true for the high risk averse producer. As the price of soybeans fell, more acres of high-oil corn were planted. For prices above $5.50, all of the producers were likely restricted by the rotation constraint from growing more than 60% of their acres in soybeans.

Simulation 3 addressed questions concerning the ability of high-oil corn to yield as well as conventional corn. High-Oil corn was not introduced into production for any of the risk aversion levels when yields remained below 138 bushels per acre. The available acres for corn production were completely utilized for high-oil corn production for yields above 152 bushels per acre for the low and medium risk averse producers and at 188 bushels per acre for the high risk averse producer.

Although the numerical results are specific to Kentucky, the general trends and implications should apply to other regions. The results should also be useful for producers growing or interested in growing other special purpose crops. The model can be easily modified to examine other special purpose crops such as soybeans and wheat.

Table 2.1. Summary Statistics for a Typical Kentucky Grain Farm for 1999

Percent of Grain Fed		0.9%
Total Acres		
	Acres tillable	1332
	Acres owned	291
	Acres crop shared	431
	Acres cash rented	265
Labor		
	Unpaid months	12.0
	Paid months	16.0
Revenue		
	Crop revenue	$249,354
	Livestock revenue	$6,563
	Government payments	$70,869
	Other farm payments	$23,844
	GROSS REVENUE	$350,630
(-)	Feed & livestock purchases	$3,437
	VALUE OF FARM PRODUCTION	$353,364
Expenses		
	Cash operating expenses	$265,351
	Depreciation	$34,823
	Change in Acct. pay/Prepaid exp.	($510)
	TOTAL OPERATING EXPENSES	$300,726
	TOTAL INTEREST EXPENSE	$26,970
Net Farm Income from Operations		$36,421
Net Farm Income		$38,226
Interest on equity capital		$40,806
Unpaid family labor		$0
Operator(s) labor and mgmt. Income		($454)
Unpaid operator labor		$24,000
Management returns		($29,536)
Production ($) per $1 non-feed cost		$0.91
Farm production ($) per person year		$152,407

Table 2.2. Correlation Matrix of Yields

	Conv. Corn	High Oil Corn	Soybeans
Conv. Corn	1		
High Oil Corn	.998	1	
Soybeans	.747	.786	1

Table 2.3. Summary Crop Yield and Price Data

	Mean Yield (bu.)	Yield CV (%)	Mean Price ($/bu.)	Price Variance ($/bu.)	Average Net Return ($/bu.)
Conv. Corn	147	19	2.40	0.28	139.62
High Oil Corn	139	20	2.65	0.63	142.41
Soybeans	48	16	5.40	1.08	103.66

Table 2.4. Variance-Covariance Matrix of Net Returns

	Conv. Corn	High Oil Corn	Soybeans
Conv.l Corn	11,517		
High Oil Corn	11,423	11,376	
Soybeans	5,371	5,594	4452

Table 2.5. Risk Aversion Parameters for Various Risk Preferences

Significance Level (α)	Z-value	Risk Aversion Parameter (RAP)
50	0	0
55 (low)	0.126	0.0000022
60	0.253	0.0000044
65 (medium)	0.385	0.0000067
70	0.524	0.0000091
75 (high)	0.675	0.0000118
80	0.842	0.0000147
85	1.037	0.0000181
90	1.282	0.0000223
95	1.645	0.0000286

Table 2.6. Base Case Results

Risk Aversion	RAP	Crop	Acres Planted
Low	(0.000022)		
		Conv. Corn	0 %
		High Oil Corn	60 %
		Soybeans	40 %
Medium	(0.000067)		
		Conv. Corn	0 %
		High Oil Corn	40 %
		Soybeans	60 %
High	(0.000118)		
		Conv. Corn	40 %
		High Oil Corn	0 %
		Soybeans	60 %

Table 2.7. 2000 High-Oil Corn Premiums Based on Illinois Study

Oil Content	Harvest Delivery	Buyer's Call
8.0%	$0.25	$0.30
7.9%	$0.24	$0.29
7.8%	$0.23	$0.28
7.7%	$0.22	$0.27
*		
6.0%	$0.05	$0.10

* Premium decreases $0.01 for each 0.1% decrease in oil content

Table 2.8. Changes in the Premium Levels

		Acreage		
Premium	**Risk Pref**	**Hybrid Corn**	**High Oil Corn**	**Soybeans**
$0.22				
	Low	60 %	0	40 %
	Medium	40 %	0	60 %
	High	40 %	0	60 %
$0.24				
	Low	0 %	60 %	40 %
	Medium	15 %	25 %	60 %
	High	40 %	0	60 %
$0.25				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0	60 %
$0.26				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	23 %	17 %	60 %
$0.28				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %
$0.30				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %
$0.32				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %

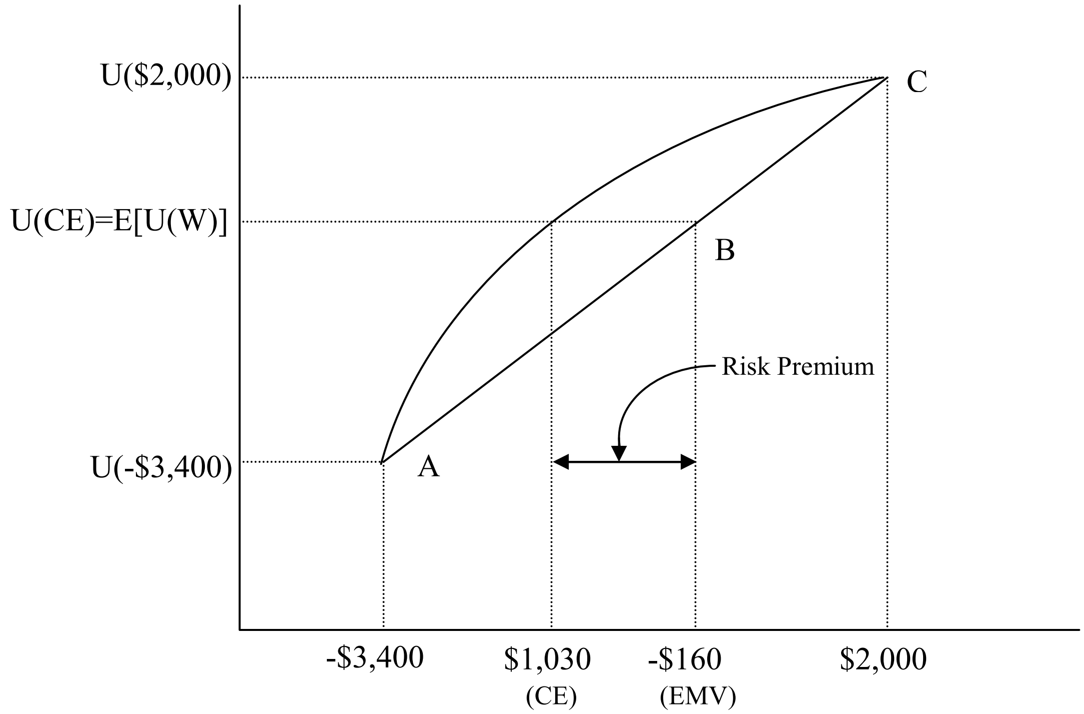
Table 2.9. Acreage Response to Changes in Soybean Prices

		Acreage		
Soybean Price	**Risk Pref**	**Hybrid Corn**	**High Oil Corn**	**Soybeans**
$4.75				
	Low	0 %	60 %	40 %
	Medium	0 %	47 %	53 %
	High	27 %	13 %	60 %
$5.00				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	38 %	2 %	60 %
$5.25				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0 %	60 %
$5.40				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0 %	60 %
$5.50				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0	60 %
$5.75				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0	60 %
$6.00				
	Low	0 %	40 %	60 %
	Medium	0 %	40 %	60 %
	High	40 %	0 %	60 %

Table 2.10. Acreage Response to Changes in High-Oil Corn Yield

High Oil Yield	Risk Pref	Acreage		
		Hybrid Corn	High Oil Corn	Soybeans
137				
	Low	60 %	0 %	40 %
	Medium	40 %	0 %	60 %
	High	40 %	0 %	60 %
138				
	Low	11 %	49 %	40 %
	Medium	40 %	0 %	60 %
	High	40 %	0 %	60 %
139				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	40 %	0 %	60 %
140				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %
142				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %
144				
	Low	0 %	60 %	40 %
	Medium	0 %	40 %	60 %
	High	0 %	40 %	60 %
146				
	Low	0 %	60 %	40 %
	Medium	0 %	41 %	59 %
	High	0 %	40 %	60 %
148				
	Low	0 %	60 %	40 %
	Medium	0 %	46 %	54 %
	High	0 %	40 %	60 %
150				
	Low	0 %	60 %	40 %
	Medium	0 %	51 %	49 %
	High	0 %	40 %	60 %

Figure 2.1. Risk Premium Example



References

Anderson, J.R., J.L. Dillon, and B. Hardaker. *Agricultural Decision Analysis.* Iowa State University Press: Ames, IA, 1977.

Babcock, B., E. Choi, and E. Feinerman. "Risk and Probability Premiums for CARA Utility Functions." *Journal of Agricultural and Resource Economics* 18(1): 17-24.

Bender, K., L. Hill, B. Wenzel, R. Hornbaker. "Alternative Market Channels for Specialty Corn and Soybeans." Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, AE-726, February, 1999.

Boehlje, M., and L.F. Schrader. "Agriculture in the 21st Century." *Journal of Production Agriculture* 9(1996): 333-341.

Dillon, C.R. "Production Practice Alternatives for Income and Suitable Field Day Risk Management." Journal of Agricultural and Applied Economics 31(August 1999): 247-261.

Harwood, J., J. Perry, R. Heifner, A. Somqaru, K. Coble. *Managing Risk in Farming: Concepts, Research, and Analysis* USDA, Economic Research Service, Report 774(March 1999).

Illinois Specialty Farm Products Web Site. http://web.aces.uiuc.edu/value/

Jensen, M., and W. Meckling. "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure." *Journal of Finance and Economics* 3(1976): 305-360.

Lajili, K., P.J. Barry, S.T. Sonka, and J.T. Mahoney. "Farmers' Preferences for Crop Contracts." *Journal of Agricultural and Resource Economics* 22(December 1997): 264-280.

Lin, W.W., W. Chambers, and J. Harwood. "Biotechnology: U.S. Grain Handlers Look Ahead." *Agricultural Outlook* 270(April 2000): 29-34.

Markowitz, H. "Portfolio Selection." *Journal of Finance* 12(1952): 77-91.

McCarl, B.A. and D.A. Bessler. "Estimating an Upper Bound on the Pratt Risk Aversion Coefficient When the Utility Function is Unknown." *Australian Journal of Agricultural Economics* 33(April 1989): 56-63.

Meyer, J. "Two-Moment Decision Models and Expected Utility Maximization." *The American Economic Review* 77(June 1987): 421-430.

Mighell, R.L., and L.A. Jones. "Vertical Coordination in Agriculture." Washington DC: USDA, Economic Research Service. AER 19(February1963).

Riley, P.A., L. Hoffman, and M. Ash. "U.S. Farmers Are Rapidly Adopting Biotech Crops." *Agricultural Outlook* 253(August 1998): 21-23.

Saxowsky, D.M., and M.R. Duncan. "Understanding Agriculture's Transition into The 21st Century: Challenges, Opportunities, Consequences and Alternatives." Agricultural Economics Report No. 181, Dept. of Agricultural Economics, North Dakota State University, March 1998.

Thomison, P.R. "Topcross High Oil Corn Production: Management Considerations". Ohio State University Fact Sheet AGF-135: 1997.

Woodworth, C. "GMOs: A Growing Concern." *Health Products Business* 45(October 1999): 34-40.

Chapter Three
Interactive Specialty Corn Analysis Tool

Introduction

The Interactive Specialty Corn Analysis Tool (ISCAT) is an Excel spreadsheet that is designed as a decision aid for grain producers considering the addition of high oil corn into their crop mix. This spreadsheet incorporates the individual producer's historical yield and other farm-level data into a mathematical programming model that maximizes a producer's expected utility. The model from Chapter 2 is applied to determine the optimal crop mix and produce a simplified income statement for low, medium, and high risk aversion levels. However, the model is more general here because more crops are included and the user has more freedom on specific acreage constraints. ISCAT also allows for a comparison of high-oil corn production under either a contract or cooperative marketing arrangement.

ISCAT uses an interactive approach to implementing the mathematical programming model that requires no knowledge of spreadsheets or math programming by the user. The use of a series of pop-up dialog boxes and concealed computations simplify the process of gathering information from the user and running the model.

Methodology

The optimal crop mix can consist of any combination of corn, soybeans, double-crop soybeans, wheat, and high-oil corn. The only restrictions imposed by the model are that any enterprise acreage be greater than zero and that the total number of acres produced be less than the total number of tillable acres available. The user can set acreage constraints that determine a certain minimum or maximum acreage for any of the crops. This allows the user to define a certain amount of acreage for specific enterprises while allowing the model to find the optimal allocation of the remaining acres subject to the risk preferences of the user. This is important when dealing with high-oil corn since it is recommended that the crop be produced in a crop rotation with soybeans (Dupont Specialty Grains). The spreadsheet allows the user to specify his/her own restrictions when dealing with this issue since the spreadsheet only deals with the current crop year. Therefore, the user can specify a certain number of acres of a particular crop (such as soybeans) that should be produced based on the previous year's crop mix. Furthermore, he/she is most familiar with their land characteristics and the rotations that have been used in the past to obtain optimal yields and allowing the user to specify the acreage results in more accurate results.

The spreadsheet sequentially solves the model for three different levels of risk aversion, (those described in Chapter 2), to allow the user to examine the impact of risk on the crop mix selection. The spreadsheet first solves a model with a risk parameter of zero (λ=Z=0) to find the appropriate variance to use in calculating the set of risk parameters that are appropriate for the individual producer's profile. Once the risk parameters are solved for a low, medium, and high-risk aversion level, the model is solved three more times using these parameters. The low risk averse level represents one who requires the mean expected value of net returns no less than 55% or the time, based on the assumption that producers are at least somewhat risk averse. To require the mean expected value of net returns no less than 65% of the time would mean that the producer also expects less than the mean expected value half the time, and is totally indifferent to risk, which is unrealistic. The medium and high risk aversion levels require the mean expected value of net returns 65% and 75% of the time, respectively.

Other than giving the user more freedom in defining constraints, the model in this chapter shares the same basic assumptions as were stated in the previous chapter. The calculation of variance assumes independence of prices and yields as well as a normal distribution for the two. Additionally, the same price volatilities are used in the model in this chapter to avoid the underestimation of price risk

Reliability of the results will depend upon the accuracy to which enterprise budgets for each of the crops are updated to reflect the individual user's operation. In other words, the results will only be as good as the data. The budgets determine the potential net returns for each of the crops that are used in the model. These budgets are included for each of the crops mentioned, with two enterprise budgets for high-oil corn, one being under a non-cooperative arrangement and one for a cooperative arrangement.

ISCAT Instructions

ISCAT contains enterprise budgets, a key variables page for specifying high-oil corn production and marketing characteristics under an independent contract and a cooperative arrangement, a series of pop-up dialog boxes for gathering information from the user, and an output page for summarizing results.

Enterprise Budgets

Enterprise budgets for conventional corn, soybeans, double-crop soybeans, wheat, and high-oil corn for both an individual contracting and cooperative marketing arrangement are included. Wheat is included as a complementary crop to double-crop soybeans; therefore wheat acres will be the same as double-crop soybean acres. The default values for these budgets are based on data obtained from the Kentucky Farm Business Management (KFBM) Program. Each of these budgets is amendable to more accurately fit the user's operation. Once the budgets have been updated, the "Key Variables" page should be visited to examine the potential differences between producing high-oil corn without a cooperative versus producing the specialty crop as a cooperative.

Key Variables Page

The "Key Variables" page (Figure 3.1) consists of three parts: (1) "Information About Specialty Corn"; (2) "Specialty Corn Without a Cooperative"; and (3) "Specialty Corn With a Cooperative". Values have been entered for nearly all of the fields on this page, but they should be updated to reflect the user's own expectations. For example, the equipment preparation cost will vary across producers. The producer should estimate his/her own equipment preparation cost, as accurately as possible, and update this field accordingly.

The "Information about Specialty Corn" section contains the basic aspects of high-oil corn that differs from conventional corn under both a non-cooperative and a cooperative arrangement. These include the seed premium, increased planting rate, extra insecticide, equipment preparation, isolation, and yield disadvantage. These values may be changed or left blank depending on the cost of the item.

Seed costs of high-oil corn are typically higher than conventional corn. According to Illinois Specialty Farm Products (ISFP) the differences have been close to $25 per bag. An increased planting rate is also necessary to help correct for loss in yield due to the 10% of the seed that consists of the special pollinator plants. The primary purpose of these pollinator plants or "TC Blend Pollinators" is to produce pollen for the grain parent or the "TC Blend Grain Parent" and they contribute very little to the grain yield (DSG). This section also allows the user to account for other production factors including any extra insecticide that may be needed, cost of cleaning and preparing equipment, and costs to isolate the crop from conventional corn that are very dependent on the structure of the producers' operation. For example, the type of equipment and method of cleaning available and the layout of the fields are important considerations to determining these costs.

The section titled "Specialty Corn Without a Cooperative" outlines the advantages and disadvantages of producing specialty corn versus conventional corn under an independent contract setting. This section allows for the user to put in the estimated premium for high-oil corn, any extra storage and transportation costs, and the percent of production that is expected to receive a premium. These will depend upon the type of contract that the producer enters. Typically, there are two main types of contracts, the harvest delivery and the buyer's call. The harvest delivery contract probably will not require additional storage costs, but may require more transportation in some areas without receiving elevators. Under a harvest delivery contract, the producer delivers the high-oil corn to the elevator at harvest and receives the cash price plus some premium based on the oil content of the corn. The buyer's call contract requires the producer to store the grain for delivery during for a period after harvest and will provide higher premiums to account for the extra storage costs. The producer stores the grain after harvest until the buyer contacts the producer and gives them a specific time period to deliver the grain.

The revenue variation section specifies the additional revenue variation expected from producing specialty corn without a cooperative compared to the revenue variation of conventional corn. Greater variation in revenue can be expected from high-oil corn due to the impact of varying oil content levels and higher yield variation due to weather impacts. This can be changed to examine how greater variation in returns in high-oil corn can impact the risk-adjusted profitability of the crop.

The section of this worksheet titled "Specialty Corn With a Cooperative" is broken down into sections dealing with factors regarding the entire cooperative, those for the individual farmer, and general advantages/disadvantages of a cooperative arrangement over an individual contract. The user can change the startup costs, the percent of equity financed by the members, and the total number of bushels of high-oil corn needed annually. Each of these will depend upon the structure of the cooperative and its goals. The user can also examine the return they may expect on their equity by changing the number of bushels provided, the planning horizon, and the discount rate.

Due to the difficulty of estimating the startup costs of a grain elevator, the spreadsheet provides an estimated startup cost based on the elevator size. Cost estimates for varying sizes of elevators based on two studies of grain elevators are used to estimate the startup costs and operating expenses for the elevator (Schnake and Stevens; Kenkel). Linear regression is used to determine the relationship between elevator size and costs and this relationship is applied to the estimate of the number of bushels needed annually.

The price premium expected from production and marketing under a cooperative arrangement should be higher due to the ability of the cooperative to provide storage and higher volume contracts. Likewise, the cooperative should be able to obtain more stable revenues across years for producers since a more dispersed area of producers will provide for lower overall yield variation, and therefore the revenue variation of specialty corn compared to conventional corn should be lower than that used for the situation without a cooperative. In years when an individual producers' crop does not yield well due to an isolated condition, premiums from the cooperative can supplement lost income.

Dialog Boxes

Once all of the budgets and the "Key Variables" worksheets have been updated, the user begins the analysis by answering some basic questions regarding aspects of their operation. Figure 3.2 is the first dialog box the user encounters. This first asks for the number of tillable acres the producer has available for crop production. The next questions are for the purpose of separating operator acres from landlord acres for the proper allocation of costs and returns to the producer. The use of operator acres allows for those acres produced on a share arrangement to be converted to the equivalent of cash rented or owned acres. For example, if a producer raises 90 acres with a two-thirds producer share agreement, then the producer has 60 operator acres.

In order to incorporated risk into the model, some data is needed to make variance calculations. The higher the variance associated with a particular crop mix, the higher the risk, due to the presence of higher uncertainty regarding what the expected return may be. Figure 3.3 is the next dialog box and allows the user to enter up to ten years of historical yield data for the land that he/she will be producing the crops on. This allows the model to use the producer's actual production data instead of averages from test plots or other sources of information. The producer can enter as much historical data that is available. Once the data is entered and the "Submit" button is clicked, this historical data is used to construct a variance-covariance matrix of returns for the crops.

The next dialog box (Figure 3.4) prompts the user to enter expected prices for the current year for each of the crops. These can be estimated in a number of ways including current forward contracts or by using Futures data. Expected prices are used instead of asking the user for historical prices or returns to avoid underestimating price risk. Using historical price information to estimate price volatility would be misleading due to several reasons. First, price volatility increases at planting time when the producer is making planting decisions. Therefore, using mean prices could cause problems since some of the variation could be eliminated. Second, the impact of farm programs that existed in the past tended to lower price volatility from what it may be today. Finally, using farm level historical prices might reflect more chance and when and how the crop was marketed rather than the true price risk. The historical yields and the expected prices are applied to the variance model described in Chapter 2 to calculate revenue variation.

The user can select whether they want to investigate the production of high-oil corn under an independent contract or cooperative arrangement (Figure 3.5). Depending upon which selection is made, the spreadsheet uses the appropriate information from the "Key Variables" worksheet (Figure 3.1) in the calculations.

The next form (Figure 3.6) allows the user to place restrictions on the number of acres of any of the crops produced. A "range" of acres can be imposed for any of the crops. For example, if the producer wants to produce between 40% and 50% of their acres in soybeans for crop rotation purposes, 40% would be entered for the minimum next to soybeans, and 50% for the maximum. If they do not want to produce any of a particular crop 0% would be entered for both the minimum and the maximum. This allows the user to adjust the current years' production based on the crops that were produced in the year before in order to adjust for crop rotation constraints.

Output Page

Once the constraints are imposed and the "Submit" button is clicked, the spreadsheet begins a series of model calculations to determine the optimal crop mix under various risk scenarios. The spreadsheet first solves a model with a risk parameter of zero (λ=Z=0) to find the appropriate variance to use in calculating the set of risk parameters that are appropriate for the individual producer's profile. Once the risk parameters are solved for a low, medium, and high-risk aversion level as described earlier, the model is solved three more times using these parameters. The output is organized as a "simplified income statement" that lists the crop mix as well as the returns and costs as shown in Figure 3.7. The number of acres for each crop is rounded to the whole number, since it is not feasible to raise each crop to the tenth or hundredth of an acre. The gross revenue figures are strictly based on the expected yield and expected prices entered on the forms presented in Figures 3.3 and 3.4. The variable and fixed costs are derived from the enterprise budgets. The cost of landlord acres is presented to outline the costs spent on the landlord's share of the acres by the producer on the acres raised on a share arrangement. For example, a producer that raises a total of 900 acres, with 30% of the acres on a two-thirds share arrangement would have 100 landlord acres. The cost of landlord acres represents those costs associated with producing on 100 acres of land that the producer did not receive a return on since 100 acres are not part of his/her share.

Application of ISCAT

Data from the Kentucky Farm Business Analysis Program, Ohio Valley Farm Analysis Group is used to develop an example farm for the ISCAT spreadsheet. Data from 60 farms from the Ohio Valley area in 1999 had an average farm size of 1,424 tillable acres with 26% owned, 28% cash rented, and 46% share rented. Ten years of average yield data for the same region was used for the historical data requirements. High-oil corn attributes are based on premiums reported in the Illinois Survey (Table 3.1), and the results of the University of Kentucky Field Tests (Pierce, Poneleit, and Shine).

The conventional corn price for the model was derived from the December futures contract price on the Chicago Board of Trade (CBOT) when 2000 planting decisions were being made, minus the basis for Kentucky ($0.20). The soybean and double crop soybean price data is the 2000 Loan Deficiency Payment (LDP) for soybeans. Since the futures price was far short of the LDP when planting decisions were being made, the LDP of $5.40 is used as the only reasonable expected price. The same method was used to get an expected wheat price of $2.90.

Independent Contract Results

The independent contract situation consists of a farmer contracting to sell the high-oil corn for harvest delivery. The farm size and production characteristics are based on the average characteristics of the Ohio Valley Farm previously described. Setting up this farm for analysis consisted of changes to the "Key Variables" page to include an expected seed premium of $25 per bag, an increased planting rate of 10%, and an expected yield drag of 7%. The expected premium is $0.25 per bushel with 95% of the crop expected to receive the premium. The anticipated revenue variation over that of conventional corn is 10%.

The seed premium of $25 per bag is based on the average seed premiums reported in the Illinois Survey Study (ISFP). The increased planting rate of 10% is to account for recommendations by the seed company (DSG) that seeding rates be increased to account for the 10% of pollen producing plants discussed in Chapter 2. An expected yield drag of 6% based on the University of Kentucky Field Tests (Pierce, Poneleit, and Shine). No extra storage costs were included since the crop will be sold under a harvest delivery contract. The anticipated revenue variation over that of conventional corn of 10% although somewhat arbitrary, is realistic. This variable is difficult to estimate since farm data is not available. The University of Kentucky Field tests show a 3% increase in yield variation, however, while field tests are designed to imitate actual conditions, some would argue that more professional management reduce yield risk over what is actually found from farm data. There is also some revenue risk associated with the uncertainty of the level of the premium. Therefore, for this analysis, 10% should be an acceptable level of variation, while this value can easily be increased and decreased to examine the impacts of revenue variation on crop mix selection.

A variance-covariance matrix of net returns for the crops under the independent contract arrangement is reported in Table 3.2. High-oil corn displays the highest variation in net returns with a variance of 5,513. Soybeans show the smallest level of variance with 1,650. The lowest risk crop combination consists of wheat and double crop soybeans, although this does not mean it is the most profitable.

Table 3.4 outlines the results under an independent contract arrangement with no acreage constraints placed on any of the crops. The riskiest crop mix consists of 1,389 acres of double crop soybeans and wheat and 35 acres of high-oil corn. Due to the lower risk aversion parameter or lower risk aversion level, variance is not of as much importance compared to net returns. The risk premium for this producer ($22,467.56) is lower than that of the medium and low risk selections, even though the total variance is much higher, because of the lower risk parameter (0.0000028) that is applied to the variance. The risk premium of $22,467.56 represents the amount that this producer would be willing to pay to receive a risk free net income of $75,623.47. Therefore, this producer is indifferent between expecting an income of $98,091.02 with the variance (risk) associated with it, and receiving the risk free income of $75,623.47.

The medium risk crop mix is a more diversified mix consisting of 175 acres of conventional corn, 824 acres of soybeans, and 425 acres of double crop soybeans and wheat. The addition of soybeans and wheat into the crop mix along with the elimination of the high-oil corn acres lowers the expected net income, but also decreases the amount of variance the producer faces, and in turn, lowers the risk of the crop mix. This producer is willing to pay $37,580.47 to receive the risk free income of $44,136.94. The risk adjusted net return this producer expects to receive is lower than that of the low risk averse producer. This makes sense because profits are compensation for taking on risk, and the more risk that is taken on, the higher the expected profits.

The lowest risk alternative, or the choice that suits the highly risk averse producer, consists of 179 acres of corn and 1,245 acres of soybeans. This producer, as well as the medium risk averse producer, does not plant any high-oil corn due to the higher variance in net returns. In this case, more of the acres were planted in soybeans than in corn. This is understandable by examining the variance-covariance matrix presented in Table 3.2. The variance of soybeans is 1,650 compared to a much higher variance of 5,012 for conventional corn. This producer is willing to pay $51,344.53 to eliminate the risk from the expected net income of $73,658.63 to get a risk adjusted net income of $22,314.10.

It is important to note that under these circumstances, for all premiums less than $0.25; no high-oil corn is produced at any risk aversion level. This also assumes that only 95% of the crop is sold as high-oil corn. In many cases some of the crop, especially parts of the acreage that are not isolated become diluted in oil content and may not qualify for the premiums due to cross pollination with other corn varieties (Chapter 2). For those situations where less than 95% of the crop receives the premium, with an expected premium of $0.25, no high oil corn is produced at any risk aversion level.

Cooperative Results

The cooperative setting is based on a producer that is a member of a cooperative that markets 1,000,000 bushels of high-oil corn per year. Startup costs for the cooperative of $1,394,052 are estimated by the spreadsheet based on two studies of operating costs and capital requirements for elevators (Schnake and Stevens; Kenkel) (See Chapter 2). The percent of member equity is the amount of the cost that is funded by the members. This case assumes the members finance half the cost through loans and fund half the cost with their own money. Assuming that this member expects that he/she can produce approximately 400 acres of high-oil corn in any given year and expects an average (conservative) yield of 120 bushels per acre, then the expected contribution to the cooperative would be 48,000 bushels per year. This would give this producer a 4.8% share in the cooperative and require an equity contribution of $33,457. Discounting this cost over a 15 year planning horizon at a discount rate of 8% would give an opportunity cost of equity of $0.026 per bushel. Therefore, this cost is applied to the producer's fixed costs per acre on the high-oil corn budget.

The expected premium that the cooperative will receive is $0.48. This assumes that the cooperative can bargain for a better premium than an individual producer. The operating costs of the cooperative are estimated at $0.18 per bushel based on an elevator size of 1,000,000 bushels per year (Kenkel). Therefore the net expected premium for the producer is $0.30.

The increased revenue variation for high-oil corn under the cooperative setting is 5%. This assumes that the cooperative can achieve lower variation in net returns than an individual producer by spreading production over a larger geographic area to reduce weather impacts, and achieving more consistent premiums through better commodity handling techniques to reduce contamination.

Table 3.3 shows the variance-covariance matrix for the crops under the cooperative marketing arrangement. A difference is noted in high-oil corn and each of the covariances that include high-oil corn. This is due to an increased variance in net revenues that is expected in the independent contract situation versus the cooperative arrangement, as specified in the "Key Variables" page.

The results of running the model under the cooperative arrangement are presented in Table 3.5. The results from the cooperative reflect the higher expected return for high-oil corn compared to the independent contract scenario. The results represent producers with the same risk preferences as the ones from the previous simulation, except this time a cooperative arrangement for marketing high-oil corn is used.

The low risk averse producer chooses to produce 831 acres of double crop soybeans and wheat and 533 acres of high-oil corn. Since the level of variance has much less impact on his/her decisions than that of the more risk averse producers, this producer chooses to invest much more of the total acreage into the crop with the highest expected net return. For this same risk preference, only 35 acres of high-oil corn is planted under the independent contract scenario.

The medium risk averse producer add soybeans and high-oil corn into the crop mix under the cooperative arrangement with 435 acres of soybeans, 658 acres of double crop soybeans and wheat, and 331 acres of high-oil corn. This is due to the greater expected higher returns with the cooperative. This producer has taken on a significantly greater amount of risk in this situation. The risk premium is $43,250.30, compared to $37,580.30 from the independent contract. This illustrates how greater expect returns allow the producer to take on more risk. The producer is able to achieve a higher risk adjusted net income in this case than in the independent contract agreement, therefore, the cooperative arrangement would be preferred.

The high risk averse producer raises combination of corn (184 acres), regular soybeans (1,175 acres), and double crop soybeans and wheat (64 acres). This producer does not produce any high-oil corn.

Summary and Conclusions

The ISCAT spreadsheet allows producers to change most all of the variables that can impact the decision of whether or not to adopt high-oil corn. This allows the producer to make a decision based on their own experience and expectations based on the characteristics and history of their operation rather than from data from other regions. The interactive aspects of the spreadsheet make it fairly simple to use, even for those that may not be very familiar with using a spreadsheet. The most visible benefits of this spreadsheet are the potential educational benefits to producers who use it. It allows the user to examine how changes in particular variables effect how the optimal crop mix changes as well as changes in the total variance of the mix.

The results of the application to data from the Ohio Valley region of the KFBM program show that even with only a 6% yield drag, $25 more seed cost a bag, and no additional transportation and storage cost, a $0.25 per bushel premium only resulted in a small adoption of high-oil corn for those producers that exhibit only a small amount of aversion to risk. There is also no guarantee that high-oil corn will receive premiums this high in future years. It is likely that as more producers enter the market and production increases, that premiums will fall.

The condition that only 95% of the corn would receive this same premium was also in place under the independent contract setting, and for levels less than 95%, no high-oil corn was produced. It is important that the crop be properly isolated from conventional corn crops and that equipment be cleaned to prevent oil dilution. It seems highly unlikely that a producer facing the same characteristics as the average data used in this simulation would adopt high-oil corn.

The situation under the cooperative arrangement proved more promising. The high-oil corn was much more widely adopted due to the higher expected premium due to patronage refunds and the potential for the cooperative to market the commodity to the end users. With the premiums and expected patronage refund in place, the producers under the cooperative arrangement faced a net price for high-oil corn of $2.70 per bushel, compared to an expected price of $2.40 per bushel for conventional corn.

This study has important implications for those considering the adoption of high-oil corn. It is important to carefully consider the production history of the particular operation that will be producing the crop. The use of enterprise budgets and tools such as those included in the ISCAT spreadsheet are essential in making a sound decision. The question of whether or not to adopt the crop depends heavily on the producer's preference towards risk.

Table 3.1. 2000 High-Oil Premiums Based on Illinois Study

	Harvest Delivery	Buyer's Call
Oil Content		
8.0%	$0.25	$0.30
7.9%	$0.24	$0.29
7.8%	$0.23	$0.28
7.7%	$0.22	$0.27
*		
6.0%	$0.05	$0.10

*Premium decreases $0.01 for each 0.1% decrease in oil content.

Table 3.2. Variance-Covariance Matrix of Net Returns (Independent Contract)

	Corn	Soybeans	DC Soybeans	Wheat	HO Corn
Corn	5012				
Soybeans	1591	1650			
DC Soybeans	1163	1430	2389		
Wheat	1899	692	-204	2026	
HO Corn	5204	2383	2505	535	5513

Table 3.3. Variance-Covariance Matrix of Net Returns (Cooperative)

	Corn	Soybeans	DC Soybeans	Wheat	HO Corn
Corn	5012				
Soybeans	1591	1650			
DC Soybeans	1163	1430	2389		
Wheat	1899	692	-204	2026	
HO Corn	3616.48	2383	2505	535	5513

Table 3.4. Independent Contract Results

	Riskiest	Medium Risk	Lowest Risk
Acres			
Corn	0	175	179
Soybeans	0	824	1245
DC Soybeans	1389	425	0
Wheat	1389	425	0
High-Oil Corn	35	0	0
Gross Revenue			
Corn	$0.00	$53,298.00	$54,516.24
Soybeans	$0.00	$179,545.68	$271,391.04
DC Soybeans	$247,519.80	$75,735.00	$0.00
Wheat	$230,810.13	$70,622.25	$0.00
High-Oil Corn	$10,810.77	$0.00	$0.00
Total	**$489,140.70**	**$379,200.93**	**$325,907.28**
Variable Costs			
Corn	$0.00	$33,747.80	$34,519.18
Soybeans	$0.00	$101,269.34	$153,072.98
DC Soybeans	$104,862.90	$34,085.48	$0.00
Wheat	$162,795.37	$49,811.40	$0.00
High-Oil Corn	$6,963.79	$0.00	$0.00
Total	**$264,622.06**	**$59,361.45**	**$187,592.16**
Fixed Costs			
Corn	$0.00	$5,691.00	$5,821.08
Soybeans	$0.00	$26,475.91	$40,019.48
DC Soybeans	$54,861.53	$16,756.29	$0.00
Wheat	$34,016.61	$10,408.25	$0.00
High-Oil Corn	$1,105.68	$0.00	$0.00
Total	**$89,983.82**	**$59,361.45**	**$45,840.56**
Cost of Landlord Acres			
Corn	$0.00	$2,538.03	$2,603.97
Soybeans	$0.00	$10,729.80	$16,211.95
DC Soybeans	$12,735.23	$3,896.75	$0.00
Wheat	$13,214.76	$4,043.48	$0.00
High-Oil Corn	$493.80	0.00	$0.00
Total	**$26,443.79**	**$21,208.05**	**$18,815.93**
Unadjusted Net Income	**$98,091.02**	**$81,717.41**	**$73,658.63**
Risk Premium	**$22,467.56**	**$37,580.47**	**$51,344.53**
Risk Adjusted Net Income	**$75,623.47**	**$44,136.94**	**$22,314.10**

Table 3.5. Cooperative Results

	Riskiest	Medium Risk	Lowest Risk
Acres			
Corn	0	0	184
Soybeans	0	435	1175
DC Soybeans	831	658	64
Wheat	831	658	64
High-Oil Corn	533	331	0
Gross Revenue			
Corn	$0.00	$0.00	$56,039.04
Soybeans	$0.00	$94,899.60	$256,338.00
DC Soybeans	$148,084.20	$117,255.60	$11,404.80
Wheat	$138,087.27	$109,339.86	$10,634.88
High-Oil Corn	$192,695.11	$107,414.51	$0.00
Total	**$478,866.58**	**$428,909.57**	**$334,416.72**
Variable Costs			
Corn	$0.00	$0.00	$35,483.40
Soybeans	$0.00	$53,526.32	$144,582.60
DC Soybeans	$62,736.55	$49,675.87	$4,831.70
Wheat	$97,395.93	$77,119.77	$7,501.01
High-Oil Corn	$118,268.69	$65,926.80	$0.00
Total	**$278,401.17**	**$246,248.77**	**$192,398.71**
Fixed Costs			
Corn	$0.00	$0.00	$5,983.68
Soybeans	$0.00	$13,993.95	$37,799.75
DC Soybeans	$32,822.13	$25,989.12	$2,527.82
Wheat	$20,351.19	$16,114.42	$1,567.36
High-Oil Corn	$21,083.95	$11,752.88	$0.00
Total	**$74,257.27**	**$67,850.37**	**$47,878.61**
Cost of Landlord Acres			
Corn	$0.00	$0.00	$2,665.96
Soybeans	$0.00	$5,670.32	$15,317.96
DC Soybeans	$7,615.04	$6,035.93	$589.38
Wheat	$7,901.78	$6,263.21	$611.58
High-Oil Corn	$8,037.77	$4,475.74	$0.00
Total	**$23,554.58**	**$22,444.90**	**$19,184.89**
Unadjusted Net Income	**$102,653.56**	**$92,365.52**	**$74,954.52**
Risk Premium	**$18,406.45**	**$43,250.30**	**$46,387.69**
Risk Adjusted Net Income	**$82,247.11**	**$49,115.23**	**$28,566.83**

Figure 3.1 Key Variables Page

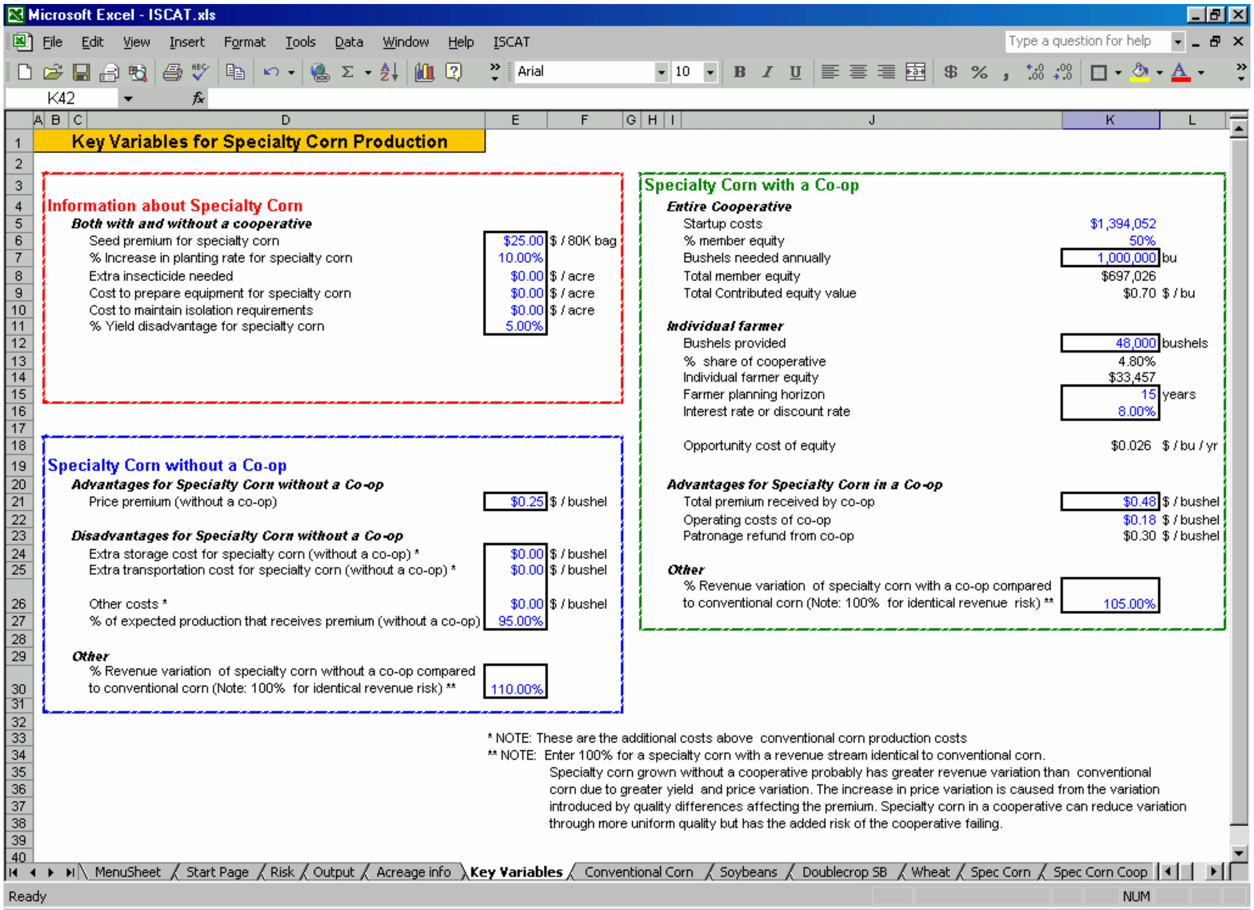


Figure 3.2. Basic Farm Info Form

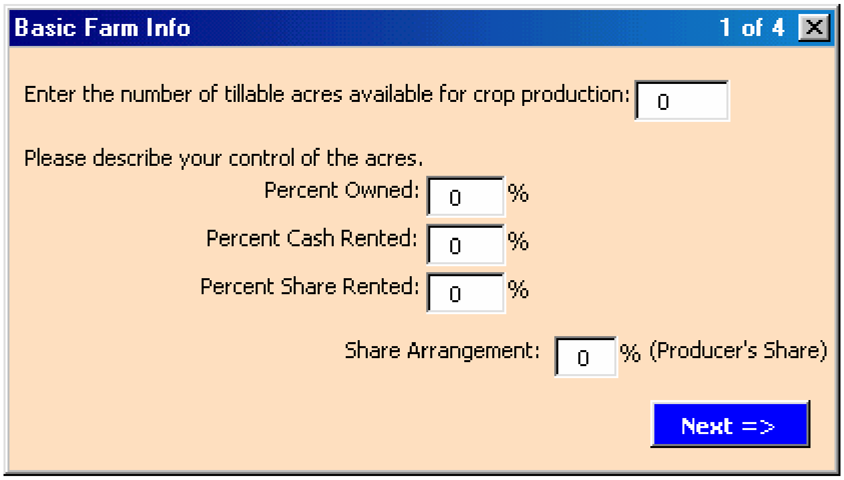


Figure 3.3. Historical Yield Data Form

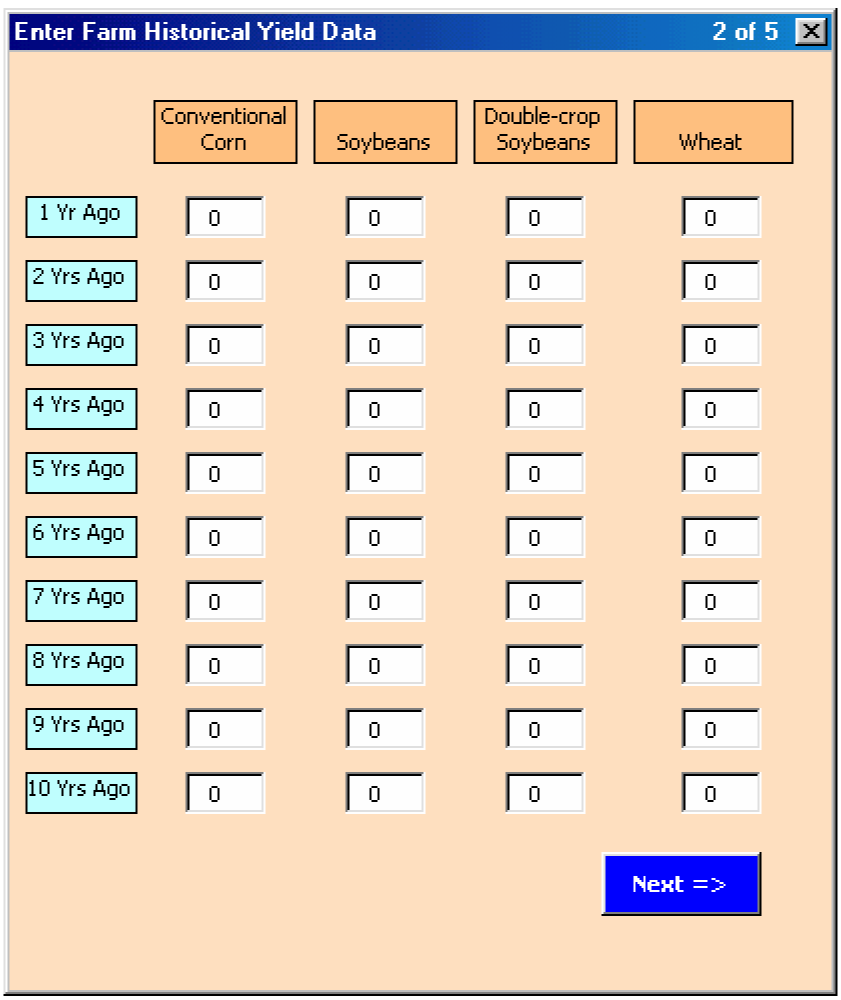


Figure 3.4. Expected Prices Form

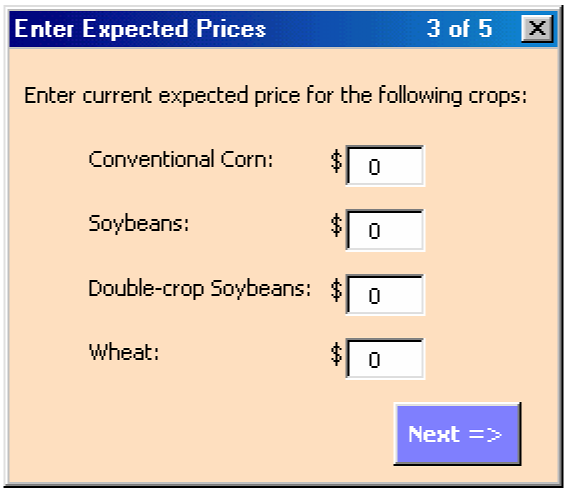


Figure 3.5. Marketing Alternatives Form

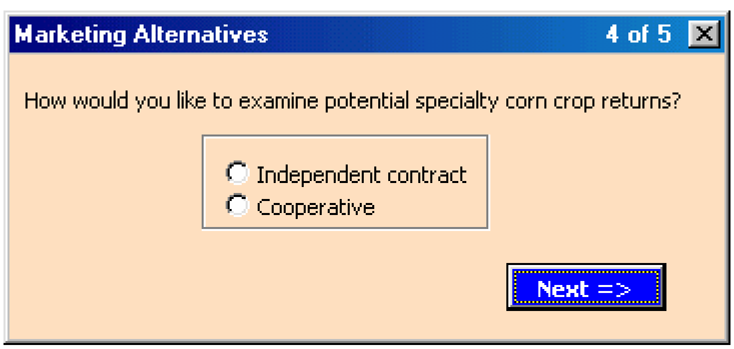


Figure 3.6. Acreage Constraints Form

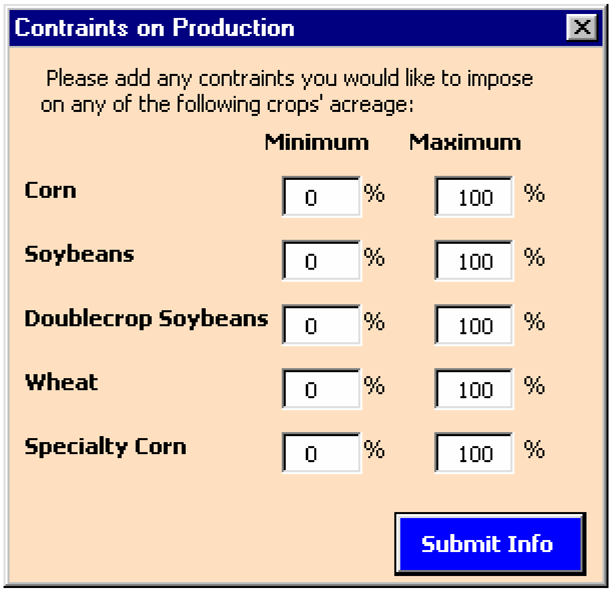
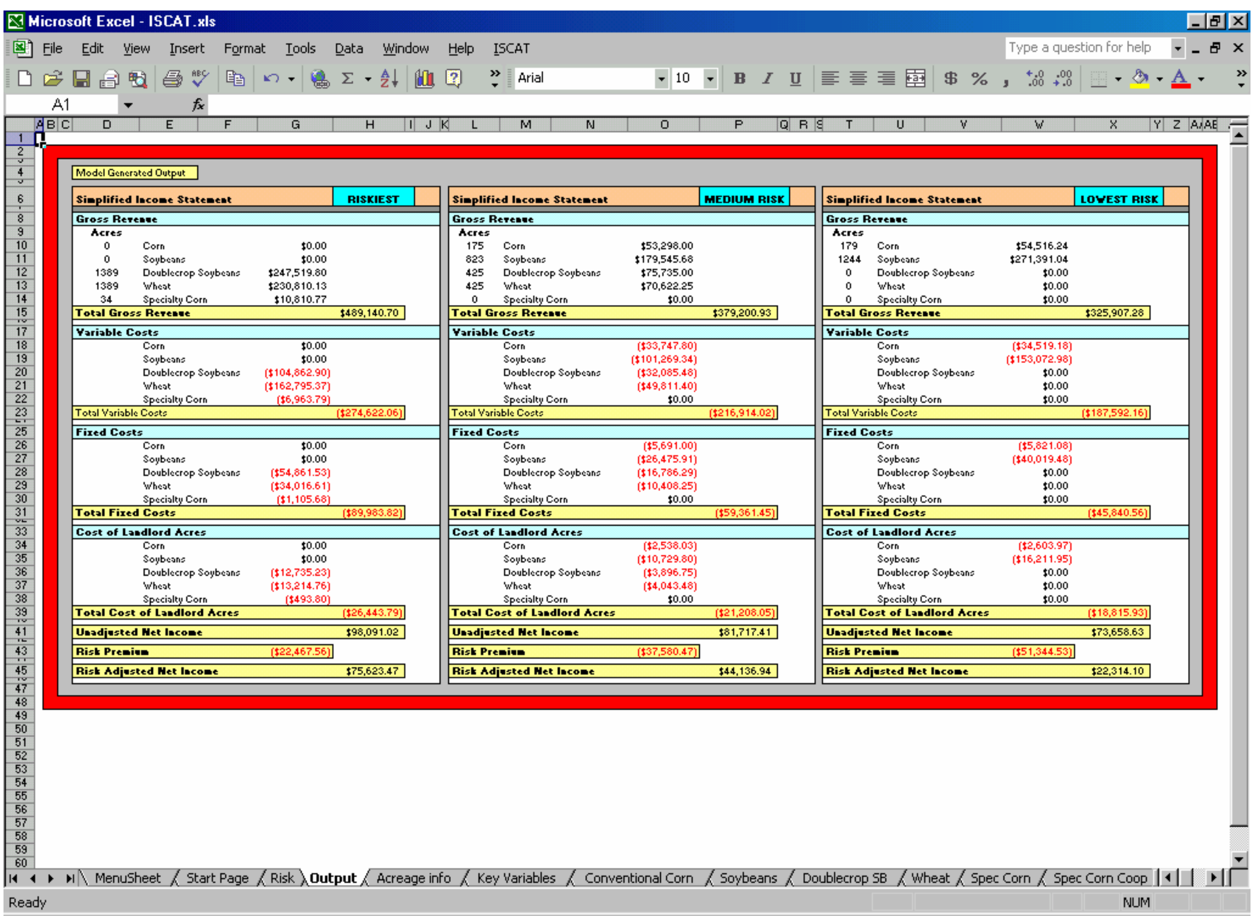


Figure 3.7. Output Page



Model Generated Output

Simplified Income Statement	RISKIEST		MEDIUM RISK		LOWEST RISK	
Gross Revenue						
	Acres		Acres		Acres	
Corn	0	$0.00	175	$53,298.00	179	$54,516.24
Soybeans	0	$0.00	823	$179,545.68	1244	$271,391.04
Doublecrop Soybeans	1389	$247,519.80	425	$75,735.00	0	$0.00
Wheat	1389	$230,810.13	425	$70,622.25	0	$0.00
Specialty Corn	34	$10,810.77	0	$0.00	0	$0.00
Total Gross Revenue		$489,140.70		$379,200.93		$325,907.28
Variable Costs						
Corn		$0.00		($33,747.80)		($34,519.18)
Soybeans		$0.00		($101,269.34)		($153,072.98)
Doublecrop Soybeans		($104,862.90)		($32,085.48)		$0.00
Wheat		($162,795.37)		($49,811.40)		$0.00
Specialty Corn		($6,963.79)		$0.00		$0.00
Total Variable Costs		($274,622.06)		($216,914.02)		($187,592.16)
Fixed Costs						
Corn		$0.00		($5,691.00)		($5,821.08)
Soybeans		$0.00		($26,475.91)		($40,019.48)
Doublecrop Soybeans		($54,861.53)		($16,786.29)		$0.00
Wheat		($34,016.61)		($10,408.25)		$0.00
Specialty Corn		($1,105.68)		$0.00		$0.00
Total Fixed Costs		($89,983.82)		($59,361.45)		($45,840.56)
Cost of Landlord Acres						
Corn		$0.00		($2,538.03)		($2,603.97)
Soybeans		$0.00		($10,729.80)		($16,211.95)
Doublecrop Soybeans		($12,735.23)		($3,896.75)		$0.00
Wheat		($13,214.76)		($4,043.48)		$0.00
Specialty Corn		($493.80)		$0.00		$0.00
Total Cost of Landlord Acres		($26,443.79)		($21,208.05)		($18,815.93)
Unadjusted Net Income		$98,091.02		$81,717.41		$73,658.63
Risk Premium		($22,467.56)		($37,580.47)		($51,344.53)
Risk Adjusted Net Income		$75,623.47		$44,136.94		$22,314.10

References

Anderson, J.R., J.L. Dillon, and B. Hardaker. *Agricultural Decision Analysis.* Iowa State University Press: Ames, IA, 1977.

Babcock, B., E. Choi, and E. Feinerman. "Risk and Probability Premiums for CARA Utility Functions." *Journal of Agricultural and Resource Economics.* 18(1): 17-24.

Illinois Specialty Farm Products
http://web.aces.uiuc.edu/value/

McCarl, B.A. and D.A. Bessler. "Estimating an Upper Bound on the Pratt Risk Aversion Coefficient When the Utility Function is Unknown." *Australian Journal of Agricultural Economics* 33(April 1989): 56-63.

Dupont Specialty Grains
http://www.dupontsg.com

Pearce, W.L., C.G. Poneleit. "1998 Kentucky Hybrid Corn Performance Test." PR-407 Agricultural Experiment Station. University of Kentucky, College of Agriculture.

Pearce, W.L., C.G. Poneleit, and P. Shine. "1999 Kentucky Hybrid Corn Performance Test." PR-421. Agricultural Experiment Station. University of Kentucky, College of Agriculture.

______. "2000 Kentucky Hybrid Corn Performance Test." PR-434. Agricultural Experiment Station. University of Kentucky, College of Agriculture.

Chapter Four
Conclusion

Specialty crops are unquestionably gaining in popularity among producers in the United States. There adoption in Kentucky seems to have spread significantly in the last few years as well. High-oil corn has proven to be the most widely adopted specialty crop in recent years. The rapid adoption of high-oil corn may be mostly due to the fact that it does not require many changes in the producers operation to grow the crop (e.g. specialized equipment). This research has analyzed the profitability of producing high-oil corn and pointed out certain characteristics of the crop that should be carefully considered when making the decision of whether or not to grow the crop. The novelty of high-oil corn limits the availability of data. Therefore, this study relied on sensitivity analysis to address this concern. This chapter outlines the results and implications of the previous discussion.

High-Oil Corn Simulations

Chapter 2 consisted of the application of high-oil corn yield data from the University of Kentucky Field Tests. The impacts of changing high-oil corn premiums, soybean prices, and soybean yields were analyzed through the use of an E-V mathematically programming model that simulated the decisions of producers with given preferences toward risk. This allowed sensitivity analysis to be performed while holding the "producer's" preference toward risk constant. This method was appropriate since the risk associated with new enterprises is an important consideration.

Quantifying the risk associated with the crops by measuring price and yield risk was appropriate to properly compare high-oil corn to other crops. The risk aversion levels that were used had significant impacts on the results. Substantially different results were discovered across the low, medium, and high risk aversion levels. This is an important consideration to the results of this study. As the risk aversion level of a producer increases (decreases), the likelihood of that producer adopting high-oil corn decreases (increases).

The first part of the analysis looked at how the price premium of high-oil corn effected its adoption. This is an important attribute of high-oil corn to consider for two reasons; the price premiums can change depending on the availability of high-oil corn and the demand for the crop and the oil composition can vary due to undesirable weather conditions. The analysis show that for the given level of variance (based on the University of Kentucky Hybrid Corn Performance Tests), a minimum premium of $0.24 was required before any high-oil corn was produced at any risk aversion level.

The ability of high-oil corn to yield as well as conventional corn continues to be questionable. Only three years of data were available, and this limitation leads to concerns over the data's ability to accurately describe the crops yielding ability in Kentucky. However, similar tests in other regions of the U.S. showed similar differences in yields, and therefore, the data were considered acceptable. The yields of high-oil corn had significant impacts on the results of the simulation. The results indicate that a yield drag of 6% or more did not result in any acres of high-oil corn being planted. Conversely, when high-oil corn yielded the same as conventional corn, a majority of the acres were planted in the crop. This exhibits the dependence of high-oil corn profitability on its ability to yield the same as conventional corn. The differences in net returns of the crops were marginal without accounting for the increased variance associated with high-oil corn, and even less with the risk term included.

ISCAT Spreadsheet

Chapter three describes the Interactive Specialty Corn Analysis Tool (ISCAT), which allows the user to input their own information in order to analyze various situations. This spreadsheet addresses the shortfalls of previous research in high-oil corn by allowing the user to analyze risk specifically related to their operation. It is important to note that while this spreadsheet does provide rational outcomes and can be a valuable decision aid, the specific outcomes of the spreadsheet depend upon the risk preferences of the user and the risk premiums should be looked at as a decision aid in ranking alternatives and not taken dollar for dollar. ISCAT is a useful tool to provide grain producers with a stronger concept of the factors that should be included in their production decisions.

The enterprise budgets can be updated to accurately reflect the user's own experience with conventional corn, soybeans, double-crop soybeans, wheat, and high-oil corn. Also, a sheet was provided for expected differences in high-oil corn and conventional corn to be specified, as well as possibilities related to independently growing the crop or using a cooperative arrangement. This allows for innumerable possibilities for sensitivity analysis for the user.

The results of applying the ISCAT spreadsheet to actual data from the Kentucky Farm Business Management program present interesting implications for producers. The results of the independent contract setting shows that when consideration is placed on the additional variance associated with the crop, it was not very profitable to producer high-oil corn for most of the likely price premium levels. Even with a premium of $0.25, only those producers with very low risk aversion preferences produced high-oil corn under the most likely situation of 6% yield drag, $25 additional seed cost per bag, and 10% more net return variance.

Under the cooperative setting, adoption of high-oil corn was much more profitable. This assumed significantly higher premiums could be captured by the cooperative achieving better price premiums based on high-oil content and additional premiums usually gained at higher levels of the marketing chain.

Summary

This research analyzed the profitability of high-oil corn production in Kentucky. Sensitivity analysis was done using an E-V mathematical programming model, and a decision aid was developed (ISCAT) for producers to utilize in making the decision of whether or not to pursue production of the crop. The research included yield data from Kentucky and made an application to Ohio Valley farm data.

The impacts of various variables were examined, and the results were interpreted to explain the impacts on high-oil corn adoption. The profitability of high-oil corn was found to be questionable, due to the importance of receiving similar yields to conventional corn, and substantial premiums. The opportunity for a cooperative arrangement seems to be an alternative that may provide the opportunity for producers to gain additional profits.

Recommendation

The results of this study have important implications for those producers considering the adoption of a specialty crop. The risks associated with the crops can be substantial and quantifying these risks is problematic. The usefulness of the ISCAT spreadsheet is not restricted to high-oil corn and can be easily modified to analyze other specialty crops. One of the most important benefits of the spreadsheet is its ability to allow producers to recognize the impact that various variables have on the adoption of specialty crops. While the accurate measurement of the risks associated with adopting a new crop can be difficult, the ability to recognize the qualitative impact that various characteristics of the crop, beyond expected net returns, will have on its adoptability can prove an invaluable skill for a decision maker. Further research is needed to determine the profitability of high-oil corn. As more crop data becomes available, more accurate measurements of the risks and benefits associated with the crop will be accessible.

BIBLIOGRAPHY

Adeola, O., and N.L. Bajjalieh. "Energy Concentration of High-Oil Corn Varieties for Pigs." Journal of Animal Science. 75(February 1997): 430-436.

Alchian, A.A. and H. Demsetz. "Production, Information Costs, and Economic Organizaation." *The American Economic Review*. 62(December 1972): 777-795.

Anderson, J.R., J.L. Dillon, and B. Hardaker. *Agricultural Decision Analysis.* Iowa State University Press: Ames, IA, 1977.

Babcock, B., E. Choi, and E. Feinerman. "Risk and Probability Premiums for CARA Utility Functions." *Journal of Agricultural and Resource Economics* 18(1): 17-24.

Barry, P.J., S.T. Sonka, and K. Lajili. "Vertical Coordination, Financial Structure, and the Changing Theory of the Firm." American Journal of Agricultural Economics. 74,5(December 1992): 1219-1224.

Bender, K., L. Hill, B. Wenzel, R. Hornbaker. "Alternative Market Channels for Specialty Corn and Soybeans." Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, AE-726, February, 1999.

Boehlje, M., and L.F. Schrader. "Agriculture in the 21st Century." *Journal of Production Agriculture* 9(1996): 333-341.

Bourgeon, J-M., R.G. Chambers. "Producer Organizations, Bargaining, and Asymmetric Information." *American Journal of Agricultural Economics.* 81,3(August 1999): 602-609.

Briggs, J.L., D.E. Maier, B.A. Watkins, and K.C. Behnke. "Effect of Ingredients and Processing Parameters on Pellet Quality." *Poultry Science*. 78(October 1999): 1464-1471.

Coase, R.H. "The Nature of the Firm." *Economica.* 4(November 1937): 286-404.

Dado, R.G. "Nutritional Benefits of Specialty Corn Grain Hybrids in Dairy Diets." *Journal of Animal Science.* 77(2): 197-207.

Dillon, C.R. "Production Practice Alternatives for Income and Suitable Field Day Risk Management." Journal of Agricultural and Applied Economics 31(August 1999): 247-261.

Dupont Specialty Grains
http://www.dupontsg.com

Gillespie, J.M. and V.R. Eidman. "The Effect of Risk and Autonomy on Independent Hog Producers' Contracting Decisions." *Journal of Agricultural and Applied Economics*. 30,1(July 1998): 175-188.

Goodhue, R.E. "Input Control in Agricultural Production Contracts." *American Journal of Agricultural Economics.* 81,3(August 1999): 616-620.

Good, D., K. Bender, and L. Hill. "Marketing of Specialty Corn and Soybean Crops." Department of Agricultural and Consumer Economics, College of Agricultural, Consumer and Environmental Sciences, University of Illinois Urbana-Champaign AE-4733, March 2000.

Harwood, J., J. Perry, R. Heifner, A. Somqaru, K. Coble. *Managing Risk in Farming: Concepts, Research, and Analysis* USDA, Economic Research Service, Report 774(March 1999).

Hueth, B. and E. Ligon. "Agricultural Supply Response Under Contract." *American Journal of Agricultural Economics.* 81,3(August 1999): 610-615.

Ibendahl, Gregg, Kimberly Zeuli, and William Pearce. "Analyzing the Profitability and Risk of High Oil Corn." No. 2000-10. Department of Agricultural Economics, University of Kentucky, June 2000.

Illinois Specialty Farm Products Web Site.
http://web.aces.uiuc.edu/value/

Jensen, M., and W. Meckling. "Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure." *Journal of Finance and Economics* (1976): 305-360.

Kalaitandonakes, N. "A Farm Level Perspective on Agrobiotechnology: How Much Value and For Whom?" *AgBioForum.* 2,2(Spring 1999): 61-64.

Kalaitzandonakes, N. and B. Bjornson. "Vertical and Horizontal Coordination in the Agro-Biotechnology Industry: Evidence and Implications." *Journal of Agricultural and Applied Economics.* 29,1(July 1997): 129-139.

Kraenzie, C. "Coops Break Supply Records." *Rural Cooperative.* (November/December 1998): 4-6.

LaCount, D.W., J.K. Drackley, T.M. Cicela, and J.H. Clark. "High-Oil Corn as Silage or Grain for Dairy Cows During an Entire Lactation." 78(August 1995): 1745-1754.

Lajili, K., P.J. Barry, S.T. Sonka, and J.T. Mahoney. "Farmers' Preferences for Crop Contracts." *Journal of Agricultural and Resource Economics* 22(December 1997): 264-280.

Leathers, H.D. "What is Farming? Information, Contracts, and the Organization of Agricultural Production: Discussion. *American Journal of Agricultural Economics.* 81,3(August 1999): 621-623.

Lin, W.W., W. Chambers, and J. Harwood. "Biotechnology: U.S. Grain Handlers Look Ahead." *Agricultural Outlook* 270(April 2000): 29-34.

MacNeil, I. "The Many Futures of Contract." *Southern California Law Review.* 47(1974): 691-738.

Markowitz, H. "Portfolio Selection." *Journal of Finance* 12(1952): 77-91.

Mahoney, J.T. "The Choice of Organizational Form: Vertical Financial Ownership Versus Other Methods of Vertical Integration." *Strategic Management Journal.* 13(1992): 559-584.

Martin, M.J. and T.G. Taylor. "A Comparison of the Efficiency of Producers Under Collective and Individual Modes of Organization." International Agricultural Trade and Development Center, University of Florida, International Working Paper Series, IW97-3 (April 1997).

McCarl, B.A. and T.H. Spreen. *Applied Mathematical Programming Using Algebraic Systems.* Unpublished, 1997.

McCarl, B.A. and D.A. Bessler. "Estimating an Upper Bound on the Pratt Risk Aversion Coefficient When the Utility Function is Unknown." *Australian Journal of Agricultural Economics* 33(April 1989): 56-63.

Meyer, J. "Two-Moment Decision Models and Expected Utility Maximization." *The American Economic Review* 77(June 1987): 421-430.

Mighell, R.L., and L.A. Jones. "Vertical Coordination in Agriculture." Washington DC: USDA, Economic Research Service. AE-19(February1963).

Parsons, C.M., Y. Zhang, and M. Araba. "Availability of Amino Acids in High-Oil Corn." *Poultry Science*. 77(July 1998): 1016-1019.

Pearce, W.L., C.G. Poneleit. "1998 Kentucky Hybrid Corn Performance Test." PR-407 Agricultural Experiment Station. University of Kentucky, College of Agriculture.

Pearce, W.L., C.G. Poneleit, and P. Shine. "1999 Kentucky Hybrid Corn Performance Test." PR-421. Agricultural Experiment Station. University of Kentucky, College of Agriculture.

______. "2000 Kentucky Hybrid Corn Performance Test." PR-434. Agricultural Experiment Station. University of Kentucky, College of Agriculture.

Rhodes, V.J, D. Flottman, and M.H. Procter. "Basic Data on U.S. Medium/Large Size Hog Operations, 1986-1987." Agricultural Economics Report 1987-17, University of Missouri, 1987.

Riley, P.A., L. Hoffman, and M. Ash. "U.S. Farmers Are Rapidly Adopting Biotech Crops." *Agricultural Outlook* 253(August 1998): 21-23.

Sandmo, A. "The Competitive Firm Under Output Price Uncertainty." *American Economic Review.* 61(March 1971): 65-73.

Saxowsky, D.M., and M.R. Duncan. "Understanding Agriculture's Transition into the 21st Century: Challenges, Opportunities, Consequences and Alternatives." Agricultural Economics Report No. 181, Dept. of Agricultural Economics, North Dakota State University, March 1998.

Schrader, L.F. "Responses to Forces Shaping Agricultural Marketing: Contracting." 68,5(December 1986): 1161-1166.

Sofranko, A., R. Frerichs, M. Samy, and B. Swanson. "Will Farmers Organize: Structural Change and Loss of Control Over Production." Illinois Specialty Farm Products, University of Illinois. Research Paper. http://web.aces.uiuc.edu/value/research/organize.html

Taylor, C. *The Farmer's Movement*. American Book Company, New York, 1953.

Thomison, P.R. "Topcross High Oil Corn Production: Management Considerations". Ohio State University Fact Sheet AGF-135: 1997.

Williamson, O.E. "Transaction Cost Economics: The Governance of Contractual Relations." Journal of Law and Economics. 22(1979): 233-261.

Welsh, R. "Vertical Coordination, Producer Response, and the Locus of Control Over Agricultural Production Decisions. *Rural Sociology.* 62,4(1997): 491-507.

Woodworth, C. "GMOs: A Growing Concern." *Health Products Business* 45(October 1999): 34-40.

Vita

The author was born in Winchester, Kentucky on October 27, 1977. He received his primary and secondary education in the Clark County School System. The author graduated in June of 1996 from George Rogers Clark High School in Winchester, Kentucky.

In August of 1996, he enrolled in the University of Kentucky with a major in Agricultural Economics. He received his Bachelor of Science in Agricultural Economics in May of 2000.

In the Spring semester of 2000, he was accepted into Graduate School through the University Scholars Program and was employed as a Research Assistant in the Department of Agricultural Economics. He was the recipient of the John C. Redman Graduate Fellowship in 2000 and 2001 and a member of Gamma Sigma Delta Honor Society.