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Economic potential of high oil oats

by

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CHAPTER I.

INTRODUCTION

Environmental degradation, water quality, soil erosion, and the loss of wildlife habitat have become significant issues for both agricultural and environmental groups. The scope of environmental degradation both current and projected is staggering. The World Bank reports that every year, 20 million hectares of agricultural land is lost to soil erosion. In the U.S. alone, estimates suggest that if current rates of cropland erosion prevail for 100 years, crop yields will be from 3-10 percent lower than they would be otherwise. Population statistics project that by the year 2025, the world human population will increase to 8.5 billion. The challenge for agriculture, then, is not only to provide adequate food, but also to achieve this level of production with less environmental damage than is taking place today.

This concern has led agricultural researchers to look for ways to strike a balance that will conserve our natural and human resources, while at the same time promote economic development. One major outcome of this concern has been the call for new technologies that minimize erosion, and other enviromental damage. For these new, less damaging technologies to have an effect, they must be used. For them to be introduced at the individual farm level, they must directly benefit the farmer. This study investigates the incorporation of oats with high groat-oil content oats as an alternative technology that may offer some answers for the enviromental problem, without any subsequent reduction in profitability.

Problem and Justification

Soil erosion and the Iowa soils

The mid-western states of the U.S. are some of most productive agricultural areas in the world. But the combination of climate, slope, and intensive cultivation has resulted in serious soil erosion problems (Mannering et al., 1985). A 1981 USDA estimate showed that average annual soil losses on a high percentage of sloping cropland exceeds soil loss tolerance values (T values) in every state in the midwest. Studies indicate that continued erosion adversely affects yields even with improved technology. Wolman (1967) reported that the effectiveness of fertilizer applications diminishes as soil properties important to plant growth decline. Rosenberry et al. (1980) showed that even with higher rates of fertilizer to offset erosion losses, yield generally declines as soil shifts from one erosion phase to another.

During the 1970s and 1980s, there was increasing pressure for Iowa farmers to produce more grain for export.

This resulted in a push to produce more from the existing land resources to offset rapidly increasing prices of farm inputs such as fuel, chemicals, and machinery (Miller et al., 1988). With recent changes in agricultural markets, the emphasis has shifted from maximum output to competition. The key to export markets in the future will be low unit production costs. These factors have created a conflict between meeting the demands of export markets and applying necessary soil and water conservation practices on their farms, leading to enviromental problems.

In 1980, the Iowa General Assembly enacted legislation which established what is referred to as the "Iowa Soil 2000 Program." The primary objective was to reduce excessive erosion from all land within the state by the year 2000. As part of this project, scientists identified areas most vulnerable to soil erosion. Figure 1.1 shows the regions of Iowa grouped by four soil erosion potential categories: least, slight, moderate, and severe (Source: Iowa State University Extension Bulletin, Pm-1056, 1988).

Northeastern Iowa was identified as having severe erosion potential. In their study Miller et al. (1988), reported that many soils in this area are derived from loess and are shallow to bedrock. Crop yields on these soils may be very low when excessive erosion has occurred due to the lack of rooting depth. The combination of severe erosion

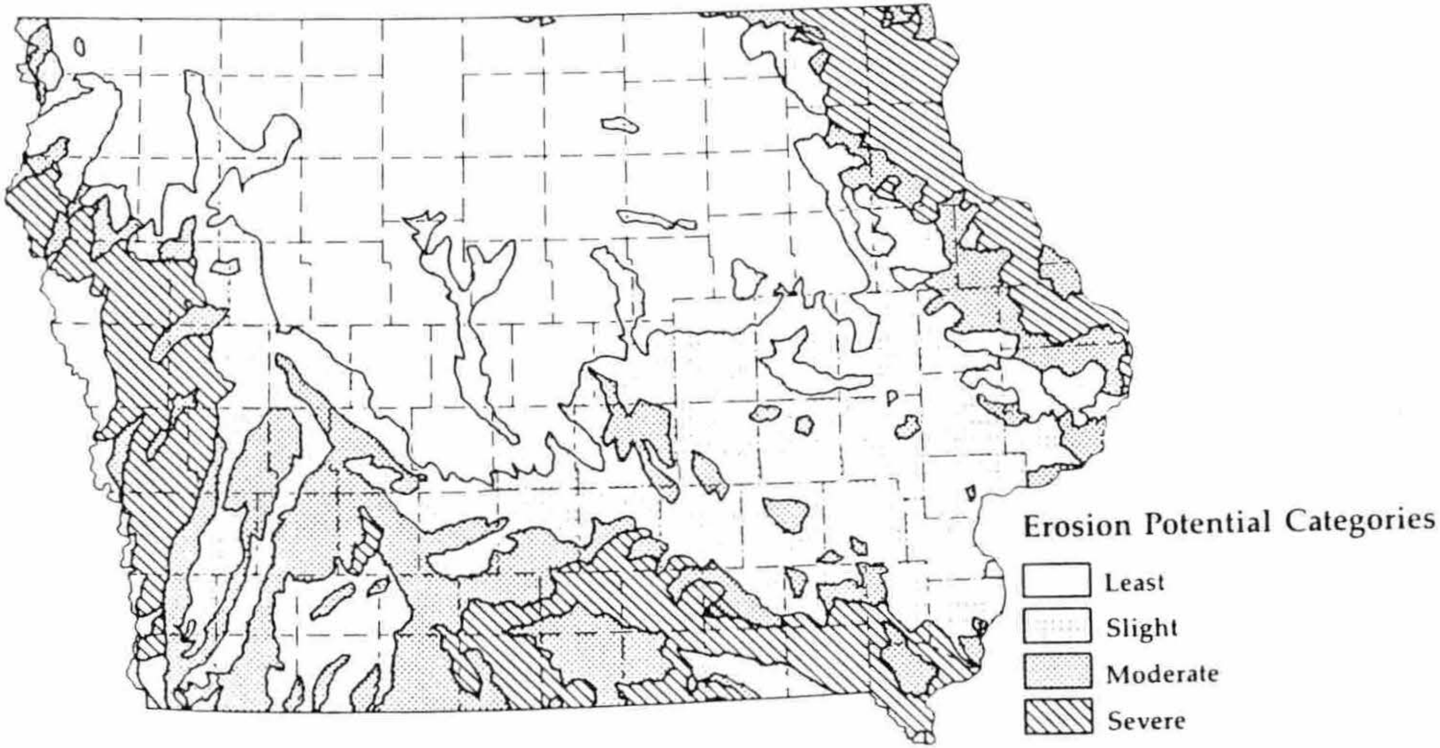

Figure 1.1 Erosion potential categories of Iowa cropland

potential and productivity loss requires agricultural practices that effectively manage these resources.

Low value of environmentally desirable crops

A major problem facing many farmers is that crops with desirable enviromental characteristics, such as small grains and legumes, have a relatively low value. They cannot compete economically with crops like soybeans or corn; therefore, farmers will not include them in their rotations. If a small grain crop that was more valuable than the existing crops could be developed, this would give farmers more options resulting in increased diversity. Farmers in areas where soybeans cannot be grown because the land is too steep would have an alternative crop that is environmentally desirable and also economically viable.

Effect of cropping pattern on soil erosion

The cropping pattern will have a large effect on the amount of soil erosion on these fragile soils. Erosion is low when the land is covered by permanent pasture or meadow, while some rotations offer more soil protection than others. Relative erosion hazards of selected crop sequences are shown in Table 1.1. (Source: "Soil Erosion and the Iowa Soil 2000 Program." Iowa State University Extension. August 1988).

Table 1.1 Relative erosion hazards of selected crop sequences. (Continuous corn = 100)[a]

Crop sequence	Relative Erosion hazard
Fallow	256
C-Sb	131
C-C-Sb	120
Continuous Corn	100
C-C-C-Ox	74
C-C-Ox	64
C-Ox	46
C-C-C-O-M	49
C-C-O-M	36
C-C-O-M-M	28
C-C-O-M-M-M	26
C-O-M	18
C-O-M-M	15
C-O-M-M-M	13
C-O-M-M-M-M	10
Continuous Cover	0

[a] C-Corn; Sb-Soybeans; O-Oats; Ox-Oats with green manure crop; M-Meadow.

This table shows that a corn-soybean rotation will lead to very high soil erosion, while a rotation that includes an oat crop will help control soil erosion by providing a cover which protects the soil from being washed away. The reductions in soil loss are due solely to increased cover from a rotation. No changes in tillage systems, contouring, terracing, or other practices are included. Again, if the crop sequences with better erosion control, more competitive economically are utilized, environmental degradation in fragile areas such as Northeast Iowa could be significantly reduced.

Crop diversity

Adding more diversity to the current existing systems will have implications for risk. Developing a crop that can be included in the farm plans will increase the diversity of the farm enterprises. Diversification implies growing two or more products in an attempt to avoid the yield and price uncertainty of a single product. The ultimate goal in diversification would be to select two products with prices (yields) that are inversely related (negatively correlated). That is when one price is at its peak, the other price would be at its minimum, with the same type of relationship existing between yields.

In fields where crops are rotated regularly, pests, weeds, insects, and pathogens cannot adapt to a single set of enviromental conditions and, therefore, do not increase as fast. Studies by Benson (1982), indicate that when intercropping is practiced, the pests in one crop may be controlled by the predators that inhabit the other. This may result in a reduction of the amount of chemicals applied to the whole system.

Economic forces over the past two decades have encouraged farmers to shift to monoculture systems. This shift has lead to a heavy reliance on herbicides and insecticides, with the penalty being that chemical poisoning is now threatening water quality. Increasing the diversity in the current systems may lead to a reduction in the amount of chemical applied.

Oats Production

There has been a gradual reduction in the acreage under oats production. During the mid-1950s, oats were a major crop in Iowa, with over six million acres harvested. Oats have declined in importance since then, with the acreage harvested for grain currently ranging from 6-7 hundred thousand acres, which is 2-3% of all principle cropland harvested. Currently oats are grown with poor production techniques on land that is too steep to be seeded to corn or soybeans (Frey and Hammond, 1975).

Factors contributing to reduction in oats acreage

There are many factors that have contributed to the low value of oats and subsequent reduction in the oats acreage. Bollingberg (1989), in his statement before the Committee on Agriculture, U.S. Senate, stated the following as reasons that may explain the decline in oat production.

The 1981 and 1985 Farm Acts, and the Department of Agriculture's implementation of the Feed Grains Program authorized under these laws, set oat target prices low relative to other competing crops and therefore failed to provide sufficient protection and incentives for farmers to grow oats.

The other problem noted is that farmers grow more highly-supported commodities year after year, regardless of the current market condition. Therefore, even though farmers have some flexibility between oats and barley, they will plant barley because its target prices have historically been between $0.96 and a $1.00 higher than those for oats.

Hoffman and Ash (1990) cited other factors that may have contributed to the decline in oats acreage as: the decline in profitability in relation to other cash crops (e.g., soybeans or corn); the decline in oats use as a feed ingredient; the decline in use within rotations; and the increase in farm enterprise specialization for both crops and livestock.

Current Research in High Groat-oil Oats

Preliminary research results obtained by oat breeders at Iowa State University indicate that high groat-oil oats may be a viable crop for farmers in Northeast Iowa. Increasing the oil percent of the oats could make it a more valuable crop. If the value of oats increases, then farmers may include it in the current farming systems. Including oats into the current farming systems is going to have implications for risk and diversity for farmers. Another advantage is that oats are an excellent soil erosion control crop, and a good rotation crop because they require lower inputs relative to other crops.

There is a considerable range in the lipid content of existing oat groats. Frey and Hammond (1975) reported that a survey of oil percentage in 445 Oats cultivars and collections gave a range of 2-11%. Recent studies at Iowa State University have demonstrated the possibility of increasing the groat-oil content through selection (Branson and Frey, 1989). Currently, oat breeders have developed an oats strain with up to 16% groat-oil content and studies show that there is potential of increasing the oil content even further.

A high groat-oil oats line may be more economically viable than the current existing cultivars. Frey and Hammond (1975) calculated that if oats had 17% groat-oil content combined with the present level of grain yield and protein content, oats might compete as an oilseed crop by producing high quality culinary oil. Since this new strain will have a higher oil percent, and may therefore be more valuable than the current commercial varieties, the introduction of high groat-oil content oats into a representative farm will have implications for income, risks, rotations, diversity, and the environment.

Composition of oat-oil

Thro et al. (1985) reported that oat-oil consists of triglycerides in which the primary fatty acids are palmitic, oleic and linoleic. Oil quality depends on relative contents of the various fatty acids. Palmitic acid contributes to oil stability, and saturated fatty acids confer properties necessary in culinary oils; of the latter linoleic acids are essential in mammalian nutrition. Linolenic acid, which occurs in very small quantities in oat oil, causes oil instability. Of the major oat-oil fatty acids oleic acid was the only one positively correlated with total oil content. Oleic and linoleic acids are nearly equal in amount in the oil of commercial oat cultivars than in other seed oils, resulting in a compromise between stability and nutritive value. Oat oil has a lower content of unstable linolenic acid than soybean oil.

Oats have seldom been considered a potential source of edible oil because the amount of oil found in the current commercial cultivars (3.8 to 8.5 %) is too low to make extraction profitable (Kalbasi-Ashtari and Hammond, 1977). Increasing the groat oil content makes extraction profitable, which makes it possible to produce oat flour. Increasing the groat oil could further make this crop a higher energy feed grain (Stothers, 1977) and perhaps a source of edible vegetable oil (Frey and Hammond, 1975) and antioxidant compounds (Hammond, 1983). Frey and Hammond (1975) calculated that if oats had 17% groat oil combined with present levels of grain yield and protein content they might compete as an oil seed crop for producing high quality culinary oil. Hammond (1983) calculated that extraction of oil from oats with 10% groat oil would add 2 cents net per kilogram to the current oats price.

Advantages of High Groat-oil Oats

The introduction of high groat-oil oats is expected to have a significant impact on existing farming systems. Oats will offer several advantages to farmers:

1. Oats is a close seeded crop and offers good ground cover to the soil, minimizing erosion.

2. Oats is an excellent rotation crop. Not only does crop rotation reduce the need for chemical fertilizer application by preserving soil fertility, but oats also requires less nitrogen from the soil compared to many other crops.
3. Including another crop in the rotation may reduce the amount of chemical applied to the fields because rotation tends to control pests, weeds, insects, and pathogens.
4. A new crop offers farmers an alternative to the existing crops and will increase the diversity of the farming system.
5. Fieldwork hours and labor requirements for farm operators are generally most constraining during planting and harvesting of field crops. Oats is a short season crop and will be planted and harvested earlier than corn or soybeans, so they do not compete with other major farming practices and may possibly improve price and yield stability.

If high groat-oil oats are grown the products will include an oat-oil of a high culinary quality, a high valued defatted oat-flour which could be used for human consumption, oat-bran, and oat-hulls. Depending on prices and markets these products could increase the value of the high groat-oil oats.

High groat-oil oats may be adapted to Northeast Iowa farm plans where corn and meadow are the major crops produced. Since oats are grown in this area of Iowa, farm operators are familiar with cultural practices for growing this crop and can make adaptations for this new system.

It is in the light of these arguments that this paper sets out to investigate the feasibility of introducing high oil oats into cropping systems currently in use or innovative cropping systems that might be developed.

Objectives

The objective of this research is to investigate the economic potential of high groat-oil oats on a representative farm in Northeast Iowa. Specifically, including the high groat-oil oats on a representative farm will be evaluated in terms of returns, annual soil loss, risk, and sensitivity to changes in the yields and prices of the high groat-oil oats.

The following specific questions will be addressed.

1. How would increasing the oil content of oats affect its value as a feed for livestock ?
2. How do the distribution characteristics of the yields, prices, and net revenues for the high groat-oil oats, in terms of the correlations, standard deviations, and mean relate to those of the other crops grown ?

3. What economic incentives related to risk and returns exist for the inclusion of the high groat-oil oats in the farm plans ?
4. What is the effect of including a soil loss constraint on risk and returns to the farm, if high groat-oil oats are available to farmers ?

Overview of the Thesis

The economic potential of high groat-oil oats will be evaluated using a representative farm in Northeast Iowa. The primary analytical technique is a whole-farm linear programming model based on data from ISU extension, and outlying research stations of Iowa State University and University of Wisconsin. The linear program will include risk parameters to investigate income and risk strategies for the representative farm.

This thesis is organized as follows. Chapter II reviews some of the theory related to adoption and assessment of a new technology, and the economic theory related to optimal portfolio selection. Chapter III includes an explanation of the analytical procedures and data. Chapter IV incorporates results and interpretation of results. Chapter V includes a summary, conclusions, and suggestions for future research.

CHAPTER II.

CONCEPTUAL CONSIDERATIONS

Numerous studies have been developed to study the process of technology transfer. The vast literature on models of technology adoption have been written by sociologists and economists. This section reviews the technology transfer process as studied by sociologists and economists. Although this study does not consider the sociological model of technology adoption, it is mentioned here because the adoption of a new technology will be influenced by sociological as well as economic factors. This study will concentrate mainly on economic factors that affect the adoption of a new technology.

Sociological Models

New knowledge is of little or no value to society until it is applied. Therefore, the factors that influence the adoption of a new technology will play a major role when a new technology is being developed or evaluated. Beal and Rogers describe the study of adoption of a new technology as a study of individual decision-making.

Definition of adoption

Adoption is defined as the process, by which, a farmer becomes aware of, gathers information about and decides to use or not to use a new farm practice (Beal and Rogers, 1960). Rogers (1962) defines adoption as the mental process through which an individual passes from first hearing about an innovation to final adoption. Feder, Just, and Zilberman (1982) define final adoption at the individual level as the degree of use of new technology in long-run equilibrium when the farmer has full information of the new technology and it's potential.

Stages of adoption process

Studies done by sociologists have showed empirical evidence that the potential adopter of a new technology moves through five stages. The earliest empirical evidence of the validity of stages in the innovation decision process comes from an Iowa study (Beal and Rogers, 1960). Later Rogers (1962) reported several studies done that showed similar evidence for the existence of stages in the innovation process. These five stages of adoption process can be described as: the awareness stage, when the individual is first exposed to a new technology; information stage, during which the individual starts to gather information of the new technology; the application stage, when the individual begins to evaluate the appropriateness of the new technology; the trial stage, when the individual decides to try the new technology on a small scale basis;

and finally the adoption stage, when the individual decides to adopt or not adopt the new technology.

Characteristics of innovations

Beal and Rogers (1960), and later Rogers (1962) reported that some characteristics of the innovations play a major role in explaining different rates of adoption of a new technology. These can be factors such as the relative advantage of the new technology over the old technology. The degree to which the new technology is perceived as being consistent with the existing values will also affect the rate of adoption of a technology. Another aspect considered significant is the level of complexity of the new technology. Generally, new ideas that are simple to understand will be adopted faster than those requiring the adopter to learn new skills. Trialability which is the extent to which an innovation may be tested can affect its rate of adoption. Finally, how observable the results of the new technology are, will influence the adoption rate. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt.

Adopter categories

Personal characteristics of the farmer may influence the adoption of a new technology. The study by Beal and

Rogers (1960) divides farmers into five adopter categories for purposes of providing an easier understanding of the diffusion process. The categories are; innovators; early adopters; early majority; late majority; and non-adopters or laggards. The criteria of categorization is a continuous variable, and its division into discrete adopter categories is similar to the division of socio-economic status into social classes.

This sociological model of adopter characteristics can be very useful in making decisions about targeting information for specific groups depending on their stage in the adoption process.

Economic Models

Economists have also studied the process of technology transfer, their efforts are combined under the broader topic of technical or institutional change (Jolly et al., 1985). Knudson and Larson (1989), define technology as generally the application of accumulated knowledge in society, and technical change as the application of new knowledge. Economists tend to use the term, technology, to describe a relatively specific and discrete way of producing something. Technical change looks at how research and development activities alter the basic relationships among inputs and outputs.

The different economic theoretical models of adoption show that observed diffusion patterns depend crucially on complicated relationships between different factors such as the risk associated with various technologies, the nature of farmers attitudes to risks, the existence of fixed adoption costs and the availability of cash resources (Feder, Just, and Zilberman, 1982). Similar innovations may experience different adoption patterns in different areas by different groups of farmers.

The following section is a review of empirical work in economics of the key explanatory factors affecting the adoption of a new technology.

Profitability

Agricultural studies support the hypothesis that profitability is one of the primary factors in explaining differential rates of adoption. One of the first economic analysis of technology transfers was Griliches' 1957 study of the diffusion of hybrid corn. Griliches' (1957) method involved a survey of the data by states and crop reporting districts. To measure the adoption, time-series data from states and crop reporting districts on relative area planted to hybrid was used. From the results, Griliches (1957) concluded that it was possible to account for a large share of the spatial and chronological differences in the use of hybrid corn with the help of economic variables. Griliches (1957) reported that differences in the both the long-run equilibrium use of hybrids and in the rate of approach to that equilibrium level are explainable by differences in the profitability of the shift from open pollinated to hybrid varieties. Measures of profitability to new technology suppliers and adopters appeared to explain most of the variation in adoption parameters. In his conclusions, Griliches (1957) did not consider the impact of "sociological" variables. He believed that the sociological variables tend to cancel themselves out, leaving the economic variables as the major determinants of the pattern of technological change.

Other early studies by Dixon (1980), Globerman (1975), and Mansfield (1981) also place primary emphasis on profitability in explaining different rates of adoption. Since these early studies, additional economic aspects added to this basic model are farm size, credit availability, risk and uncertainty associated with the different technologies, fixed adoption costs, labor supply problems, tenure type and the availability of cash resources (Feder, Just, and Zilberman, 1982).

Farm size

In their survey, Feder, Just, and Zilberman (1982) found that farm size was one of the first factors on which the empirical adoption literature focused. Farm size can have different effects on the rate of adoption depending on the characteristics of the technology and institution setting. They reported that the relationship of farm size to adoption depends on such factors as fixed adoption costs, risk preferences, human capital, credit constraints, labor requirements, and tenure arrangements.

Human capital investment

Human capital investments and investments in education, health, information, and experience will have an effect on adoption behavior. Rahm and Huffman (1984) used a model of adoption behavior to study differences econometrically in farmers decisions to adopt reduced-tillage practices and the efficiency of farmers adoption decisions. The empirical results obtained from microdata, showed that investments in farmers formal schooling and continuing education enhance the efficiency of the adoption decision.

Labor availability

The availability of labor affects farmers' decisions regarding adoption of new agricultural practices or inputs.

Some new technologies are relatively laborsaving, while others are labor using. In their survey Feder, Just, and Zilberman (1982) gave an example of an ox cultivation technology as being laborsaving, therefore its adoption may be encouraged by labor shortage. While, on the other hand, HYV technology generally requires more labor inputs so labor shortages may prevent adoption. They also note that new technologies may increase the seasonal demand for labor so that adoption is less attractive for those with limited family labor or those operating in areas with less access to labor markets.

Credit availability

Several studies have found that the lack of credit is an important factor in limiting the adoption of innovations. Access to capital in the form of either accumulated savings or capital markets is necessary in financing the adoption of many new agricultural technologies (Feder, Just, and Zilberman, 1982). Feder (1982) analyzed the impact of a binding credit constraint on the adoption decisions involving two interrelated, agricultural innovations. The results demonstrated that policies which include subsidies on input and output prices, special credit facilities, and various methods to disseminate information may have different effects on adoption of apparently complementary components of a new technological package.

Learning and information

Studies show that learning and information are important factors in the adoption decision under uncertainty. Feder and O'Mara (1982) formulated an aggregate innovation diffusion model based on the assumption that individual farmers revise their beliefs in a Bayesian fashion. They hypothesized that learning and information play a major role in innovation diffusion. In their model, a diffusion process was constructed where uncertainty about an innovation (high-yielding varieties-HYV) depends on the cumulative area allocated to HYV. This represents experience. With the accumulation of experience, uncertainty declines, and the innovation is adopted by an increasing proportion of producers. Another approach used by Hierbert (1974) was to introduce experience explicitly into an uncertainty model of the adoption process. He examined the effect of "learning" under uncertainty on the decision to adopt fertilizer responsive seed varieties. "Learning" is interpreted to mean gaining more information about the probability distribution of output which reduces the possibility of allocative error. Hiebert (1974) found that additional information and enhanced ability to 'decode' information are shown to increase the likelihood of adoption.

Risk and uncertainty

In recent years there have been many studies trying to empirically establish the role of perceived risk and risk aversion in explaining the adoption of innovations. There may be subjective risk because yields and net revenues are uncertain with the new technology, or objective risk due to weather variations, pest susceptibility, and uncertainty regarding timely availability of inputs (Feder, Just, and Zilberman, 1982). Farmers' technology choices are based on their exposure to information regarding new technology. Therefore, domestically developed new varieties may be received more favorably by farmers than unfamiliarly imported varieties. Feder, Just, and Zilberman (1982) hypothesize that more exposure to appropriate information through various communication channels reduces subjective uncertainty. In their survey they found that many studies on the impact of risk and uncertainty have been plagued by measurement problems. In many cases, proxies which measure the extent of information to which the farmer is exposed, are used. These proxies may be; visits by extension agents; attendance of demonstrations; exposure to mass media; literacy; level of education; and period of time spent out of the village.

Portfolio Theory

From the above discussion it is obvious that there are many factors that will influence the adoption of a new technology. In this study we are concerned with two of these factors, profitability, and the role of perceived risk and risk aversion in explaining the adoption of a new technology. In this context, technology evaluation and adoption can be represented as a portfolio choice problem.

The availability of a new production technology presents the farmer with a portfolio selection problem: Should the new technology (an asset) be added to the existing portfolio? If so what changes in the existing portfolio are required?

The aim of portfolio analysis is to allocate resources across a selection of risky activities that maximizes the decision makers utility (Anderson, Dillon, and Hardaker, 1977). Portfolio analysis in the farm setting investigates the diversification of economic activities to reduce risk and enhance the economic viability (Lee et al. 1988). This discussion on portfolio theory follows closely the work by Markowitz (1959); Copeland and Weston (1988); and Anderson, Dillon, and Hardaker (1977).

One of the earliest analysis of portfolio selection was by Markowitz (1959). Markowitz (1959) derived an expected profit-variance (E, V) frontier and then showed that, under certain conditions the efficient frontier that maximizes expected utility can be derived from the expected utility hypothesis. He defined the efficient frontier as the combination of investments that provide either the highest possible return for any specified degree of risk or the lowest possible risk for any specified expected return.

The optimal portfolio for an investor in Markowitz's (1959) model is determined by the tangency point between the efficient frontier and the investor's expected utility indifference curve. This is illustrated in Figure 2.1. The figure shows three different indifference curves and the investment opportunity set. Portfolios on the efficient set constitute combinations having maximum expected net return, E, for given variance of net return, V, or minimum V for given E. The (E, V) frontier is thus known as the efficiency locus or the efficient set in (E, V) portfolio analysis. The figure is constructed such that risk is measured on the horizontal axis and the expected returns on the vertical axis. Thus, more risky activities have a higher variance and are located more to the right in the figure, and the higher the expected returns the higher the activity.

In order to maximize utility of the optimal portfolio chosen, the marginal rate of substitution between the investors preference for risk and return represented by

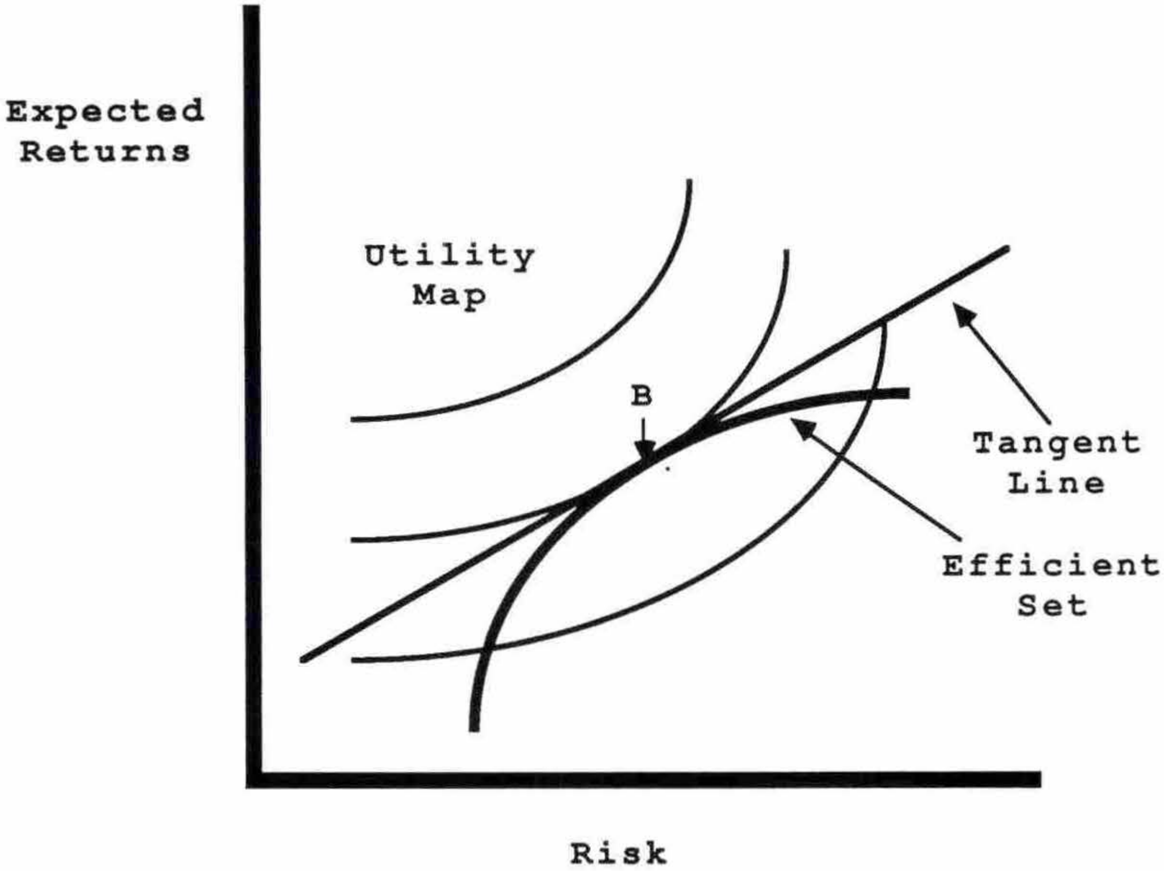

Figure 2.1 Portfolio Selection Model

indifference curves must equal the marginal rate of transformation of the efficient set. The line drawn tangent to the indifference curve at B, in Figure 2.1, is the marginal rate of substitution between risk and return. This line is also tangent to the efficient set at point B. Therefore the slope represents the trade-off between risk and return offered by the opportunity set.

The utility-maximizing portfolio can be found by trying different portfolios along the efficiency locus until one where the marginal rate of transformation between risk and return along the minimum variance opportunity set just equals the marginal rate of substitution along the indifference curve is found. The fact that this point is unique is guaranteed by the convexity of the indifference curve and the convexity of the upper half of the efficient set.

Diversification in portfolio theory

The theory of diversification also plays an important role in the portfolio theory. As the number of assets in the portfolio increases, the portfolio variance decreases and approaches the average covariance. Investors are able to minimize the variance of the portfolio for a given level of expected returns by investing in more than one type of enterprise.

If investment returns are not correlated, then diversification can eliminate risk. If correlations among returns of investments are perfectly correlated, or the returns from all the investments fluctuate in perfect unison, then diversification would not eliminate risk. In general, returns on investments are more correlated with those in the same industry than those of different industries.

To reduce risk it is important to avoid portfolios whose investments are all highly correlated with each other. Enterprises having negative correlations have the greatest potential for stabilizing income through diversification. If returns for two enterprises are negatively correlated, low annual returns for one are generally accompanied by high annual returns for the other, and vice versa.

Diversification often allows the variability of a portfolio's return rate to be significantly less than the variability of the individual components of the portfolio. Variability of total farm income depends upon not only the variability of individual enterprise returns but also upon the correlation of returns among enterprises.

MOTAD

Several quantitative methods have been developed that present the analysis of technology choice within a portfolio framework to address risk in decision making, but no available procedure is completely satisfactory. Most of those approved use risk-programming that are based on either mean-variance or MOTAD (minimizing of total absolute deviations) decision criteria (Tauer, 1983).

Hazell (1971) developed a linear programming method that minimizes total absolute deviations around the mean level of income. In this model, the risk efficient frontier is derived from the expected income-absolute deviations (E-A) frontiers. Efficient E-A farm plans can be defined as those having minimum mean absolute income deviation for given expected income level, E. The E-A frontier is developed by parametrically running the model with regard to mean income and minimizing deviations from mean income (Watts, Held, and Helmers, 1984). Hazell (1971) notes that the E-A criterion has an important advantage over the E-V criterion in that it allows a linear programming model to be used in deriving the efficient E-A farm plans. By redefining the variables, the E-A criterion can be transformed so the model is solved on conventional linear programming codes with the parametric option, and provides a set of farm plans that are efficient for expected income and mean absolute income deviation.

Target MOTAD

Both the expected income-variance (E, V) and expected income-absolute deviations (E, A) criteria have been frequently used to analyze crop mixes, livestock production decisions and marketing strategies. These criteria have been criticized because they are not always consistent with the widely accepted utility approach to decision-making under uncertainty (McCamley and Kliebenstein, 1987).

Tauer (1983) and Watts et al. (1984), both proposed an alternative model for computing risk efficient mixtures of risky alternatives. They presumed that most decision makers do not base their estimation of the risk associated with a particular enterprise on the mean and variance (or mean absolute deviation), but rather on negative deviations from some target level of income. Earlier studies by Fishburn (1977) showed that investors frequently associate risk with failure to attain a target return. Fishburn's (1977) results also showed a close relationship between stochastic dominance criteria and the mean-risk dominance model in which risk was measured as deviations from a target return.

Target MOTAD maximizes mean income subject to a limit on the total negative deviations measured from a fixed target rather than from the mean. Tauer notes that the proposed model is a two-attribute risk and return model. Any given solution is associated with one (or more) combination(s) of target income, T, and the absolute value of expected negative deviations from target income, λ. A Target MOTAD frontier can be developed for each target of interest.

The Target MOTAD model has the form:

(1) $\text{Max } c'x$

Subject to

(2) $Ax \leq b$

(3) $-Cx - y = -uT$

(4) $p'y \leq \lambda$

(5) $x, y \geq 0$

where

c,	is an n element column vector of expected returns for the various activities,
x,	is an n element column vector of activity levels,
b,	is an m element column vector of resource or technical levels,
A,	is an m by n matrix of resource or technical requirements,
C	is an s by n matrix of returns associated with the activities for various states of nature,
y,	is an s element column vector of deviations from target income,
T,	is target income, u is a column vector of 1's,
p,	is an s element column vector of probabilities

associated with the various states of nature,

λ, is the absolute value of expected negative deviations from target income,

n, is the number of activities, m is the number of resource constraints, and

s, is the number of observations or states of nature.

This Target MOTAD is similar in construction to models used by Tauer (1983), Watts et al. (1984), and later by McCamley and Kliebenstein (1987).

One of the major advantages of Target MOTAD is that portfolios on the Target MOTAD efficient frontier are all members of the second-degree stochastic dominance (SSD) efficient set. This reduces the need for strong assumptions about the decision makers utility function or the statistical distribution of the portfolio assets. The minimization of the total absolute negative deviations also captures some of the same ideas and reasoning of the safety-first approach of decision-making. A safety-first criterion may be more appropriate for modelling the behavior of limited resource farmers or small farms which are most frequently part-time farming operations as well (Herr, 1988).

The utility map of an individual is difficult to define. Empirical problems in measuring individual utilities as well as measuring aggregated utility across individuals have been reported in many studies. When the utility function and its parameters are not well known, it may be appropriate to identify all solutions associated with a larger class of utility functions (Williams, Llewelyn, and Barnaby, 1990).

As a first step toward evaluating risk and returns of the high groat-oil oat technology an efficiency frontier will be estimated using Target MOTAD. In this way, all of the information in the model and its underlying data base can be conveniently displayed.

CHAPTER III.

METHODOLOGY AND DATA

To examine the economic potential of introducing a high groat-oil oat line into the existing farming systems, a representative farm from Northeast Iowa was selected.

Northeast Iowa has soils of the Fayette and Fayette-Dubuque-Stonyland soil association areas. The soils found in this area are Downs with 2-20% slopes, Fayette with 1-30% slope and Dubuque with 5-20% slope. On the steepest slopes there is steep stonyland which is not suitable for cultivation. According to a USDA Soil Survey in 1989; Fayette soils are well drained and are on gently sloping to moderately sloping ridgetops and moderately steep to very steep sideslopes; Dubuque soils are shallow to limestone bedrock on the lower part of the side slope; Downs soils are well drained and are on gently sloping and moderately sloping to moderately steep sideslopes. Miller et al. (1988), reported that the soils in this area are formed in loess on narrow ridgetops. These soils have a high potential to erode. Figure 3.1 presents the relation of slope, vegetation and parent materials to soils of the Fayette and Fayette-Dubuque-Stonyland soil association areas in Northeast Iowa (Iowa State University Cooperative Extension Service Bulletin AG-35, 1965).

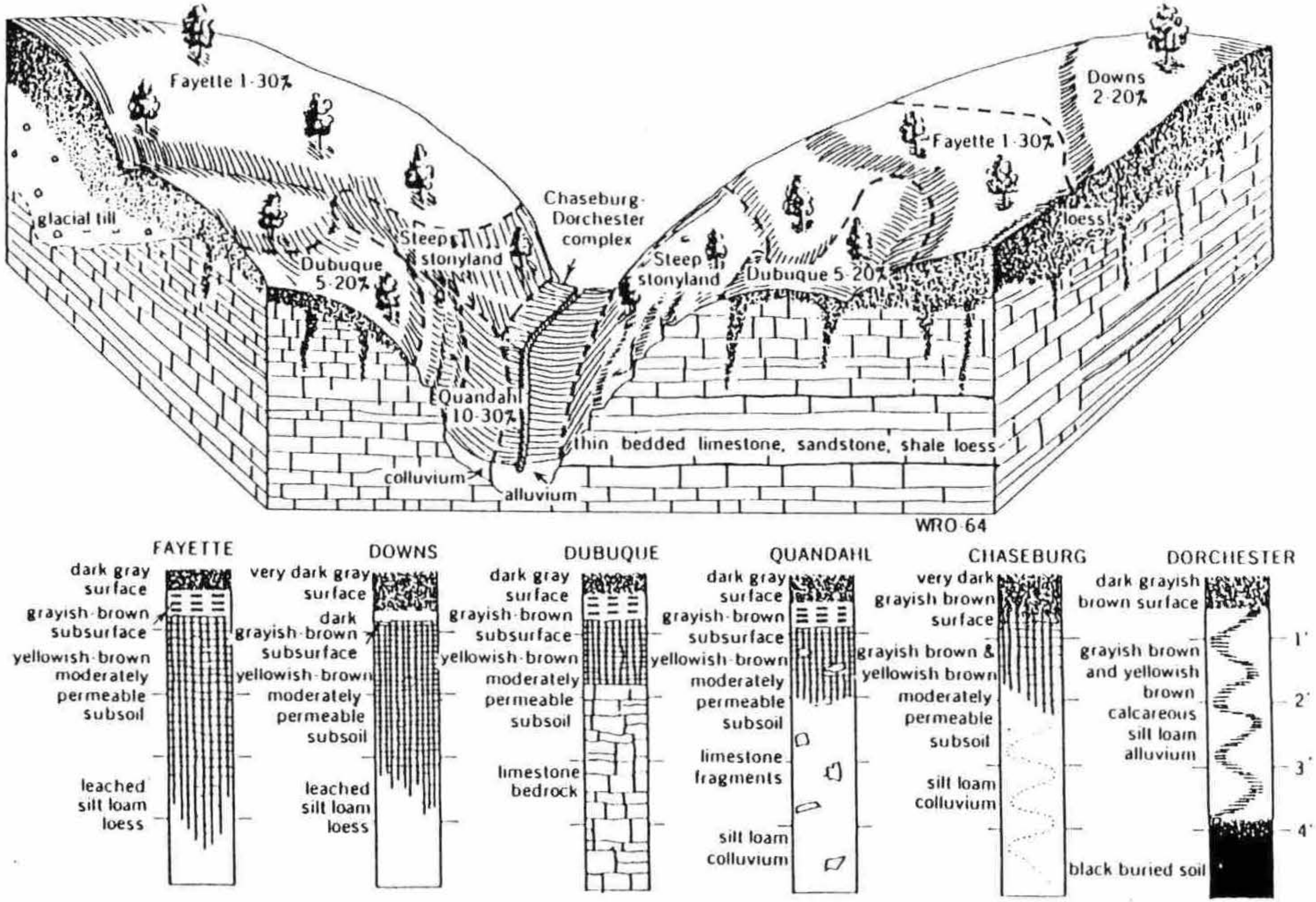

Figure 3.1 Relationship of slope, vegetation and parent materials of soils in the representative farm

General description of Northeast Iowa

The average temperature in this area is 47.30 degrees, with an average precipitation of 22.17 inches. In Northeast Iowa crop production accounts for 54% of the gross product, while livestock contributes 15% (Duffy, 1989).

The major crops grown in this area are corn, soybeans, oats, wheat, and hay. Corn is produced in the largest quantity, with 1,348,000 acres harvested for grain (Iowa Agricultural Statistics, 1989). The corn produced in this area makes up about 12.6% of the total corn produced in Iowa. In this area the production of soybeans is on a much smaller scale, with 475,000 acres harvested for beans, this is about 6% of the total acres harvested for Iowa (Iowa Agricultural Statistics, 1989). A large acreage of oats is planted for all purposes, 294,000 acres, of this acreage less than half, 146,000 acres is harvested for grain. About 25% of all oats produced in Iowa is from Northeast Iowa (Iowa Agricultural Statistics, 1989). Hay and alfalfa hay are major crops because this is the main livestock producing area.

According to the Iowa Agricultural Statistics for 1989, three of the leading counties in hogs and pigs production, and four of the leading counties in cattle and calves production are in Northeast Iowa. Annual inventories of cattle and calves is approximately 800,000 head.

Approximately 3,660,000 head of hogs are marketed each year for Northeast Iowa. More than 50% of all milk cows in Iowa, 187,000 head, are found in this area.

Farm Description

The size of the representative farm and its soil resources were based on the acreage of the farm described by Pope et al. (1982), for the purposes of this study the acreage was doubled to reflect a commercially viable operation. Gross farm size was assumed to be 830 acres. Approximately 30 acres of land was assumed to be used for the homestead, roads, drainage ways, and other non-agricultural purposes.

The farm descriptions are summarized in Table 3.1. Each of the soil types is defined in terms of soil type legend, slope class, erosion phase, and capability class.

Soil mapping units (SMU)

From Table 3.1, the soil type legend, slope class, and the erosion phase can all be collectively identified as a soil mapping unit (SMU). The soil mapping unit (SMU) symbol classifies a soil type according to its slope class and erosion phase. This data is from "Iowa Soil Properties and Interpretations Database (ISPAID) for 1990."

Table 3.1 Description of the representative farm

Principal Soil Association: Fayette-Dubuque-Stonyland,
Location: Central Allamakee,
Gross Farm Size: 830 acres, Net farm size: 800 acres

Soil Type Name	Soil Type Legend	Slope Class	Erosion Phase	Capability Class	Acres of SMU
Fayette	163	C	1	3E	80
Fayette	163	D	2	3E	200
Fayette	163	E	2	4E	56
Steep Rock	478	G	1	7S	224
Downs	162	C	1	3E	240

Soil type legend Each soil is a associated with a particular soil type legend, and in this farm these soil type legends are: Fayette - 163, Steep rock - 478, and Downs - 162. After consultations with Gerald Miller and Thomas Colvin (Agronomy extension and Agricultural Engineer, Iowa State University, 1990) the steep rock was excluded from the model because it is not suitable for farming.

Slope class In the representative farm the slope classes of the soils are specified as follows:

C = 5-9% = Moderately sloping

D = 9-14% = Strongly sloping

E = 14-18% = Moderately steep (Western Iowa = 14-20%)

G = 25-40% = very steep

Erosion risk generally increases with increasing slope.

Land capability class A land capability class and subclass is defined for the farm. Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The numbers used are 1 to 7 and they indicate progressively greater limitations and narrower choices for practical use. The letters used E, W, S indicate the soils limitation within one class (ISPAID, 1990). For example Fayette has a land capability class of 3E.

Defining Crop Rotations

There are five crops included in this study corn, soybeans, alfalfa hay (as the meadow), oats, and the high oil oats (HFOats). Although there are other crops grown in Iowa, these crops make up approximately 90% of the total crop acres harvested in Iowa (Iowa Agricultural Statistics, 1989).

Upon consultation with Michael Duffy (1990b) and Craig Chase (1990), Extension Economists, Iowa State University, twelve rotations were defined for the purpose of this study:

Continuous Corn

Corn-Soybeans
Corn-Corn-Oats-Meadow
Corn-Oats-Meadow-Meadow
Corn-Oats-Meadow
Corn-Oats
Corn-Corn-Oats-Meadow-Meadow
Corn-Corn-HFOats-Meadow
Corn-HFOats-Meadow-Meadow
Corn-HFOats-Meadow
Corn-HFOats
Corn-Corn-HFOats-Meadow-Meadow

These rotations were selected because they included oats and allowed comparison with the existing cropping systems. For comparison, these rotations include activities with regular oats and high oil oats. Some rules of thumb used in making the rotation choices were:

1. No continuous soybeans were used because of disease and weed control problems.
2. No soybean following meadow rotations were used because corn normally follows meadow to utilize the nitrogen fixed.
3. Corn following oats, and corn following HFOats rotations were included to make it possible to compare it to the corn following soybeans rotation.
4. No continuous oats rotation was included, because of

frequent disease and pest problems, and reduction in yield.

Defining Tillage Systems

Three tillage systems were defined after consultation with Michael Duffy (1990b) and Craig Chase (1990). It was presumed that these would be representative of the different tillage systems used in Iowa. These tillage systems were also chosen because reasonably accurate data was available. The three tillage systems were chisel, ridge, and no-till tillage. The operations in each tillage system were defined according to the rotation.

Description of tillage systems

The chisel tillage system uses full width cultivation and seedbed preparation. A chisel is used after harvest to bury the crop stubble, this is followed by a fall fertilizer application. The land is disked in the spring just before planting. This is followed by a rotary hoe and a herbicide application. In summer there is usually one cultivation before the crops are harvested in the fall. A moldboard plow was included for a corn following meadow rotation. The ridge tillage system included the same field operations as the chisel tillage system, with the exclusion of the fall chisel plow, and the tandem disk in spring. The major difference between ridge till and the no-till was in the planting equipment used, the no-till system used. It is important to note that the no-till received some cultivations. No-till for the purposes of this study is defined as no preplant tillage. Studies by Erbach (1982), and later by Brown et al. (1989), found that it is not uncommon for no-till systems to include one cultivation for weed control in Iowa.

Field operations and costs involved in the tillage systems

The field operations involved in each tillage system for the rotations were defined after consultation with Thomas Colvin and Craig Chase (Agricultural Engineer and Extension Economist, Iowa State University, 1990).

The estimated machinery costs are from the "Estimated Costs of crop production in Iowa, 1990" (Duffy, 1990a). The cost estimates are for on-farm use, excluding labor. The size of machinery assumed is an average of those in used in Iowa. Variable costs per acre include fuel, oil, and repairs.

These systems are defined in terms of the field operations for the different crops in Tables 3.2 to 3.8. The tables describe the field operations involved in each tillage system for all the crops in the study. The tables include the season the operation is performed; su-summer,

Table 3.2 Description of tillage systems for corn following corn

Field operation	Chisel	Ridge	No-Till
Broadcast Granular P & K (f)	X	X	X
Chisel plow (f)	X		
Anhydrous Ammonia (f)	X	X	X
Tandem disk (sp)	X		
Rotary hoe (sp)	X	X	
Plant (sp)	X	X	X
Herbicide (sp)	X	X	X
Cultivation (su)	X	2X	2X
Harvest (f)	X	X	X

Table 3.3 Description of tillage systems for corn following soybeans

Field operation	Chisel	Ridge	No-Till
Broadcast Granular P & K (f)	X	X	X
Chisel plow(f)	X		
Anhydrous Ammonia	X	X	X
Tandem disk(sp)	X		
Rotary hoe (sp)	X	X	
Plant (sp)	X	X	X
Herbicide (sp)	X	X	X
Cultivation (su)	X	2X	2X
Harvest (su)	X	X	X

Table 3.4 Description of tillage systems for corn following meadow

Field operation	Chisel	Ridge	No-Till
Broadcast N P K (f)	X	X	X
Moldboard plow (f)	X	X	
Tandem disk (sp)	X		
Rotary hoe (sp)	X	X	
Plant (sp)	X	X	X
Herbicide (sp)	X	X	X
Cultivation (su)	2X	2X	X
Harvest (f)	X	X	X

Table 3.5 Description of tillage system for soybeans following corn

Field operation	Chisel	Ridge	No-Till
Chisel plow (f)	X		
Tandem disk (sp)	X		
Field cultivator (sp)	X		
Rotary hoe (sp)	X	X	X
Plant (sp)	X	X	X
Herbicide (su)	X	1.5X	1.5X
Cultivation (su)	X	2X	2X
Harvest (f)	X	X	X

Table 3.6 Description of tillage systems for meadow following meadow, oats or HFOats

Field operation	Chisel	Ridge	No-Till
Broadcast P & K (f)	X	X	X
Harvest:			
Mower-conditioner (su)	3X	3X	3X
Bale (su)	3X	3X	3X
Haul (su)	3X	3X	3X

Table 3.7 Description of tillage systems for oats or HFOats following corn

Field operation	Chisel	Ridge	No-Till
Chisel (f)	X		
Tandem disk (sp)	X	2X	
Field cultivate (sp)	X	X	
Drill seed (sp)	X	X	
No-Till drill (sp)			X
Harvest (su)	X	X	X
Rake (su)	X	X	X
Bale (su)	X	X	X

Table 3.8 Description of tillage systems for corn following oats or HFOats

Field operation	Chisel	Ridge	No-Till
Broadcast N P K (f)	X	X	X
Chisel plow (f)	X	X	
Spread Anhydrous Ammonia (sp)	X	X	X
Tandem Disk (sp)	X		
Field cultivate (sp)	X		
Plant (sp)	X	X	X
Rotary Hoe (sp)	X	X	
Herbicide (sp)	X	X	X
Cultivation (su)	X	2X	2X
Harvest (f)	X	X	X

sp-spring, and f-fall. For example, from Table 3.3, the no-till tillage system for a corn following corn rotation would involve: Broadcast granular P & K application in the fall, an anhydrous ammonia application in the fall, plant in spring, herbicide application in spring, two cultivations in summer, and harvesting in the fall.

Fieldwork hours

Hours of fieldwork by system and rotation were calculated using data from "Estimating Field Capacity of Farm Machines, 1986." Labor requirements were estimated by attaching farm machinery field capacities to the operations listed for the tillage systems. These capacities which estimated hours per acre were then summed across each tillage system and for each rotation.

To calculate number of fieldwork hours available for the three different seasons: The number of suitable fieldwork days were estimated using "Fieldwork days in Iowa, 1980," then these figures were converted to field labor hours available using relationships estimated between crop acres and field labor hours in spring and fall (Edwards and Boehlje, 1980).

Hours of fieldwork by system and rotation are presented in Table 3.9. In this table CC is continuous corn, CS is corn-soybeans, CCOM is corn-corn-oats-meadow, COMM is corn-oats-meadow-meadow, COM is corn-oats-meadow, CO is corn-oats and CCOMM is corn-corn-oats-meadow. In general, rotations that include meadow have a much higher labor requirement in the summer because meadow is harvested three times. Rotations such as CC, CS, and CO do not require as much labor. The CC and CS rotations require the most labor in the fall.

By defining field operations by time-period, a labor requirement is obtained for 3 time periods: fall, spring, and summer.

Table 3.9 Hours of fieldwork per acre by tillage systems for the rotations

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Chisel tillage							
Fall labor	0.75	0.61	0.41	0.25	0.29	0.37	0.35
Spring labor	0.41	0.45	0.28	0.18	0.24	0.39	0.22
Summer labor	0.15	0.24	1.56	2.81	2.03	0.40	2.28
Ridge tillage							
Fall labor	0.59	0.45	0.33	0.21	0.24	0.29	0.28
Spring labor	0.28	0.30	0.27	0.19	0.26	0.38	0.21
Summer labor	0.30	0.31	1.60	2.81	2.03	0.47	2.31
No-Till tillage							
Fall labor	0.59	0.45	0.27	0.15	0.16	0.29	0.23
Spring labor	0.30	0.30	0.19	0.12	0.16	0.24	0.16
Summer labor	0.30	0.31	1.56	2.77	1.98	0.47	2.28

Budgeting Crop Activities

Costs of production

Crop budgets were constructed to reflect returns over variable costs. The primary source of data for the costs of production were obtained from a long-term fertility study conducted at Nashua Research Station (unpublished data, Northeast Iowa Research Center, 1980-1989). The Nashua study included costs of production for four different nitrogen fertilizer levels, but the purposes of this study only three were chosen. Nitrogen was applied in anhydrous ammonia form. All the nitrogen was applied to the first year corn.

Herbicide programs varied by rotation but not by tillage system. This is because there have been no recent studies done that reflect different herbicide programs for the three tillage systems selected in this study.
In collecting the cost data for the cropping activities, the general aim is to find costs that reflect average crop production cost situations across all cropping activities.

The costs of the seed, chemical and fertilizer (phosphate and potash) applied were all obtained from the Nashua organic study (unpublished data, Northeast Iowa Research Center, 1980-1989). The costs used in this study were ten-year averages of the period between 1980 and 1989.

To develop the machinery costs for the crops for each of the three tillage systems, the lists of various field operations on tables 3.2 to 3.9 were used. Variable costs for these machinery for different field operations were calculated using "Estimated Costs of Crop Production in Iowa, 1990". A sample of the total variable costs for the rotations are shown in Tables 3.10 to 3.12. Sample budgets for rotations, under the three tillage systems, at 100 lbs of nitrogen are provided in Tables 3.10 to 3.12. The budgets for 50 lbs and 200 lbs of nitrogen applied are attached in the Appendix.

Yield and price data

The ten-year yield data was from a crop rotation study conducted at the Lancaster Experiment Station in Southwestern Wisconsin on Fayette-Dubuque soils (unpublished data set, University of Wisconsin Agricultural Research Center, 1980-1989). Nitrogen was applied to corn in the rotations at rates of 50, 100, 200 pounds per acre.

Ten-year time-series data on the prices of corn, soybeans, oats, and meadow was obtained from "Agricultural Prices 1989-1980 summaries". These prices were adjusted for inflation using the implicit deflator for GDP, 1980:100 (The WEFA Group, World Economic Service - Historical Data, 1990).

Table 3.10 Costs per rotated acre for chisel tillage, at 100 lbs of nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	19.33	19.29	27.39	22.56	30.08	28.57	21.91
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	23.39	21.76	15.86	12.24	13.35	15.60	14.47
Fertilizer	32.88	26.51	28.75	26.58	27.38	28.58	27.84
Machinery	23.55	21.04	26.49	29.65	27.47	21.96	28.43
Var Costs	129.68	109.93	113.20	98.16	107.71	109.97	104.47

Table 3.11 Costs per rotated acre for ridge tillage, at 100 lbs of nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	19.33	19.29	27.39	22.56	30.08	28.57	21.91
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	23.39	21.76	15.86	12.24	13.35	15.60	14.47
Fertilizer	32.88	26.51	28.75	26.58	27.38	28.58	27.84
Machinery	20.97	18.18	25.14	28.95	26.54	21.71	27.35
Var Costs	127.10	107.08	111.85	97.46	106.77	109.72	103.39

Table 3.12 Costs per rotated acre for no-till system, at 100 lbs of nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	19.33	19.29	27.39	22.56	30.08	28.57	21.91
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	23.39	21.76	15.86	12.24	13.35	15.60	14.47
Fertilizer	32.88	26.51	28.75	26.58	27.38	28.58	27.84
Machinery	21.66	19.31	23.45	27.08	24.04	20.05	26.00
Var Costs	127.79	108.20	110.16	95.59	104.28	108.06	102.03

Intermediate products

In developing the coefficients of the production activities for the model farm, it was assumed that all the farm output was sold. Because yields were assumed to be stochastic, the model did not allow for the transfer of produce from one enterprise to another. For example all of the corn produced in the farm was sold for cash. Corn required for livestock was purchased directly to the livestock at market prices. In this way the risk of crop pricing and production and livestock costs was integrated in the model's structure.

Soil Loss Data

The annual soil loss on a given soil mapping unit (SMU) under a given tillage system was estimated using the

Universal Soil Loss Equation (USLE). The universal soil loss equation enables planners to predict the average rate of soil erosion for each feasible alternative combination crop system and management practice in association with a specified soil type, rainfall pattern, and topography (Nethery, 1990). The equation is expressed as follows:

$$A = R\ K\ L\ S\ C\ P$$

where,

A, is the computed soil loss per unit area, expressed in tons per acre per year.

R, is the rainfall and runoff factor. "R" values in Iowa are 150 and 175.

K, is the erodibility factor for the particular soil type.

L, the slope-length factor, is a ratio of soil loss from the field slope length to that from a 72.6 ft length under identical conditions.

S, the slope-steepness factor, is the ratio of soil loss from the field slope gradient to that from a 9 percent slope under otherwise identical conditions. The slope length and steepness factors are combined into a common factor referred to as the LS factor when using the formula.

C, the cover and management factor, is the ratio of soil loss from an area with the specified cover and management to that from an identical area in tilled continuous fallow.

P, the supporting practice factor "P" in USLE describes the effect of contour or cross-slope tillage practices on sheet and rill erosion.

The USLE is designed to predict longterm-average soil losses for specified condition. To obtain the annual soil loss for the cropping activities under the three tillage systems, information from a USDA technical guide notice was used.

Several assumptions were used to calculate the annual soil loss for the four soil mapping units:

Calculation of RKLS factors

In Table 3.13, the estimated RKLS and the T-values for each SMU are presented. The RKLS factor is simply the product of the estimated R, K, L, and S. The T-value is not part of the USLE. It is a limit of the average annual loss that an acre of soil of defined characteristics can tolerate per year and still permit a high level of crop productivity to be sustained economically and indefinitely. The "R" value used in this study was 175. The "K" factor was obtained from ISPAID 5.1 data (1990). To calculate the "LS" factor the length of slope assumed was 200 feet.

Table 3.13 RKLS factors

Soil Type	SMU	R	K	LS	RKLS	T
Fayette	163C1	175	0.32	0.95	53.20	5
Fayette	163D2	175	0.37	2.00	129.50	5
Fayette	163E2	175	0.37	4.00	259.00	5
Downs	162C1	175	0.28	0.95	46.55	5

Calculation of the C and P factors

The crop management factors, C, and the supporting practice factor, P, for the different combinations of tillage systems and crop rotations are presented in Tables 3.14 to 3.16. To calculate the "C" factor an assumption of 30% cover after planting was used for chisel and ridge tillage systems, and a 50% cover after planting for the no-till system. In the calculation of the "P" factor, the support practice used was contouring. Contouring was assumed to be practiced for all the systems. A moderate (3-5") ridge was assumed for the chisel tillage, for the ridge tillage ridge systems with ridge height greater than or equal to 6" was used, and low (1-3%) ridge was used for the no-till.

In the tables the C and P factors are described in terms of slope, EI, and Row Grade, where EI is the storm intensity factor, and Row Grade is an assumption of how well

Table 3.14 C and P Factors, 5-9% slope, EI 100, row grade 0%

Rotation	Chisel	Ridge	No-Till
C-C	0.09	0.06	0.03
C-S	0.12	0.07	0.06
C-C-O-M	0.06	0.04	0.03
C-O-M-M	0.04	0.03	0.03
C-O-M	0.04	0.03	0.03
C-O	0.07	0.05	0.05
C-C-O-M-M	0.05	0.04	0.03

Table 3.15 C and P Factors, 9-14% slope, EI 100, row grade 0%

Rotation	Chisel	Ridge	No-Till
C-C	0.11	0.07	0.05
C-S	0.14	0.09	0.10
C-C-O-M	0.06	0.05	0.04
C-O-M-M	0.05	0.04	0.04
C-O-M	0.05	0.04	0.03
C-O	0.08	0.06	0.07
C-C-O-M-M	0.06	0.04	0.04

Table 3.16 C and P Factors, 14-18% slope, EI 100, row grade 0%

Rotation	Chisel	Ridge	No-Till
C-C	0.12	0.08	0.06
C-S	0.15	0.10	0.12
C-C-O-M	0.07	0.05	0.04
C-O-M-M	0.05	0.04	0.04
C-O-M	0.05	0.04	0.04
C-O	0.09	0.07	0.08
C-C-O-M-M	0.07	0.05	0.04

the row follows the contour. In this study a 0% row grade was used. This implies that the row crops follow the contour perfectly. An EI value of 100 was assumed.

An indication of potential erodibility of the various cropping systems can be obtained from Tables 3.14 to 3.16. Note that the CS rotation had the largest CP factor, and rotations that include a meadow had the lowest CP factors for all three slopes. The larger the CP factor the greater the erosion potential of the soil will be. The No-Till system also had the lowest CP values for all the rotations. There is a 25-40% increase in the CP factor as the slope increase from C slopes to E slopes. With the CC and CO rotations showing a 33% and a 28% increase in CP factors, respectively.

Yield adjustment for tillage systems and soil types

Upon consultation with Richard Cruse (Agronomist, Iowa State University, 1990a) adjustment factors to determine the differences in yields between tillage systems and soil types were defined for the rotations. These factors are based on long term studies done by Cruse. It is necessary to adjust the yields because the type of tillage system used on the land will have an impact on yield. This may be because cultivation tends to loosen the soil. The soil type will also have an effect on yield, some soils have a higher potential for better yields than others.

To adjust the yield for the different soil types: The Downs silty loams were assumed to have 10% more yield potential than the Fayette soils. By using the Corn Suitability Ratings (1988), corn yields from the Downs soils have been shown to be an average of 10% higher than corn yields from the Fayette soils.

The adjustment factors for the tillage systems are shown in Table 3.17. These adjustment factors were for the whole rotation not just the row crops. These factors show that the no-till system will have lower yield potential the chisel and ridge tillage systems.

Table 3.17 Adjustment factors for tillage systems

	Tillage system		
Rotation	Chisel	Ridge	No-till
CC	0	0	-10%
CS	0	0	-3%
CCOM	0	0	-3%
COMM	0	0	-3%
COM	0	0	-3%
CO	0	0	0
CCOMM	0	0	0

Livestock Activities

Two livestock enterprises included in the model are farrow to finish hogs and a dairy enterprise. These livestock enterprises were selected after consultations with animal scientists suggested that the potential of utilizing HFOats as animal feed would be greater in dairy and hogs enterprises. The following is a brief description of each livestock enterprise in the LP model. The budgets used for the livestock enterprise are from "Livestock Enterprise Budgets for Iowa-1990" (Edwards and Judd).

Farrow-to-finish hogs enterprise

There is one farrow to finish hogs activity, in total confinement. Each sow produces 1.8 litters of pigs annually which are fed on the farm. A weaning average of 8.2 pigs is assumed, minus 0.40 death loss and 0.40 for replacement, leaving 7.4 pigs per litter to be fed to 235 lbs. The model allowed for 100 sows per year. In this farm all the labor required for the farrow-to finish hogs enterprise was hired, this implying that a permanent person was hired to take care of the hogs. Income from the hog enterprise comes from the sale of market hogs and cull sows. The output used for the market hogs and cull sows are from the "Livestock enterprise budgets for Iowa - 1990" (Edwards and Judd). Ten-year time-series data (1980-1989) of the prices was obtained from the

"USDA Agricultural Marketing Service Iowa - Southern Minnesota Direct Hogs" in Des Moines, Iowa.

Dairy enterprise

A dairy enterprise is included in the model. Each cow unit produces 15,000 lbs of milk annually. The income of the dairy enterprise comes from the sale of milk, 0.32 head of a cull cow, 0.49 head of a dairy calf, and 0.12 head of a replacement heifer. The model had a limit of 50 dairy cows per year. The labor required in the dairy enterprise was all hired labor. The yields used in the enterprise are from the "Livestock enterprise budgets for Iowa - 1990". The prices for the dairy yields are from "Agricultural Prices Summaries 1980-1989".

Manure credit

The variable costs for the livestock were adjusted for manure credit by assuming all the manure produced would be sold at its nutrient value. The nutrients in livestock manure as produced were obtained from "Livestock Waste Facilities Handbook, 1985". These nutrients were then priced using the fertilizer prices in "Estimated Costs of Crop Production in Iowa - 1990". The value of manure credit is presented in Tables 3.18 and 3.19.

Table 3.18 Value of manure credit for the dairy enterprise ($/cow/year)

Nutrient	Amount Produced	Price per lb	Total Value ($)
Nitrogen	210 lb/yr	$ .19	39.9
Phosphate	116 lb/yr	$ .25	29.0
Potassium	166 lb/yr	$ .14	23.24
Total Value			92.14

Table 3.19 Value of manure credit for the hog enterprise ($/1.8 litters/year)

Nutrient	Amount Produced	Price per lb	Total Value ($)
Nitrogen	151.2 lb/yr	$ .19	28.73
Phosphate	115.2 lb/yr	$ .25	28.8
Potassium	118.8 lb/yr	$ .14	16.63
Total Value			74.16

Livestock prices and budgets

The prices for both livestock enterprises are adjusted for inflation using the Implicit deflator for GDP, 1980:100. The farrow to finish activity has facilities that allow for 100 sows a year. The dairy activity has facilities for 50 dairy cows a year. Budgets for the livestock enterprises are shown in Tables 3.20 and 3.21.

Table 3.20 Swine Production (1.8 litters/sow/year)
Farrow-to-Finish Total Confinement

INCOME		$
Market Hogs (235lb * 7.4 head)		1443.55
Cull Sows (400lb * 0.38 head)		103.51
Manure credit		74.16
Gross Income		1621.22
VARIABLE COSTS		
Feed Costs		
Corn @ 2.43 per bushel	194.4 bu	472.39
Supplement and Minerals		443.52
Feed Additives		25.00
Total Feed Costs		940.91
Veterinary and health		50.40
Fuel, repairs, utilities		72.00
Bedding, marketing, misc.		54.00
TOTAL VARIABLE COSTS		1117.31
INCOME ABOVE VARIABLE COSTS		503.91

Table 3.21 Grade A Dairy (One Cow Unit)
15,000 lb of milk per cow annually

INCOME			$
Milk Sales	150 cwt of milk		1528.50
Cull cow	0.35 head * 1300 lb		150.42
Dairy calf	0.49 head		27.93
Repl. Heifer	0.15 head		117.66
Manure credit			92.14
Gross Income			1916.65
VARIABLE COSTS			
Feed Costs			
Corn @ 2.01 per bushel		112 bu	272.16
Corn Silage			264.45
Hay equivalents			
Salts and minerals			10.40
Protein Supplement			84.50
Improved pasture			10.50
Milk replacer, calf starter			17.00
Total Feed Costs			659.01
Hauling			67.50
Veterinary and Health			52.00
Fuel, repairs, utilities			153.00
Breeding Fees			28.00
Bedding, misc.			70.00
TOTAL VARIABLE COSTS			1029.51
INCOME ABOVE VARIABLE COSTS			887.14

Feeding Value of the HFOats

To determine the feeding value of the HFOats for the livestock, least cost rations (LCR) from the Animal Science Department were used. Before developing the LCR rations HFOats was first analyzed to determine its composition.

Analysis of HFOats

Sell (Animal Scientist, Iowa State University, 1990) analyzed the HFOats to determine the percentage of metabolizable energy, protein, dry matter, ash, and fat content of the whole seed. The tests done were for three samples of varying oil percentages: 15.43, 12.51, and 5.8. The 5.8% oil content oats was used as control, because it represents the oil percent of the current existing varieties. The results of this analysis are provided in Table 3.22.

These results indicate that besides the oil content there was no significant difference in the chemical composition of high oil oats and the regular oats. Although the results show a slight reduction in nitrogen level it was felt that the results showing a decrease in nitrogen were not significant because the samples used were very small and may not be representative.

Table 3.22 Results of the analysis to determine composition of high oil oats

	Groat oil content		
Item	15.43	12.51	5.8
		%	
Dry Matter	92.44	92.11	91.47
Protein	12.06	13.85	13.79
Ash	3.10	2.76	2.56
Ether Extract	9.90	8.00	4.29
Fiber	31.76	30.41	30.82
Bulk Density	14.05	12.51	15.72

Least cost rations

Upon consultation with Jerry Sell and Douglas Kenealy (Poultry and Dairy Scientists, Iowa State University, 1990) least cost rations for hogs and dairy were developed using results from the analysis and using data from the "United States-Canadian Tables of Feed Composition for Dairy and Swine (NRC, 1988)". The LCR model was a linear programming model called Brill.

LCR for hogs Three least cost rations were formulated for three stages of swine growth: lactating sow, 5-10 kg hogs, and 50-110 kg hogs. These three rations differ in amount of nutrients required. The feeds considered were corn, soybean meal, bone meal, regular oats, and HFOats (high oil oats). There were restrictions on the amount of metabolizable energy, protein, lysine, tryptophan, calcium, and phosphorous.

LCR for dairy In formulating the ration for dairy, the feeds considered for this study were corn silage, alfalfa hay, soybean meal, corn, regular oats, and HFOats (high oil oats). There were restrictions on the amount of energy for lactation, crude protein, dry matter intake, digestible fiber, and the amount of forage consumed. The rations were formulated for a cow with average body weight of 1400 lbs, between the age of 10 months to 3 years, about 15,000 lbs of milk per year with 3.5% average fat test.

Sensitivity analysis of the LCR

The LCR for the dairy and farrow-to-finish hogs enterprise were initially run by pricing the HFOats at a very high price, and regular oats at the current price, 4.7 cents per lb. This was the base run, and the solution obtained was assumed to be the standard. Then HFOats and oats were priced at the same price (4.7 cents/lb) and the model was run. By examining at what level the HFOats came into solution this model was used to examine whether the feeding value of the oats increased when the oil content increased. Sensitivity analysis on prices and oil content was also tested. The following steps were involved in the sensitivity analysis.

Pricing sensitivity To study how sensitive the optimal ration was to price change, the price of the HFOats was increased and decreased gradually to determine the price at which the HFOats left the solution or replaced the corn in the solution.

Impact of increasing oil content To examine the impact of a further increase in the oil content of oats, it was assumed that the oil content of the HFOats could be further increased to 22%. The assumption that the only change in the composition was in oil content was made. This oats with 22% oil content was then included in the LCR. By pricing it at the at the regular oats price, the feeding value was examined. Then to study how sensitive the optimal results were to prices, the price was increased and decreased very gradually.

Pricing High Oil Oats

Since the HFOats is a new crop there is no existing data on its price. A method of pricing the HFOats was selected after consultations with Earl Hammond and Larry Johnson (Food Technologists, Iowa State University, 1990). HFOats was priced using its constituents. Each product from the oats would be priced separately, then the prices of all these components would be added up to give the price of the HFOats (high oil oats). Oats would be priced in two ways depending on the use of the meal byproduct. If the byproduct could be used as a defatted oat-flour, or the byproducts could fed to livestock. The pricing formulas are given below:

Pricing HFOats as a human food

Price of HFOats ($/bu) = price of oat-oil +
price of defatted oat-flour +
price of oat-hulls.

Pricing HFOats as an animal feed

Price of HFOats ($/bu) = price of oat-oil +
price of oat feed +
price of oat hulls.

Prices of HFOats products

There is no data available on the prices of oat-oil or oat feed because these products do not exist. Johnson (1990) and Hammond (1990) suggested that prices of products that may be similar in composition to these two could be used. The price of corn-oil could be used to price oat-oil because the oat-oil would be very close in composition to corn-oil. To price the defatted oat flour, which is oat flour after the oil has been removed, consultations were held with Steve Mavity (1990). He suggested that the defatted oat flour would sell at a higher price than the regular oat flour, because it has less spoilage and less oil. Therefore a premium of $1.00 per bushel above the price of regular oats flour for the defatted oat flour was suggested. The price of corn gluten feed was used to price the oat meal or oat feed.

Equations utilized to calculate the price HFOats

The following equations developed by Johnson were utilized to calculate the processor's value of HFOats when the byproduct was used as a human food or as an animal feed.

Price of HFOats as a human food:

Processor's Value =
Value contributed by oil($/bu) = W * 75% groat in berry * Y * Z
\+
Value contributed by flour($/bu) = W * 75% groat in berry * (100 - Y%) * A
\+
Value contributed by hulls($/bu) W * 25% hull in berry * B

Price of Oats as animal feed

Processor's Value =
Value contributed by oat-oil = W * 75%groat in berry * Y%* Z
\+
Value contributed by hulls = W * 25% hull in berry * B
\+
Value contributed by feed = W * (100-Y%) * Q

where,

W = test weight of oats (the standard is 32 lb/bu)

Y = percent oil in groat (15.43% was used in this study)

Z = price of corn oil in (cts/lb)

100 - Y = percent of defatted flour in groat

A = price of oat-flour in ($/bu)

B = price of oat hulls in (cts/lb)

Q = price of corn gluten feed (CGF) * %protein in oatmeal feed 21% protein in CGF

These results are made under the assumption that 75% of berry is groat, and all calculations are for 6.5% moisture in berry.

Source of price data

Using these equations and time series data for corn oil, corn gluten feed (CGF), oat flour, and oat hulls the price of HFOats was developed. The price for corn oil and corn gluten feed (CGF) were obtained from "USDA Situation and Outlook Reports, for Oils and Feed, 1980-1989," respectively. The prices for oat hulls were provided by Quacker Oats Co., and the price for oat flour were provided by Arrowhead Mills, Hereford, Texas.

Processing margin

The prices calculated using the above equations were the processor's value of the HFOats (high oil oats). To get the price farmers would receive a margin had to be deducted from this price to allow for the cost of processing the HFOats and profit. Since there is no data available on the costs of processing oil from HFOats, this premium was calculated by assuming the processing of the HFOats would be similar to soybean processing. Time series prices of the spread between value of product and soybean price were obtained from the "USDA Oil Crops Situation and Outlook Yearbook 1989". A similar spread was used for the spread between value of product and HFOats price received by the farmers. The price reported for the spread between value of products and soybean price was in dollars per bushel. Since there are 60 lb per bushel of soybean, the margin was adjusted to reflect the price per pound then multiplied by 32 to make it price per bushel of oats. Un other words, the processing margin was calculated on a weight rate than volume basis.

Target MOTAD Model Structure

The schematic structure of the Target MOTAD model is given in figure 3.23. The model consists of approximately 430 cropping activities, 6 livestock activities plus activities associated with risk. The Target MOTAD model requires a historical revenue or price series over a period of years, from which, each year's negative deviation from the Target income is calculated. Risk is incorporated in this model through stochastic prices and crop yields for the farm enterprise. Livestock production output was assumed to be non-stochastic. In this study historical prices and yields for the farm over a ten-year period (1980-1989) were used to calculate the negative deviations from the Target income level in each year, with each year's data given an equal weight.

The risk measure, λ in the empirical model of the representative farm is altered parametrically, at the same income level, to find alternative solutions. These solutions differed in terms of risk, expected income, and activities chosen. Very low levels of λ typically resulted in infeasible solutions. A solution identical to the deterministic solution was found when λ gets large enough that further increases in risk measure will not change the activities selected.

The software package utilized to solve the Target MOTAD model is the General Algebraic Modelling System GAMS (Brooke, Kendrick, and Meeraus, 1988). Linear Programming was used as the solution algorithm. GAMS is designed to make construction and solution of large and complex mathematical programming models more straight forward and easier to understand by users of models from other disciplines. GAMS was developed by an economic modelling group at the World Bank.

Calculation of Target income

The Target income was assumed to be the total cash living expenses, real estate taxes, life insurance, intermediate and long-term debt payments. Table 3.24 presents the balance sheet for the case farm based on "1988 Farm Business Summaries," for Northeast Iowa. Debt service for intermediate and long term debt assume 10 and 40 year amortization at 9 percent, respectively.

Family living expenses and life insurance are based on "1989 Family Living Expenditures of Iowa Farm Families." The income target is summarized in Table 3.25.

To compare solutions under a different target income, this target income was increased by assuming a higher debt to asset ratio of 70%, to give an income of $91,850.

Table 3.23 Simplified Target MOTAD model[a]

	Activities								
							Neg.Dev		
Constraints	XRot	FTFH	Dairy	Hlab	SDair	SHog	80	81	RHS
Obj Function	X	X	X	X	X	X			
Land	X								X
FTFH Faclim		X							X
Dairy faclim			X						X
Labor lim	X	X	X						X
FTFH yield		X							X
Dairy yield			X						
T-values	X								X
Annual income									
1980	-X				-X	-X	-y		-T
1981	-X				-X	-X		-y	-T
"									
Risk							.1y	.1y	λ

[a] XRot are rotation activities, FTFH is a farrow-to-finish hogs operation, Hlab is hire labor, SDair is sell dairy output, SHog is sell hog output, Neg. Dev is negative deviations from the target income, FTFH Faclim is the limit for the hogs facilities, Dairy Faclim is the limit on dairy facilities, Labor lim is the limit on fieldtime hours available per season.

Table 3.24 The calculation of Target income

	Assets		Liabilities	
	Percent	Value ($)	Percent	Value ($)
Short term	25	349,527	30	155,190
Intermediate term	20	279,621	10	51,730
Long term	55	768,960	60	310,380
Total		1,398,109		517,300

Table 3.25 Target income

Item	$
Total Cash Living Expenses	18,465
Long Term Debt payments	28,524
Intermediate Debt payments	8,061
Real Estate Taxes	6,912
Life Insurance	1,624
Target Income	63,586

CHAPTER IV.

RESULTS AND DISCUSSION

The results of this investigation are divided into four sections. To analyze the feeding value of the high oil oats, results from least cost rations for hogs and dairy will be discussed. This is followed by a discussion on pricing of the high oil oats. Then, descriptive statistics, correlations of the prices, yields and net revenues of the enterprises are compared. Finally, results from Target MOTAD linear programming model of the representative farm are used to evaluate the economic implications of including the high oil oats in farm plans.

The Least Cost Rations

To determine the feeding value of the HFOats for livestock, least cost rations (LCR) from Animal Science Department were used. The linear programming model used was Brill (The Brill Corporation, 1988). LCR were formulated for a dairy and farrow-to-finish hogs enterprises. The results from this analysis are reported below.

Least cost rations for swine

Three sets of rations were formulated for the farrow-to-finish swine operation. These rations were for three stages of the swine growth: lactating sow, hogs weighing

5-10 kilograms, and 50-110 kilograms. A typical swine ration for swine weighing 50-110 kilograms is presented on Table 4.1. The feeds considered in the formulation of this LCR for 50-110 kilogram hogs are corn, oats, soybean meal, mealy bonemeal, limestone, vitamins, minerals and some specific amino acids.

Table 4.1 Typical ration for swine weighing 50-110 kilograms

Ingredient Name	Percent of Mix	cents per lb
Corn	83.87	4.6
Oats	6.23	4.7
Soybean Meal	5.36	9.0
Mealy bone meal	3.00	11.0
Limestone	0.75	2.0
Minerals	0.30	42.0
Vitamin	0.30	67.0
Lysine	0.19	128.0

LCR for lactating sow Results from least cost rations for lactating sows indicate that the ration choices were sensitive to changes in price. When priced at the current oats price which is 4.7 cents per lb, HFOats made up 14.57% of the feed ration, while regular oats only constituted 5.79% of feed ration at that price. When the price of the HFOats was increased from 4.7 cents to 4.92

cents per lb, HFOats was replaced by the regular oats. This is higher than the price of corn. A decrease in price did not increase the percentage of HFOats in solution, this may imply that at oil content (9.9%), HFOats would never replace all the corn in the ration.

To study the implications of increasing the oil content of HFOats even further, a least cost ration was formulated for lactating sows assuming the HFOats had about 22% oil content. It was assumed that only oil content increased. Protein composition was held constant. At the current oat price, HFOats (22% oil content) and regular oats replaced corn in the diet. The ration was composed of 63.49%, and 15.86% HFOats and regular oats, respectively, and the soybean meal in the diet increased to approximately 16%. When the price of the HFOats (22% oil content) was increased to 4.92 cents per lb, it was replaced by the corn. Decreasing the price had no effect on this solution.

<u>LCR for 5-10 kilogram hogs</u> At 4.7 cents per pound, the current oats price, HFOats made up 22.6% of the ration and corn made up 70.94%. Decreasing the price of HFOats from 4.70 cents to 4.20 cents per lb, increased the percentage of HFOats in solution to 33.13%. A price increase to 4.92 cents per lb or greater resulted in HFOats being replaced by regular oats, which came into solution at a level of 9%.

This least cost ration was then run assuming oats had 22% oil content. The HFOats (22% oil content) came into solution at 20.19%, regular oats at 12.20%, and corn at 62.13%. These results were not sensitive to a price decrease. However, when the price was increased to 5.11 cents per lb or greater, HFOats (22% oil content) was replaced by corn and regular oats. These results suggest that HFOats would not be considered a major feed for hogs at this stage of growth.

LCR for 50-110 kilogram hogs Finally, a least cost ration was formulated for 50-110 kg hogs. This is a finishing ration and represents a major component in the total feed consumption by swine. At the current oat price, HFOats came into solution at 16.90%, while corn made up 74.58% of the diet. A decrease in price from 4.7 cents to 4.2 cents per lb resulted in HFOats entering the solution at 62.85%, and corn falling to 28.79%. These results were sensitive to a price increase. HFOats dropped out of solution when the price was increased to 4.81 cents per lb.

When the oil content for the HFOats in this least cost ration was increased to 22% at the current oat prices, the HFOats (22% oil content) entered the solution at 43.23%, corn at 39.01%, and regular oats at 13.24%. There was no change in solution when the price of oats was decreased to 4.2 cents per lb. However, increasing the price to 5.14

cents per lb resulted in HFOats (22% oil content) dropping out of solution and being replaced by corn and regular oats at levels of 83.87% and 6.23%, respectively.

Results from the dairy least cost ration

A least cost ration was formulated for a dairy enterprise. The typical ration for a dairy enterprise producing about 15,000 lbs of milk per year is shown in Table 4.2. The feeds considered in formulating the feed ration for the dairy enterprise are alfalfa hay, corn silage, shelled corn, oats, soybean meal 44%, limestone, and minerals.

Table 4.2 Typical ration for a dairy enterprise

Ingredient name	Pounds of dry matter	Pounds as-fed
Alfalfa hay	26.26	29.2
Shelled corn	20.95	23.8
Oats	2.93	3.3
Soybean meal 44%	4.17	4.7
Monosodium phosphate	0.21	0.2
plain salt	0.27	0.3

The results from the dairy ration were interesting in that the HFOats replaced corn in almost all instances. At current oats price, HFOats made up 43.9% of the ration, corn silage made up 44%, and alfalfa hay and soybean meal made up the rest. Corn was not in solution. The percentage of HFOats in the optimal solution did not vary as its price decreased. However, as the price increased from 10.34 to 11.08 cents per lb the percentage of HFOats dropped to 28.68%, and corn came into the solution at 13.87%. This solution would not change until the price of HFOats increased to 16.99 cents per lb.

Increasing the oil content of the HFOats further to 22% did not affect the above solution. The HFOats (22% oil content) behaved like the 9.9% oil content oats.

Summary of the LCR results

In summary, the results for the swine least cost rations imply that increasing the oil content would increase the feeding value of oats. This result is more significant for lactating sows and 50-110 kg finishing pigs. For the HFOats to completely replace all the corn in the feed rations, however, it would have to be priced at a much lower price than the corn.

Increasing the oil content to 22% resulted in more HFOats replacing the corn in the ration, although this result was very sensitive to a price increase.

The least cost rations for dairy indicate that increasing the oil content of oats would significantly improve its feeding value. In the tests done, when priced at the current price for oats, HFOats replaced the corn in the feed ration. The results were moderately sensitive to increased prices.

In the dairy ration increasing oil content to 22% gave the same results as the 9.9% oil content oats. These results imply that a further increase in oil content from 9.9% to 22% for dairy feed would not be necessary.

Pricing High Oil Oats

The prices of the high oil oats that were calculated are shown in Tables 4.3 and 4.4. The prices were determined for a ten year period. Table 4.3 shows the results of pricing oats when the byproducts of the HFOats are used for human food consumption. Table 4.4 shows the results of pricing oats when the byproducts are used as feed for livestock. The prices presented in these tables are all in nominal terms.

These results indicate that pricing oats as human food would increase the value of oats. When oats is priced as a human food the products that are considered are oat-oil, defatted oat-flour, and oat-hulls. The results indicate that an average of 83.3% of the price is contributed by the price of defatted oat flour. The remaining 13.67% is contributed by the oil and the hulls.

Table 4.3 Price of high oil oats
(oats priced as human food)

Year	Contribution of Oat-oil	Contribution of Oat-flour	Contribution of Oat Hulls	Processing Margin	Price of HFOats
	$/bu	$/bu	$/bu	$/bu	$/bu
1980	0.706	2.302	0.137	0.683	2.462
1981	0.554	2.786	0.137	0.672	2.805
1982	0.546	3.143	0.136	0.709	3.116
1983	0.584	3.351	0.136	0.704	3.367
1984	0.769	3.469	0.132	0.757	3.613
1985	0.731	3.705	0.068	0.747	3.757
1986	0.442	3.705	0.044	0.731	3.461
1987	0.512	3.746	0.020	0.992	3.286
1988	0.604	4.434	0.020	0.864	4.194
1989	0.500	5.176	0.076	1.040	4.711

Table 4.4 Price of high oil oats
(oats priced as animal feed)

Year	Contribution of Oat-oil	Contribution of Feed	Contribution of Hulls	Processing Margin	Price of HFOats
	$/bu	$/bu	$/bu	$/bu	$/bu
1980	0.706	1.045	0.137	0.683	1.205
1981	0.554	0.964	0.137	0.672	0.983
1982	0.546	0.996	0.136	0.709	0.968
1983	0.584	0.982	0.136	0.704	0.998
1984	0.769	0.618	0.132	0.757	0.761
1985	0.731	0.767	0.068	0.747	0.819
1986	0.442	0.801	0.044	0.731	0.556
1987	0.512	0.992	0.020	0.992	0.531
1988	0.604	1.006	0.020	0.864	0.766
1989	0.500	0.976	0.076	1.040	0.512

The results shown in Table 4.4 suggest that if the by-product can only be sold as a feed ingredient then, HFOats will have a processor value equivalent to existing oats. The prices presented in this table are low when compared to the price of HFOats priced as a human food because the feed produced does not contribute as much value to the price of the HFOats as does oat-flour.

Comparison of regular oats and HFOats prices

A comparison of these prices to the regular oats prices are shown on Table 4.5. The price of regular oats reported in this table represents the market value with no processing margin deducted. These results indicate that on the average, pricing oats as a human food may increase the value of oats by 95%. This result is very significant, and it implies that if a high oil oats crop was produced commercially its greatest potential will be in its use to produce oat flour. Therefore, to increase the value, HFOats would have to be produced and utilized as human food.

The Variability of Farm Enterprises

The standard deviation measures the variability for a given enterprise, while the coefficient of variation provides a measure for comparing variability relative to the mean of a particular enterprise. In this section some

Table 4.5 A comparison of the prices of oats

Year	HFOats Human Food	HFOats Animal Feed	Regular Oats
1980	2.462	1.205	1.70
1981	2.805	0.983	1.90
1982	3.116	0.968	1.70
1983	3.367	0.998	1.80
1984	3.613	0.761	1.90
1985	3.757	0.819	1.30
1986	3.461	0.556	1.17
1987	3.286	0.531	1.60
1988	4.194	0.766	2.90
1989	4.711	0.512	1.82
Average	3.477	0.810	1.779

descriptive statistics are presented to study the variability of individual enterprises.

Price statistics

Ten-year means, standard deviations, and coefficients of variation (CV) for alternative enterprise prices are shown on Table 4.6. The prices presented have been adjusted for inflation using the implicit deflator for GDP, 1980:100 (The WEFA, World Economic Service - Historical Data, 1990).

According to prices, livestock enterprises are less variable than the crop enterprises with respect to the coefficient of variation. The price of market hogs shows the least amount of variability (CV = .126). From the crop enterprises the prices of oat flour and HFOats (priced as animal feed) show the least amount of variability, CV = .139, and CV = .141. The prices of oat hulls and corn show the highest amount of variability with CV = .643, and CV = .315.

Yields statistics

Table 4.7 provides the means, standard deviations, and coefficients of variation for alternative crop enterprise yields. The yields presented in this table were for the Downs soil type with 100 lbs of nitrogen fertilizer applied to the crops.

Table 4.6 Means, standard deviations, and coefficients of variation for alternative enterprise prices

Enterprise	Ten-Year Mean Prices	Standard Deviation	Coefficient of Variation
Corn ($/bu)	1.98	0.623	0.315
Oats ($/bu)	1.42	0.357	0.251
Soy ($/bu)	5.00	1.201	0.240
Hay ($/ton)	45.87	10.027	0.219
HFOats(feed)[a] ($/bu)	1.25	0.176	0.141
HFOats(food)[b] ($/bu)	2.74	0.248	0.090
Corn-oil ($/ton)	20.24	5.093	0.252
Corn Gluten Feed($/ton)	86.37	18.735	0.217
Oat Flour ($/cwt)	9.81	1.368	0.139
Oat Hulls ($/ton)	17.68	11.363	0.643
Cull Cow ($/head)	33.06	5.497	0.166
Milk Cow ($/head)	784.43	209.858	0.268
Calves ($/head)	55.85	9.730	0.174
Milk ($/cwt)	10.19	1.495	0.147
Market Hogs ($/head)	37.73	4.760	0.126
Cull Cow ($/head)	30.99	5.855	0.189

[a] HFOats (feed) is high oil oats priced as animal feed.
[b] HFOats (food) is high oil oats priced as human food.

Table 4.7 Means, standard deviations and coefficients of variation for alternative crop enterprise yields

Enterprise	Ten-Year Mean Yields	Standard Deviation	Coefficient of Variation
Continuous Corn (bu/A)	125.00	39.330	0.315
Corn after Meadow (bu/A)	141.54	45.350	0.320
Corn after Oats (bu/A)	130.93	37.133	0.283
Corn after Soy (bu/A)	146.93	35.756	0.243
Oats after Corn (bu/A)	65.21	17.897	0.274
Soy after Corn (bu/A)	41.61	15.441	0.371
Meadow after Oats (ton/A)	4.41	1.473	0.334
Continuous Meadow (ton/A)	4.66	1.250	0.268

The yields of a corn after soybeans rotation show the least amount of variability with CV = .243. On the other hand, the highest amount of variability is shown by the yields of soybeans in this rotation (corn-soybean) with CV = 0.371. This may suggest that even though the yields of corn in a corn-soybean rotation are less variable, the effect is offset by the variability of soybean yields in this rotation. In general, these results suggest that the overall variability of yields for crops is more constant compared to the variability of the prices.

Enterprise gross margins

Mean gross margins, standard deviations, and coefficients of variation for the alternative enterprises of the farm are presented on Table 4.8. Gross margins are defined as the gross income minus variable costs. Livestock enterprises are less variable than crop enterprises with respect to the coefficient of variation. The dairy enterprise shows the least amount of variability relative to its mean (CV = .275) followed by the hog enterprise (CV = .355). The greatest variability is displayed by the gross margin of the corn-oats rotation (CV = .866), followed by the continuous corn rotation (CV = 0.779).

An important implication of these results is that rotations that include HFOats show a much lower variability

Table 4.8 Mean gross margins, standard deviations and coefficients of variation for alternative enterprises[a]

Enterprise	Ten-Year Mean Gross Margin	Standard Deviation	Coefficient of Variation
	($)	($)	
CC ($/A)	92.48	72.00	0.779
CS ($/A)	140.55	101.04	0.719
CCOM ($/A)	94.95	61.65	0.649
COMM ($/A)	104.08	49.57	0.476
COM ($/A)	76.93	49.33	0.641
CO ($/A)	63.76	55.24	0.866
CCOMM ($/A)	107.77	57.14	0.530
CCAM ($/A)	120.25	59.41	0.494
CAMM ($/A)	139.00	55.44	0.399
CAM ($/A)	113.20	49.05	0.433
CA ($/A)	118.03	56.03	0.475
CCAMM ($/A)	135.03	53.17	0.394
DAIRY ($/cow)	1001.75	275.18	0.275
HOGS ($/lit)	464.23	164.84	0.355

[a] Where CC is continuous corn, CS is corn-soybeans, CCOM is corn-corn-oats-meadow, COMM is corn-oats-meadow-meadow, COM is corn-oats-meadow, CO is corn-oats, CCOMM is corn-corn-oats-meadow-meadow, CCAM is corn-corn-HFOats-meadow, CAMM is corn-HFOats-meadow, CAM is corn-HFOats-meadow, CA is corn-HFOats, CCAMM is corn-corn-HFOats-meadow-meadow.

compared to those rotations that include the regular oats. The corn-HFOats rotation has a CV of 0.475 compared with 0.866 for regular oats. This dramatic reduction in relative viability is largely due to an increase in the mean of the HFOats rotation rather than a decrease is in variance.

The Correlation Matrices

The variability of total farm income depends upon not only the variability of individual enterprise returns (Tables 4.6, 4.7, and 4.8), but also upon the correlation of returns among the farm enterprises. Ideally, enterprises having negative or low correlations will have the greatest potential for stabilizing income through diversification.

Correlations between crop yields

Correlation coefficients between crop enterprise yields are provided in Table 4.9. Oat yield has low correlations with all other crop enterprises, the lowest being the correlation with soybean oat and meadow yields which are both negative. This low correlation between oats and meadow yield suggests that rotations that include oats and meadow would have a more stable yield than rotations that include corn and soybeans.

Table 4.9 Correlation coefficients of crop enterprise yields[a]

	MC	CC	CO	OM	CS	SC	MM	OC
MC	1	.478	.235	.787	.773	.861	.805	.993
CC		1	.306	.301	.338	.304	.390	.571
CO			1	−.029	−.073	.052	.048	.174
OM				1	.759	.646	.978	.778
CS					1	.748	.829	.743
SC						1	.639	.754
MM							1	.792
OC								1

[a] Where MC is corn after meadow, CC is corn after corn, CO is oats after corn, OM meadow after oats, CS is soybeans after corn, SC is corn after soybeans, MM is continuous meadow, and OC is corn after oats.

Correlations between enterprise prices

Table 4.10 shows the correlations between the enterprise prices. The prices shown have been adjusted for inflation using the implicit deflator for GDP, 1980:100. The price of HFOatHF (priced as human food) is negatively correlated with all the other prices, although there is a positive correlation between HFOatHF and oat-flour (0.691). This is as expected because a very high percent of the price of the HFOats, about 83.3%, is contributed by the oat-flour. The price of HFOatF (priced as feed) behaves differently. The price is positively correlated with all other crop prices except the prices of HFOatHF (priced as human food) and oat-flour. This probably reflects the fact that the corn-oil and corn gluten feed one major price components.

These results alone suggests that diversifying the farm enterprises by including HFOatsHF (priced as human foods), may stabilize farm income.

Correlation between enterprise gross margins

The correlation coefficients matrices for the gross margins for all the enterprises on the farm are presented in Table 4.11. All the gross margins among the enterprises are positively correlated. Rotations that include the HFOats are least correlated with the CC (continuous corn) and CS (corn-soybean) rotations. The CAMM (corn-HFOats-meadow-

Table 4.10 Correlation coefficients of enterprise prices

	Corn	Oats	Soy	Hay	HFOatF	HFOatHF	Cornoil	CGF
Corn	1	.537	.899	.600	.884	-.144	.789	.675
Oats		1	.679	.698	.523	.031	.377	.452
Soy			1	.652	.752	-.217	.602	.778
Hay				1	.431	.487	.216	.264
HFOatF					1	-.374	.670	.745
HFOatHF						1	-.207	-.547
Cornoil							1	.319
CGF								1
OatFlr								
Oathull								
Cullcow								
Milkcow								
Calves								
Milk								
Mkthog								
Cullsow								

OatFlr	Oathull	Cullcow	Milkcow	Calves	Milk	Mkthog	Cullsow
-.222	.883	.746	.781	.512	.831	.387	.440
.063	.604	.595	.513	.554	.362	-.003	-.014
-.057	.819	.833	.764	.704	.698	.202	.239
.327	.622	.380	.328	.345	.309	-.135	-.144
-.507	.932	.683	.876	.329	.908	.643	.685
.691	-.211	-.381	-.493	-157	-.459	-.642	-.658
-.351	.541	.571	.564	.351	.697	.291	.385
-.176	.793	.858	.894	.702	.709	.433	.462
1	-.251	.028	-.294	.409	-.492	-.836	-.835
	1	.764	.910	.470	.893	.522	.567
		1	.896	.887	.735	.216	.285
			1	.614	.919	.535	.610
				1	.352	-.177	-.133
					1	.680	.766
						1	.983
							1

Table 4.11 Correlation coefficients of enterprise gross margins

	CC	CS	CCOM	COMM	COM	CO	CCOMM
CC	1	.617	.794	.692	.770	.761	.789
CS		1	.878	.744	.766	.820	.867
CCOM			1	.837	.963	.958	.990
COMM				1	.872	.772	.879
COM					1	.960	.965
CO						1	.931
CCOMM							1
CCAM							
CAMM							
CAM							
CA							
CCAMM							
DAIRY							
HOGS							

CCAM	CAMM	CAM	CA	CCAMM	DAIRY	HOGS
.776	.432	.569	.532	.662	.670	.766
.833	.489	.521	.529	.743	.890	.537
.978	.509	.734	.697	.867	.930	.718
.841	848	.670	.559	.752	.680	.574
.976	.578	.832	.775	.871	.845	.670
.956	.445	.765	.768	.823	.885	.689
.978	.563	.743	.690	.879	.916	.668
1	.561	.837	.805	.919	.866	.656
	1	.611	.498	.624	.291	.440
		1	.973	.926	.570	.557
			1	.901	.569	.535
				1	.770	.661
					1	.641
						1

meadow) and the CA (corn-HFOats) rotations have the lowest correlations with the gross margins of other enterprises in the farm.

Target MOTAD

Target MOTAD models are used to examine the economic potential of incorporating HFOats in the farm plans for Northeast Iowa. As described in Chapter 3, the model is solved parametrically to generate an E-A efficient frontier with respect to a specific target income. The expected returns along the frontier of expected deviations from the target. The more risk averse a farmer is, the more willing she will be to sacrifice expected income for reduced variability below a target income level. Therefore risk averse farmers would select lower expected income, λ pairs along the frontier. A risk neutral farmer would select a portfolio equivalent to the deterministic profit maximizing farm plan.

Model scenarios

Nine Target MOTAD scenarios are presented for discussion. Eight are based on the same target income of $63,586. The last solution is based on a higher Target income, $91,850. Given a target income, an efficiency frontier is estimated for the different scenarios by parametrically varying λ from 0 to M, where M is a large number. Specifically, these scenarios can be described in the following way:

1. Scenario 1 is the base run, the results are obtained under the initial prices and yield.
2. Scenario 2, the model is run under the initial prices and yields, and a soil loss constraint is imposed.
3. Scenarios 3 and 4 examine the effect of a 15% increase and decrease in yields of HFOats.
4. Scenarios 5 and 6 were used to study the effect of increasing and decreasing the price of the HFOats by 15%.
5. Scenarios 7 and 8 examined the impact of an increase or decrease in the price of nitrogen fertilizer from $0.19 to $0.29 and $0.09, respectively.
6. The last scenario was utilized to study the impact of a an increase in target income from $63,586 to $91,850. The target income is increased by assuming a higher debt to asset ratio for the representative farm.

Definitions

Before discussing the Target MOTAD results several terms used in the text need to be defined:

1. There are three nitrogen levels, nitrogen 1 (50 lbs N), nitrogen 2 (100 lbs N), and nitrogen 3 (200 lbs N).

2. The tillage systems discussed are no-till, and ridge till (ridge tillage system). The chisel tillage system never came into the optimal solution.
3. The rotations in the results are; CS is corn-soybeans, CA is corn-HFOats, CAM is corn-HFOats-meadow, and CAMM is corn-HFOats-meadow-meadow.
4. In the discussion of results the different land types are referred to as: Land 1, is Fayette (163C1) with slope C, and erosion phase 1; Land 2, is Fayette (163D2) with slope D and erosion phase 2; Land 3, is Fayette (163E2) with slope E and erosion phase 2; and Land 4, is Downs (162C1) with slope C, and erosion phase 1.

Resource constraints in the model (RHS)

The Target MOTAD model was run with the resource constraints on available fieldtime hours, land and livestock facilities. In the second scenario a soil loss constraint was imposed. There was no constraint on labor hired. The model allowed for labor to be hired for the livestock enterprises only. A total of 5310 hours of labor were hired for all the models, this provided for all the labor requirements of the two livestock enterprises. Both livestock enterprises entered all the solution results at their maximum levels. Fieldtime available was not a binding constraint in any of the scenarios. In general the CS rotation required less labor than the CA rotation, and all rotations that included a meadow required more labor than the CS and CA rotations. The resource constraints are summarized in Table 4.12.

Table 4.12 The resource constraints in the model

Activity	Right hand side (RHS)
Fieldtime Available	
Spring	400 hours
Summer	1361 hours
Fall	790 hours
Land Available	
Fayette (163C1) - Land 1	80 acres
Fayette (163D2) - Land 2	200 acres
Fayette (163E2) - Land 3	56 acres
Downs (162C1) - Land 4	240 acres
Soil Loss Limit	
Land 1	400 tons
Land 2	1000 tons
Land 3	280 tons
Land 4	1200 tons
Livestock Facilities	
Hogs	100 litters
Dairy	50 cows

Base run results

The results from the base run of the model are presented in Table 4.13. In this model results were obtained at the initial prices and yields, by varying λ from \$600 to \$70. The target income used is \$63,586.

In this model a risk neutral farmer placed all the land in the four different land types in a ridge till CS rotation at nitrogen level 2. The expected mean net income for the risk neutral solution is \$100,752. In this study, risk aversion increases are represented by a decrease in the expected negative deviations (λ), from the target. In this solution the effect of risk aversion is initially expressed by a shift to a lower nitrogen level, from 100 lbs to 50 lbs. A more risk averse farmer replaced the CS rotation by a no-till CA rotation at nitrogen level 2, in land 1, 2, and 3. This shift from the CS rotation to a CA rotation reduces the annual soil loss per acre. A highly risk averse farmer reduces the nitrogen level even further and places all of land 1, 2, and 3 in a no-till CA rotation at nitrogen level 1. This farmer places 58 acres of land 4 in a ridge till CS rotation at nitrogen level 1, and 182 acres in a CAMM rotation at nitrogen level 1. At this level of risk aversion (λ = 70) the expected income decreased to \$90022.04, a reduction of \$10,729.

These results imply that as risk aversion increases inclusion of HFOats at lower nitrogen levels reduces income variability. This result also suggests that yields of crops are more stable or less variable when lower levels of nitrogen fertilizer are applied. This result is supported by a comparison of the coefficient of variability of yields under different nitrogen levels.

When the expected negative deviations are 300 or 400, the model chooses a mixed tillage system and nitrogen level. This is not a very practical result, because no farmer would buy two different sets of equipment for the same piece of land. These mixed results may be due to the model trying to balance between a high expected income and a specified level of risk aversion.

This initial run did not have a soil loss constraint. However, the amount of soil erosion exceeded the maximum acceptable soil loss level only in land 2 and 3. This limit, which is measured in T-values, is 5 tons per acre for all the land types in this farm. As risk aversion increased the model shifted from a more erosive CS rotation to a less erosive CA rotation, and consequently less soil erosion. For a highly risk averse farmer, the maximum acceptable soil loss level was exceeded solely by land 3. These results indicate that as risk aversion increases the model tends to choose rotations that are more environmentally desirable.

The chisel tillage never entered the optimal solution in the base run. This is probably because it required more field operations than either the ridge till or no-till systems, and was therefore more expensive.

Table 4.13 Trade-offs between risk and mean income, for the base run

Solution No.		Solution under Certainty	600.00	500.00	Expected 400.00
Mean Net Income ($)		100751.66	100487.57	100177.05	99753.00
Target Income			63586.00	63586.00	63586.00
Field Time					
Spring	hrs.	86.40	86.40	86.40	85.08
Summer	hrs.	89.28	89.28	89.28	92.81
Fall	hrs.	129.60	129.60	129.60	126.07
Rotations					
Land1					
RTill.CS.N1	ac.		80.00	80.00	80.00
RTill.CS.N2	ac.	80.00			
NTill.CA.N1	ac.				
NTill.CA.N2	ac.				
NTill.CA.N3	ac.				
Land2					
RTill.CS.N1	ac.		122.00	200.00	156.00
RTill.CS.N2	ac.	200.00	78.00		
NTill.CA.N1	ac.				
NTill.CA.N2	ac.				44.00
NTill.CA.N3	ac.				
Land3					
RTill.CS.N1	ac.			56.00	56.00
RTill.CS.N2	ac.	56.00	56.00		
NTill.CA.N1	ac.				
NTill.CA.N2	ac.				
Land4					
RTill.CS.N1	ac.			84.00	240.00
RTill.CS.N2	ac.	240.00	240.00	156.00	
RTill.CAMM.N1	ac.				
Annual Soil Loss					
Land1	tons/Ac	1.93	1.93	1.93	1.93
Land2	tons/Ac	5.71	5.71	5.71	5.42
Land3	tons/Ac	12.77	12.77	12.77	12.77
Land4	tons/Ac	1.69	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
300.00	200.00	100.00	70.00
99092.16	98286.54	97120.77	90022.04
63586.00	63586.00	63586.00	63586.00
79.97	76.32	76.32	57.66
106.44	116.16	116.16	213.99
112.44	102.72	102.72	71.32
66.00			
	80.00	80.00	80.00
14.00			
	65.00	200.00	200.00
200.00	135.00		
56.00			
		8.00	56.00
	56.00	48.00	
240.00	240.00	240.00	58.00
			182.00
1.82	1.31	1.31	1.31
4.41	4.41	4.41	4.41
12.77	10.36	10.36	10.36
1.69	1.69	1.69	0.71

Both livestock enterprises entered the optimal solution at their highest levels. This may be because there was no limit on amount of labor hired.

Model with a soil loss constraint

The second scenario uses the same level of prices and yields as the base run, but a constraint is imposed on the amount of acceptable soil loss on each of the SMU (soil mapping unit). The constraints used are T-values at a level of 5 tons per acre for all land types. The results from this scenario are provided in Table 4.14.

In this model a risk neutral farmer places all land 1 under a ridge-till CS rotation, at nitrogen level 2. In Land 2 the soil loss constraint is binding, and the farmer places 124 acres under a ridge-till CS rotation at nitrogen level 2 and 76 acres under a no-till CA rotation at nitrogen level 3. The soil loss constraint is also binding for land 3. The risk neutral farmer places 18.2 acres of land 3 in a ridge-till CA rotation and 37.8 acres under a CAM rotation at with nitrogen level 3. All of land 4 is placed under a ridge-till CS rotation at nitrogen level 2. The soil loss constraint is not binding for land 4.

In land 2 and 3, where the soil loss constraint is binding, the solution gives a mixed rotation. Two tillage systems are specified for land 3. These mixed solutions are the consequence of the model maximizing expected profits within the bounds set by the constraint.

The expected net income for the risk neutral solution is $99,193, which is $1,558 lower than the base solution with no soil loss constraint. This can be considered the penalty for imposing a soil loss constraint.

In this model increased risk aversion is expressed by a reduction of the nitrogen level. The more risk averse farmer will begin to replace the CS rotations in land 1 and 4 by a CA rotation. The highly risk averse farmer places all land 1 and 2 in a no-till CA rotation at nitrogen level 1. Land 3 is under the CA rotation but with the ridge-till system. All of land 4 is placed in a ridge-till system with 140 acres in a CS rotation and 100 acres in a CAMM rotation, both at nitrogen level 1.

For a highly risk averse farmer the soil loss constraint on land 2 is no longer binding. This is because the CA rotation selected results in less soil erosion than the CS rotation. Another significant result is that at very high levels of risk aversion, the model utilized only 32 acres of land 3, while 24 acres were idled. The combined requirements of a low λ plus the soil loss constraint could not be achieved with the entire resource in production of any available crop or rotation.

Table 4.14 Trade-offs between risk and mean income, for the model with a soil loss constraint

Solution No.	Solution under Certainty		Expected
		550.00	500.00
Mean Net Income ($)	99193.38	99076.24	98931.19
Target Income		63586.00	63586.00
Field Time			
Spring hrs.	86.54	86.54	86.73
Summer hrs.	116.83	116.19	116.19
Fall hrs.	115.53	115.77	115.77
Rotations			
Land1			
RTill.CS.N1 ac.	80	80	80
NTill.CA.N1 ac.			
NTill.CA.N2 ac.			
Land2			
RTill.CS.N1 ac.		66	98
RTill.CS.N2 ac.	124	58	26
RTill.CA.N2 ac.		76	76
RTill.CA.N3 ac.	76		
NTill.CA.N1 ac.			
NTill.CA.N2 ac.			
Land3			
RTill.CA.N1 ac.			
RTill.CA.N2 ac.		20	20
RTill.CA.N3 ac.	18.2		
RTill.CAMM.N2 ac.		36	36
NTill.CAM.N3 ac.	37.8		
Land4			
RTill.CS.N1 ac.			
RTill.CS.N2 ac.	240	240	240
RTill.CAMM.N1 ac.			
Annual Soil Loss			
Land1 tons/Ac	1.93	1.93	1.93
Land2 tons/Ac	5.00	5.00	5.00
Land3 tons/Ac	5.00	5.00	5.00
Land4 tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
400.00	300.00	200.00	100.00
98596.05	98098.11	97192.85	91873.39
63586.00	63586.00	63586.00	63586.00
86.73	77.91	75.27	65.30
116.19	125.43	132.46	164.70
115.77	106.53	99.49	81.81
80			
			80
	80	80	
124	88		
76	112		
		108	200
		92	
			32
20	20	20	
36	36	36	
186	240	180	140
54			
		60	100
1.93	1.31	1.31	1.31
5.00	4.98	4.41	4.41
5.00	5.00	5.00	5.00
1.69	1.69	1.69	1.15

Price and yield sensitivity

A sensitivity analysis was conducted to investigate the effects of a 15% change in prices and yields on the efficiency frontier of HFOats. To change the prices, all initial price observations for HFOats were increased or decreased by 15%. To change the yields each of the initial yields of the HFOats was either increased or decreased by 15%. The solutions for the sensitivity are presented in Tables 4.15 to 4.18. This 15% change only influenced the mean and standard deviations of the HFOats. The coefficient of variation did not change.

A risk neutral farmer responds to a 15% decrease in the price or the yield of HFOats by choosing the same activities as those in the base solution. In this solution the farmer is concerned with maximizing expected profits, and since the revenue from HFOats is lower, then the optimal choice is a CS rotation. The expected mean net income for both these models was $100,751.

When the price or the yields of the HFOats were increased by 15% a risk neutral farmer placed all of land 1, 2, and 3 under a no-till CA rotation at nitrogen level 3. Land 4 was placed in a ridge-till CS rotation at nitrogen level 2. The expected mean net income for a 15% increase in price and yield were $101,443 and $101,241, respectively. A 15% increase in the prices of HFOats gives a higher expected

Table 4.15 Trade-offs between risk and mean income, for 15% decrease in the prices of HFOats

Solution No.		Solution under Certainty		Expected
			600.00	500.00
Mean Net Income ($)		100751.66	100487.57	100177.57
Target Income			63586.00	63586.00
Field Time				
Spring	hrs.	86.40	86.40	86.40
Summer	hrs.	89.28	89.28	89.28
Fall	hrs.	129.60	129.60	129.60
Rotations				
Land1				
RTill.CS.N1	ac.		80.00	80.00
RTill.CS.N2	ac.	80.00		
NTill.CA.N1	ac.			
Land2				
RTill.CS.N1	ac.		66.00	200.00
RTill.CS.N2	ac.	200.00	134.00	
NTill.CA.N1	ac.			
Land3				
RTill.CS.N1	ac.		56.00	56.00
RTill.CS.N2	ac.	56.00		
NTill.CA.N1	ac.			
NTill.CA.N3	ac.			
Land4				
RTill.CS.N1	ac.			84.00
RTill.CS.N2	ac.	240.00	240.00	156.00
Annual Soil Loss				
Land1	tons/Ac	1.93	1.93	1.93
Land2	tons/Ac	5.71	5.71	5.71
Land3	tons/Ac	12.77	12.77	12.77
Land4	tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
400.00	300.00	250.00	230.00
99311.67	96945.08	95761.79	95288.48
63586.00	63586.00	63586.00	63586.00
85.13	80.23	77.78	76.80
92.66	105.74	112.27	114.89
126.20	113.05	106.61	103.99
38.00		48.00	16.00
42.00	80.00	32.00	64.00
200.00	74.00		
	126.00	200.00	200.00
56.00			
	56.00	56.00	56.00
240.00	240.00	240.00	240.00
1.60	1.31	1.68	1.43
5.71	4.89	4.41	4.41
12.77	10.36	10.36	10.36
1.69	1.69	1.69	1.69

Table 4.16 Trade-offs between risk and mean income for a 15% increase in the the price of HFOats

Solution No.		Solution under Certainty	Expected	
			300.00	250.00
Mean Net Income ($)		101443.32	101269.19	101174.03
Target Income			63586.00	63586.00
Field Time				
Spring	hrs.	76.32	76.32	76.32
Summer	hrs.	116.16	116.16	116.16
Fall	hrs.	102.72	102.72	102.72
Rotations				
Land1				
NTill.CA.N1	ac.			
NTill.CA.N2	ac.		80.00	80.00
NTill.CA.N3	ac.	80.00		
Land2				
NTill.CA.N1	ac.			
NTill.CA.N2	ac.		32.00	134.00
NTill.CA.N3	ac.	200.00	168.00	76.00
Land3				
NTill.CA.N1	ac.			
NTill.CA.N2	ac.		56.00	56.00
NTill.CA.N3	ac.	56.00		
Land4				
RTill.CS.N1	ac.			
RTill.CS.N2	ac.	240.00	240.00	240.00
RTill.CAMM.N1	ac.			
RTill.CAMM.N2	ac.			
Annual Soil Loss				
Land1	tons/Ac	1.27	1.27	1.27
Land2	tons/Ac	4.41	4.41	4.41
Land3	tons/Ac	10.36	10.36	10.36
Land4	tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)				
200.00	150.00	100.00	50.00	0.00
101064.94	100894.42	100723.86	100130.26	99490.61
63586.00	63586.00	63586.00	63586.00	63586.00
76.32	76.32	76.32	76.32	76.32
116.16	116.16	116.16	116.16	116.16
102.72	102.72	102.72	102.72	102.72
				4
80.00	80.00	80.00	80.00	76.00
			16.00	200.00
200.00	200.00	200.00	184.00	
56.00	56.00	56.00	56.00	56.00
20.00	124.00	230.00	240.00	240.00
220.00	116.00	10.00		
1.27	1.27	1.27	1.27	1.27
4.41	4.41	4.41	4.41	4.41
10.36	10.36	10.36	10.36	10.36
1.69	1.69	1.69	1.69	1.69

Table 4.17 Trade-offs between risk and mean income, for 15% decrease in the yields of HFOats

Solution No.	Solution under Certainty		Expected
		600.00	500.00
Mean Net Income ($)	100751.66	100487.57	100177.06
Target Income		63586.00	63586.00
Field Time			
Spring hrs.	86.40	86.40	86.40
Summer hrs.	89.28	89.28	89.28
Fall hrs.	129.60	129.60	129.60
Rotations			
Land1			
RTill.CS.N1 ac.		2.00	80.00
RTill.CS.N2 ac.	80.00	78.00	
NTill.CA.N1 ac.			
NTill.CA.N2 ac.			
NTill.CA.N3 ac.			
Land2			
RTill.CS.N1 ac.		200.00	200.00
RTill.CS.N2 ac.	200.00		
NTill.CA.N1 ac.			
NTill.CA.N2 ac.			
NTill.CA.N3 ac.			
Land3			
RTill.CS.N1 ac.			56.00
RTill.CS.N2 ac.	56.00	56.00	
NTill.CA.N1 ac.			
NTill.CA.N3 ac.			
Land4			
RTill.CS.N1 ac.			84.00
RTill.CS.N2 ac.	240.00	240.00	156.00
RTill.CAMM.N1 ac.			
RTill.CAMM.N2 ac.			
Annual Soil Loss			
Land1 tons/Ac	1.93	1.93	1.93
Land2 tons/Ac	5.71	5.71	5.71
Land3 tons/Ac	12.77	12.77	12.77
Land4 tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
400.00	300.00	250.00	230.00
99296.66	96872.06	95659.77	95174.85
63586.00	63586.00	63586.00	63586.00
85.13	80.23	77.78	76.80
92.66	105.74	112.27	114.89
126.22	113.15	106.61	103.99
80.00			
	80.00	80.00	80.00
158.00	132.00		
42.00	68.00	200.00	200.00
56.00		48.00	16.00
	56.00	8.00	40.00
240.00	240.00	240.00	240.00
1.93	1.31	1.31	1.31
5.43	5.26	4.41	4.41
12.77	10.36	12.45	11.04
1.69	1.69	1.69	1.69

Table 4.18 Trade-offs between risk and mean income, for a 15% increase in yields of HFOats

Solution No.		Solution under Certainty		Expected
			300.00	250.00
Mean Net Income ($)		101241.72	101070.71	100977.25
Target Income			63586.00	63586.00
Field Time				
Spring	hrs.	76.32	76.32	76.32
Summer	hrs.	116.16	116.16	116.16
Fall	hrs.	102.72	102.72	102.72
Rotations				
Land1				
NTill.CA.N1	ac.			
NTill.CA.N2	ac.		80.00	80.00
NTill.CA.N3	ac.	80.00		
Land2				
NTill.CA.N1	ac.			
NTill.CA.N2	ac.		88.00	134.00
NTill.CA.N3	ac.	200.00	112.00	76.00
Land3				
NTill.CA.N1	ac.			56.00
NTill.CA.N3	ac.	56.00	56.00	
Land4				
RTill.CS.N1	ac.			
RTill.CS.N2	ac.	240.00	240.00	240.00
Annual Soil Loss				
Land1	tons/Ac	1.31	1.31	1.31
Land2	tons/Ac	4.41	4.41	4.41
Land3	tons/Ac	10.36	10.36	10.36
Land4	tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)				
200.00	150.00	100.00	50.00	0.00
100869.59	100699.03	100528.47	99944.59	99315.73
63586.00	63586.00	63586.00	63586.00	63586.00
76.32	76.32	76.32	76.32	76.32
116.16	116.16	116.16	116.16	116.16
102.72	102.72	102.72	102.72	102.72
				4.00
80.00	80.00	80.00	80.00	76.00
			16.00	200.00
200.00	200.00	200.00	184.00	
56.00	56.00	56.00	56.00	56.00
20.00	124.00	230.00	240.00	240.00
220.00	116.00	10.00		
1.31	1.31	1.31	1.31	1.31
4.41	4.41	4.41	4.41	4.41
10.36	10.36	10.36	10.36	10.36
1.69	1.69	1.69	1.69	1.69

income than a 15% increase in yields.

A risk averse farmer responds to a 15% decrease in the price or yields by first reducing the nitrogen level. Then as risk aversion increases the farmer gradually shifted from the CS rotation to the CA rotation. This shift although similar to the shift in the base model, generates lower expected incomes. This is because the net revenue from the HFOats are lower because of the reduction in the prices or yields. A highly risk averse farmer applies nitrogen at level 1 and places most of land 1, 2, and 3 in a no-till CA rotation, and all of land 4 in a ridge-till CS rotation.

When there is a 15% increase in the price or the yield of HFOats, decreasing λ a gradual reduction in the nitrogen level of all the rotations. In these two solutions a risk averse farmer maintains the CA and CS rotations but reduces the nitrogen applied to level 1. The expected income for the highly risk averse farmer is \$99,491 and \$99,316 for a price and yield increase, respectively. These results were obtained at a zero level of deviation from the target income.

Sensitivity to the cost of nitrogen

The effect of changing the nitrogen costs is examined in scenarios 7 and 8. To carry out this study the price of nitrogen fertilizer in \$ per pound was increased by about

50% from $0.19 to $0.29, and decreased by the same percentage to $0.09. These results are presented in Table 4.19 and 4.20.

A risk neutral farmer would respond to a 50% increase in the cost of nitrogen by placing all the land under a ridge till CS rotation, at nitrogen level 2, the same solution as the base plan. A 50% decrease had no effect on the risk neutral plan.

When the price of nitrogen increases, increasing λ results in a reduction in the nitrogen level for all the rotations. It is interesting to note that as risk aversion increases, the model shifts to the lower nitrogen level at lower levels of risk aversion than those displayed in the base run. A risk averse farmer gradually shifts to a no-till CA rotation at nitrogen level 1. The highly risk averse farmer will place all land 1, 2, and 3 in this rotation. A ridge till CS rotation at a lower nitrogen level is used on 235 acres of land 4.

A risk averse farmer reacts to an decrease in nitrogen costs by shifting from the CS rotation to a no-till CA rotation, at nitrogen level 3. But, as risk aversion increases the farmer shifts to nitrogen level 1. Land 4 is placed under the CS rotation at a lower nitrogen level.

This sensitivity analysis implies that changes in the cost of nitrogen have only a minor effect on the selection

Table 4.19 Trade-offs between risk and mean income, for a $0.10 increase in the cost of nitrogen fertilizer

Solution No.	Solution under Certainty		Expected
		600.00	500.00
Mean Net Income ($)	99311.66	99267.49	99205.55
Target Income		63586.00	63586.00
Field Time			
Spring hrs.	86.40	86.40	86.40
Summer hrs.	89.28	89.28	89.28
Fall hrs.	129.60	129.60	129.60
Rotations			
Land1			
RTill.CS.N1 ac.		80.00	80.00
RTill.CS.N2 ac.	80.00		
NTill.CA.N1 ac.			
Land2			
RTill.CS.N1 ac.		200.00	200.00
RTill.CS.N2 ac.	200.00		
NTill.CA.N1 ac.			
Land3			
RTill.CS.N1 ac.		56.00	56.00
RTill.CS.N2 ac.	56.00		
NTill.CA.N1 ac.			
Land4			
RTill.CS.N1 ac.		70.00	236.00
RTill.CS.N2 ac.	240.00	170.00	4.00
RTill.CAMM.N1 ac.			
Annual Soil Loss			
Land1 tons/Ac	1.93	1.93	1.93
Land2 tons/Ac	5.71	5.71	5.71
Land3 tons/Ac	12.77	12.77	12.77
Land4 tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
400.00	300.00	200.00	150.00
98344.04	97465.25	96586.46	95908.02
63586.00	63586.00	63586.00	63586.00
83.56	80.65	77.75	75.63
96.86	104.61	112.36	119.78
122.02	114.27	106.52	101.56
80.00	80.00	48.00	
		32.00	80.00
186.00	8.00		
14.00	192.00	200.00	200.00
56.00	56.00		
		56.00	56.00
240.00	240.00	240.00	235.00
			5.00
1.31	1.93	1.68	1.68
5.61	4.46	4.41	4.41
12.77	12.77	10.36	10.36
1.69	1.69	1.69	1.65

Table 4.20 Trade-offs between risk and mean income, for a $0.10 decrease in nitrogen cost

Solution No.		Solution under Certainty	500.00	Expected 400.00
Mean Net Income ($)		102191.66	102036.53	101706.71
Target Income			63586.00	63586.00
Field Time				
Spring	hrs.	86.40	84.55	80.62
Summer	hrs.	89.28	94.21	104.70
Fall	hrs.	129.60	124.67	114.18
Rotations				
Land1				
RTill.CS.N2	ac.	80.00	18.00	
NTill.CA.N1	ac.			
NTill.CA.N2	ac.			
NTill.CA.N3	ac.		62.00	80.00
Land2				
RTill.CS.N2	ac.	200.00	200.00	144.00
NTill.CA.N1	ac.			
NTill.CA.N2	ac.			
NTill.CA.N3	ac.			56.00
Land3				
RTill.CS.N2	ac.	56.00	56.00	
NTill.CA.N1	ac.			
NTill.CA.N2	ac.			
NTill.CA.N3	ac.			56.00
Land4				
RTill.CS.N1	ac.			
RTill.CS.N2	ac.	240.00	240.00	240.00
RTill.CAMM.N1	ac.			
RTill.CAMM.N2	ac.			
Annual Soil Loss				
Land1	tons/Ac	1.93	1.45	1.31
Land2	tons/Ac	5.71	5.71	5.34
Land3	tons/Ac	12.77	12.77	10.36
Land4	tons/Ac	1.69	1.69	1.69

Negative Deviations, Lambda ($)			
300.00	200.00	100.00	50.00
101376.90	100592.97	99465.99	98460.76
63586.00	63586.00	63586.00	63586.00
76.69	76.32	76.32	76.32
115.18	116.16	116.16	116.16
103.70	102.72	102.72	102.72
	24.00		2.00
	56.00	80.00	78.00
80.00			
12.00			
			200.00
		200.00	
188.00	200.00		
		46.00	56.00
		10.00	
56.00	56.00		
	240.00	240.00	240.00
240.00			
1.31	1.31	1.31	1.31
4.48	4.41	4.41	4.41
10.36	10.36	10.36	10.36
1.69	1.69	1.69	1.69

of cropping systems for all levels of expected income and λ.

Sensitivity to a higher target income

The impact of a higher target income was explored in scenario 9. In this scenario the target income was increased by assuming a higher debt-to-asset ratio of the farm. The target income that was calculated was $91,850. A higher target income represents a reduced risk bearing ability. Consequently, the efficient frontier may be comprised of lower risk portfolios. Feasible solutions were obtained by varying λ from 2900 to 3600. These results are presented in Table 4.21.

Since the target income has no impact on the portfolio for a risk neutral farmer, the deterministic farm plan in this scenario is the same as the base run. With the higher target income, risk aversion is expressed by a very gradual decrease in nitrogen level. This is followed by a shift to a no-till CA rotation at nitrogen level 1, for lands 1, 2, and 3. Land 4 is divided - 132 acres is placed in a CS rotation and 108 acres is placed in a ridge till CAMM, both at nitrogen level 1. In this case the first feasible solution comes at much higher levels of deviation from target income λ, at 2900 as compared to the 70 in the base solution.

These results imply that increasing the level of target

Table 4.21 Trade-offs between risk and mean income, for a higher target income

Solution No.		Solution under Certainty	3600.00	3500.00	Expected 3400.00
Mean Net Income ($)		100751.66	100647.14	100498.60	100234.03
Target Income			91850	91850.00	91850.00
Field Time					
Spring	hrs.	86.40	85.78	84.94	83.96
Summer	hrs.	89.28	90.89	93.19	95.78
Fall	hrs.	129.60	127.99	125.70	123.10
Rotations					
Land1					
RTill.CS.N1	ac.				80.00
RTill.CS.N2	ac.	80.00	80.00	80.00	
NTill.CA.N1	ac.				
NTill.CA.N2	ac.				
NTill.CA.N3	ac.				
Land2					
RTill.CS.N1	ac.				18.00
RTill.CS.N2	ac.	200.00	200.00	200.00	100.00
NTill.CA.N1	ac.				
NTill.CA.N2	ac.				82.00
NTill.CA.N3	ac.				
Land3					
RTill.CS.N1	ac.				56.00
RTill.CS.N2	ac.	56.00	36.00	8.00	
NTill.CA.N1	ac.				
NTill.CA.N2	ac.		20.00	48.00	
NTill.CA.N3	ac.				
Land4					
RTill.CS.N1	ac.				
RTill.CS.N2	ac.	240.00	240.00	240.00	240.00
RTill.CAMM.N1	ac.				
Annual Soil Loss					
Land1	tons/Ac	1.93	1.93	1.93	1.93
Land2	tons/Ac	5.71	5.71	5.71	5.18
Land3	tons/Ac	12.77	11.90	10.67	12.77
Land4	tons/Ac	1.69	1.69	1.69	1.69

Negative Deviations, Lambda ($)				
3300.00	3200.00	3100.00	3000.00	2900.00
99865.85	99455.16	98917.66	97978.78	92774.45
91850.00	91850.00	91850.00	91850.00	91850.00
82.89	81.76	78.62	76.32	65.16
98.65	101.67	110.03	116.16	174.70
120.23	117.21	108.85	102.72	83.93
	80.00	76.00		
			68.00	80.00
80.00		4.00	12.00	
156.00	46.00			
6.00				
				200.00
38.00	154.00	200.00	200.00	
56.00	56.00			
			56.00	56.00
		56.00		
	158.00	240.00	240.00	132.00
240.00	82.00			
				108.00
1.31	1.93	1.90	1.31	1.31
5.47	4.70	4.41	4.41	4.41
12.77	12.77	10.36	10.36	10.36
1.69	1.69	1.69	1.69	1.10

income did not affect the structure of the optimal portfolio along the E-A frontier. This suggests that the assessment of risks and returns from high oil oats would not be greatly different for farmers with significantly different abilities to bear risk.

Risk and Expected Income Frontiers

Risk and expected returns associated with the Target MOTAD model solutions are graphically illustrated in figures 4.22 and 4.23. Figure 4.22 compares results from the base solution to the solution with a binding soil loss constraint, and to the solutions with a 15% change in yields and prices. These graphs demonstrate that the slopes of the solutions become flatter as net income increases, indicating that marginal increases in net income are possible only by allowing even greater marginal increases in risk aversion.

Base run and the binding soil loss constraint

In comparing the base solution (A) to the solution with a binding soil loss constraint (B), this solution looks like a parallel inward shift of the base solution. These graphs are shown on Figure 4.22.

When the level of acceptable deviations from the target are very low, the solution with a soil loss constraint is very steep. This solution represents less expected income at each level of risk compared to the base solution. At high levels of risk aversion, the expected net income for the solution with a binding soil loss constraint becomes very low. This is because when the level of λ was 100, the model did not use 24 acres of available land 3.

Frontiers for a price and yield change

The frontiers for price and yield sensitivity are also presented on Figure 4.22. The frontiers for a price and yield increase both lie above and to the left of the base solution. It is interesting to note that a 15% increase in prices generates more expected income at each level of risk aversion than a 15% increase in yields. Thus, when compared to the base solution these two solutions generate more expected income at each given level of risk aversion. This means that less risk aversion is incurred with these two solutions at each level of expected income.

On the other hand, the frontiers of the solutions with a yield and price decrease are almost identical. They lie below the base solution at low deviations from target, $400 or less. At higher expected deviations from target income, $500 or above, they have the same solution as the base run. This can explained by the fact that at higher levels of acceptable deviations from the target income the model selects the CS rotations for all these solutions. As risk

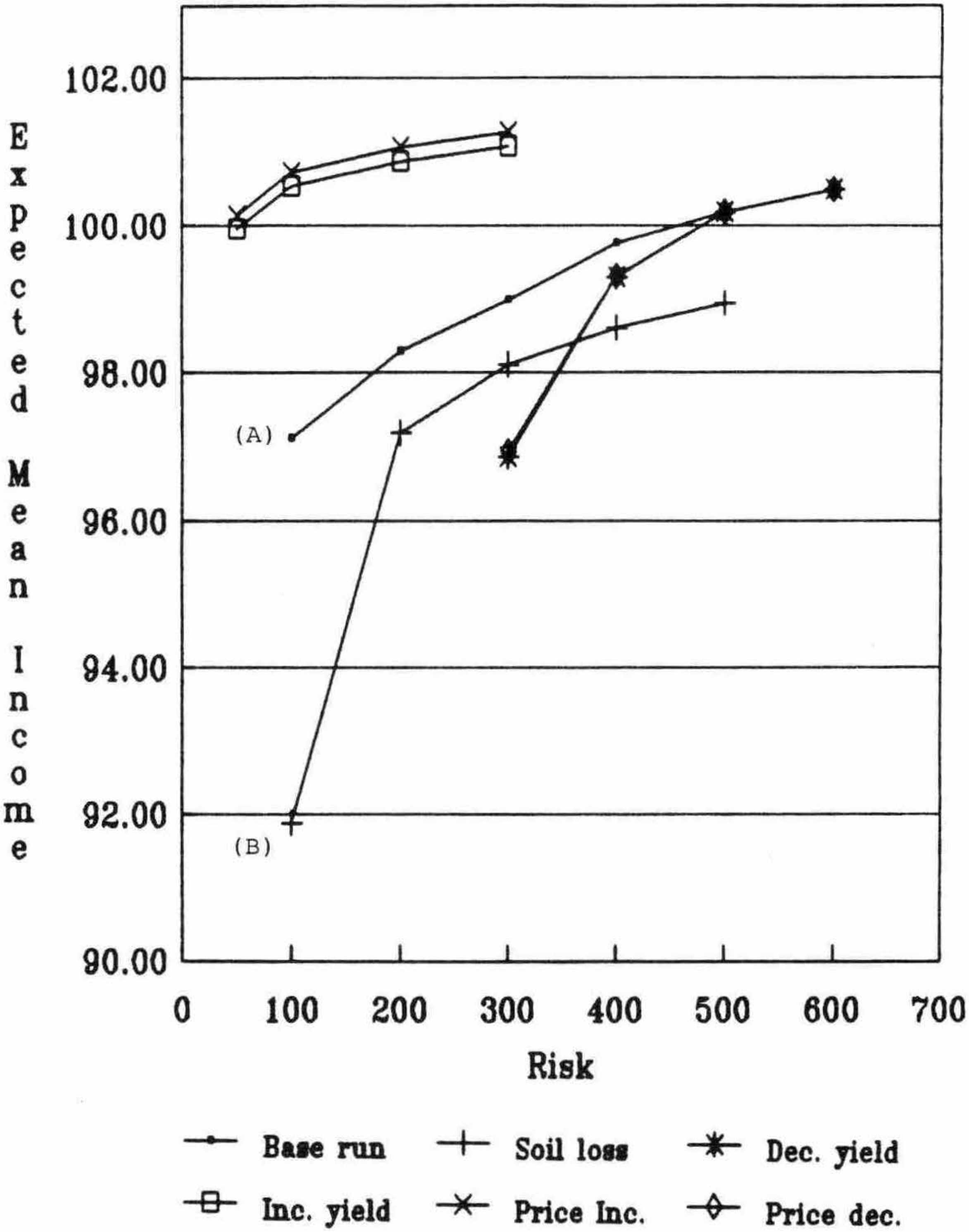

Figure 4.22 Risk and expected returns associated with Target MOTAD solutions

aversion increases, however, the model chooses the CA rotation which had lower yields and prices.

Frontier of a change in nitrogen costs

Figure 4.23 illustrates the efficiency frontiers of the base solution (A) compared to the solution with a soil loss constraint(B), and frontiers for an increase in nitrogen costs (C) and decrease in nitrogen costs (D). Although changes in the price of nitrogen had no effect on the optimal farm plans, the slope of the frontiers are affected. This might suggest some change in the portfolio for individuals with relatively constant levels of risk aversion.

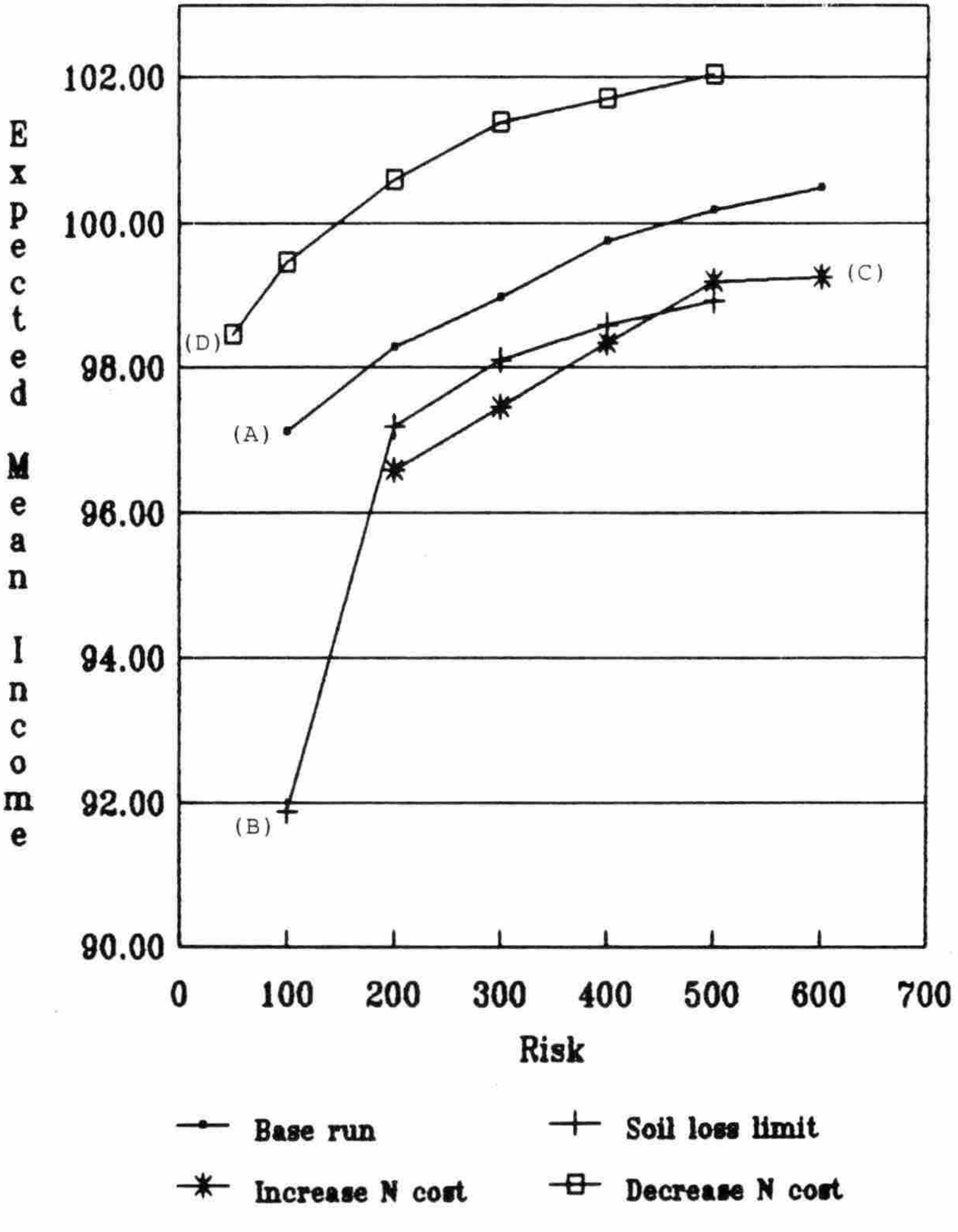

Figure 4.23 Risk and expected returns associated with Target MOTAD solutions

CHAPTER V.

SUMMARY AND CONCLUSIONS

This study examined the introduction of a high oil oats cultivar in a representative farm of Northeast Iowa. To do this a price was developed for the high oil oats. The high oil oat was priced both as a human food and animal feed. The feeding value of the high oil oats was investigated by developing least cost rations for dairy and hogs. Finally, a risk programming model was used to study the potential adoption of high oil oats.

Preliminary studies to estimate the price of the HFOats indicated that the value of oats could be increased by an average of 95% (this average was for a ten-year period) if the major products of HFOats were priced as a human food. Most of the estimated value increase was attributed to introducing defatted oat-flour. This implies that the value of increasing the oil content of oats is to provide an economic incentive to produce defatted oat-flour. Increasing the oil content of oats makes extraction of oil more economically feasible. A defatted oat-flour would be produced as a byproduct of this process.

Increasing the value of oats through genetic modification led to HFOats being included in the optimal farm plans. However, the impact of this single crop improvement was most significant in simple rotations like

CA. This is demonstrated in the model by the inclusion of rotations like CA as well as CAMM and CAM on a smaller scale. More complex rotations like CCAMM never entered the optimal solutions. Although increased diversity was an objective, the resulting rotations still include only two to three crops. The HFOats simply replaces soybeans.

Environmental effects of agricultural practices can be enhanced by focusing on cropping systems containing desirable crops. This conclusion is evident from the reduced levels of soil erosion from rotations that included HFOats.

Introduction of a new crop with different uses from existing crops can have a positive effect when risk is considered. When risk is not considered the optimal farm plans generally consisted of a CS rotation. In the Target MOTAD solutions CS rotations were replaced by rotations that included HFOats as risk aversion increased. Therefore, including HFOats in the farm plans reduced the variability of net revenue and stabilized farm income.

Yields of crops planted with lower nitrogen levels are less variable than those planted with higher nitrogen levels. These results indicate that when risk aversion is considered a lower nitrogen level is preferred.

Although this study focused on the adoption of high oil oats from an economic perspective, implications can be drawn from examining the sociological model of technology transfer. The characteristics of this technology suggest that it may easily be adopted by farmers in Northeast Iowa. Oats is not a new crop in Northeast Iowa, but because of the low value only about 50% is harvested for grain purposes. Since the farmers in this area are familiar with cultural practices for growing oats, relatively little learning will be required. Furthermore, most farmers own machinery needed for oats production.

Suggestions for Further Research

The most significant conclusions from this study are as a result of assuming that there was a ready market for the defatted oat-flour. However, this assumption may not necessarily be true. A future research effort should attempt to analyze the extent and structure of the market for the defatted oat-flour. Further, as a specialty crop it is likely that HFOats would be produced under contract with major processors. The structure of production contracts could have a major effect on the risk and returns from HFOats. The component technique used for pricing HFOats assumes that products of HFOats are similar in composition to existing products. Therefore, oat-oil was priced like corn-oil. However, if oat-oil proves to be a better quality oil than corn-oil, the price used in this model could be underestimated. A similar problem exists with pricing oat feed as corn gluten feed.

This study assumed that the agronomic characteristics of high oil oats were similar to those of regular oats. Therefore, identical costs of production and yields for regular oats and HFOats were assumed. Since HFOats is still in the development stage, no finished varieties exist for testing this assumption.

Recent research by agronomists at Iowa State University has examined the potential of narrow strips as an alternative method of crop rotation. Preliminary evidence suggests planting corn and oats in strips can increase the yields of both crops (Cruse, 1990b). So far this research has only considered regular oats. Further research efforts can be focused on the potential of HFOats in this strip intercropping system.

In this research the effect of government commodity programs was not considered. Developing a model that includes HFOats rotations and incorporates the effects of government programs would improve to this model. Government programs may lead to different results from those reported in this study (Williams, Llewelyn and Barnaby, 1990).

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APPENDIX

Costs per Rotated Acre for a Chisel Tillage, at 50 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	22.31	21.20	15.61	12.25	13.37	15.06	14.26
Fertilizer	26.51	23.33	25.57	24.98	25.25	25.40	25.29
Machinery	23.55	21.04	26.31	29.34	27.22	21.84	28.18
Var. Costs	123.50	106.19	109.89	96.27	105.35	106.76	101.72

Costs per Rotated Acre for a Ridge Tillage, at 50 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	22.31	21.20	15.61	12.25	13.37	15.06	14.26
Fertilizer	26.51	23.33	25.57	24.98	25.25	25.40	25.29
Machinery	20.97	18.18	24.96	28.64	26.29	21.60	27.11
Var. Costs	120.92	103.34	108.55	95.57	104.42	106.52	100.64

Costs per Rotated Acre for a No-Till System,
at 50 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	22.31	21.20	15.61	12.25	13.37	15.06	14.26
Fertilizer	26.51	23.33	25.57	24.98	25.25	25.40	25.29
Machinery	21.66	19.31	23.26	26.77	23.80	19.94	25.75
Var. Costs	121.61	104.46	106.85	93.70	101.93	104.86	99.28

Costs per Rotated Acre for a Chisel Tillage,
at 200 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	24.47	22.30	16.40	12.51	13.71	16.13	14.90
Fertilizer	48.75	34.45	36.69	30.54	32.67	36.52	34.18
Machinery	23.55	21.04	26.85	30.34	27.95	22.02	28.99
Var. Costs	147.90	118.41	122.35	103.09	113.84	119.14	112.06

Costs per Rotated Acre for a Ridge Tillage,
at 200 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	24.47	22.30	16.40	12.51	13.71	16.13	14.90
Fertilizer	48.75	34.45	36.69	30.54	32.67	36.52	34.18
Machinery	20.97	18.18	25.51	29.64	27.02	21.77	27.91
Var. Costs	145.32	115.55	121.01	102.39	112.90	118.89	110.98

Costs per Rotated Acre for a No-Till System Tillage,
at 200 lbs of Nitrogen

Item	CC	CS	CCOM	COMM	COM	CO	CCOMM
Seed	20.60	19.29	27.71	22.56	30.08	29.21	22.17
Chemical	30.53	21.35	14.70	7.14	9.43	15.27	11.82
Misc	24.47	22.30	16.40	12.51	13.71	16.13	14.90
Fertilizer	48.75	34.45	36.69	30.54	32.67	36.52	34.18
Machinery	21.66	19.31	23.81	27.77	24.52	20.11	26.55
Var. Costs	146.01	116.68	119.31	100.52	110.41	117.23	109.62