Probability of Irrigated Corn Being Profitable in a Humid Region

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Abstract

We used Monte Carlo simulation to evaluate the probability of the net present value (NPV) being positive for investing in irrigation for corn production in Tennessee. The probability of NPV>0 ranged from 78-89% for a 200-acre field using 1994-2013 prices, and 87-99% for a 125-acre field using 2006-2013 prices.

Introduction

Global demand for grains has been increasing in response to growing population, expanding economies in developing countries, and rising biofuels production, among other factors (Trostle, 2008). Irrigation of grain crops is expanding in humid regions of the world to meet growing global demand for grains (Mullen, Yu, and G. Hoogenboom, 2009; Rosegrant, Ringler, and Zhu, 2009; Schaible and Aillery, 2012). Rosegrant, Ringler, and Zhu (2009) predict over half of global cereal production will be under irrigation by 2050. In the United States, irrigation of grain crops in humid regions such as the Southeast has grown rapidly in the last several years (Banerjee and Obembe, 2013; Salazar et al., 2012; Schaible and Aillery, 2012).

Most humid regions of the United States receive enough annual rainfall to produce corn without irrigation, but the purpose of irrigation is to supplement rainfed corn production during periodic short-term droughts. Economic research on irrigation in humid regions has primarily focused on the benefits from managing production risk through higher and more stable yields. Early research by Boggess et al. (1983) and Boggess and Amerling (1983) found that irrigation maximized crop net returns and reduced production risk under Florida growing conditions. However, Boggess et al. (1983) found that, if crop prices decreased below a certain threshold, the cost of irrigation was greater than the benefits from irrigation; thus, crop prices needed to remain above this threshold for irrigation to be feasible. Boggess, Anaman, and Hanson (1985) surveyed farmers in the southeastern United States and found irrigation was the most common risk management response to rainfall variability. Recently, Dalton, Porter, and Winslow (2004) compared irrigation with crop insurance to manage potato production risk in the northeastern United States. They found that crop insurance was risk inefficient and supplemental irrigation was risk efficient depending on the scale (i.e., field size) of the system, with a larger scale providing more risk-management benefits. DeJonge, Kaleita, and Thorp (2007) calculated a breakeven corn price of $4.60/bu for irrigating corn on a 125-acre field in Iowa, and concluded that irrigation was not profitable given the expected corn price of $2/bu used in the analysis.

Although the abovementioned papers provide useful insights, the profitability and risk of irrigating corn in humid regions has likely changed with higher corn prices in recent years. The primary driver of the upward shift in corn prices since 2006 has been the subject of extensive debate, but most analysts agree that multiple factors, such as growing demand for grains, rising meat consumption and expanding biofuels production, have influenced the rise in prices (de Gorter, Drabik, and Just, 2013; Trostle, 2008). Mullen, Yu, and G. Hoogenboom (2009), using a multi-crop production model for the southeastern United States, found that energy cost slightly influenced irrigation water demand, but crop prices had the greatest influence on irrigation water demand. The profitability and risk of investing in an irrigation system for corn production in a humid region is unknown for the higher corn prices of recent years.

Additionally, the aforementioned studies used simulated yield data and excluded inputs other than water (Boggess et al., 1983; Boggess and Amerling, 1983; Dalton, Porter, and Winslow, 2004; DeJonge, Kaleita, and Thorp, 2007). Along with water, nitrogen (N) fertilizer is considered to be the most important input in corn production (Stone et al., 2010), providing the highest return on dollar spent(Pikul, Hammack, and Riedell, 2005). Water and N fertilizer are complements in crop production; thus, irrigation will likely increase both yield and the profit-maximizing N fertilization rate (Dinnes et al., 2002; Stone et al., 2010; Vickner et al., 1998). Using non-profit-maximizing N fertilization rates and yields could misrepresent returns to irrigation. For instance, if net returns were compared assuming 150 lb/acre N was applied to both non-irrigated and irrigated corn, the net returns from irrigating corn might be underestimated since irrigated corn will likely require more N fertilizer than non-irrigated corn. Selecting the profit-maximizing N fertilization rates for non-irrigated and irrigated corn levels the playing field for yields and returns to irrigation.

We calculated the expected net present value (NPV) and the probability of a positive NPV of investing in a center-pivot irrigation system for corn production for three field sizes and two energy sources in Tennessee. Monte Carlo simulation was conducted using corn, N, and energy prices from 1994-2013. We also simulated the model using prices for the 1994-2005 and 2006-2013 periods to analyze the impact of the shift in corn prices. We use actual field-experiment data to estimate stochastic yield response to N fertilizer for non-irrigated and irrigated corn. Profit-maximizing yields and N rates were used to determine net returns for non-irrigated and irrigated corn.

Data

Corn N fertilization experiments were conducted at the University of Tennessee Milan Research and Education Center from 2006 to 2012. Non-irrigated corn was produced on a Grenada soil and irrigated corn was grown on a Loring soil. Both soils were considered highly suitable for corn production in Tennessee. Corn rotated with soybeans (corn after soybeans) was planted in 76-cm rows in April on fields that have been under no-till production (Yin et al., 2011).

The experimental design was a randomized complete block with six N fertilization treatments as strip-plots and four replications. The annual N fertilization rates were 0, 55, 110, 165, and 220 lb/acre in 2006 and 2007. In 2008, a treatment of 275 lb/acre was added to the experiments. Each plot was 15 feet wide and 30 feet long. The N source was ammonium nitrate, uniformly broadcast on the soil surface around planting time. Phosphorus (P) and Potassium (K) were applied based on University of Tennessee soil-test recommendations. All other production inputs, such as weed, pest and disease control, were similar for the non-irrigated and irrigated experiments and followed the University of Tennessee's recommended management practices.

Supplemental water was uniformly applied to the irrigated plots using a Valley linear irrigation system (Valmont Irrigation, Valley, NE). The supplemental water rates were based on the Management of Irrigation Systems in Tennessee (MOIST) soil moisture management system program, which is an online irrigation scheduler available for corn producers in Tennessee (Leib, 2012a). The data indicate that 2007 and 2012 were drought years, requiring 10.32 acre/inches and 8.50 acre/inches in supplemental irrigation; respectively. In 2009, rainfall was an abundant, reducing the total amount of supplemental irrigation to 3.28 acre/inches.

Prices used in the simulations were from 1994-2013 and converted in 2013 dollars using the seasonally adjusted annual Gross Domestic Product (GDP) Implicit Price Deflator (Federal Reserve Bank, 2013). Tennessee corn and N prices were collected from USDA-NASS (2013a). United States diesel and electricity prices were collected from the United State Energy Information Administration (US-EIA, 2013). The averages and standard deviations of the prices are displayed in Table 1 for the different simulation periods.

Irrigation System

Investment

The cost of irrigation equipment vary by field size, well depth, and energy source. We generalized the cost of irrigating corn by estimating the cost of a typical non-towable, center-pivot system (Verbree, 2012; USDA-NASS, 2013b). Non-irrigated and irrigated field sizes of 60 acre, 125 acres, and 200 acres were selected to reflect the range of field sizes in Tennessee. Table

2 shows the capital investment by well expense and system investment. Estimated investment costs were from actual bid prices for installing a non-towable center-pivot system in West Tennessee provided by a West Tennessee irrigation dealership and personal communication with an irrigation extension specialist in West Tennessee (Verbree, 2012).

We assumed the center-pivot system had a 20-year useful life and zero salvage value, which follows the assumptions of Ding and Peterson (2012) and Guerrero et al. (2010). We also assumed the producer financed the cost of the well and system over five years at a 5% interest rate, which is what Guerrero et al. (2010) used. The total capital investment cost of the equipment was depreciated under the Modified Accelerated Cost-Recovery System over five years at a 25% marginal tax rate. Finally, the risk-adjusted discount rate was 1.5%, which is lower that what other irrigation investment studies have used (Carey and Zilberman, 2002; Guerrero et al., 2010; Seo et al., 2008), but reflects the current real discount rate (U.S. Department of the Treasury, 2013).

Operating

A preliminary review of the data suggested that irrigation requirements vary across years. Taking a simple average of irrigation rates would overweight the high irrigation requirements for the 2007 and 2012 drought years and the low irrigation requirements for 2009 when timely rainfall occurred. Therefore, we weighted annual irrigation rates from the experiment to calculate the expected irrigation rate. We follow Lambert, Lowenberg-DeBoer, and Malzer's (2007) method of creating annual weights based on the irrigation data. In our model, the annual weights (θ_t) were determined as $\theta_t = \prod_t \phi(w_t) \Big/ \sum_{t=0}^{T} \prod_t \phi(w_t)$ where w_t is the total irrigation water observed in year t (t=1,…,T); and $\phi(w_t)$ is the standard normal probability density function. The weighting is based on the rule of probability multiplication and assumes that the irrigation rate in year *t* is independent of the rates in other periods (Lambert, Lowenberg-DeBoer, and Malzer, 2007). The expected irrigation rate was $w = \sum_{t=1}^{T} \theta_t w_t$. An expected irrigation rate of 6.88 acre-inches/year was found with a standard deviation of 2.16 acre-inches/year. This rate was close to the same as the average annual irrigation rate of 6.90 acre-inches/year reported in the 2007 Census of Agricultural Farm and Ranch Irrigation Survey for Tennessee (USDA-NASS, 2013b).

An important decision for producers in the southeastern United States is whether to use diesel or electricity to power their irrigation system. The annual energy costs using diesel and electric power to apply the expected irrigation rate (*w*) were calculated following Rogers and Alam's (2006) energy cost formulas. To make these calculations, a weighted-average pump operating pressure of 39 pounds per square inch was chosen using data from the 2007 Census of Agricultural Farm and Ranch Irrigation Survey (USDA-NASS, 2013b), and an average pump-lift distance of 250 feet was used, which is a typical well depth in Tennessee (Verbree, 2012; USDA-NASS, 2013b). Leib (2012b) showed the importance of including the fixed cost of running electricity to the pump; therefore, we used three fixed costs of $10,000, $15,000, and $20,000 to run electricity to the pump.

Jensen (1980) and McGrann (1986a, 1986b) estimated annual repair and maintenance costs for irrigation equipment as a percentage of the initial cost of the equipment, as proposed in the American Agricultural Economic Association (AAEA) Commodity Costs and Returns Handbook (2000). We calculated repair and maintenance costs using 1.7% of the initial cost, which is within the range stated in the AAEA Handbook (2000). We assumed an annual irrigation labor cost of $12/acre (Leib, 2011b).

Simulation Framework

To estimate the expected NPV and the probability of a positive NPV, we first established the annual net returns to N for corn production for non-irrigating and irrigating corn producers using partial budgets:

$$E(\tilde{\pi}_{\lambda}) = E[\tilde{p}y_{\lambda}(x_{\lambda}) - \tilde{r}x_{\lambda} - \lambda(\tilde{c}w + l + m)], \tag{1}$$

where $E(\tilde{\pi}_{\lambda})$ is the expected net return in \$/acre; λ is a binary variable with λ=1 for irrigation and λ=0 for non-irrigation; $\tilde{p}$ is the uncertain price of corn in \$/bu; $y_{\lambda}(x_{\lambda})$ is yield in bu/acre and is a function of the N fertilizer rate x_{λ} in lb/acre; $\tilde{r}$ is the uncertain price of N fertilizer in \$/lb; $\tilde{c}$ is the uncertain cost of energy for pumping water in \$/inch/acre; w is the expected irrigation water rate in inch/acre; l is the expected labor cost related to irrigation in \$/acre; and m is irrigation maintenance and repair costs in \$/acre.

We estimated yield response functions for non-irrigated and irrigated corn to determine the respective profit-maximizing N rates. Recently, many researchers have found stochastic plateau response functions are more suitable than their deterministic plateau response function counterparts (Boyer et al., 2013; Biermacher et al., 2009; Tembo et al., 2008; Tumusiime et al., 2011). Data from the experiment were used to estimate linear response stochastic plateau (LRSP) functions developed by Tembo et al. (2008) for non-irrigated and irrigated corn:

$$y_{ti} = \min(\beta_0 + \beta_1 x_{ti}, \mu + u_t) + v_t + \varepsilon_{ti}, \tag{2}$$

where y_{ti} is the corn yield in bu/acre in year t on plot i; β_0 and β_1 are the yield response parameters; x_{ti} is the quantity of N fertilizer applied in lb/acre; μ is the expected plateau yield in bu/acre; $u_t \sim N(0, \sigma_u^2)$ is the year plateau random effect; $v_t \sim N(0, \sigma_v^2)$ is the year intercept random effect; and $\varepsilon_{ti} \sim N(0, \sigma_e^2)$ is the random error term. Independence is assumed across the three stochastic components. Because irrigation was applied as needed to supplement rainfall and did not follow prescribed rates in the experiment, the irrigation amounts were not included in the response functions. Equation (2) was estimated using the NLMIXED procedure in SAS 9.1 (SAS Institute Inc., 2003).

The profit-maximizing N fertilization rate is (Tembo et al., 2008):

$$x^* = \frac{1}{\beta_1}(\mu + Z_\alpha \sigma_u - \beta_0), \tag{3}$$

where Z_α is the standard normal probability of $\tilde{r}/(\tilde{p}\beta_1)$ at the α significance level. The profit-maximizing expected yield is (Tembo et al., 2008):

$$E(y_{ti}) = (1 - \Phi)a + \Phi(\mu - \frac{\sigma_u \phi}{\Phi}), \tag{4}$$

where $\Phi = \Phi[a - \mu/\sigma_u]$ is the cumulative normal distribution function; $a = \beta_0 + \beta_1 x$; and $\phi = \phi[a - \mu/\sigma_u]$ is the standard normal density function. Note that the expected yield (equation 4) and the profit-maximizing N fertilization rate (equation 3) are functions of the prices of corn and N; thus, the optimal expected yield and N fertilization rate change in the simulation as the prices of corn and N change.

Depreciation and annual interest were subtracted from net returns (equations 1) to calculate total taxable net returns:

$$\tilde{K}_\lambda = \tilde{\pi}_\lambda - \lambda Dep - \lambda Int, \tag{5}$$

where $\tilde{K}_\lambda$ is the annual taxable net returns; *Dep* is the annual depreciation of the irrigation system; and *Int* is the annual interest payment on the loan. The total taxable net returns was multiplied by the marginal tax rate to determine the annual amount paid in taxes. Annual cash flows were determined by subtracting annual loan payment for the irrigation system and the annual tax payment from the net returns:

$$\tilde{F}_{\lambda} = \tilde{\pi}_{\lambda} - \lambda PMT - \lambda(\tilde{K}_{\lambda}\tau), \tag{6}$$

where $\tilde{F}_{\lambda}$ is the annual cash flow; *PMT* is the annual loan payment for the irrigation system; and τ is the annual tax rate.

Expected annual cash flows for non-irrigated and irrigated corn were simulated for the 20-year useful life of the irrigation system:

$$\tilde{V} = -IC + \sum_{t=1}^{T} \frac{\tilde{F}_{t1} - \tilde{F}_{t0}}{(1+\eta)^{t}}, \tag{7}$$

where *IC* is the initial investment in irrigation equipment in year t=1; $\tilde{F}_{t1}$ is the annual cash flow for irrigated corn; $\tilde{F}_{t0}$ is the annual cash flow for non-irrigated corn; T=20 is the useful life of the irrigation equipment; and η is the risk-adjusted discount rate. The discount rate was the producer’s opportunity cost of investing in the irrigation equipment, representing the net return a producer would receive from an alternative investment (i.e., the Treasury bond). The discount rate was equal to the risk-free discount rate plus the risk premium (Seo et al., 2008). If NPV=0, the present value of the net cash flow from irrigating corn equals the opportunity cost of irrigating corn (i.e., the benefit from an alternative investment), and the producer is indifferent between investing in the irrigation system and an alternative investment. If NPV>0, the producer would enhance net returns by investing in the irrigation system than the alternative investment. The annual cash flows were simulated for a 20-year useful life of the irrigation investment to calculate equation (7). NPV (equation 7) was simulated 5,000 times and the results were used to determine the probability that NPV>0.

Prices were drawn from a multivariate normal distribution, $[p,n,c] \sim N(0, \mathbf{\Sigma})$, where $\mathbf{\Sigma} = \mathbf{TT'}$. As an example, the random draws for the price of corn were determined as $\tilde{\mathbf{p}} = \overline{p} + \mathbf{Tz}$ with z random draws and an average corn price of $\overline{p}$ (Greene, 2008). The cost data for the irrigation system and parameter estimates from the LRSP functions were substituted into the simulation model (equation 7) along with the equations for the randomly drawn prices for corn, nitrogen, and energy.

Results

Yield Response Functions

Table 3 presents the parameter estimates for the LRSP functions for non-irrigated and irrigated corn. All parameter estimates were significant ($p \leq 0.05$). The intercept parameter estimates suggest the expected yield for irrigated corn was 23 bu/acre higher than for non-irrigated corn when zero N fertilizer was applied. Slope parameter estimates (yield response to N fertilizer) were similar for irrigated and non-irrigated corn, suggesting that irrigated and non-irrigated corn responded similarly to N fertilizer. The estimated plateau was 66 bu/acre higher for irrigated corn than for non-irrigated corn, demonstrating the expected yield gain from timely application of irrigation. The plateau random effect was smaller for irrigated corn than for non-irrigated corn, indicating year-to-year yield variability was reduced with irrigation. The reduction in plateau yield variability with irrigation shows a reduction in production risk.

The expected profit-maximizing N fertilizer rates (equation 3) and the expected profit-maximizing yields (equation 4), calculated from the estimated LRSP functions, are presented in Table 4 for each time period. The profit-maximizing yield for irrigated corn was 61 bu/acre higher than for non-irrigated corn and the profit-maximizing N rate for irrigated corn was 32 lb/acre higher than for non-irrigated corn for all time periods. These findings demonstrate how assuming similar N rates for non-irrigated and irrigated corn can result in misleading net returns and over or under stating the profitability of investing in irrigation. In the simulation model, as the prices of corn and N changed, so did the profit-maximizing N rates and corn yields.

NPV Results

Table 5 displays the expected NPVs for investing in irrigation and the probability of the investment's NPV being positive for the three time periods, three field sizes, and two energy sources. Using prices from 1994-2013, expected NPV was negative for all energy sources on the 60-acre field with a zero probability of the NPV being greater than zero. Expected NPV was highest for using electric energy on the 60-acre field when the cost of running electricity to the pump was $10,000. If the cost of running electricity to the well exceeded $10,000, the expected NPV was higher when using diesel. For the 125-acre field, expected NPV was negative for all energy sources. The probability of a positive NPV was 3% when diesel was the energy source and ranged from 11% to 31% depending on the fixed cost of running electrical energy to the well. The expected NPV was higher for electric power than for diesel regardless of the fixed cost of running electricity to the irrigation unit. Irrigating the 200-acre field using electric power produced the only scenarios where expected NPV was positive for 1994-2013 average prices. NPV ranged from $36,714, when the fixed cost of running electricity to the well was $20,000 to $59,352, when the fixed cost of running electricity to the well was $20,000. The probability of a NPV greater than zero was 78% to 89% for electric energy. When using diesel energy, the NPV was negative and the probability of NPV being positive was 49%. Overall, investing in supplement irrigation for corn production, given 1994-2013 average prices, would likely be unfeasible on Tennessee corn fields less than 200 acres.

For prices between 1994 and 2005, expected NPV was negative for all field sizes and energy sources. Producers would be better off investing their money in U.S. Treasury Bonds (the alternative investment). The expected NPV was highest for diesel energy on the 60-acre field and probability of NPV>0 was zero for all energy sources on the 60-acre and 125-acre fields. The probability of NPV>0 ranged from 1 to 5% on the 200-acre field. However, expected NPV was higher for electric power than for diesel when the fixed cost of running electricity to the well was $15,000 or less. For the 200-acre field, the fixed cost of electrical-power setup was spread over enough acres to make electrical power competitive with diesel power. Using prices during the 1994-2005 period, investment in supplemental irrigation for corn production would be unfeasible.

Given prices after 2006, expected NPV increased for all field sizes and energy sources. For the 60-acre field, expected NPV was still negative and the probability of NPV>0 was still zero for all energy scenarios. The simulation result indicates that even at the current high prices, irrigating corn on a 60-acre field in Tennessee had a negative NPV. Electric power with a fixed cost of running electricity to the well of $15,000 or less had a higher NPV than diesel energy on the 60-acre field. This result was different from the pre-2006 price scenario where diesel was the preferred energy source. Expected NPV for the 125-acre field was $37,182 when diesel was the energy source, and ranged from $67,215 to $89,827 when electrical energy was used, depending on the power source and electrical setup cost. The probability of NPV>0 ranged from 97% to 99% for electric energy and 87% for diesel energy. If a corn producer invested in an irrigation system on a 125-acre field, given prices that prevailed during the 2006-2013 period, the probability of NPV>0 would be between 87% and 99%. Expected NPV for a 200-acre field was positive for all energy sources and ranged from \$207,542 to \$218,848 when electrical energy was used and the probability of NPV>0 was 100% regardless of the fixed cost. The expected NPV was \$132,354 when diesel was the energy source and the probability of NPV>0 was 99%. Results for the preferred energy source on the 200-acre field are similar to the results for the 125-acre field—the producer's NPV was higher using electric power.

Conclusions

We evaluated the NPV of investing in a center-pivot irrigation system to produce corn in West Tennessee. We consider three field sizes and two energy sources, and explore how the recent change in corn prices might have impacted the profitability of corn irrigation. Data used in this study came from a corn N-rate experiment located near Milan, Tennessee. We estimated yield response functions to N for non-irrigated and irrigated corn, and used the estimated optimal yields and N fertilization rates for non-irrigated and irrigated corn to estimate the returns to irrigation. Little is known about the economics of irrigating corn in humid regions, but the results from this study will help extension personnel and producers in the southeastern United States determine if irrigating corn is profitable for various field sizes and energy sources.

Results from this study show that corn yield was increased and stabilized with irrigation in Tennessee. On average, irrigation increased corn yield by 66 bu/acre in this study. Prior to 2006, the expected NPV for irrigating corn was negative across all field sizes and energy sources. However, post-2006, the expected NPV was positive for fields of 125 acres or larger that used either diesel or electric power. The probability of NPV being positive for fields of 125 acres or larger, that used either diesel or electric power, ranged between 3% and 31% for prices prevailing before 2006 and increased to between 87% and 100% for prices prevailing from 2006-2013. The expected NPV for using electric power was higher than for diesel power for all fields of 125 acres or larger. This result likely explains why irrigation investment has increased in Tennessee recently.

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Table 1. Average Prices and Standard Deviations Used in the Simulations by Time Period

Time Period	Corn ($/bu)	Nitrogen ($/lb)	Diesel ($/gallon)	Electricity ($/kWh)
1994-2013	$3.79 (1.407)	$0.53 (0.149)	$2.37 (0.911)	$0.08 (0.008)
1994-2005	$3.09 (0.741)	$0.43 (0.052)	$1.77 (0.364)	$0.08 (0.001)
2006-2013	$4.99 (1.507)	$0.70 (0.093)	$3.39 (0.574)	$0.09 (0.007)

Data Source: USDA- NASS (2013a) and US-EIA (2013).
Note: Standard deviations are in parenthesis.

Table 2. Center-Pivot Investment Costs (US $) by Field Size

	Field Size		
Cost Item[a]	60 acre	125 acre	200 acre
Well Setup			
Drilling	$20,000	$20,000	$20,000
Pump	$20,000	$24,500	$26,500
Power Unit	$10,000	$15,200	$25,500
Irrigation Rig			
Sprinklers	$2,000	$2,600	$4,500
Spans	$48,000	$65,000	$99,000
Installation	$6,700	$8,000	$9,300
Total Costs			
Field	$106,700	$135,300	$184,256
Per Acre	$1,778.33	$1,082.40	$921.28

Source: Personal communications with irrigation dealerships in West Tennessee and an irrigation expert (Verbree, 2012).

[a] This is the base cost by item for the irrigation equipment. When electric energy is used, three additional fixed costs were to run electricity to the well were included to the fixed cost.

Table 3. Estimated Corn Yield Response to N for Non-irrigated and irrigated Corn Grown after Soybeans Using a Linear Response Stochastic Plateau Function

	Response Functions	
Parameter	Non-Irrigated Corn	Irrigated Corn
Intercept	66.189***	89.705***
N	0.7407***	0.805***
Plateau	155.70***	218.36***
Plateau random effect	682.70***	280.53**
Intercept random effect	166.96***	207.14***
Random error	245.07***	273.40***
−2 Log-likelihood	1520.7	1563.4

***=significant at *p*=0.01; **=significant at *p*=0.05.

Table 4. Expected Profit-Maximizing Yields (bu/acre) and Nitrogen (lb/acre) Rates for Non-irrigated and irrigated Corn by Time Period

Time Period	Non-Irrigated Corn	Irrigated Corn
1994-2012		
Expected Yield (bu/acre)	145	206
Nitrogen Rate (lb/acre)	131	163
1994-2005		
Expected Yield (bu/acre)	146	207
Nitrogen Rate (lb/acre)	133	165
2006-2012		
Expected Yield (bu/acre)	145	206
Nitrogen Rate (lb/acre)	131	162

Table 5. Expected Net Present Value of Investing in Irrigation and Probability that the Expected Net Present Value Is Positive by Time Period, Field Size and Energy Source

Energy Source and Time Period	60 acre		125 acre		200 acre	
	Expected NPV[a]	Probability [b]	Expected NPV	Probability	Expected NPV	Probability
1994-2013						
Diesel	$(120,080)	0%	$(58,859)	3%	$(14,912)	49%
Electric $10,000	$(113,481)	0%	$(16,940)	31%	$59,352	89%
Electric $15,000	$(124,787)	0%	$(28,245)	20%	$48,019	84%
Electric $20,000	$(136,093)	0%	$(39,551)	11%	$36,714	78%
1994-2005						
Diesel	$(136,438)	0%	$(87,547)	0%	$(67,212)	2%
Electric $10,000	$(146,482)	0%	$(83,976)	0%	$(47,932)	5%
Electric $15,000	$(157,788)	0%	$(95,282)	0%	$(59,238)	2%
Electric $20,000	$(169,093)	0%	$(106,587)	0%	$(70,544)	1%
2006-2013						
Diesel	$(76,568)	0%	$37,182	87%	$132,354	99%
Electric $10,000	$(63,056)	0%	$89,827	99%	$230,153	100%
Electric $15,000	$(74,362)	0%	$78,521	99%	$218,848	100%
Electric $20,000	$(85,667)	0%	$67,215	97%	$207,542	100%

[a] These numbers are the expected NPVs for investing in an irrigation system over a 20-year useful life, given the average prices for each time period.

[b] These numbers are the probabilities that the expected NPVs are greater than zero for investing in an irrigation system over a 20-year useful life, given the average prices for each time period.