ECONOMICS OF MANAGING HARD RED WINTER WHEAT FOR PROTEIN CONTENT

By

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ECONOMICS OF MANAGING HARD RED WINTER

WHEAT FOR PROTEIN CONTENT

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Abstract:
Hard Red Winter Wheat (HRW) is the primary cash crop grown in Oklahoma. HRW wheat is graded on physical characteristics such as moisture content, percent defects, test weight, and protein content. The average Oklahoma producer's wheat will be tested for all of these characteristics except protein content. The overall objective of this research is to determine the expected net returns from the production of Oklahoma HRW wheat managed for enhanced grain protein content and marketed to enhance the probability of receiving a protein premium price. Data were collected in an Oklahoma field experiment at Lahoma and Lake Carl Blackwell in 2011, 2012 and 2013. Treatments included four rates of late season foliar N applied in the form of two different sources of N at two different growth stages. A linear response plateau functional form was found to provide the best fit to the data. The plateau N rate was 9.5 pounds per acre applied at the growth stage of post anthesis (Feekes 10.5). The average plateau protein percentage was 14.41. The costs of field operations and the prices of inputs were calculated to determine if a late season foliar N application at flag leaf (Feekes 9) or post anthesis (Feekes 10.5) to facilitate production of high protein wheat was economical. The protein premiums required for a slightly risk averse producer to be indifferent between producing high protein wheat and utilizing traditional methods ranged from \$0.44 to \$0.50 per bushel, for the four different production systems analyzed in the study. The average protein premium for wheat with a protein percentage of 12.6% was \$0.40 per bushel. The greatest barrier to producers capturing these premiums is the capability to deliver the wheat at a time and location that would pay a protein premium. Protein value depends on the quantity available in marketing channels. This is not known until the United States wheat crop is harvested, tested, and stored. In some years there is a possibility that regionally there will not be a premium for high protein wheat.

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CHAPTER I

INTRODUCTION

Hard Red Winter (HRW) wheat is the primary cash crop grown in Oklahoma. Over the last five years Oklahoma has produced an average of 100,150,000 bushels of HRW wheat per year, while over the same period the United States as a whole produced an average of 854,239,200 bushels of HRW wheat per year. Oklahoma ranks second behind Kansas in total HRW wheat production in the United States (NASS, 2013). As shown in Figure I-1, from 2006-2010 Oklahoma and Texas combined to produce thirteen percent of the winter wheat crop. The HRW wheat harvest in the United States will usually begin in May and will continue through August and cover states from Texas through Montana (Kenkel et al., 1994).

The United States' wheat crop is graded on physical characteristics, amount of foreign material, falling number, percent defects, moisture content, test weight, and protein content of the grain. The supply and demand of these characteristics play a large role in determining prices for both spring and winter wheat. There will often be a premium paid for different levels of protein content in wheat. Wheat with a higher protein percentage commonly receives a premium above wheat with lower protein percentages (Carlson, 1993). Market modifications for wheat have been created around the world based on protein levels with premiums being paid for increases above standard levels. Espinosa and Goodwin (1991) state that wheat is an excellent example of an agricultural commodity demonstrating wide differences in quality that can impact its selling price.

Grain protein is an essential characteristic in deciding the baking and milling quality of wheat (Woolfolk et al., 2002). Protein is used as a scale for flour mills on the potential end-use performance of the wheat as higher protein content is correlated with gluten strength, increased kernel hardness, and loaf volume (Brown et al., 2005; Gallardo, 2007). Millers prefer to purchase and use wheat that is homogeneous and consistent; this in turn enables them to more easily provide a consistent product to their customers (Regnier and Holcomb, 2004). There is also a strong demand for homogeneity in the flour performance of the wheat to meet the requirements of high-speed processing facilities (Perterson et al., 1998). Therefore, if the wheat that millers purchase is not consistently above the protein standard they may incur the additional expense of purchasing high protein wheat to produce a product with uniformity (Gallardo, 2007).

The protein content of hard red winter wheat produced under dryland condition in the Great Plains varies by region. The Great Plains has a broad range of wheat production practices, erratic insect and disease pressures, dramatic variations in climatic conditions, as well as significant genetic diversity that affects quality in cultivars utilized across the region (Peterson et al., 1998). Therefore, millers will not know the protein content or the quality of the wheat crop as a whole until after the North American wheat harvest season has been completed, which is several months after the Oklahoma harvest (Gallardo, 2007). Therefore, when Oklahoma wheat is sold at harvest, the quality of the wheat crop and the potential value of protein are unknown. This causes Oklahoma producers to face a marketing system that does not routinely pay for protein content.

Brown et al. (2005) find that supplying sufficient nitrogen (N) to the wheat crop is the most important management practice for producing wheat with high protein. Other factors also contribute to grain protein content such as variety of wheat grown, insect and weed control and water management, however, efficient management of N throughout the growing season plays a vital role in generating high protein, high quality HRW wheat. Grain protein content and yield have an inverse relationship that is very easy to detect in dryland production systems (Brown et al., 2005). This is usually because N is applied before planting or before the wheat has started to joint to avoid yield loss due to trampling. Wheat will use N that is accumulated during early to mid-vegetative growth for yield potential. The surplus of N will allow the plant to support more seed bearing tillers that will primarily have the greatest effect on the grain yield. However, after the wheat plant has started to head out the N uptake is used much less efficiently for increasing yield since the seeds per tiller have been set and the yield potential has been predominantly determined. This is when an application of N can be applied for the wheat to produce a kernel with greater amounts of protein as the N will not be used for yield potential (Brown et al., 2005). Studies have found that it is possible to increase protein content by a foliar application of N at the growth stage of post anthesis (Feekes 10.5) in hard red winter wheat (Bly and Woodard, 2003).

The purpose of this research is to determine if it is possible for an Oklahoma producer to improve their profit by implementing a production strategy to enhance the expected protein content of wheat and a marketing strategy to capture the expected protein premium. For an Oklahoma producer to capture a premium for protein, the wheat produced on the farm would have to be segregated and stored at harvest, either on the farm, or elsewhere. Later in the marketing year, the producer could merchandize the wheat directly to the millers that in some years are expected to be willing to pay a protein premium. Producers who use this segregated storage strategy would incur storage and other ownership costs.

Objectives:

Overall Objective

- The overall objective of this research is to determine the expected net returns from the production of Oklahoma HRW wheat managed for enhanced grain protein content and marketed to enhance the probability of receiving a protein premium price.

Specific Objectives

- Determine protein content and grain yield response to a late season foliar N application at flag leaf or post anthesis to HRW wheat
- Determine the costs of both late season foliar N applications
- Determine the expected storage and other ownership costs that would be incurred for a grain marketing strategy designed to extract protein premiums.

CHAPTER II

REVIEW OF LITERATURE

Demand for High Protein Wheat

The wheat crop produced both domestically and abroad is used to produce many products that are commonly made of flour. The flour comes from a variety of combination of the five different wheat classes, each consisting of multiple varieties that likely do not have the same end-use characteristics (Janzen, Mattson, and Wilson, 2001). Stiegert and Blanc (1997) describe wheat as a heterogeneous good that is graded on certain physical characteristics and other contract specifications. These grades are determined by the test weight, percentage of damaged kernels, and foreign material in the wheat. The quality of wheat is important to end-use processors because it assists them in deciding how much to pay for different classes of wheat. Grading information also provides data that can be used to predict the flour yield that certain wheat will produce.

Millers are required to produce flours with certain high-volume baking requirements for downstream customers. The minimum protein percentages are normally included in the specifications as it is a good indicator of what the performance of the wheat will be in the baking of breads, rolls and other products. Bale and Ryan (1977) imply that the protein content in wheat is used to differentiate wheat classes. Stiegert and Blanc (1997) mention that protein quality is used as an indicator of end-use functionality. The end users typically will specify the protein levels of the wheat because of the concealed functional characteristics represented by the protein. The functional characteristics include falling numbers, as well as absorption. Functional characteristics will not typically be measured in the marketing system that is in place, however protein is measured fairly easily therefore it is the measure that the wheat marketing system uses as a proxy for the end use functionality of wheat (Wilson, Wilson and Dahl, 2005).

The amount of protein desired is based on the processing technology, products produced, and on competing supplies. The demand for wheat with high protein comes from the demand for bread, whereas the demand for low protein wheat is derived from the demand for cakes, biscuits and pastries. The demand for protein is growing. “Prior to 1973/74, the price differentials in international markets were relatively small, likely reflecting the supply/demand situation and the lack of distinguishing differences in value among different classes of wheat. Since then, price differentials have increased in nearly all markets, reflecting increased differentiation in the international market” (Wilson, 1989, p. 76). “Since the early 1970s, wheat marketing has evolved from a simple system which recognized a small set of grade qualities to the current system in which prices are determined in a complex system that reflects the value of wheat characteristics that reduce milling costs or meet specific end uses” (Parcell and Stiegert, 1998, p.141) .

Wilson, Wilson and Dahl (2005) estimated protein demand by using data from the USDA Export Grain Inspection System (EGIS) of the Federal Grain Inspection System (FGIS). The variables included in the data were very detailed ship-lot grade and grain characteristics. For each of the shipments information on the grade, class protein level, whether protein content was specified, as well as individual grade and non-grade determining factors were reported by the FGIS. Through this study Wilson, Wilson and Dahl (2005) found that protein prices were highly elastic and that the elasticity increased for wheat with higher protein levels. They report that if there was an increase in the available quantity of higher protein wheat, there would be a disproportionately large increase in demand. This could result in larger incomes for the producers selling the high protein wheat. In the same study they found that HRW wheat protein content specification increased from 41% of exports in 1987/88 to over 90% in the 2000's. They also found that other country's probability of purchasing high protein wheat depends on the quality of the wheat produced in their own country. When there is high protein in their country they purchase lower protein wheat for blending purposes.

Different geographical locations with different agronomic and climatological conditions will favor different wheat varieties, which in turn provide the potential for extensive heterogeneity among the world's supply of wheat (Janzen, Mattson, and Wilson 2001). Brown et al. (2005) explain some reasons for the variation in quality of wheat throughout the world. They state, "While some rain-fed production areas, such as the Northern Plains, have climates that allow the routine production of high protein hard wheat or durum classes, other rain-fed areas produce high protein wheat less frequently depending on available moisture, temperature and greater fluctuations in yields" (Brown et al., 2005, p. 3). Studies by Peterson et al. (1998) and Wilson and Gallagher (1990) found that growing locations, cultivars, soils, nutrients, climate and topography impact and account for the differences in end-use characteristics, namely being test weight, kernel size, and protein content.

Historically, wheat that has high protein content has been somewhat scarce, demanding a higher price compared to wheat with lower protein content. This difference in price is referred to as a "protein premium". The premium is constantly changing based on demand, changing supplies of wheat, and also the protein content of the wheat. There have been instances where there is not a premium paid for protein (Bale and Ryan, 1977). Parcell and Stiegert (1998) report that wheat buyers do collect samples of wheat throughout production regions to know the quality of wheat that is produced. Certain regions then receive premiums and other regions have their wheat discounted based on the demand for certain characteristics, particularly protein. Espinosa and Goodwin (1991) conducted a study on the wheat characteristics in Kansas and found that with a one percentage point increase in the protein percentage there would be an increase of 4.92 cents-per-bushel for that type of wheat. Gallardo (2007) found that Mexican millers were willing to pay more for an increase in protein content from 11% to 13% than for any other end-use performance characteristic.

The price premium that high protein wheat will bring above lower protein wheat is not consistent. Parcell and Stiegert (1998) found in a U.S. study of the demand for wheat grain characteristics that exclusively increasing the protein content did not add a consistent value. The market value of protein at a point in time depends on both the demand for and supplies of protein in the aggregate wheat stock. Results of studies that have attempted to determine the marginal value of increasing wheat grain protein content are summarized in Table II-1.

Managing for High Protein Wheat

Field studies have found that producers can increase the grain protein content of their wheat crop. Bly and Woodard (2003) found that grain protein content can be increased by a late season foliar N treatment. In the study, nine of the 12 site years showed significant response to late season N application. Fowler (2002) notes that grain protein content is largely influenced by the level of N available in the soil, and that when grain protein content showed a positive response to N fertilization there was also a positive yield response.

Woodard and Bly (1998) report that during drier years the test weight and kernel weight of the wheat were lower since carbohydrate production is diminished. The grain protein content will almost always be greater under droughty conditions since the N pool remaining for the crop after the yield requirement is met will be greater than in years with more moisture. This leads most producers to believe that there is an inverse relationship between yield and protein content. However, proper N fertilization can lead to large increases in grain protein content as well as yield. This is a sharp contradiction to the inverse relationship that is normally observed between grain yield and grain protein content when cultivar differences are all that are considered (Fowler, 2003). Brown et al. (2005) believe that with more correct knowledge on the fundamentals of N use by wheat, the relationship between yield, protein and available N, and the correct management of N should enable producers to produce acceptable protein along with high yields more consistently. They believe that with effective N management it is much more likely to produce high protein, high quality hard wheat.

Wheat that is produced with low protein is usually the result of insufficient N availability to satisfy both the yield and protein content. There are other factors that can contribute to low protein but typically the reason is inadequate N at critical times during the growing season (Brown et al., 2005). Unfortunately, the problem cannot be solved by simply applying the economically optimal amount of N in one application. If the N required for both protein and yield is applied prior to, or at planting, then there is the potential that the wheat plant will use this N for forage production which causes the plant to use greater amounts of moisture. Also, the possibility of lodging becomes much greater. If lodging occurs then the yield and quality of the wheat crop is negatively affected (Brown et al., 2005). The timing of the N applications, the N rate, and the variety of wheat may all influence protein content. The greatest response from protein to foliar N application was detected when sufficient quantities of N were applied in split applications such that it was not limiting (Bly and Woodard, 2003; Woodard and Bly, 1998). Bly and Woodard (2003) found that applying the foliar N application at the growth stage of post-pollination produced the top grain protein content in every year of the study. Therefore post-pollination was the optimal growth stage to apply N to increase protein content. Post-pollination is similar to Feekes growth stage 10.5 shown in Figure II-1.

Marketing High Protein Wheat

U. S. farmers have multiple options for marketing their grain. They could harvest and immediately deliver their wheat to the local elevator and sell at the cash market price. They could store the wheat in the local elevator while incurring the cost to do so, and sell later. They also could store the wheat in on-farm storage and deliver it to a market of their choice at a later date. For the most part most U.S. wheat will eventually pass through a local elevator (Kansas Wheat Commission, 2007). Anderson and Brorsen (2005) found that around 90 percent of the wheat harvested in Oklahoma was stored in commercial elevators. The on-farm storage that is available in Oklahoma was found to be used primarily to store wheat seed for the next cropping season.

Upon arrival at the elevator, samples are taken to assess the grade according to FGIS requirements. Also in some cases tests are conducted to determine the falling number and protein content if the market is demanding this information. All of these factors may be used for determining the price the farmer receives. For the most part, the price received will be a function of the world market price adjusted for transportation costs and quality attributes (Kansas Wheat Commission, 2007). However Baker, Herrman and Loughin (1999) argue that the current system for marketing HRW wheat that is produced in the Southern Plains does not reward producers that deliver high quality wheat to the local elevator. The reason for this is as Espinosa and Goodwin (1991) imply that the efficiency of the grading system in place for wheat is in question because the information retrieved from the standard grading characteristics demonstrates some separation from the quality information inferred by the end-use characteristics. Also, numerous measures of quality that are found at the mill and bakery are not accurately reflected in the price of wheat. This would cause a producer to have to store the wheat on farm to deliver to a market where the price of wheat reflects the quality being demanded by the mill and bakery.

CHAPTER III

METHODOLOGY

Agronomic

Experiments were conducted at two locations in north central Oklahoma to evaluate the effect that a late season N application applied at flag leaf (Feekes 9) or post anthesis (Feekes 10.5) would have on the yield and quality of HRW wheat. The study was conducted over three years, but the protein data were only collected for two of the years. Two different sources of late season N were evaluated, Urea Ammonium Nitrate (UAN) (28-0-0) and CoRoN (25-0-0). UAN is high in salt content and foliar application may cause tissue burning on wheat. Under normal production practices, UAN is streamed onto wheat in low temperature conditions at or before the growth stage of first hollow stem (Feekes 3-Feekes 5) to avoid as much damage to the leaf area of the plant as possible. However, in the study the UAN was broadcast onto the wheat for there to be a uniform application across all plants.

CoRoN, produced by the Helena Chemical Company, is the registered name for a controlled release specialty fertilizer that has been formulated to provide the crop with weeks of steady nutrition. CoRoN is also non-corrosive with low potential for leaf burn. CoRoN was included in the study to determine the effect that the tissue burn from the UAN would have on the yield and protein content of the wheat. CoRoN was selected as the non-corrosive fertilizer because of its availability to the region.

Different rates of the late season N were applied to facilitate determination of the optimal amount of N to apply. The N rates included in the experiment were, 0, 6, 12, and 24 pounds per acre. The standard fertilization received by all the plots was based on a yield goal of 40 bushels per acre which matches the production history of the area surrounding the research sites. The N demand was then calculated using the formula of two pounds of N per acre for every bushel per acre yield goal; therefore, it was decided to apply 80 pounds of N per acre as standard fertilization. Split application of N is common in wheat production as it allows for more efficient use of the N. The split application strategy that was used in the experiment was to apply 40 pounds of N per acre in the form of urea (46-0-0) before planting and also 40 pounds of N per acre in the form of UAN was top-dressed at the growth stage of hollow stem. Late season N foliar rates were then added to some plots to determine their effect on the grain protein content and yield of the wheat. There was also a check plot that did not receive any N fertilizer during the experiment, as well as a plot that received only the standard farmer practice application of N and did not receive any late season foliar N throughout the duration of the study (Arnall, 2015).

The experiments were conducted at two separate Oklahoma agricultural experiment stations; one near Lahoma, and one near Lake Carl Blackwell (LCB). The Lahoma station is on the eastern edge of Major County, has a soil type classified as Grant Silt Loam-fine-silty, mixed, superlative, thermic Udic Agriustoll. LCB is located about six miles west of Stillwater, in Payne County, and contains a soil type of Port Silt Loam-fine-silty, mixed, superactive, thermic Cumulic Haplustoll. Both sites are managed by Oklahoma State University faculty, staff, and graduate students. Characteristics of each site can be seen in Table III-1. The trials were conducted over two cropping seasons, starting in the fall of 2010 and concluding in the summer of 2012 following the wheat harvest. The trial consisted of fourteen treatments that were arranged in a randomized complete block design, with each replication occupying a 10 by 20 foot plot. The treatments were replicated three times at each location in both years producing a total of four site years. Table III-2 shows the treatment structure that was used throughout the experiment.

The yield and protein data that were collected from the experiment were statistically analyzed by the SAS procedure PROC MIXED. PROC MIXED enables users to fit a variety of mixed linear models to data to test hypotheses. PROC MIXED also allows users to compute the least squares means of the data as well as their variances (SAS, 2008). Differences across source, growth stage applied, year, and location were tested. The yield models had yield as a function of several different variables. Linear and quadratic models were analyzed with PROC MIXED to determine wheat grain yield and protein percentage response to late season foliar N applications at flag leaf and post anthesis. The first model was constructed with yield as the dependent variable and used to predict grain yield response to both late season foliar N application. The linear models for yield and protein are described below:

$$Y_{ijklm} = \beta_0 + \beta_1 Loc_i + \beta_2 Year_j + \beta_3 Source_k + \beta_4 Growthstage_l + \beta_5 Rate_m + e_{ijklm}$$

$$P_{ijklmn} = \beta_0 + \beta_1 Loc_i + \beta_2 Year_j + \beta_3 Source_k + \beta_4 Growthstage_l + \beta_5 Rate_m + \beta_5 Yield_n + e_{ijklmn}$$

$$Y_{ijklm} = min\ (\beta_0 + \beta_5 Rate_m, P_r) + \beta_1 Loc_i + \beta_2 Year_j + \beta_3 Source_k + \beta_4 Growthstage_l + e_{ijklm}$$

$$P_{ijklmn} = min\ (\beta_0 + \beta_5 Rate_m, P_s) + \beta_1 Loc_i + \beta_2 Year_j + \beta_3 Source_k + \beta_4 Growthstage_l + \beta_5 Yield_n + e_{ijklmn}$$

where Y_{ijklm} is the estimated grain yield at the *i*th Location for the *j*th Year for the *k*th Source at the *l*th Growthstage with the *m*th Rate. β_0 is the intercept parameter, $\beta_1, \beta_2, \beta_3,\ and\ \beta_4$ and β_5 are the slope coefficients to be estimated. Loc_i represents experiment location of the experiment (*l*=Lahoma or LCB), $Year_j$ refers to the harvest year (*j*=2011, 2012 or 2013). $Source_k$ identifies what late season N was applied (*k*=UAN or CoRoN). $Growthstage_l$represents the growth stage at which the late season N was applied (*l*=Flag Leaf or Post Anthesis). $Rate_m$ identifies the pounds of late season N applied to the wheat (*m*=0, 6, 12, 24). e_{ijklmn} is the error term. Where $P_r$is the average plateau yield and P_{ijklmn} is the protein percentage at the *i*th Location for the *j*th Year for the *k*th Source at the *l*th Growthstage with the *m*th Rate and a *n*th Yield. $Yield_n$ stands for the grain yield. P_r represents the average plateau yield, and P_s identifies the average plateau protein percentage.

The ideal response function is chosen based on selecting the functional form that will most precisely present the relationship between yield and N (Griffin et al., 1987). Quadratic functional forms are often used to model crop yield response to N; however, past research has found that linear response plateau functions are sometimes found to provide a statistically superior fit to the data than polynomial functions (Chambers and Lichtenberg, 1996; Frank et al., 1990; Grimm et al., 1987; Llewelyn and Featherstone, 1997). Therefore, a linear response plateau model (LRP) was chosen to model protein response to late season foliar N applications. A chart of protein percentage response to late season foliar N applications at flag leaf and post anthesis can be seen in figures III-1. The rates of the late season N that were applied to the wheat were 0, 6, 12, and 24 pounds per acre. As seen in Figure III-1 the plateau effect is noticeable for protein content at the 12 pounds per acre level. A linear response plateau functional form was used to determine protein percentage response to late season foliar N. A linear response plateau functional form was also used to determine the yield response to late season foliar N. As seen in Figure III-2 the response to late season foliar N is not as noticeable in for yield as it is in protein.

PROC NLMIXED was used to estimate the LRP model. To determine which variables to include in the LRP model, the rate variable was taken out of the linear protein model. Then the variables that had a significant impact on the protein content of the wheat in the linear model were included in the LRP model. To determine the model with the best fit to the data the log-likelihood values were used with the smaller value being preferred (Boyer et al., 2012).

The pre-plant N fertilizer source used in the field experiment was urea, but the pre-plant N source used for the budgets in Table III-5 is anhydrous ammonia (82-0-0). This change was implemented since anhydrous ammonia is the more common source of preplant N for wheat production in Oklahoma. Urea (46-0-0) was used in the experiment because it is in a solid form and is much easier to apply to small research plots than anhydrous ammonia which is in a gas form (Arnall, 2015). However, for commercial farms the economic savings from using anhydrous ammonia are expected to exceed the inconvenience cost. Another budgeted practice that differs from the practices used in the field experiments is the banding of diammonium phosphate (DAP) (18-46-0) with the wheat seed at planting. This is a common production practice designed to facilitate root contact with phosphorus (P) at a very early growth stage. P is immobile in the soil. Therefore, banding of DAP is done to give the plant the early nutrients needed to reach the yield goal. However, since DAP also contains N, the amount of N banded with DAP applications is deducted from the budgeted quantity of preplant N applied (Zhang and Raun, 2006).

Economic

The field operations described in Table III-5 are for the production styles of No-Till (NT), No-Till Protein Management (NTPM), Conventional Till (CT), and Conventional Till Protein Management (CTPM). These systems were assumed to be representative of Oklahoma commercial wheat production. It is assumed that differences between budgeted practices and those used in the field experiments would not influence wheat grain yield response and wheat protein percentage response. Conventional tillage was used to conduct the experiments. Budgets were prepared for production systems.

Prices listed in Table III-6 were obtained via a phone interview with a sales representative of Farmers Grain Cooperative located in North Central Oklahoma. Farmers Grain Cooperative was chosen as the source to collect input price information because they have thirteen locations across Oklahoma allowing them to provide services to a large area of the state. The prices and inputs were then incorporated into budgets. The interest rate of 6% was obtained by Sahs (2015) from an interview with a representative at the Federal Reserve Bank of Kansas City as the most common rate for farm operating loans. The rates for taxes and insurance were acquired from the Oklahoma State University enterprise budgets that are produced annually and are built to be a planning tool for comparing expected revenues and costs across crops in Oklahoma. The fungicide and insecticide were both budgeted under the assumption that an application would be required only one third of the years. Thus, a third of their use cost is included in the budgets. The budgeted yield is 40 bushels of wheat per acre. This was chosen to match the yield goal established in the trials by Arnall, Mullock, and Seabourn (2012). The wheat prices chosen for the budgets were the historical five year average (2010-2014) prices received by Oklahoma producers (NASS, 2015). Wheat prices were collected for each month over the five years and then were averaged and used in the budget depending on the month the wheat was projected to be sold.

Both custom farming and equipment ownership management styles were analyzed. Budgets were built for No-Till Own (NTO), No-Till Custom (NTC), Conventional Till Own (CTO), Conventional Till Custom (CTC), No-Till Own Protein Management (NTOPM), No-Till Custom Protein Management (NTCPM), Conventional Till Own Protein Management (CTOPM), and Conventional Till Custom Protein Management (CTCPM). Custom harvesting prices were used for all production systems, with the traditionally managed farms hauling their wheat to the local elevator for sale and the systems producing wheat for higher protein content hauling their wheat to on-farm storage. The charge for hauling the grain during harvest was uniform across all production practices, because according to (Doye and Sahs 2014) custom harvesters charge a flat rate for hauling grain. Extra charges can be assessed if the location exceeds a distance from the grain field, but for this study the local markets and on farm storage was assume to be within the limit of the base charge. The land required to grow the wheat crop was assumed to be rented across all of the different production and management practices. The $40 per acre was assigned as the standard cash rent based on cash rental rates for dryland farms in North Central Oklahoma (Doye, and Sahs, 2013). The budgets for both protein and non-protein management are included in Table III-7 through Table III-14.

An additional cost for the protein management strategies was the trampling of the wheat when the late season foliar N was applied at flag leaf or post anthesis. The wheat is in a late enough growth stage that plants crushed by the applicator tires cannot recover and produce harvestable yield. Therefore it was determined that if the sprayer had a boom width of 100 feet and made two 15 inch tracks, each pass would result in a 2.5% per acre yield reduction (Weisz et al., 2011).

The fixed cost for the machinery and equipment used in the ownership systems were calculated using MACHSEL software (Kletke, and Sestak, 1991). MACHSEL allows users to input equipment prices, the number of times the equipment will be used, and in what month the equipment will be used. The software also accounts for farm size and will give per acre estimates of total machinery fixed costs as well as the estimated costs of lubricants, fuel, and repairs. The farm size selected for this study was 1,000 acres. The machinery cost for the self-propelled sprayer was acquired from Lazarus (2014) as MACHSEL did not have a self-propelled sprayer listing in their inventory. Prices for the equipment used in the budgets were found using fastline.com and tractorhouse.com. Both websites list agricultural equipment that is for sale from private owners as well as certified equipment dealerships providing a very competitive market that reflects prices offered to producers around the country. Most of equipment listed for sale in each of the categories used in this research was the John Deere brand. Therefore, prices of John Deere equipment were used because of its relative availability over other brands. The equipment used for each production system is included in Table III-15 and the equipment price information is available in Table III-16.

Protein premium data used in this study were collected over twenty years, 1995-2014. The data acquired for this study were collected by the Chicago Mercantile Exchange (CME) as reported by *Milling and Baking News* for HRW wheat located at Kansas City, Missouri. The premiums are reported as cents above the futures contracts. Therefore, to obtain prices that truly reflected the protein premium without basis, the price for ordinary wheat was subtracted from each protein class. Ordinary wheat is considered to be untested for protein or contain 10.5% protein (Steigert and Blanc, 1997). The data include the premium high and low for each week for levels ranging from 10.5% to 14%. The highs and lows for each week were averaged and used as the price for that particular week. The monthly average was acquired by grouping the weeks into months and then averaging the weekly prices. The monthly prices were then averaged over the twenty years of premiums reported to determine the twenty year average nominal protein premiums for each month as reported in Table III-17. A price index was used to deflate the data into real terms. The price Oklahoma farmers received for their wheat was chosen to be the price index. December 2014 was chosen as the base month since it was the last month for which protein premium data were available. The real prices are in Table III-18. These prices are not guaranteed to the producers, but were the best information available on the protein premiums. Therefore, it was determined to use these data to construct expected returns.

Since Oklahoma HRW wheat is harvested relatively early in the U.S. HRW wheat harvest season, protein percentages in the aggregate crop and the protein premiums that may be paid during the crop year are unknown at harvest. Local elevators do not test for and do not differentiate farmer-delivered wheat by protein percentage. Thus, to obtain a protein premium a farmer must store and maintain ownership. Storage enables the producer to maintain ownership until the protein premium for the season is revealed. Most Oklahoma elevators do not have the facilities that would be required to segregate wheat by ownership. Therefore, it is assumed that to capture potential protein premiums on-farm storage would be required. Thus, the costs of on-farm storage were incorporated into the budgets.

Prices and bin dimensions were collected from three on-farm grain storage manufacturing companies that are prominent in the Midwest. The grain storage facilities were priced to have perforated floors with fans that run on electricity to control wheat moisture, and sweep augers for unloading purposes. Five grain bin sizes were considered. The larger the grain bin the cheaper per bushel the bin is to construct. However, there is the possibility of variability in the protein percentage of the wheat, so one grain bin large enough to hold the producer's entire wheat crop may not be the most desirable option. Therefore, five different sizes of grain bins were analyzed to determine the price of constructing and maintaining on-farm storage. The size of grain bins that were analyzed and their pricing information can be found in Table III-19. The prices listed are for the construction of the bin but do not include the cost of the concrete pad and the cost of any electrical wiring. To accurately price the entire storage structure a spreadsheet was used on the construction of steel bins in Oklahoma, the spreadsheet was developed by Oklahoma State University Agricultural Economics Extension Department. Another spreadsheet developed by the University of Illinois was used to determine the storage costs of storing wheat in on farm storage (Farmdoc, 2008). Partial budgets were also constructed to help producers identify the dollars per acre return or loss provided by the protein management system.

Budgets were based on the assumptions of a single producer with 1,000 acres of wheat and an average yield of 40 bushels per acre. Therefore, it was decided to plan for the ability to store the entire wheat crop plus extra storage capacity in case of an above average harvest. The construction of two grain bins holding over 40,000 bushels together would give the producer the ability to segregate his wheat crop into two different protein classes if necessary. The Sukup bin that holds 24,822 bushels was the bin incorporated into the budget because it was the bin that was determined to best fit the operation. An auger was chosen as the transportation source of the wheat from the truck into the bins because a grain pit with a grain leg cost considerably more and was not deemed economical for average Oklahoma producers.

The expected net returns were calculated using the yield and protein content data from the Arnall, Mullock, and Seabourn (2012) experiment. They are reported as expected returns because the market used to collect the protein premiums is located in Kansas City, Missouri and thus is probably inaccessible to Oklahoma producers individually but is accessible for larger grain merchandising companies and thus the premiums are possible for Oklahoma producers to capture. The expected returns equation is:

$$EP = (WP * Yield) + (PP * Yield) - PC - EC$$

Where EP is the expected profit ($/acre), WP is the wheat price received ($/bu), Yield is the wheat grain yield (bu/ac), PP is the expected protein premium ($/bu), PC represents the production costs for standard wheat production ($/bu), and EC equals the extra costs of producing wheat for high protein content ($/acre).

The expected net returns of wheat were analyzed using stochastic dominance criteria. Stochastic dominance was chosen so that different production styles could be compared as well as the potential risk associated with the different production systems. Stochastic dominance represents a set of relations between a pair of distributions. A very prevalent use of stochastic dominance is the analysis of alternative production strategies which is the purpose of the stochastic dominance tests in this study (Davidson, 2006). The net returns were analyzed on a per acre basis. The stochastic dominance analysis was conducted by using SIMETAR (Richardson and Feldman, 2005).

To determine a risk aversion coefficient range for agricultural producers, Hardaker et al. (2004) and Anderson and Dillon (1992) suggest dividing 0.5 and 4 by the average farm net worth per acre. The number 0.5 represents a moderately risk averse producer and 4 represents a strongly risk averse producer in the lower and upper bounds of the risk aversion coefficient suggested by Anderson and Dillon (1992). The net worth data on a whole farm basis were collected using the Kansas Farm Management Association (KFMA). Kansas data were used because Oklahoma whole farm net worth data are not available. In December of 2013 the KFMA reported an average farm net worth of $1,697,363, with an average farm size of 1,517 acres (Kansas Farm Management Association, 2014). Using these data the average farm net worth per acre comes out to be $1,118.89. Dividing 0.5 and 4 by $1,118.89 produce the lower and upper limits for the risk aversion coefficient, which are approximately 0.00045 and 0.004. SIMETAR is used to produce the certainty equivalents that are calculated for slightly risk averse producers (0.00045), moderately risk averse producers (0.0022) and strongly risk averse producers (0.004). The certainty equivalents indicate the amount of money a producer would be willing to receive to become indifferent between a production practice with a lower expected income and relatively less variability and a production practice with a larger expected income but greater expected variability. These certainty equivalents can be used to determine the percentage increase or decrease in input prices and revenues at which the decision maker would be indifferent between strategies.

The twenty-year real average protein premium price for July was the protein premium incorporated into each of the protein management production styles, NTOPM, NTCPM, CTOPM, and CTCPM. The July price was used because it was on average the second highest premium behind June. Using June as the premium price was considered infeasible as the majority of the wheat harvest in the state of Oklahoma occurs in June and would leave little time for producers to market their grain.

CHAPTER IV

FINDINGS

Agronomic

Findings from data produced by the experiment on the response of protein content and yield to a late season application of foliar N at both flag leaf (Feekes 9) and post anthesis (Feekes 10.5) by Arnall, Mullock, and Seaborn (2012) are presented in Table IV-1 through Table IV-3. Yields and protein results that were recorded from the 14 treatments are shown. The treatment that averaged the highest yield over the duration of the study was treatment 12 (6,CoRoN,FL) with an average yield of 60.9 bushels per acre. However, this yield was statistically significantly different only from the check. Treatment 13 (12,CoRoN,PA) recorded the highest average protein percentage among the different treatment strategies with its average at 13.43%. However, this protein percentage level was different only from the check and farmer practice.

Yields in the experiment were above normal average yields for the region. The test sites at Lahoma had been fallowed the year prior to the planting of the 2011 wheat crop (Arnall, Mullock, and Seaborn, 2012). The rate of late season foliar N that produced the greatest average yield was 24 pounds of N per acre, which registered an average yield of 58.46 bushels per acre. However, this yield was not statistically greater than the yield obtained by the farmer practice. The late season N rate of 12 pounds per acre recorded the highest average protein percentage averaging 13.05% over the duration of the experiment. However, this level was not significantly different from the levels obtained by the other treatments that received late season N. The late season N source that recorded the highest mean protein level was in the form of UAN that posted a mean protein percentage of 13.05, however, CoRoN was the source of late season N that registered the largest average yield of 57.95 bushels per acre. However, the grain yield and protein percentage were not statistically significantly different between the two sources of late season N. The results for the remainder of the N rates and N sources from the study can be found in Table IV-4 and Table IV-5. The linear model was used to estimate the yield response to late season foliar N. The null hypothesis of homoskedasticity could not be rejected at the 5% significance level. Therefore, no correcting for heteroskedasticity was needed. A linear model was also used to estimate protein percentage response. The heteroskedasticity test for the protein model found that the null hypothesis of homoskedasticity was rejected at the 5% significance level. Therefore, the heteroskedasticity was corrected for in all of the protein models using the SAS Proc Mixed repeated option to address the unequal variance of residuals. Proc NL Mixed was used to model the linear response plateau models.

In the yield model the late season foliar N application at flag leaf and post anthesis did not show any significant effects on the yield of the wheat at the 95% confidence level ($P<0.05$) or the 90% confidence level ($P<0.1$). The significant variables were *Location* which showed a 34.07 bushel per acre increase in the Lahoma yields compared to the LCB yields. Harvest *year* also was significant and showed an increase of 14.19 bushels per acre for the 2012 yields compared to the 2011 yields. Both variables were significant at the 95% confidence level. The rest of the variables and their effects on wheat grain yield can be viewed in Table IV-7.

The protein percentage model showed that the location and harvest year were significant at the 95% confidence level as well as the late season foliar N application. There was a reduction in the protein by 0.91 percentage points from not applying the late season foliar N application as opposed to applying the late season application of N at post anthesis. There was a decline in the protein percentage by 0.34 percentage points from applying at flag leaf as opposed to post anthesis, however, this was significant only at the 90% confidence level. The yield variable was significant at the 95% confidence level and was shown to be negatively correlated with the protein content of the wheat. The rest of the variables and their effect on the protein percentage can be viewed in Table IV-7.

The graph of the protein content data available in Figure III-1 showed a plateau formation occurring after 12 pounds of N. Therefore two linear plateau models were fit to the data with protein content as the dependent variable. The first model is assuming the late season foliar N application was applied at flag leaf. The source of N is not included as a variable because it did not have a statistically significant effect on the protein content in the linear model listed in Table IV-7. The rate of N does not significantly change the protein content when applied at the growth stage of flag leaf. The plateau was determined to be at 12.77% protein. The results from this model can be viewed in Table IV-8.

The second linear plateau model determined the optimal rate of late season foliar N applied at the growth stage of post anthesis. The rate of late season N was shown to be statistically significant at the 95% confidence level. The rate of late season N increased the protein content of the wheat by 0.14 percentage points for every pound of late season N applied from the intercept value of 13.08% to the plateau of 14.41% protein. Yield was shown to be negatively correlated with protein percentage, and location had a statistically significant effect on protein percentage. The rest of the results from this model can be viewed in Table IV-8.

Linear plateau models were developed to determine the effect of a late season foliar N application on the yield of wheat at the growth stages of flag leaf (Feekes 9) and post anthesis

(Feekes 10.5). For the growth stage of flag leaf location and harvest year variables were significant at the 90% confidence level. At the growth stage of flag leaf the average yield was 41.47 bushels per acre and the yield plateau was 42.51 bushels per acre, both were significant at the 95% confidence level. The rate of late season N was not significant but showed a 0.14 bushel per acre increase for every pound of N applied. The variables significant at the 90% confidence level were location and harvest year. The rest of the results can be viewed in Table IV-9.

The linear plateau for yield at the growth stage of post anthesis found the average yield to be 41.17 bushels per acre and the yield plateau to be 43.44 bushels per acre, both were significant that the 95% confidence level. Other variables that were significant at the 95% confidence level were location and harvest year. The rate of the late season N was not significant but showed an increase of 0.12 bushels per acre increase from each pound of N applied. The rest of the results can be viewed in Table IV-9.

Economic

The monthly means from the protein premium data collected from the CME can be viewed in Table III-18. A graph is available in Figure IV-2. For all the protein classes except 11% protein, June was the month that averaged the greatest protein premium over the twenty year period for which data were available. There was no volume data reported with the premiums that were supplied by *Milling and Baking News,* this possibly could be part of the reason for the month of June being the highest protein premium. Early in the marketing year, quantities available for purchase are relatively greater and millers have more options. Late in the marketing year millers have fewer options and could be expected to bid more to meet specifications. The 14% protein content class maintained the highest average protein premium across every month that was analyzed. This was not a surprise since 14% protein is fairly rare and there is usually not a large supply even in higher protein years.

Management of wheat to increase protein content increases the cost of production as many more practices needed to be performed as well as the purchase of grain handling facilities. The storage cost for on-farm storage was $0.27 per bushel stored. This was treated as a function of the yield in this study and not considered a fixed cost. The variation in the yields that were collected from Lahoma and LCB produced the decision to treat the on-farm storage cost as a variable cost instead of a fixed cost. Therefore, $0.27 per bushel was the most representative cost per bushel of on-farm storage.

The expected net returns of the treatments in the experiment testing the effect of a late season foliar N application at post anthesis were analyzed to determine the best treatment strategy for wheat production. The farmer practice treatment averaged the greatest net returns for all production styles posting net returns of $107, $91, $130 and $108 per acre for the production styles of NTO, NTC, CTO, and CTC, respectively. Farmer practice consisted of applying fertilizer only for yield with split applications of N, one pre plant and the second application applied at the growth stage of first hollow stem (Feekes 6). The descriptions of the treatments are available in Table III-2. The tables of average expected net returns for each treatment in each production practice can be viewed in Table IV-10.

The net returns were analyzed using stochastic dominance criteria. The certainty equivalents of each of the four production styles are listed in Tables IV-10 through Table IV-14. First degree stochastic dominance was not able to differentiate among the alternative strategies. The first degree and second degree dominance tables can be viewed in Table IV-15 through Table IV-18. The farmer practice treatment produced the greatest returns per acre across all of the risk preferences except for the slightly risk averse producer. In the slightly risk averse scenario, treatment 10 (12,UAN,PA) produced the greatest net returns per acre when the equipment was owned by the producer. When the producer already owns the equipment the only extra cost in applying the extra foliar N to the crop is very small compared to when a producer has to hire a custom applicator. This is why when the equipment is owned, treatment 10 (12,UAN,PA) would be preferred by slightly risk averse producers. The difference between the treatment with the highest net returns per acre and any other treatment is the premium that the producer would have to receive for the producer to become indifferent between the two production systems. Therefore, it is possible to compare different strategies to determine which strategy would be preferred across different levels of risk preference.

Producers would be interested in the amount of protein premium required to produce enough revenue to cover the extra costs of producing wheat with high protein content. Therefore, the protein management strategies were analyzed again to determine the amount of protein premium this would require. To do this the revenue was calculated as yield per acre multiplied by the wheat price. The certainty equivalents were then subtracted from the farmer practice production strategy to identify the extra cost of each different protein management production strategy. The net returns per acre for a producer to become indifferent across all risk levels can be viewed in Table IV-19. Then the differences for each treatment were divided by their individual average yield over the course of the experiment. This produced the protein premium that each treatment strategy would require for a producer to be indifferent between it and the traditional farmer practice strategy. The results can be viewed in Table IV-20. Treatment 2 Pro which consisted of the farmer practice strategy but included the additional costs for protein management and the extra revenues from the protein premium, posted the lowest amount of protein premium required at $0.41 per bushel followed closely by treatment 10 (12,UAN,PA) which would require a $0.44 per bushel premium for the producer to become indifferent between traditional wheat production and protein management production in a CTO production system with a slightly risk averse attitude. The rest of the protein premiums required for the producer to become indifferent across different risk levels can be viewed in Table IV-20.

Several partial budgets were constructed for each of the production systems to determine the expected marginal benefits of protein management. The budgets were set up with a yield goal of 40 bushels per acre. There were three different scenarios that were studied, the activities of managing for protein and receiving a protein premium versus not managing for protein and not receiving a protein premium were analyzed. Managing for protein and receiving a protein premium versus not managing for protein and receiving a protein premium was studied to determine if the management of wheat for protein provided any economic advantage. Managing for protein and receiving a protein premium but not incurring the costs of transportation and storage versus not managing for protein and receiving a protein premium was analyzed to determine what affect storage and transportation costs had on the protein management system The 1.14 bushels per acre yield increase and the 0.975 percentage points protein increase from the late season N application were included to properly determine the economic impact of the management style. The only budget that found late season protein management to be more profitable was the budget where the transportation cost and storage cost were not incurred. This budget showed a $3.30 increase in profit per acre compared to non protein management with the producer owning the equipment. Under custom hire the budget showed a $0.45 loss compared to non protein management. The partial budgets can be viewed in Table IV-21 and Table IV-26.

The parital budgets are assuming that the protein premium would be paid every year. As stated previously by Bale and Ryan 1997, there have been instances where there is not a premium paid for protein. Therefore it is not always feasible for producers to market for high protein wheat. The breakeven protein premium per bushel for each of the partial budget scenarios listed above are available in Table IV-27 and Table IV-28, these were produced to help the producer determine how high of a protein premium to demand for protein content management to be a feasible economic option.

The source of N was not significant in increasing either protein content or yield. Also CoRoN was $0.80 per pound more than UAN. Therefore, with wheat prices at $6.65 per bushel CoRoN would have to increase the yield by over one bushel per acre if the optimal rate of 9.5 pounds of N were applied as included in the partial budgets. Therefore UAN was used in the partial budgets and CoRoN was not included.

CHAPTER V

CONCLUSION

The United States wheat crop is graded on physical characteristics such as falling number, moisture content, percent defects, test weight, amount of foreign material and protein content. Research was conducted to determine if applying N at certain growth stages of HRW wheat would increase protein content in the wheat grain. Then with the yield and protein content data, research was conducted to determine if the expected additional returns from late season foliar N applications at post anthesis would be sufficient to offset the cost of the late season N application and the additional cost incurred to segregate and store wheat on-farm as necessary to obtain protein premiums. Four different production practices were considered when implementing the protein management strategy. These production practices were No-till with the equipment owned by the farmer/operator (NTO), No-till with custom farming (NTC), Conventional till with the equipment owned by the farmer/operator (CTO), Conventional till with custom farming (CTC).

Yield and protein content data were produced in an experiment at two different Oklahoma locations for two growing seasons from 2010-2012. Fourteen treatments were replicated three times each year. The fourteen treatments were evaluated to determine which produced the greatest net returns per acre. Field operations were based on common practices used on Oklahoma farms. Input prices were collected from local sources that would be available to the majority of farmers in Oklahoma.

Wheat prices were collected from USDA data, and protein premiums were collected from the *Milling and Baking News*

Regression models were fit to determine the effect of the late season foliar N application at both growth stages on the yield and protein content of the wheat. The late season foliar N did not have a statistically significant effect on the yield of the wheat in the experiment at either growth stage. However, the growth stage when the late season foliar N was applied did have an effect on the protein content of the wheat. The application at the growth stage of post anthesis increased the protein content of the wheat by 0.9075 percentage points compared to no late season N being applied and also an increase of 0.3415 percentage points when compared to the late season N application at the growth stage of flag leaf. The rate of the late season N applied significantly increased the protein content when applied at post anthesis up to a plateau of 14.41% protein content. A yield increase was determined to be 1.14 bushels per acre at the growth stage of post anthesis, and 1.33 bushels per acre at the growth stage of flag leaf.

The economic procedures included building budgets to determine the cost of production and then apply them to the yield and protein content data to determine which treatment would provide the Oklahoma producer the optimal economic strategy for each of four different production systems. As well as building partial budgets to help producers view the extra costs, and revenues of a production system that manages for high protein content. Of the fourteen different treatment strategies, no treatment strategy dominated by first degree stochastic dominance, there was no second degree stochastic dominance exhibited by any treatment over the rest of the group. However, some treatments dominated a single other treatment but there was no one treatment that stood above the group.

The protein management systems expected returns do show economic benefits compared to traditional wheat management at the slightly risk averse level for production systems that the producer owns the application equipment. An application of late season N in the form of foliar UAN at the growth stage of post anthesis showed an increase of $1.6 per acre for both conventional till and no till at the slightly risk averse level above the farmer practice treatment. However, even though the late season protein application showed to have greater returns for a slightly risk averse producer it is still hard to guarantee that this is the best production strategy for producers in Oklahoma. As stated in chapter III the returns calculated in this study are expected returns and there are very few grain buying facilities in Oklahoma that would honor the protein prices received from the *Milling and Baking News*. Most large grain merchandising companies base their protein premium on the demand from their customers that depends on the current physical characteristics of the United States wheat crop (Dixon, 2015).

The best strategy for Oklahoma producers would be to produce their own partial budgets similar to the ones presented in Chapter IV to determine the costs of producing high protein wheat and then develop relationships with grain merchandising companies, and if the premium is sufficient to justify the costs, then the producers could capture the extra profit by producing high protein wheat. The partial budgets showed that if a producer would have access to a protein market that would pay every year, and would require no extra storage or transportation costs then it would be more profitable than traditional wheat production practices.

The protein premiums required for producers to become indifferent between the farmer practice strategy and the protein management strategies were developed to provide a producer with the information of how much more per bushel they would need to cover the expected costs. This would help the producer if a possibility arose to contract wheat for a protein premium.

Further research could be conducted on the wheat protein content and the basis levels of country elevators to determine if there is a protein premium passed on to the producers in the form of a smaller basis. If this could be proven to be true then managing wheat for high quality and high protein would be a much more viable option as the two major expenses of the production practice of managing for protein which are trucking expense and on farm storage would be diminished greatly.

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APPENDICES

Table II-1. Results from Previous Studies Discovering Marginal Value of a Protein Content Increase of 1%

Authors	Years of Study	Region	Marginal Value $/bu
Stiegert and Blanc (1997)	1984-1992	Japan	$0.32
Ahmadi-Esfahani and Stanmore (1994)	1976-1991	Australia	$0.26
Uri et al. (1994)	1990-1991	United States	$0.17
Veeman (1987)	Mid-1970's	United States	$0.05
Veeman (1987)	Early 1980's	United States	$0.18

Table III-1. Experiment Treatment Locations and Descriptions

	Lahoma 2011	Lahoma 2012	LCB 2011	LCB 2012
Soil type	Grant Silt Loam	Grant Silt Loam	Port Silt Loam	Port Silt Loam
Mean temperature	58.78˚F	61.85˚F	60.64˚F	62.38˚F
Yearly percipitation	23.38 inches	21.67 inches	23.02 inches	20.63 inches
Plot dimensions	10X20 feet	10X20 feet	10X20 feet	10X20 feet
Pre-plant N(lbs/acre)	40	40	40	40
Top dress N(lbs/acre)	40	40	40	40
Yield goal(bu/ac)	40	40	40	40

Temperature and percipiation data obtained from the Mesonet sites located at Lahoma and Lake Carl Blackwell, Oklahoma.

Table III-2. Treatments for Each Location

Treatment	Rate of Late Season N (lbs/ac)	Source	Timing	Description
1	0			Check
2	0			Farmer Practice
3	6	UAN	Flag Leaf	6,UAN,FL
4	12	UAN	Flag Leaf	12,UAN,FL
5	24	UAN	Flag Leaf	24,UAN,FL
6	6	CoRoN	Flag Leaf	6,CoRoN,FL
7	12	CoRoN	Flag Leaf	12,CoRoN,FL
8	24	CoRoN	Flag Leaf	24,CoRoN,FL
9	6	UAN	Post Anthesis	6,UAN,PA
10	12	UAN	Post Anthesis	12,UAN,PA
11	24	UAN	Post Anthesis	24,UAN,PA
12	6	CoRoN	Post Anthesis	6,CoRoN,PA
13	12	CoRoN	Post Anthesis	12,CoRoN,PA
14	24	CoRoN	Post Anthesis	24,CoRoN,PA

Treatments 2-14 received 40 lb N/ac pre-plant and 40 lb N/ac topdressed at the growth stage of first hollow stem.

Table III-3. Yield and Protein Linear Models

	Yield	Protein
Intercept	X	X
Location (1 if Lahoma; 0 otherwise)	X	X
Year (1 if 2011; 0 otherwise)	X	X
Year (1 if 2012; 0 otherwise)	X	
Source of late season N (1 if UAN; 0 otherwise)	X	X
Source of late season N (1 if CoRoN; 0 otherwise)	X	X
Growth stage of late season N (1 if Flag Leaf; 0 otherwise)	X	X
Growth stage of late season N (1 if Post Anthesis; 0 otherwise)	X	X
Growth Stage of late season N (1 if FP[a]; 0 otherwise)	X	X
Rate	X	X
Yield (bushels per acre)		X

[a] FP refers to the farmer practice of 40 lb N/ac pre-plant and 40 lb N/ac topdressed at the growth stage of first hollow stem that was applied to all treatments except the unfertilized check. X identifies which variables were included in the Yield and Protein models

Table III-4. Yield and Protein Linear Response Plateau Models

	Yield	Protein
Intercept	X	X
Rate	X	X
Yield Plateau	X	
Protein Plateau		X
Location (1 if Lahoma; 0 otherwise)	X	X
Year (1 if 2011; 0 otherwise)	X	X
Year (1 if 2012; 0 otherwise)	X	
Source of late season N (1 if UAN; 0 otherwise)	X	
Source of late season N (1 if CoRoN; 0 otherwise)	X	

X identifies which variables were included in the Yield and Protein models

Table III-5. Field Operations For Protein and Non-Protein Management

Field Operations	Date	NT	CT	NTPM	CTPM
Chisel	June		x		x
Herbicide (glyphosate dicamba and AMS)	June	x		x	
Chisel	July		x		x
Herbicide (glyphosate dicamba and AMS)	July	x		x	
Field cultivator	August		x		x
Herbicide (glyphosate dicamba and AMS)	August	x		x	
Apply Nitrogen (82-0-0)	September	x	x	x	x
Plant wheat	October	x	x	x	x
Band fertilizer (18-46-0)	October	x	x	x	x
Herbicide (glyphosate and AMS)	October	x		x	
Apply Nitrogen (28-0-0)	January	x	x	x	x
Apply insecticide (chlorpyrifos) (1/3 of years)	January	x	x	x	x
Apply herbicide (2,4-D chlorsulfuron-metsulfuron AMS)	March	x	x	x	x
Apply late season N application	March/April			x	x
Apply fungicide (1/3 of years)	April	x	x	x	x
Harvest wheat and haul to on-farm storage or off-farm sale	June	x	x	x	x
Store wheat in on-farm storage	June			x	x
Haul wheat off-farm to sell	July			x	x

NT=No-till
CT=Conventional Till
NTPM=No-till Protein Management
CTPM=Conventional Till Protein Management

Table III-6. Operating Inputs for Wheat Production Systems

Operating Inputs	Unit	Price($)	NTCPM	NTC	NTOPM	NTO	CTCPM	CTC	CTOPM	CTO
			Production Systems							
Custom chisel	acre	$12.81					2	2		
Custom field cultivation	acre	$10.82					1	1		
Custom herbicide application	acre	$6.10	5	5			1	1		
Custom 82-0-0 application	acre	$11.98	1	1			1	1		
Custom wheat planting	acre	$16.16	1	1			1	1		
Custom UAN application	acre	$4.73	2	1			2	1		
Custom fungicide/insecticide application	acre	$5.15	0.33	0.33			0.33	0.33		
Custom harvesting	acre	$22.97	1	1	1	1	1	1	1	1
Harvesting charge for bushels over 20 bu/acre	bu.	$0.23	20	20	20	20	20	20	20	20
Wheat seed	bu.	$13.50	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Anhydrous Ammonia (82-0-0)	lbs.	$0.31	37.80	37.80	37.80	37.80	37.80	37.80	37.80	37.80
Diammonium Phosphate (18-46-0)	lbs.	$0.29	50	50	50	50	50	50	50	50
Urea Ammonium Nitrate (28-0-0)	lbs.	$0.16	228.57	142.86	228.57	142.86	228.57	142.86	228.57	142.86
CoRoN (25-0-0)	lbs.	$0.96	96		96		96		96	
Herbicide (glyphosate)	gal.	$18.50	1	1	1	1				
Herbicide (dicamba)	oz.	$0.74	12	12	12	12				
Herbicide (chlorsulfuron+flucarbazone)	oz.	$11.50	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Herbicie (2,4-D)	oz.	$0.19	8	8	8	8	8	8	8	8
Ammonium Sulphate (AMS)	lbs.	$0.28	4.25	4.25	4.25	4.25	0.85	0.85	0.85	0.85
Insecticide (chlorpyrifos)	oz.	$0.27	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Fungicide (prothioconazole+tebuconazole)	oz.	$2.42	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Seed treat insecticide (imidacloprid)	oz.	$1.76	3.6	3.6	3.6	3.6				
Diesel	gal.	$2.17			1.2	0.83			3.67	2.73
Custom hauling (830 bu/load)	mile	$4.00	100		100		100		100	

NTCPM=No-till Custom Protein Management NTC=No-till Custom NTOPM=No-till Own Protein Management NTO=No-till Own
CTCPM=Conventional till Custom Protein Management CTC=Conventional till Custom CTOPM=Conventional till Own Protein Manangement
CTO=Conventional till Own
This table includes rates of 24 lbs of N in the form of CoRoN
This table includes the rate of late season UAN as 24 lbs of N per acre
100 miles was determined to be the average trip a typical Oklahoma producer would have to travel to deliver wheat to a market that paid a protein premium

Table III-7. Budgeted Costs No-Till with the Equipment Owned by the Producer (NTO)

Production	Units	Price	Quantity	$/Acre
Wheat	Bu.	$ 6.47	40	$ 258.72
Total				$ 258.72
Operating Inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
Glyphosate	oz	$ 0.14	128.00	$ 18.50
2,4-D	oz	$ 0.19	8.00	$ 1.55
Dicamba	oz	$ 0.74	12.00	$ 8.91
Chlorsulfuron+Flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	5.95	$ 1.67
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Annual operating capital		6%	70.99	$ 4.26
Custom harvest	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Commercial storage (1 month)	bu	$ 0.03	40.00	$ 1.20
Machinery labor	hour	$ 10.00	0.51	$ 5.09
Fuel	gal	$ 2.17	1.53	$ 3.31
Lube	ac	$ 0.24	1.00	$ 0.24
Repairs	ac	$ 2.84	1.00	$ 2.84
Total operating costs				$ 170.82
Returns above total operating costs				$ 87.90
Fixed costs				
Machinery				
Interest at	6%	$ 13.11	1	$ 13.11
Taxes at	1%	$ 3.20	1	$ 3.20
Insurance	0.6%	$ 2.15	1	$ 2.15
Depreciation		$ 20.69	1	$ 20.69
Rent		$ 40.00	1	$ 40.00
Total fixed costs				$ 79.15
Total costs				$ 249.98
Returns above all specified costs				$ 8.74

The budget is assuming a yield of 40 bu/ac.
Commercial storage costs reflect charges of Farmers Cooperatives across Oklahoma.

Table III-8. Budgeted Costs No-Till with Custom Hire (NTC)

Production	**Units**	**Price**	**Quantity**	**$/Acre**
Wheat	Bu.	$ 6.47	40	$ 258.72
Total				$ 258.72
Operating Inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
Glyphosate	oz	$ 0.14	128.00	$ 18.50
2,4-D	oz	$ 0.19	8.00	$ 1.55
Dicamba	oz	$ 0.74	12.00	$ 8.91
Chlorsulfuron+Flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	5.10	$ 1.43
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Annual operating capital		$ 0.06	102.12	$ 6.13
Custom application herbicide	ac	$ 6.10	5.00	$ 30.50
Custom application liquid fert	ac	$ 4.73	1.00	$ 4.73
Custom anhydrous app	ac	$ 11.98	1.00	$ 11.98
Custom fungicid/insecticide app	ac	$ 5.15	0.33	$ 1.72
Custom planting	ac	$ 16.16	1.00	$ 16.16
Custom harvesting	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Commercial storage (1 month)	bu	$ 0.03	40.00	$ 1.20
Total operating costs				$ 226.06
Returns above total operating costs				$ 32.66
Fixed costs				
Rent	$	$ 40.00	1	$ 40.00
Total fixed costs				$ 40.00
Total costs				$ 266.06
Returns above all specified costs				$ (7.34)

The budget is assuming a yield of 40 bu/ac.
Commercial storage costs reflect charges of Farmers Cooperatives across Oklahoma.

Table III-9. Budgeted Costs Conventional Till with the Equipment Owned by the Producer (CTO)

Production	**Units**	**Price**		**Quantity**	**$/Acre**	
Wheat	Bu.	$	6.47	40	$	258.72
Total					$	258.72
Operating Inputs						
Wheat seed	lbs	$	13.50	1.50	$	20.25
28-0-0	lbs	$	0.16	142.86	$	23.21
18-46-0	lbs	$	0.29	50.00	$	14.50
82-0-0	lbs	$	0.31	37.80	$	11.53
2,4-D	oz	$	0.19	8.00	$	1.55
Chlorsulfuron+Flucarbazone	oz	$	11.50	0.40	$	4.60
AMS	lbs	$	0.28	0.85	$	0.24
Fungicide	oz	$	2.42	1.67	$	4.04
Insecticide	oz	$	0.27	5.33	$	1.46
Crop insurance	ac	$	7.00	1.00	$	7.00
Custom harvest	ac	$	27.48	1.00	$	27.48
Transportation at harvest	bu	$	0.23	40.00	$	9.20
Commercial storage (1 month)	bu	$	0.03	40.00	$	1.20
Annual operating capital	ac		6%	55.19	$	3.31
Machinery labor	ac	$	3.08	1.00	$	3.08
Lube	ac	$	0.86	1.00	$	0.86
Fuel	gal	$	2.17	2.81	$	6.09
Repairs	ac	$	3.20	1.00	$	3.20
Total operating costs					$	142.79
Returns above total operating costs					$	115.93
Fixed costs						
Machinery						
Interest at	6.00%	$	15.18	1	$	15.18
Taxes at	1.00%	$	3.74	1	$	3.74
Insurance	0.60%	$	2.36	1	$	2.36
Depreciation		$	22.54	1	$	22.54
Land rent		$	40.00	1	$	40.00
Total fixed costs					$	83.82
Total costs					$	226.62
Returns above all specified costs					$	32.10

The budget is assuming a yield of 40 bu/ac.
Commercial storage costs reflect charges of Farmers Cooperatives across Oklahoma.

Table III-10. Budgeted Costs Conventional Till with Custom Hire (CTC)

Production	**Units**	**Price**	**Quantity**	**$/Acre**
Wheat	Bu.	$ 6.47	40	$ 258.72
Total				$ 258.72
Operating Inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
2,4-D	oz	$ 0.19	8.00	$ 1.55
Chlorsulfuron+flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	0.85	$ 0.24
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Annual operating capital	ac	6%	92.46	$ 5.55
Custom liquid fertilizer app	ac	$ 4.73	1.00	$ 4.73
Custom herbicide app	ac	$ 6.10	1.00	$ 6.10
Custom fungicide/insecticide app	ac	$ 5.15	0.33	$ 1.72
Custom chisel	ac	$ 12.81	2.00	$ 25.62
Custom field cultivation	ac	$ 10.82	1.00	$ 10.82
Custom anhydrous app	ac	$ 11.98	1.00	$ 11.98
Custom planting	ac	$ 16.16	1.00	$ 16.16
Custom harvesting	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Commercial storage	bu	$ 0.03	40.00	$ 1.20
Total operating costs				$ 208.92
Returns above total operating costs				$ 49.80
Fixed costs				
Rent	$	$ 40.00	1	$ 40.00
Total fixed costs				$ 40.00
Total costs				$ 248.92
Returns above all specified costs				$ 9.80

The budget is assuming a yield of 40 bu/ac.
Commercial storage costs reflect charges of Farmers Cooperatives across Oklahoma.

Table III-11. Budgeted Costs No-Till Protein Management with the Equipment Owned by the Producer (NTOPM)

Production	Units	Price	Quantity	$/Acre
Wheat	Bu.	$ 6.47	40	$ 258.72
Protein	13% Protein	$ 0.58	40	$ 23.32
Total				$ 282.04
Operating Inputs				
Wheat seed	bu	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
Glyphosate	oz	$ 0.14	128.00	$ 18.50
2,4-D	oz	$ 0.19	8.00	$ 1.55
Dicamba	oz	$ 0.74	12.00	$ 8.91
Chlorsulfuron+flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	5.95	$ 1.67
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Custom harvest	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Annual operating capital	ac	6%	71.71	$ 4.30
Machinery labor	hour	$ 10.00	0.58	$ 5.80
Fuel	gal	$ 2.17	1.65	$ 3.58
Lube	ac	$ 0.24	1.00	$ 0.24
Repairs	ac	$ 3.11	1.00	$ 3.11
Foliar N application (28-0-0)	lbs	$ 0.16	42.86	$ 6.96
Foliar N application CoRoN	lbs	$ 0.96	0.00	$ -
Trampling loss	ac	2.50%	282.04	$ 7.05
Transportation cost	mile	$ 4.00	4.82	$ 19.28
Total operating costs				$ 204.21
Returns above total operating costs				$ 77.83
Fixed costs				
Machinery				
Interest at	6%	$ 13.91	1	$ 13.91
Taxes at	1%	$ 3.20	1	$ 3.20
Insurance	0.6%	$ 2.15	1	$ 2.15
Depreciation		$ 21.49	1	$ 21.49
Storage	bu	$ 0.27	50	$ 13.45
Land rent		$ 40.00	1	$ 40.00
Total fixed costs				$ 94.20
Total costs				$ 298.41
Returns above all specified costs				$ (16.37)

The budget is assuming a 12lb/ac application of Late Season N in the form of UAN, a 40 bushel yield/ac and 13% protein content. The wheat is sold in July

Table III-12. Budgeted Costs No-Till Protein Management with Custom Hire (NTCPM)

Production	**Units**	**Price**	**Quantity**	**$/Acre**
Wheat	Bu.	$ 6.47	40	$ 258.72
Protein	13% Protein	$ 0.58	40	$ 23.32
Total				$ 282.04
Operating Inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
Glyphosate	oz	$ 0.14	128.00	$ 18.50
2,4-D	oz	$ 0.19	8.00	$ 1.55
Dicamba	oz	$ 0.74	12.00	$ 8.91
Chlorsulfuron+flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	5.10	$ 1.43
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Annual operating capital		6%	104.88	$ 6.29
Custom application herbicide	ac	$ 6.10	5.00	$ 30.50
Custom application liquid fert	ac	$ 4.73	2.00	$ 9.46
Custom anhydrous application	ac	$ 11.98	1.00	$ 11.98
Custom fungicid/insecticide app	ac	$ 5.15	0.33	$ 1.72
Custom planting	ac	$ 16.16	1.00	$ 16.16
Custom harvesting	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Foliar N application (28-0-0)	lbs	$ 0.16	42.86	$ 6.96
Foliar N application CoRoN	lbs	$ 0.96	0.00	$ -
Trampling loss	ac	2.50%	282.04	$ 7.05
Transportation cost	mile	$ 4.00	4.82	$ 19.28
Total operating costs				$ 263.05
Returns above total operating costs				$ 19.00
Fixed costs				
Machinery				
Interest at	6.00%	0.8	1	$ 0.80
Depreciation		0.8	1	$ 0.80
Storage	bu	$ 0.27	49.644	$ 13.45
Rent		$ 40.00	1	$ 40.00
Total fixed costs				$ 55.05
Total costs				$ 318.10
Returns above all specified costs				$ (36.06)

The budget is assuming a 12lb/ac application of Late Season N in the form of UAN, a 40 bushel yield/ac and 13% protein content. The wheat is sold in July

Table III-13. Budgeted Costs Conventional Till Protein Management with Equipment Owned by the Producer (CTOPM)

Production	Units	Price	Quantity	$/Acre
Wheat	Bu.	$ 6.47	40	$ 258.72
Protein	13 % Protein	$ 0.58	40	$ 23.32
Total				$ 282.04
Operating inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
2,4-D	oz	$ 0.19	8.00	$ 1.55
Chlorsulfuron+flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	0.85	$ 0.24
Fungicide	oz	$ 2.42	1.67	$ 4.04
Insecticide	oz	$ 0.27	5.33	$ 1.46
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Custom harvest	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Annual operating capital	ac	6%	55.92	$ 3.35
Machinery labor	hour	$ 10.00	0.38	$ 3.79
Lube	ac	$ 0.86	1.00	$ 0.86
Fuel	gal	$ 2.17	2.93	$ 6.36
Repairs	ac	$ 3.47	1.00	$ 3.47
Foliar N application (28-0-0)	lbs	$ 0.16	42.86	$ 6.96
Foliar N application CoRoN	lbs	$ 0.96	0.00	$ -
Trampling loss	ac	2.50%	282.04	$ 7.05
Transportation cost	mile	$ 4.00	4.82	$ 19.28
Total operating costs				$ 176.18
Returns above total operating costs				$ 105.87
Fixed costs				
Machinery				
Interest at	6.00%	$ 15.98	1	$ 15.98
Taxes at	1.00%	$ 3.74	1	$ 3.74
Insurance	0.60%	$ 2.36	1	$ 2.36
Depreciation		$ 23.34	1	$ 23.34
Storage	bu	$ 0.27	50	$ 13.45
Rent		$ 40.00	1	$ 40.00
Total fixed costs				$ 98.88
Total costs				$ 275.06
Returns above all specified costs				$ 6.99

The budget is assuming a 12lb/ac application of Late Season N in the form of UAN, a 40 bushel yield/ac and 13% protein content. The wheat is sold in July

Table III-14. Budgeted Costs Conventional Till Protein Management with Custom Hire (CTCPM)

Production	**Units**	**Price**	**Quantity**	**$/Acre**
Wheat	Bu.	$ 6.47	40	$ 258.72
Protein	13% Protein	$ 0.58	40	$ 23.32
Total				$ 282.04
Operating inputs				
Wheat seed	lbs	$ 13.50	1.50	$ 20.25
28-0-0	lbs	$ 0.16	142.86	$ 23.21
18-46-0	lbs	$ 0.29	50.00	$ 14.50
82-0-0	lbs	$ 0.31	37.80	$ 11.53
2,-4D	oz	$ 0.19	8.00	$ 1.55
Chlorsulfuron+flucarbazone	oz	$ 11.50	0.40	$ 4.60
AMS	lbs	$ 0.28	0.85	$ 0.24
Insecticide	oz	$ 0.27	5.33	$ 1.46
Fungicide	oz	$ 2.42	1.67	$ 4.04
Crop insurance	ac	$ 7.00	1.00	$ 7.00
Annual operating capital	ac	6%	95.22	$ 5.71
Custom liquid fertilizer app	ac	$ 4.73	2.00	$ 9.46
Custom herbicide app	ac	$ 6.10	1.00	$ 6.10
Custom fungicide/insecticide app	ac	$ 5.15	0.33	$ 1.72
Custom chisel	ac	$ 12.81	2.00	$ 25.62
Custom field cultivation	ac	$ 10.82	1.00	$ 10.82
Custom anhydrous application	ac	$ 11.98	1.00	$ 11.98
Custom planting	ac	$ 16.16	1.00	$ 16.16
Custom harvesting	ac	$ 27.48	1.00	$ 27.48
Transportation at harvest	bu	$ 0.23	40.00	$ 9.20
Foliar N application (28-0-0)	lbs	$ 0.16	42.86	$ 6.96
Foliar N application CoRoN	lbs	$ 0.96	0.00	$ -
Trampling loss	ac	2.50%	282.04	$ 7.05
Transportation cost	mile	$ 4.00	4.82	$ 19.28
Total operating costs				$ 245.91
Returns above total operating costs				$ 36.13
Fixed costs				
Machinery				
Interest at	6.00%	$ 0.80	1	$ 0.80
Depreciation		$ 0.80	1	$ 0.80
Storage	bu	$ 0.27	50	$ 13.45
Rent		$ 40.00	1	$ 40.00
Total fixed costs				$ 55.05
Total costs				$ 300.97
Returns above all specified costs				$ (18.92)

The budget is assuming a 12lb/ac application of Late Season N in the form of UAN, a 40 bushel yield/ac and 13% protein content. The wheat is sold in July.

Table III-15. Machinery Complements for No-Till and Conventional Till Wheat Production Systems

Machine	No-till	Conventional Tillage
Tractor	X	X
Sprayer	X	X
No-till air seeder	X	
Conventional air seeder		X
Chisel plow		X
Field cultivator		X
No-till anhydrous applicator	X	
Conventional anhydrous applicator		X

Table III-16. Machinery Price Estimates

Machine	Operating width in feet	Model	Year	Price	Source
Tractor (4WD, 375 hp)		9330	2011	$183,500	Fastline.com
Sprayer (275 hp)	100	4830	2012	$250,100	Fastline.com
No-Till air seeder	40	1890	2014	$155,000	Fastline.com
Conventional air seeder	44	730	2012	$104,500	Fastline.com
Chisel plow	40	2410	2013	$50,500	Tractorhouse.com
Field cultivator	55	2210	2012	$59,000	Fastline.com
No-Till anhydrous applicator	57.5	2510H	2010	$70,000	Tractorhouse.com
Anhydrous applicator	42.5	2510C	2011	$53,500	Tractorhouse.com

All equipment was considered to be John Deere in response to John Deere having the largest volume of equipment available for sale in each category of equipment. Prices acquired on 2-20-15.

Table III-17. Nominal Twenty Year Monthly Average Protein Premium Price (cents per bushel above Ord)

Months	11%	11.6%	12%	12.6%	13%	13.6%	14.0%
January	5.79	16.32	22.28	26.00	33.28	39.50	46.53
February	5.64	19.95	28.05	33.26	42.79	51.99	64.85
March	6.75	18.86	27.33	32.43	40.44	51.05	60.80
April	6.86	17.77	24.23	29.04	36.50	44.28	56.01
May	6.34	20.97	29.05	33.51	40.41	48.35	59.87
June	7.40	23.71	31.73	36.17	42.77	49.23	62.07
July	9.07	19.59	26.63	32.18	37.72	44.19	53.26
August	5.97	15.96	21.31	24.61	28.90	35.84	42.73
September	5.05	13.66	20.33	23.06	28.93	34.08	38.90
October	5.74	17.73	25.37	27.95	33.36	38.03	42.59
November	6.96	21.51	28.88	32.17	34.59	40.51	46.24
December	6.24	16.93	23.83	27.42	32.03	37.57	43.00

Ord wheat is considered wheat that is either not tested for protein or wheat that is 10.5% protein. The premium data were collected from 1995-2014 by the CME and reported by *Milling and Baking News.* The values are calculated by subtracting the ord values from the values for the classes of wheat reported above. This was done to eliminate the basis that was possibly in the prices since the original prices were reported as cents above futures.

Table III-18. Real Twenty Year Monthly Average Protein Premium Price (cents per bushel above Ord)

Month	11%	11.6%	12%	12.6%	13%	13.6%	14%
January	8.39	22.68	30.08	35.50	44.46	53.40	61.38
February	7.43	24.82	32.90	39.45	48.80	59.45	71.95
March	9.27	24.25	33.63	40.00	49.01	60.34	70.36
April	10.03	24.12	32.88	40.27	51.14	62.01	74.73
May	8.78	27.56	39.01	46.14	56.27	68.86	82.78
June	9.80	30.85	42.74	49.99	59.84	70.90	86.40
July	12.35	26.87	37.64	47.35	58.31	69.51	81.74
August	8.81	22.32	30.05	35.55	43.66	54.61	64.81
September	7.72	19.95	29.13	33.84	42.52	51.90	59.81
October	8.81	23.83	34.28	38.93	46.90	54.84	61.72
November	10.47	28.64	38.56	44.08	50.03	58.78	66.33
December	9.34	23.67	32.59	38.24	46.53	55.52	62.36

The price Oklahoma producers received for wheat was used to deflate the nominal values with December 2014 as the base price.

Table III-19. Grain Bin Storage Size, Price Per Bushel of Capacity, and Total Cost

Company	Bushels	Diameter	$/bu	Total Cost ($)
GSI	11,175	27	2.34	26,149.50
GSI	26,744	36	1.43	38,243.92
GSI	32,713	42	1.48	48,415.24
GSI	49,077	48	1.31	64,290.87
GSI	54,616	48	1.20	65,539.20
Golden Grain	10,175	27	2.01	20,460.00
Golden Grain	20,675	36	1.48	30,568.00
Golden Grain	31,655	42	1.36	43,136.00
Golden Grain	40,385	45	1.25	50,375.00
Sukup	11,809	27	2.35	27,762.33
Sukup	24,822	36	1.68	41,774.92
Sukup	34,403	42	1.51	51,936.64
Sukup	42,969	42	1.44	61,903.49
Sukup	51,335	48	1.32	67,692.33
Sukup	55,817	42	1.40	78,386.81
Sukup	62,523	48	1.34	83,549.84

Table IV-1. Mean Yield and Protein Results from Late Season Foliar Nitrogen Application Treatment Experiment

Treatment		Yield	Protein Percentage
1	Check	46.83^{b}	11.03^{c}
2	Farmer Practice	54.70^{ab}	12.08^{bc}
3	6,UAN,FL	52.54^{ab}	12.8^{ab}
4	12,UAN,FL	56.38^{ab}	12.89^{ab}
5	24,UAN,FL	56.08^{ab}	13.38^{ab}
6	6,CoRoN,FL	56.52^{ab}	12.19^{abc}
7	12,CoRoN,FL	54.94^{ab}	12.61^{ab}
8	24,CoRoN,FL	58.56^{a}	12.72^{ab}
9	6,UAN,PA	55.72^{ab}	12.84^{ab}
10	12,UAN,PA	57.35^{ab}	13.27^{ab}
11	24,UAN,PA	56.29^{ab}	13.13^{ab}
12	6,CoRoN,PA	59.12^{a}	12.71^{ab}
13	12,CoRoN,PA	54.91^{ab}	13.43^{a}
14	24,CoRoN,PA	57.67^{ab}	12.83^{ab}

Note: Means with the same letter are not statistically different at the 95% confidence level

Table IV-2. Lahoma Mean Yield and Protein Results from Late Season Foliar Nitrogen Application Treatment Experiment

Location	Treatment	Yield	Protein Percentage
Lahoma	Check	58.40^{b}	11.05^{d}
Lahoma	Farmer Practice	66.12^{ab}	11.6^{cd}
Lahoma	6,UAN,FL	61.85^{ab}	12.68^{abc}
Lahoma	12,UAN,FL	68.05^{ab}	12.18^{bcd}
Lahoma	24,UAN,FL	65.01^{ab}	13.23^{ab}
Lahoma	6,CoRoN,FL	67.65^{ab}	11.52^{cd}
Lahoma	12,CoRoN,FL	66.41^{ab}	12.18^{bcd}
Lahoma	24,CoRoN,FL	71.27^{a}	12.33^{bcd}
Lahoma	6,UAN,PA	68.06^{ab}	12.32^{abc}
Lahoma	12,UAN,PA	65.95^{ab}	13.35^{ab}
Lahoma	24,UAN,PA	66.11^{ab}	12.63^{abc}
Lahoma	6,CoRoN,PA	73.59^{a}	12.12^{bcd}
Lahoma	12,CoRoN,PA	67.12^{ab}	13.72^{a}
Lahoma	24,CoRoN,PA	68.28^{ab}	12.63^{abc}

Note: Means with the same letter are not statistically different at the 95% confidence level

Table IV-3. LCB Mean Yield and Protein Results from Late Season Foliar Nitrogen Application Treatment Experiment

Location	Treatment	Yield	Protein Percentage
LCB	Check	35.27[b]	11.02[b]
LCB	Farmer Practice	43.28[ab]	12.57[ab]
LCB	6,UAN,FL	43.23[ab]	12.92[ab]
LCB	12,UAN,FL	44.71[ab]	13.60[a]
LCB	24,UAN,FL	47.15[a]	13.52[a]
LCB	6,CoRoN,FL	45.47[ab]	12.87[ab]
LCB	12,CoRoN,FL	43.46[ab]	13.03[ab]
LCB	24,CoRoN,FL	45.85[ab]	13.10[ab]
LCB	6,UAN,PA	43.37[ab]	13.07[ab]
LCB	12,UAN,PA	48.75[a]	13.18[ab]
LCB	24,UAN,PA	46.48[ab]	13.62[a]
LCB	6,CoRoN,PA	44.64[ab]	13.30[ab]
LCB	12,CoRoN,PA	42.71[ab]	13.13[ab]
LCB	24,CoRoN,PA	47.07[a]	13.03[ab]

Note: Means with the same letter are not statistically different at the 95% confidence level

Table IV-4. Mean Yield and Protein Percentage of Different Sources of Nitrogen

Source	Yield	Protein Percentage
UAN	55.73[a]	13.05[a]
CoRoN	56.95[a]	12.75[a]
Check	46.83[b]	11.03[b]
FP	54.70[ab]	12.08[a]

Note: Means with the same letter are not statistically different at the 95% confidence level

Table IV-5. Mean Yield and Protein Percentage of Different Rates of Late Season Nitrogen

Rate	Yield	Protein Percentage
6	55.97[a]	12.64[ab]
12	55.90[a]	13.05[a]
24	57.15[a]	13.01[a]
FP	54.70[a]	12.08[b]

Note: Means with the same letter are not statistically different at the 95% confidence level

Table IV-6. Goodness of Fit Measures for Yield and Protein Model Estimation

Model	Yield -2 Log Likelihood	Protein -2 Log Likelihood
Linear	1085.9	523.9
Quadratic	1092.8	538.7
LRP FL	675.1	224.4
LRP PA	933.5	229.5

Note: LRP FL=Linear Response Plateau at the growth stage of Flag Leaf
LRP PA=Linear Response Plateau at the growth stage of Post Anthesis
Smaller is better for the -2 Log Likelihood value

Table IV-7. Results of the Linear Model Variables For Protein and Yield of the Wheat

Parameters	Yield	Protein	Protein (NoRate)
Intercept	41.45**	13.02**	13.30**
	(2.231)	(0.603)	(0.608)
Location (1 if Lahoma; 0 LCB)	25.87**	1.24**	1.13**
	(1.284)	(0.385)	(0.392)
Year (1 if 2011; 0 otherwise)	-4.66**	1.34**	1.37**
	(1.840)	(0.268)	(0.270)
Year (1 if 2012; 0 otherwise)	9.71**	-	-
	(1.720)	-	-
No application of late season N (1 if FP; 0 otherwise)	-1.70	-0.55	-0.91**
	(2.929)	(0.439)	(0.409)
Source of late season N (1 if UAN; 0 otherwise)	-1.18	0.31*	0.31
	(1.335)	(0.192)	(0.196)
Growth stage of late season N (1 if Flag Leaf; 0 otherwise)	-1.09	-0.35*	-0.34*
	(1.333)	(0.193)	(0.197)
Rate	0.10	0.03**	-
	(0.090)	(0.013)	-
Yield	-	-0.03**	-0.03**
	-	(0.011)	(0.011)
-2 Log Likelihood	1727.3	526.8	523.9

The dependent variable for the yield equation is bushels per acre. The dependent variable for the two protein equations is protein percentage in the harvested grain.
*Significant at the 90% Confidence Level
**Significant at the 95% Confidence Level
Standard Errors are in parentheses

Table IV-8. Results of the Protein Linear Plateau Models for the Effect of the Rate of the Late Season Nitrogen Application on the Protein Content of Wheat

Parameters	Flag Leaf	Post Anthesis
Intercept	11.75**	13.08**
	(1.059)	(0.743)
Rate of late season foliar N	0.07	0.14**
	(0.462)	(0.446)
Protein content plateau	12.77**	14.41**
	(1.036)	(0.964)
Location (1 if Lahoma, 0 otherwise)	0.35	2.17**
	(0.690)	(0.550)
Harvest year (1 if 2011, 0 otherwise)	2.56**	0.30
	(0.556)	(0.457)
Yield	-0.02**	-0.05**
	0.018	(0.017)
-2 Log Likelihood	224.4	229.5

The dependent variable is protein percentage in the harvested grain.
*Significant at the 90% Confidence Level
**Significant at the 95% Confidence Level
Standard Errors are in parentheses

Table IV-9. Results of the Yield Linear Plateau Models for the Effect of the Rate of the Late Season Nitrogen Application on the Yield of Wheat

Parameters	Flag Leaf	Post Anthesis
Intercept	41.47**	41.17**
	(3.787)	(2.96)
Rate of late season foliar N	0.14	0.12
	(0.485)	(0.232)
Yield plateau	42.51**	43.44**
	(3.376)	(0.964)
Location (1 if Lahoma, 0 otherwise)	24.43**	24.75**
	(4.40)	(3.04)
Harvest year (1 if 2011, 0 otherwise)	-5.42*	-4.84*
	(2.97)	(2.637)
Harvest year (1 if 2012, 0 otherwise)	8.11**	9.88**
	(2.78)	(2.345)
Source of Late Season N (1 if UAN, 0 otherwise)	-1.22	0.15
	(2.87)	(1.969)
-2 Log Likelihood	675.1	933.5

The dependent variable is protein percentage in the harvested grain.
*Significant at the 90% Confidence Level
**Significant at the 95% Confidence Level
Standard Errors are in parentheses

Table IV-10. Mean Net Returns Per Acre for Each Treatment and the Four Different Production Practices ($/ac)

Treatment	NTO	NTC	CTO	CTC
Check	84.17	68.09	107.53	85.22
Farmer Practice	107.33	91.24	130.69	108.38
Farmer Practice with Protein Premium	96.10	80.02	119.47	97.16
6,UAN,FL	58.26	38.57	81.62	55.71
12,UAN,FL	88.27	68.58	111.62	85.71
24,UAN,FL	84.43	64.74	107.78	81.87
6,CoRoN,FL	61.71	42.02	85.07	59.15
12,CoRoN,FL	29.32	9.63	52.68	26.77
24,CoRoN,FL	16.45	-3.24	39.81	13.90
6,UAN,PA	83.06	63.37	106.42	80.50
12,UAN,PA	98.92	79.23	122.28	96.37
24,UAN,PA	81.79	62.10	105.15	79.24
6,CoRoN,PA	86.57	66.88	109.93	84.02
12,CoRoN,PA	44.48	24.79	67.84	41.93
24,CoRoN,PA	8.12	-11.57	31.47	5.56

Table IV-11. Certainty Equivalents for the Treatment Strategies in a No-till Production Practice Owning the Equipment ($/ac)

	Risk Aversion		
Treatment	Low	Moderate	Strong
Check	80.01	64.73	51.36
Farmer Practice	103.89	90.47	77.47
Farmer Practice with Protein Premium	92.90	80.66	69.24
6,UAN,FL	55.95	47.01	38.48
12,UAN,FL	84.83	71.68	59.35
24,UAN,FL	82.38	74.15	65.83
6,CoRoN,FL	59.52	51.02	42.85
12,CoRoN,FL	26.84	17.26	8.18
24,CoRoN,FL	13.19	0.59	-11.28
6,UAN,PA	80.22	69.14	58.47
12,UAN,PA	96.68	87.83	79.07
24,UAN,PA	78.70	66.59	54.75
6,CoRoN,PA	83.05	69.01	55.14
12,CoRoN,PA	41.17	28.34	16.17
24,CoRoN,PA	5.75	-3.60	-12.84

Table IV-12. Certainty Equivalents for the Treatment Strategies in a No-till Production Practice Using Custom Hire ($/ac)

	Risk Aversion		
Treatment	Low	Moderate	Strong
Check	63.93	48.64	35.27
Farmer Practice	87.81	74.39	61.39
Farmer Practice with Protein Premium	76.81	64.58	53.16
6,UAN,FL	36.26	27.32	18.79
12,UAN,FL	65.14	52.00	39.66
24,UAN,FL	62.69	54.46	46.15
6,CoRoN,FL	39.83	31.34	23.16
12,CoRoN,FL	7.15	-2.43	-11.51
24,CoRoN,FL	-6.50	-19.10	-30.97
6,UAN,PA	60.53	49.45	38.78
12,UAN,PA	76.99	68.14	59.38
24,UAN,PA	59.02	46.91	35.06
6,CoRoN,PA	63.36	49.32	35.45
12,CoRoN,PA	21.48	8.65	-3.52
24,CoRoN,PA	-13.93	-23.29	-32.53

Table IV-13. Certainty Equivalents for the Treatment Strategies in a Conventional-till Production Practice Owning the Equipment ($/ac)

	Risk Aversion		
Treatment	Low	Moderate	Strong
Check	103.37	88.09	74.72
Farmer Practice	127.26	113.83	100.83
Farmer Practice with Protein Premium	116.26	104.02	92.60
6,UAN,FL	79.31	70.37	61.84
12,UAN,FL	108.19	95.04	82.71
24,UAN,FL	105.73	97.51	89.19
6,CoRoN,FL	82.88	74.38	66.21
12,CoRoN,FL	50.20	40.62	31.54
24,CoRoN,FL	36.54	23.95	12.07
6,UAN,PA	103.58	92.50	81.83
12,UAN,PA	120.04	111.19	102.43
24,UAN,PA	102.06	89.95	78.11
6,CoRoN,PA	106.41	92.37	78.49
12,CoRoN,PA	64.53	51.70	39.53
24,CoRoN,PA	29.11	19.75	10.52

Table IV-14. Certainty Equivalents for the Treatment Strategies in a Conventional-till Production Practice Using Custom Hire ($/ac)

	Risk Aversion		
Treatment	Low	Moderate	Strong
Check	81.06	65.78	52.41
Farmer Practice	104.95	91.52	78.53
Farmer Practice with Protein Premium	93.95	81.71	70.29
6,UAN,FL	53.39	44.46	35.93
12,UAN,FL	82.27	69.13	56.80
24,UAN,FL	79.82	71.60	63.28
6,CoRoN,FL	56.97	48.47	40.30
12,CoRoN,FL	24.29	14.71	5.63
24,CoRoN,FL	10.63	-1.96	-13.84
6,UAN,PA	77.67	66.59	55.92
12,UAN,PA	94.13	85.28	76.52
24,UAN,PA	76.15	64.04	52.20
6,CoRoN,PA	80.50	66.46	52.58
12,CoRoN,PA	38.62	25.79	13.62
24,CoRoN,PA	3.20	-6.16	-15.40

Table IV-15. Estimates of First and Second Degree Stochastic Dominance for the Treatment Styles in NTO

Treatment		1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
		First Degree Dominance														
Check	1															
FP	2								FDD	FDD					FDD	FDD
FP Pro Prem	2 Pro									FDD						FDD
6,UAN,FL	3									FDD						
12,UAN,FL	4															
24,UAN,FL	5								FDD	FDD						FDD
6,CoRoN,FL	6															FDD
12,CoRoN,FL	7															
24,CoRoN,FL	8															
6,UAN,PA	9								FDD	FDD						FDD
12,UAN,PA	10				FDD				FDD	FDD					FDD	FDD
24,UAN,PA	11								FDD	FDD						FDD
6,CoRoN,PA	12									FDD						FDD
12,CoRoN,PA	13															
24,CoRoN,PA	14															
		Second Degree Dominance														
Check	1				SDD				SDD	SDD					SDD	SDD
FP	2	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
FP Pro Prem	2 Pro	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,UAN,FL	3								SDD	SDD					SDD	SDD
12,UAN,FL	4								SDD	SDD					SDD	SDD
24,UAN,FL	5	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,CoRoN,FL	6				SDD				SDD	SDD					SDD	SDD
12,CoRoN,FL	7									SDD						SDD
24,CoRoN,FL	8															
6,UAN,PA	9				SDD			SDD	SDD	SDD					SDD	SDD
12,UAN,PA	10	SDD		SDD	SDD	SDD	SDD	SDD	SDD	SDD	SDD		SDD	SDD	SDD	SDD
24,UAN,PA	11								SDD	SDD					SDD	SDD
6,CoRoN,PA	12								SDD	SDD					SDD	SDD
12,CoRoN,PA	13									SDD						SDD
24,CoRoN,PA	14															

Table IV-16. Estimates of First and Second Degree Stochastic Dominance for the Treatment Styles in NTC

Treatment		1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
First Degree Dominance																
Check	1															
FP	2				FDD				FDD	FDD					FDD	FDD
FP Pro Prem	2 Pro				FDD					FDD						FDD
6,UAN,FL	3									FDD						
12,UAN,FL	4															
24,UAN,FL	5								FDD	FDD						FDD
6,CoRoN,FL	6															FDD
12,CoRoN,FL	7															
24,CoRoN,FL	8															
6,UAN,PA	9								FDD	FDD						FDD
12,UAN,PA	10				FDD				FDD	FDD					FDD	FDD
24,UAN,PA	11								FDD	FDD						FDD
6,CoRoN,PA	12									FDD						FDD
12,CoRoN,PA	13															
24,CoRoN,PA	14															
Second Degree Dominance																
Check	1				SDD				SDD	SDD					SDD	SDD
FP	2	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
FP Pro Prem	2 Pro	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
6,UAN,FL	3								SDD	SDD					SDD	SDD
12,UAN,FL	4								SDD	SDD					SDD	SDD
24,UAN,FL	5	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,CoRoN,FL	6				SDD				SDD	SDD					SDD	SDD
12,CoRoN,FL	7									SDD						SDD
24,CoRoN,FL	8															
6,UAN,PA	9				SDD			SDD	SDD	SDD					SDD	SDD
12,UAN,PA	10	SDD		SDD	SDD	SDD	SDD	SDD	SDD	SDD	SDD		SDD	SDD	SDD	SDD
24,UAN,PA	11								SDD	SDD					SDD	SDD
6,CoRoN,PA	12								SDD	SDD					SDD	SDD
12,CoRoN,PA	13									SDD						SDD
24,CoRoN,PA	14															

Table IV-17. Estimates of First and Second Degree Stochastic Dominance for the Treatment Styles in CTO

Treatment		1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
	First Degree Dominance															
Check	1															
FP	2								FDD	FDD					FDD	FDD
FP Pro Prem	2 Pro									FDD						FDD
6,UAN,FL	3									FDD						
12,UAN,FL	4															
24,UAN,FL	5								FDD	FDD						FDD
6,CoRoN,FL	6															FDD
12,CoRoN,FL	7															
24,CoRoN,FL	8															
6,UAN,PA	9								FDD	FDD						FDD
12,UAN,PA	10				FDD				FDD	FDD					FDD	FDD
24,UAN,PA	11								FDD	FDD						FDD
6,CoRoN,PA	12									FDD						FDD
12,CoRoN,PA	13															
24,CoRoN,PA	14															
	Second Degree Dominance															
Check	1				SDD				SDD	SDD					SDD	SDD
FP	2	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
FP Pro Prem	2 Pro	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,UAN,FL	3								SDD	SDD					SDD	SDD
12,UAN,FL	4								SDD	SDD					SDD	SDD
24,UAN,FL	5	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,CoRoN,FL	6				SDD				SDD	SDD					SDD	SDD
12,CoRoN,FL	7									SDD						SDD
24,CoRoN,FL	8															
6,UAN,PA	9				SDD			SDD	SDD	SDD					SDD	SDD
12,UAN,PA	10	SDD		SDD	SDD	SDD	SDD	SDD	SDD	SDD	SDD		SDD	SDD	SDD	SDD
24,UAN,PA	11								SDD	SDD					SDD	SDD
6,CoRoN,PA	12								SDD	SDD					SDD	SDD
12,CoRoN,PA	13									SDD						SDD
24,CoRoN,PA	14															

Table IV-18. Estimates of First and Second Degree Stochastic Dominance for the Treatment Styles in CTC

Treatment		1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
	First Degree Dominance															
Check	1															
FP	2				FDD				FDD	FDD					FDD	FDD
FP Pro Prem	2 Pro				FDD					FDD						FDD
6,UAN,FL	3									FDD						
12,UAN,FL	4															
24,UAN,FL	5								FDD	FDD						FDD
6,CoRoN,FL	6															FDD
12,CoRoN,FL	7															
24,CoRoN,FL	8															
6,UAN,PA	9								FDD	FDD						FDD
12,UAN,PA	10				FDD				FDD	FDD					FDD	FDD
24,UAN,PA	11								FDD	FDD						FDD
6,CoRoN,PA	12									FDD						FDD
12,CoRoN,PA	13															
24,CoRoN,PA	14															
	Second Degree Dominance															
Check	1				SDD				SDD	SDD					SDD	SDD
FP	2	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
FP Pro Prem	2 Pro	SDD			SDD	SDD			SDD	SDD			SDD	SDD	SDD	SDD
6,UAN,FL	3								SDD	SDD					SDD	SDD
12,UAN,FL	4								SDD	SDD					SDD	SDD
24,UAN,FL	5	SDD			SDD	SDD			SDD	SDD			SDD		SDD	SDD
6,CoRoN,FL	6				SDD				SDD	SDD					SDD	SDD
12,CoRoN,FL	7									SDD						SDD
24,CoRoN,FL	8															
6,UAN,PA	9				SDD			SDD	SDD	SDD					SDD	SDD
12,UAN,PA	10	SDD		SDD	SDD	SDD	SDD	SDD	SDD	SDD	SDD		SDD	SDD	SDD	SDD
24,UAN,PA	11								SDD	SDD					SDD	SDD
6,CoRoN,PA	12								SDD	SDD					SDD	SDD
12,CoRoN,PA	13									SDD						SDD
24,CoRoN,PA	14															

Table IV-19 . Increase in Net Returns Per Acre for to Cover Costs Above Farmer Practice

NTO Risk Aversion	Units	1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
		Check	FP	FP Pro Prem	6,UAN,FL	12,UAN,FL	24,UAN,FL	6,CoRoN,FL	12,CoRoN,FL	24,CoRoN,FL	6,UAN,PA	12,UAN,PA	24,UAN,PA	6,CoRoN,PA	12,CoRoN,PA	24,CoRoN,PA
Strong	$/ac	0.00	0.00	26.51	70.23	43.47	51.49	59.83	96.77	113.89	47.59	37.15	51.13	42.71	94.25	121.94
Moderate	$/ac	0.00	0.00	24.46	64.34	42.06	44.77	55.24	92.10	111.96	43.76	31.31	48.14	42.49	90.68	116.98
Slightly	$/ac	0.00	0.00	22.53	58.70	40.56	38.74	50.95	87.59	110.01	40.22	25.97	45.64	42.75	87.28	112.56
NTC Risk Aversion																
Strong	$/ac	0.00	0.00	26.51	73.83	47.08	55.10	63.44	100.37	117.50	51.20	40.75	54.74	46.32	97.85	125.54
Moderate	$/ac	0.00	0.00	24.46	67.95	45.67	48.38	58.84	95.71	115.57	47.36	34.92	51.75	46.10	94.29	120.59
Slightly	$/ac	0.00	0.00	22.53	62.31	44.17	42.34	54.55	91.19	113.61	43.83	29.58	49.24	46.36	90.88	116.17
CTO Risk Aversion																
Strong	$/ac	0.00	0.00	26.51	70.23	43.48	51.49	59.84	96.77	113.89	47.59	37.15	51.14	42.72	94.25	121.94
Moderate	$/ac	0.00	0.00	24.46	64.34	42.07	44.77	55.24	92.10	111.97	43.76	31.32	48.15	42.50	90.69	116.99
Slightly	$/ac	0.00	0.00	22.53	58.71	40.57	38.74	50.95	87.59	110.01	40.22	25.97	45.64	42.76	87.28	112.57
CTC Risk Aversion																
Strong	$/ac	0.00	0.00	26.51	73.83	47.08	55.10	63.44	100.37	117.50	51.20	40.75	54.74	46.32	97.85	125.54
Moderate	$/ac	0.00	0.00	24.46	67.95	45.67	48.38	58.84	95.71	115.57	47.36	34.92	51.75	46.10	94.29	120.59
Slightly	$/ac	0.00	0.00	22.53	62.31	44.17	42.34	54.55	91.19	113.61	43.83	29.58	49.24	46.36	90.88	116.17

Note: NTO= No-till with the equipment owned by the operator
NTC=No-till with custom hire
CTO= Conventional till with equipment owned by the operator
CTC= Conventional till with custom hire
Strong= lower limit of risk aversion
Moderate= average limit of risk aversion
Slightly= upper limit of risk aversion

Table IV-20. Protein Premium Required for Extra Revenues of Protein Management to be Equal to Extra Costs ($/bu)

NTO Risk Aversion	Units	1	2	2 Pro	3	4	5	6	7	8	9	10	11	12	13	14
		Check	FP	FP Pro Prem	6,UAN,F L	12,UAN, FL	24,UAN, FL	6,CoRoN, FL	12,CoRo N,FL	24,CoRo N,FL	6,UAN,P A	12,UAN, PA	24,UAN, PA	6,CoRoN, PA	12,CoRo N,PA	24,CoRo N,PA
Strong	$/bu	0	0	0.48	1.36	0.75	0.9	1.04	1.77	1.88	0.85	0.63	0.89	0.7	1.7	2.08
Moderate	$/bu	0	0	0.45	1.24	0.73	0.78	0.96	1.68	1.85	0.78	0.53	0.84	0.7	1.64	1.99
Slightly	$/bu	0	0	0.41	1.14	0.7	0.68	0.89	1.6	1.82	0.72	0.44	0.79	0.7	1.58	1.92
NTC Risk Aversion																
Strong	$/bu	0	0	0.48	1.43	0.82	0.96	1.1	1.83	1.94	0.91	0.69	0.95	0.76	1.77	2.14
Moderate	$/bu	0	0	0.45	1.31	0.79	0.85	1.02	1.75	1.91	0.84	0.6	0.9	0.76	1.7	2.05
Slightly	$/bu	0	0	0.41	1.2	0.77	0.74	0.95	1.66	1.88	0.78	0.5	0.86	0.76	1.64	1.98
CTO Risk Aversion																
Strong	$/bu	0	0	0.48	1.36	0.75	0.9	1.04	1.77	1.88	0.85	0.63	0.89	0.7	1.7	2.08
Moderate	$/bu	0	0	0.45	1.24	0.73	0.78	0.96	1.68	1.85	0.78	0.53	0.84	0.7	1.64	1.99
Slightly	$/bu	0	0	0.41	1.14	0.7	0.68	0.89	1.6	1.82	0.72	0.44	0.79	0.7	1.58	1.92
CTC Risk Aversion																
Strong	$/bu	0	0	0.48	1.43	0.82	0.96	1.1	1.83	1.94	0.91	0.69	0.95	0.76	1.77	2.14
Moderate	$/bu	0	0	0.45	1.31	0.79	0.85	1.02	1.75	1.91	0.84	0.6	0.9	0.76	1.7	2.05
Slightly	$/bu	0	0	0.41	1.2	0.77	0.74	0.95	1.66	1.88	0.78	0.5	0.86	0.76	1.64	1.98

NTO= No-till with the equipment owned by the operator
NTC=No-till with custom hire
CTO= Conventional till with equipment owned by the operator
CTC= Conventional till with custom hire
Strong= lower limit of risk aversion
Moderate= average limit of risk aversion
Slightly= upper limit of risk aversion

Table IV-21. Partial Budget Protein Mangagement Versus No Protein Management with Equipment Owned by Producer

Additional Costs	Units	Price	Quantity	$/Acre
Late season foliar N application	ac	$ 1.25	1	$ 1.25
UAN	lbs	$ 0.16	33.93	$ 5.51
Transportation	mi	$ 4.00	4.82	$ 19.28
On-farm storage	bu	$ 0.31	40.00	$ 12.44
Reduced Returns				
Trampling loss		2.5%	$ 298.54	$ 7.46
Total additional costs and reduced returns				$ 45.94

Additional Returns	Units	Price	Quantity	$/Acre
Protein premium at 14%	bu	$ 0.82	40	$ 32.70
Yield increase	bu	$ 6.65	1.14	$ 7.58
Reduced costs				
Total additional returns and reduced costs				$ 40.27
Net change in income				$ (5.67)

Table IV-22. Partial Budget Protein Mangagement Versus No Protein Management with Custom Hire

Additional Costs	Units	Price	Quantity	$/Acre
Late Season Foliar N Application	ac	$ 5.00	1	$ 5.00
UAN	lbs	$ 0.16	33.93	$ 5.51
Transportation	mi	$ 4.00	4.82	$ 19.28
On-farm Storage	bu	$ 0.31	40.00	$ 12.44
Reduced Returns				
Trampling Loss		2.5%	$ 298.54	$ 7.46
Total Additional Costs and Reduced Returns				$ 49.69

Additional Returns	Units	Price	Quantity	$/Acre
Protein Premium at 14%	bu	$ 0.82	40	$ 32.70
Yield increase	bu	$ 6.65	1.14	$ 7.58
Reduced Costs				
Total Additional Returns and Reduced Costs				$ 40.27
Net Change in Income				$ (9.42)

Table IV-23. Partial Budget No Protein Mangagement and Marketing Wheat for High Protein Versus No Protein Management with Equipment Owned by Producer

Additional Costs	Units	Price	Quantity	$/Acre
Transportation	mi	$ 4.00	4.82	$ 19.28
On-farm Storage	bu	$ 0.31	40.00	$ 12.44
Reduced Returns				
Total Additional Costs and Reduced Returns				$ 31.72
Additional Returns	Units	Price	Quantity	$/Acre
Protein Premium at 12%	bu	$ 0.38	40	$ 15.06
Reduced Costs				
Total Additional Returns and Reduced Costs				$ 15.06
Net Change in Income				$ (16.66)

Table IV-24. Partial Budget No Protein Mangagement and Marketing Wheat for High Protein Versus No Protein Management with Custom Hire

Additional Costs	Units	Price	Quantity	$/Acre
Transportation	mi	$ 4.00	4.82	$ 19.28
On-farm Storage	bu	$ 0.31	40.00	$ 12.44
Reduced Returns				
Total Additional Costs and Reduced Returns				$ 31.72
Additional Returns	Units	Price	Quantity	$/Acre
Protein Premium at 12%	bu	$ 0.38	40	$ 15.06
Reduced Costs				
Total Additional Returns and Reduced Costs				$ 15.06
Net Change in Income				$ (16.66)

Table IV-25. Partial Budget Protein Mangagement and Marketing Wheat with No Storage or Transportation Costs Versus No Protein Management with Equipment Owned by the Producer

Additional Costs	Units	Price	Quantity	$/Acre
Late Season Foliar N Application	ac	$ 1.25	1	$ 1.25
UAN	lbs	$ 0.16	33.93	$ 5.51
Reduced Returns				
Trampling Loss		2.5%	$ 275.21	$ 6.88
Total Additional Costs and Reduced Returns				$ 13.64
Additional Returns	Units	Price	Quantity	$/Acre
Protein Premium at 14%	bu	$ 0.23	40	$ 9.37
Yield increase	bu	$ 6.65	1.14	$ 7.58
Reduced Costs				
Total Additional Returns and Reduced Costs				$ 16.94
Net Change in Income				$ 3.30

Table IV-26. Partial Budget Protein Mangagement and Marketing Wheat with No Storage or Transportation Costs Versus No Protein Management with Custom Hire

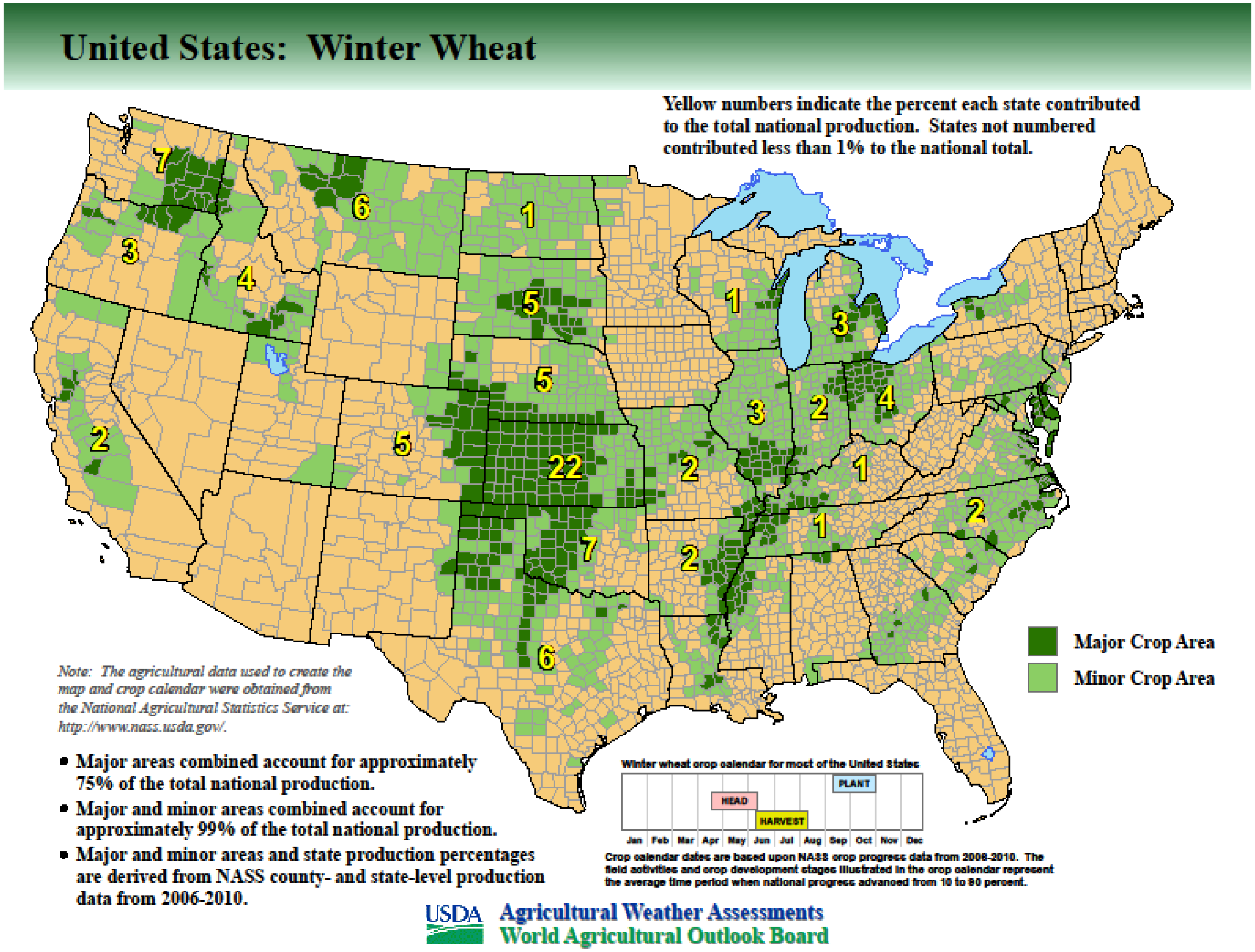
Additional Costs	Units	Price	Quantity	$/Acre
Late Season Foliar N Application	ac	$ 5.00	1	$ 5.00
UAN	lbs	$ 0.16	33.93	$ 5.51
Reduced Returns				
Trampling Loss		2.5%	$ 275.21	$ 6.88
Total Additional Costs and Reduced Returns				$ 17.39
Additional Returns	Units	Price	Quantity	$/Acre
Protein Premium at 14%	bu	$ 0.23	40	$ 9.37
Yield Increase	bu	$ 6.65	1.14	$ 7.58
Reduced Costs				
Total Additional Returns and Reduced Costs				$ 16.94
Net Change in Income				$ (0.45)

Table IV-27. Protein Premiums Required for Breakeven Profits with Equipment Owned by the Producer

	Units	Table IV-21	Table IV-23	Table IV-25
Aditional Costs	$/ac	45.94	31.72	13.64
Additonal Returns	$/ac	7.58	0	7.58
Protein Premium Required	$/bu	0.96	0.79	0.15

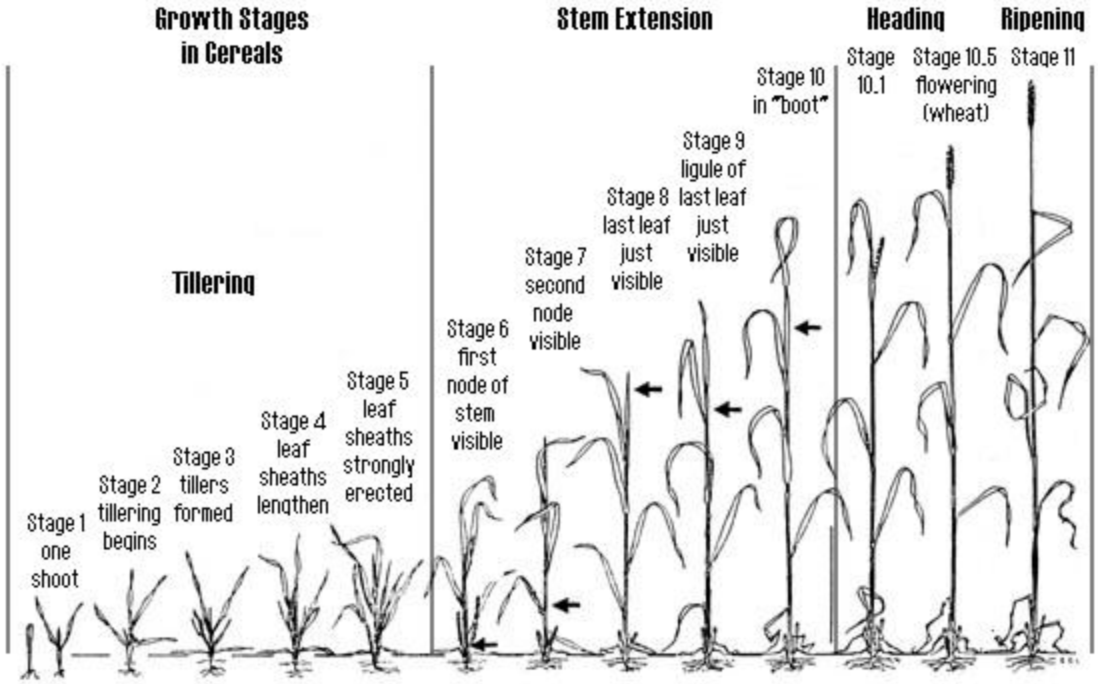
Table IV-28. Protein Premiums Required for Breakeven Profits with Custom Hire

	Units	Table IV-22	Table IV-24	Table IV-26
Aditional Costs	$/ac	49.69	31.72	17.39
Additonal Returns	$/ac	7.58	0	7.58
Protein Premium Required	$/bu	1.05	0.79	0.25



Source: Chapin, Brenda. Office of the Chief Economist, USDA. 3/7/2012.

Figure I-1. U.S. Wheat Production Map



Source: nue.okstate.edu

Figure II-1. Feekes Growth Stages

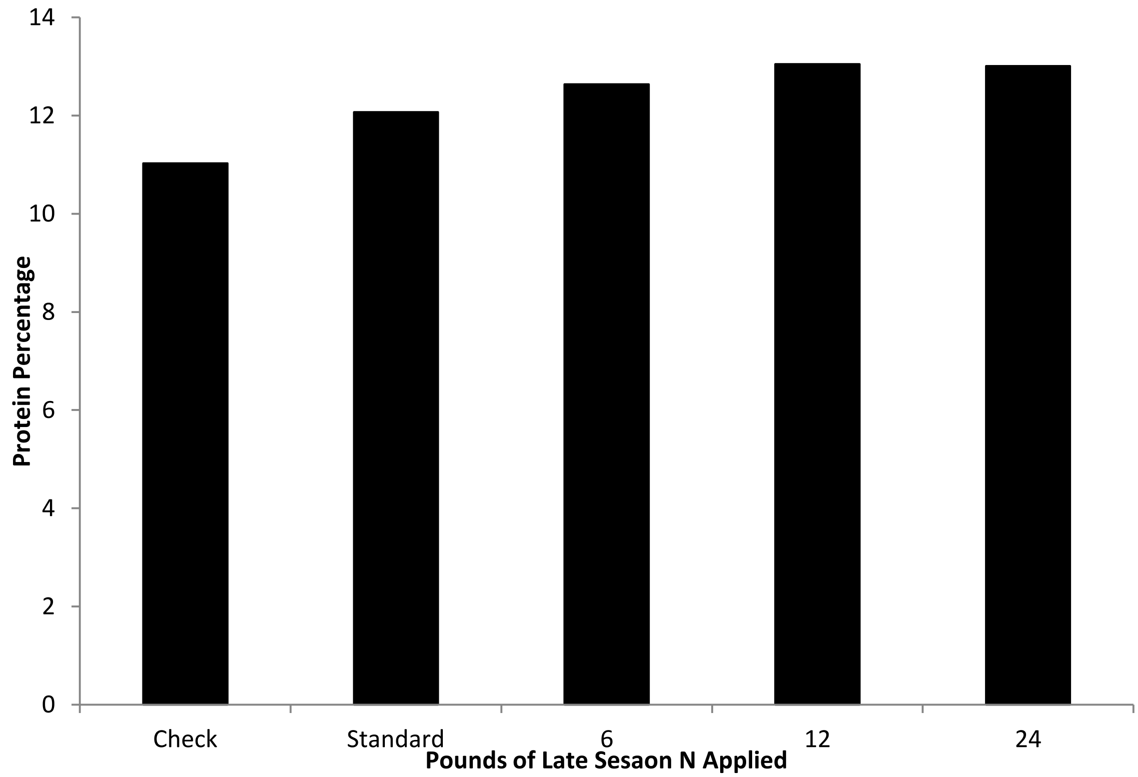


Figure III-1. Graph of the Protein Percentage of Different Rates of Late Season Foliar Nitrogen

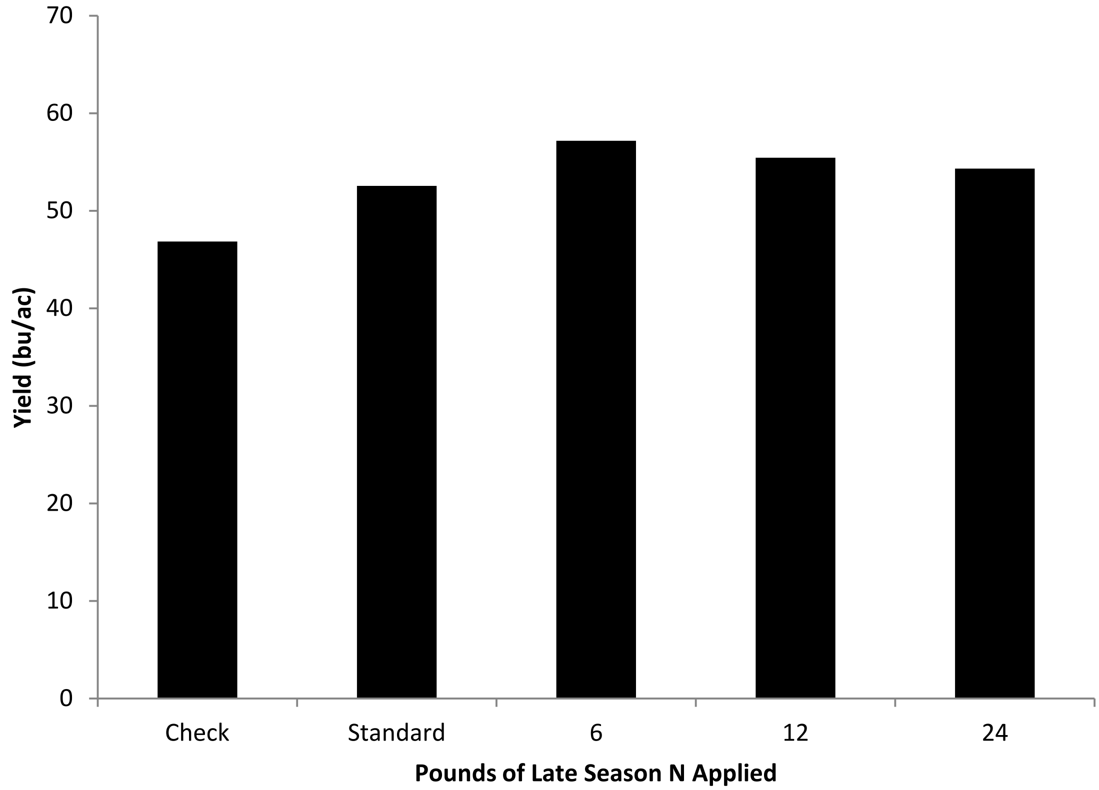


Figure III-2. Graph of the Yield of Different Rates of Late Season Foliar Nitrogen

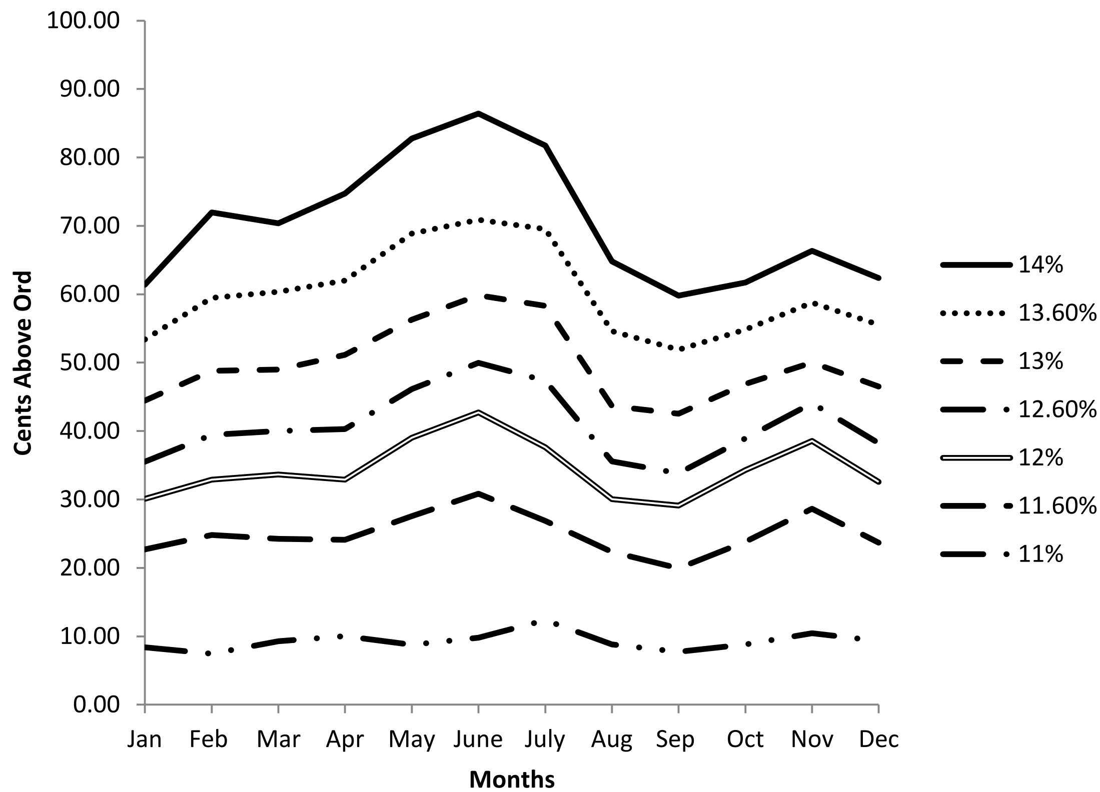


Figure IV-1. Real Monthly Average Protein Premiums from 1995-2014

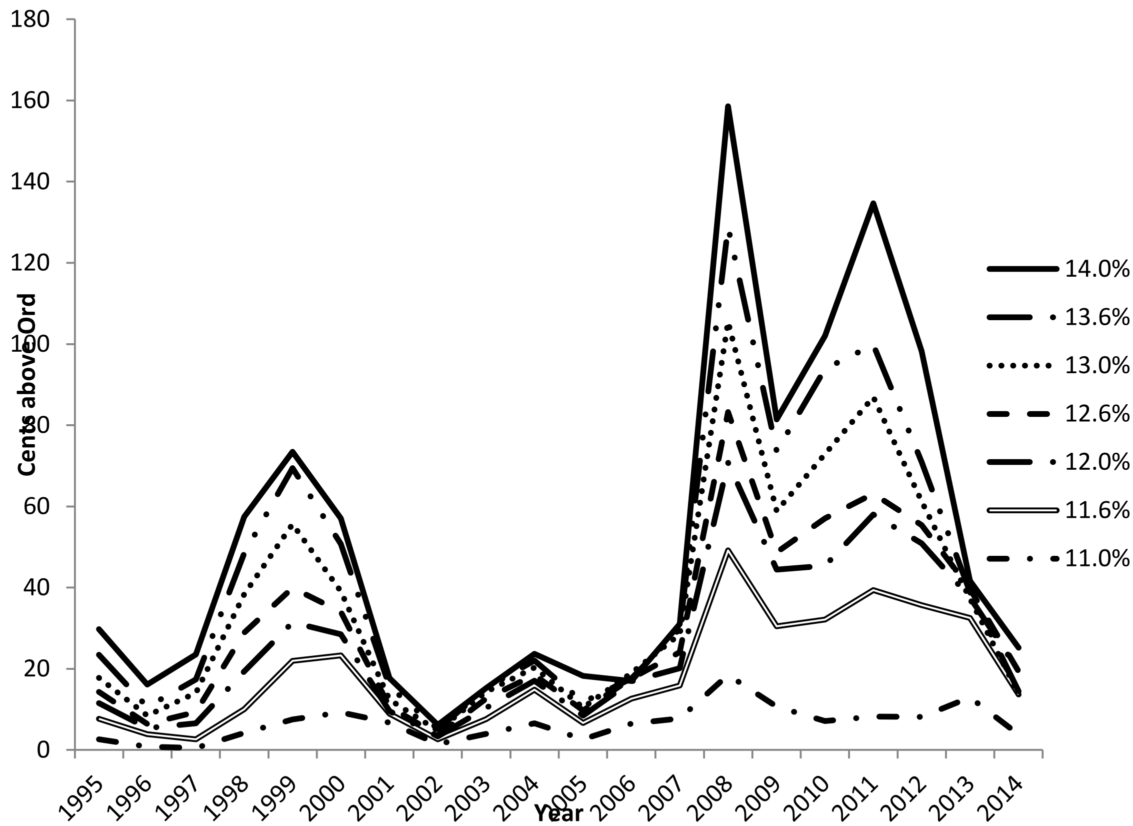


Figure IV-2. Nominal Protein Premiums Over 20 Year Period

VITA

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