Simulating Returns to Alternative Crop Mixes in Northeastern Louisiana

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ABSTRACT

Rising production costs and volatility in commodity prices have forced agricultural producers to diversify their farm acreage as a means of increasing farm profitability. A financial farm-level simulation model is constructed to examine net returns over total variable production costs per rotational acre for a representative corn, cotton, and soybean farming operation located in the Mississippi River delta region of Louisiana. Results indicate that a predominant corn followed by a corn-soybean crop mix generates the highest net returns above variable costs to the producer when harvest month futures prices are considered with respect to simulated input parameters and expected yields.

Introduction

Agricultural producers in northeastern Louisiana are diversifying their farming operations to remain financially solvent. Farm management decisions are on-going and range from deciding on the appropriate crop mix model, variety selection, input application timing, harvest optimization, marketing, and reinvestment in farm capital. Each decision requires an understanding in crop physiology, management science, economics, and, in particularly, risk management. Producers are able to check futures prices and market their crop electronically, structure bank loans based on historical land production, off-set yield risk with the purchase of insurances policies, and manage income risk through direct and counter-cyclical farm payments.

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Given the political climate that surrounds the 2012 Farm Bill, both the Senate and House Agriculture Committees have proposed eliminating direct and counter-cyclical payments to producers. The political future of these payments is of concern to producers, as these payments provide a safety net in the form of income protection. Given the fact that counter-cyclical payments are tied to market price, corn and soybean prices have exceeded their specified target price benchmark – essentially not being issued nor included in any income calculations to the operation. While direct payments are not tied to price or production, these payments provide an income benefit to a Louisiana producer of approximately $19.80 for corn, $48.86 for cotton, and $8.80 per acre for soybeans, respectfully. More so, forecasting the input markets (e.g., fertilizer and fuel) from one crop year to the next can become complex when trying to predict the relationship of multiple variables into an economic model to forecast farm profitability. Variables are often dependent and correlated to price movements over a particular time period. Even more importantly, trends in the prices for competing crops and the resulting acreage shifts must also be considered.

For the farm manager, deciding on which cropping system to employ on-farm is based upon the expected costs and returns for each alternative system. Through the use of an enterprise budget, potential revenue and expenses as well as profit for a single enterprise can be estimated. Enterprise budgets can be created for different levels of production or types of technology (Kay, Edwards, and Duffy, 2004). The primary purpose of enterprise budgets is to estimate the projected costs, returns, and profit per unit of the enterprise(s) – usually covering a year or less. These budgets can help in identifying the more profitable enterprises to be included in the whole-farm plan. Once completed, an enterprise budget contains the data needed to compute the cost of production, break-even yield, and break-even price for each commodity being evaluated (Kay, Edwards, and Duffy, 2004). Enterprise budgets also allow the farm manager to evaluate alternative land rent shares (percentage of crop receipts paid to the landowner for land and/or water privileges) or cash rental fees in order to determine to optimal rent for their production system and its resulting effect on net returns.

Crop rotations often increase the yields of the rotated crops, an effect which may be more pronounced when yields are limited by specific problems that are affected by the cropping sequence. Helmers et al. (2001), Ebelhar and Ware (2003), and Ebelhar, Clark, and Martin (2010) cite the benefits of rotating crops to include: a) maintenance of crop yields; b) control of diseases, insects, and weeds; and c) prevention of soil erosion, as well as include diversification of income and risk reduction. If a crop has limited yield potential due to a production-related issue, then rotating that crop with another crop can be a way to limit the impact of the production issue and help improve yields. For example, if nematodes are a limiting factor, one way to address this production-related issue is to rotate acreage to a crop that is not impacted by nematodes. Profitability of rotations versus continuous mono-cropping is determined by the magnitude of crop responses and, perhaps more importantly, by commodity prices of the included crops (Boquet et al., 2004). Helmers et al. (2001) states that risk associated with cropping systems results from the variability in returns across time and arises from year-to-year changes in yields, crop process, and input costs. Bullen et al. (2004) emphasizes that producers need to carefully consider rotation systems as a way to maintain profit and improve soil and cropping conditions. However, choices among rotational systems are more dependent on local agronomic and management considerations than on yield increases and rotational profitability. In some instances, rotations can have significant yield benefits but may be no more profitable than a mono-crop depending on the production expenses incurred with rotating an alternative enterprise. An important consideration point to Bullen et al. (2004) is that the yield increases from a rotational system must be large enough to offset the reduced income from the production of the alternative crop (Boquet et al., 2004).

As previously stated on enterprise budgeting, income from each enterprise is shown along with the quantity, unit, and price associated with each production input used. To compare the profitability of each alternative crop rotation, the concept of a rotation acre assumes that each crop in the rotation sequence is produced in equal proportion each year or each acre could be thought of as being composed of an equal proportion of each crop in the rotation (Guidry et al., 2001). Given the fact that current agricultural policy is more market-driven, producers have to be more responsive to market signals because of increased income risk and uncertainty (Guidry et al., 2001). Recent farm bills have allowed producers greater flexibility in their crop mix and recent increases in grain prices have made grain production a viable alternative (Ebelhar et al., 2011). Paxton, Guidry, and Hague (2003) identify that producers in northeast Louisiana are rotating crops in response to changing market signals and the ability of producers to practice crop rotation without fear of jeopardizing benefits under government programs. This is echoed in Guidry et al. (2001) that with the removal of acreage restrictions and government payments no longer tied to production, producers have the flexibility to select cropping systems based on market signals rather than policy provisions. This has brought increased interest in the use of crop rotations as both a production and marketing risk management tool.

The Mississippi River delta region of northeastern Louisiana includes the parishes of: East Carroll, Franklin, Madison, Morehouse, Richland, Tensas, and West Carroll. This region of the state has accounted for approximately 73 percent of Louisiana's corn production, 62 percent of Louisiana's cotton production, and 42 percent of Louisiana's soybean production from 2002 to 2011. Over the past three years, planted acreage in this region of the state has seen corn average 409,833, cotton 141,833, and soybeans 391,667. Figure 1 illustrates a significant decline in cotton acreage.

Reasons that can be attributed to this acreage decline in cotton are the yield and price of competing crops – most noticeably corn and soybeans. Corn and soybean crops that are produced in northeastern Louisiana have lower management intensity when compared to cotton. A noticeable production cost difference exists in fertilizer, seed, insect control programs, as well as with harvesting costs when cotton is compared to corn and soybeans in this region. In the latter part of the past decade, cotton acreage in Louisiana has shifted into more profitable alternatives – namely acreage expansion in corn, soybeans, and wheat. A suppressed cotton market price and rising input costs coupled with increased grain prices have caused cotton acres to reach an historic low at less than 300,000 acres statewide. Ebelhar et al. (2011) states that higher grain prices are lower cotton prices have eroded the cotton base while corn production has greatly increased in the last few years. Corn and soybean production are increasing while cotton declines in the Mississippi delta. This observation can be applied to cotton production in northeastern Louisiana.

Historical variable production costs per acre for each crop, specific to this region of the state are listed in Table 1. The projected variable production cost per acre for corn produced in northeastern Louisiana for 2012 is estimated at $474.60, cotton at $547.51, and soybeans at $310.92. During the ten year period from 2002 to 2011, total variable production costs per acre for non-irrigated corn, cotton, and soybeans averaged $319.43, $475.96, and $170.43, respectively. Production costs have increased over the past decade in corn, cotton, and soybeans by $239.72, $98.07, and $193.29 per acre respectively. From 2008 to 2009, total variable production expenses for all crops witnessed their greatest increase with total variable costs for corn increasing by an amount of $152.49, cotton by $71.95, and soybeans by $72.55 per acre respectively.

Energy-related farm inputs have increased significantly in recent years, which can adversely affect a producer's bottom line. This was witnessed by Louisiana producers in 2008 and 2009. These increases were driven primarily from large increases in costs associated with fertilizers, chemicals, and seed. Over the ten year observation period, fertilizer, chemical, seed, and fuel inputs compose (on average) two-thirds of total variable costs per acre for corn and soybeans and half of the variable costs per acre for cotton produced in the Louisiana delta region. Diesel fuel price per gallon has undergone nearly a three-fold increase, from $0.94 per gallon in 2002 to $2.75 per gallon in 2011, reaching its highest unit price in 2008 at $2.90 per gallon. Unit costs for phosphate and potash fertilizer have tripled, while nitrogen costs have increased to 2.5 times their unit cost level since 2002 (Deliberto & Salassi, 2012) (Figures 2 and 3.) Fertilizer prices for nitrogen, phosphate, and potash reach highs of $0.53, $0.88, and $0.75 per pound respectively in 2009. Fertilizer prices have climb as energy prices increase, especially natural gas. Natural gas comprises 70-90 percent of the cost of nitrogen fertilizer production (Johnson, Yates, and Smith, 2006). Fertilizer composes approximately 33 percent of the total variable cost per acre for corn, while the fertilizer share for cotton and soybeans are less than 10 percent of total variable costs.

Commodity prices from 2002-2011 averaged $3.52 per bushel for corn, $0.58 per pound for cotton, and $8.09 per bushel for soybeans. However, since 2007, national market prices for each crop have exceeded this average price level-further illustrating crop price volatility. Since that point in time, average prices are calculated to be $4.66, $0.68, and $10.08

per unit for corn, cotton, and soybeans. In 2011, national marketing year prices reached highs across all crops, specifically $6.10 corn, $0.92 cotton, and $11.90 soybeans. The 2005 to 2011 average national marketing year average (MYA) price index for corn, cotton, and soybeans appears in Figure 4. In examining the price indices from 2005 to 2011, corn was calculated at an average of 268 percent of its 2000-04 index price. Soybeans followed at 209 percent with cotton at 190 percent of its respected index.

Ethanol, principally derived from corn, is the dominant biofuel used in the United States (Welch et al., 2007). Increased demand for corn by the ethanol industry drives the price of corn higher, thus increasing net returns for corn producers. As the net returns for corn increase, producers expand corn plantings by displacing acreage of competing crops, e.g., cotton (Welch et al., 2007). The authors go onto state that since increased production of ethanol will result in increased returns for corn and soybean producer, producers of cotton that have the productive flexibility to grow alternative crops may switch their planting intention towards corn and soybeans and plant fewer cotton acres.

Materials and Methods

A financial farm simulation model was constructed using SAS (SAS Institute Inc., 2008) for the Mississippi River delta region of northeast Louisiana to evaluate grower share of net returns above total variable costs per acre for selected crop mix levels. There are 13 corn, cotton, and soybean crop mix choices that were included in this analysis. Crop mix choices ranged from mono-cropped selections to two-thirds/one-third crop mix models. There were ten variables incorporated into the farm financial simulation model: price per unit per commodity; farm diesel price per gallon; nitrogen (N) fertilizer price per pound; phosphate (P) fertilizer price per pound; potash (K) fertilizer price per pound; and crop yield per commodity. Market prices, input prices, and yield levels for non-irrigated corn, dryland cotton, and non-irrigated soybeans were obtained from the previous ten years of data (2002-2011) to provide an accurate depiction of the variability of yield within the region per commodity grown (USDA/NASS 2011). Our analysis was for the 2012 year, therefore trends in the price, yield, and input costs were removed.

The simulation process generated 1,000 observations per variable using a multivariate empirical distribution model via the SIMETAR software program developed by Richardson, Schumann, and Feldman (2008). Stochastic simulations rely on the interactions of random variables within a model to analyze the uncertainty in that model and how those variables behave under alternative conditions that are imposed. Each random variable is entered into model so that its subsistent distribution can be estimated and the distribution of each variable is then randomly sampled so that probabilistic outcomes can be modeled (Richardson, Schumann, and Feldman, 2008). Stochastic simulation models allow changes in variables that represent random occurrences that correspond to risks associated with farm management decision making (Flanders & Wailes, 2010). Multivariate empirical distribution has the flexibility to impose the historical variability on any assumed mean value and accounts for the interrelationships occurring in the data (Richardson, Klose, and Gray, 2000; Flanders, 2008). The resulting simulated random variables are bounded by historical minimums and maximums of the original data (Flanders, 2008). By using historical price and yield information specific to northeastern Louisiana, distribution functions of each variable are constructed around a selected mean level representative of expected market and growing condition for the region.

The 2012 projected regional yield level per commodity, input prices for N, P, and K fertilizer, as well as farm diesel fuel were referenced from Deliberto and Salassi (2012) to serve as the mean values, so that the simulated mean is a function of the historic variability of each parameter. In a similar methodology as that in Paxton, Guidry, and Hague (2003), constant costs were assumed for each cropping mix and expressed in 2012 prices. The mean market price parameters for each crop were selected relative to the near-by harvest month futures contracts. Values resembled expected market conditions for the purposes of variable estimation. It is noted that this research was conducted in mid-June of 2012, hence harvest month contracts for corn was $5.30 per bushel for a September 2012 contract; $0.6765 per pound for an October 2012 cotton contract; and $13.28 per bushel for a November 2012 soybean contract. Mean values used for the simulation period are listed in Table 2 for price, yield, fertilizer, and fuel variables.

Production practices and required inputs for each crop were obtained from the *Projected Cotton Costs and Returns for Northeast Louisiana*. This publication lists technical field operations that serve as an outline to the farm manager of the application timing and input quantity guidelines necessary for the establishment of a successful crop. Input expenses are categorized: custom operations, herbicides, fungicides, insecticides, seed, operator labor, hired labor, fuel, fertilizer, repair, and interest on capital. (Figures 5 to 7.) Production costs in the model were assumed constant for all input cost categories with exception to fertilizer and fuel. Reductions in input costs and the potential for yield increases have been associated with rotational crops in this region of Louisiana.

When cotton is produced in rotation with corn, the nitrogen fertilizer rate was reduced by 25 pounds per acre (Guidry et al., 2001). Yield response is associated with a crop rotation versus a mono-crop situation. For instance, cotton yields in a rotation with corn and soybeans can be upwards of 15 percent greater when compared to a cotton mono-crop. Similarly, a 10 percent yield benefit exists to corn and soybeans when these crops are produced in rotation with one another as opposed to farm acreage being devoted to continuous cropping patterns (Boquet et al., 2004; Paxton, Guidry, and Hague, 2003). It is further assumed that the grower elects to participate in direct and count-cyclical programs for the 2012 crop year. A standard land rent of 20 percent is assumed in this analysis where the landlord receives 20 percent of the crop in exchange for land privileges. The landlord assumes a 20 percent cost share in the hauling and drying expense categories for corn and only the hauling category for soybeans. The hauling cost is included in the cost of ginning the seedcotton. The cotton gin is assumed to take the cotton seed as payment for ginning. The land rental assumption is consistent with observations and communication with producers in this region of the state for these particular crops.

It is further realized that differences exist relative to the ownership costs of grain combines, conventional cotton harvesters, and on-board module building cotton harvesters. From a fixed cost standpoint, the added expense of owning multiple types of harvesters can greatly increase the cost of production and the amount held in capital assets. This can result in a significant impact on the producer's return on assets and return on investment (Govert & Ballou, 2006). Therefore, Govert and Ballou (2006) state that owning a number of combines or cotton harvesters can place limitations on the producer's ability to vary their crop mix from year-to-year. While recent studies have indicated that these new on-board module builders have the potential to improve field efficiency and can reduce equipment costs of excess boll buggies, tractors, and the labor skill need for each-there is an increased cost of acquiring this new technology ($200,000 more than a conventional picker). When accounting for this new technology in an enterprise budget, fixed cost per acre would increase significantly. Producers in northeastern Louisiana commonly produce corn, cotton, and soybeans as rotational crops across their farming operations. Although the amount of acreage devoted to each crop is influenced by market signals (e.g., commodity price), most possess the necessary harvesting equipment. In times of declining prices for cotton, producers with large farming operations may enter into harvesting groups with other producers in their region. In the likelihood that a producer has significantly reduced their cotton acreage, allocating the fixed costs of a conventional harvester or module builder across their smaller acreage can be costly. Hence, the harvesting cost is "contracted" to a third party, reflecting a line-item budget expense to the producer. For the purpose of this analysis, variable harvest cost per acre for a conventional cotton picker is included.

Results and Discussion

Results from the farm simulation model for 13 alternative crop mix selection are presented in Tables 3 and 4. These results are evaluated based on the grower's share of net returns above total variable costs per alternative crop mix choice. Simulation of the 2012 simulated yield level for corn (CR), cotton (CT), and soybean (SY) crops, selected production input parameters, and the near-by harvest month futures prices for each commodity, indicates that a producer would favor a rotation consisting of a corn or a predominant corn-soybean mix of farm acres in the Mississippi River delta region of Louisiana. The crop mix that produced the highest level of net return per acre to the grower was a corn mono-crop (100CR) followed by: 66CR-33SY, 50CR-50SY, 33CT-66SY, and a 66CR-33CT mix. Four out of the top five crop mixes, in terms of grower net returns above variable costs, included a majority (greater than a 50%) of acres devoted to corn. The remaining crop mix options in Table 4 indicate that as farm acreage shifts out of corn acres and into a predominant cotton operation (e.g., crop mixes 2, 7, 11, and 13); the grower's share of net returns per acre is greatly reduced.

The rank of each of the 13 crop mix choices appears is presented in Table 4. The parentheses next to the crop mix description denote its original identification number listed in the preceding table. Outside of mono-cropped corn, a 66CR-33SY and a 50CR-50SY yielded returns $29.94 and $44.88 per acre less than the 100CR crop. When cotton is entered into the crop mix model at 33CT-66SY and 66CR-33CT, the return level above variable cost decreases by $59.86 and $68.19 per acre compared to the 100CR mix. The consideration of greater cotton acreage, relative to selected simulated price and yields witnesses the return level of the producer reduced in excess of $100 per acre compared to the 100CR or 66CR-33SY mix. This can be attributed to a lower net return margin associated with cotton production compared to corn and soybean profit margin. The coefficient of variation, interpreted as a level of risk, was 30.6 percent for corn, 195.6 percent for cotton, and 28.1 percent for soybean crops across all model iterations. Results indicate that cotton production in the Mississippi River delta region of Louisiana has the highest degree of risk to the grower followed by corn and soybeans. A partial explanation of the increased risk associated with cotton production can be attributed to the variability in yield levels over the ten year period opposed to relatively consistent yield level in corn and soybean production in northeastern Louisiana. Soybean production exhibits the lowest level of production risk due to the fact that fuel and fertilizer compose a smaller percentage of the variable costs for this crop as compared to corn and cotton. The profitability of crops such as corn and cotton, that have high fertilizer and fuel requirements, is adversely affected to a greater degree when these cost categories undergone unit increases. This coincides with results in Table 4 that show that predominant crop mixes that favor cotton (2, 7, 11, and 13) exhibited the lowest net return level per acre while incorporating the highest degree of risk to the producer.

Summary

The relative proportion of costs and returns will ultimately determine the risk preference for the producer. In the wake of suppressed commodity prices and rising input costs, agricultural producers in the Louisiana are diversifying their farm acreage in efforts to increase profitability. Simulated results from examining the historical production data of the northeast Louisiana Mississippi River delta region from 2002 to 2011coupled with current production cost estimates, indicate that a predominant corn and corn-soybean rotation generates the greatest level of net returns above variable costs compared to a crop mix that has a predominate acreage devoted to cotton. This outcome supports the realization that cotton acres in northeastern Louisiana are declining in-lieu of higher profit margin associated with corn production.

Although this model is specific to input prices and crop yields in northeastern Louisiana, this model can be applied to other crops that can be produced in a rotational based system. However, equitable land rental rates and harvesting system requirements warrant additional consideration by the farm manager when deciding on the appropriate crop mix/rotation. Specific to the northeastern Louisiana simulation model, the inclusion of a share rental percentage was selected that calculated rent as a percentage of gross income as well as the associated percentage of farm program payments. This share rent varies as prices and yield levels change. On the other hand, fixed cash rent are predetermined by the producer and landlord and is budgeted as a line-item expense incurred by the producer, meaning the variability of a rent is removed. Consideration should be placed on cotton harvest system costs per rotational acre. Since ownership of cotton harvesters are allocated over that total number of acres harvested, the smaller the acreage the greater the fixed cost. Therefore, the number of acres to devote to cotton or grain production has an influence on returns beyond that of the variable cost threshold.

In applying this model to specific locale and agronomic site characteristics such as each crop mix option analyzed warrants examination of production history, on-farm budgeting, equitable land rental charges, equipment requirements, storage, and marketing strategies for each crop. From a practicality standpoint, each producer should evaluate projected farm input prices, interest rates, and market prices for the upcoming crop year prior to planting. Diversification can aid in the management flexibility on-farm, given the desire to expand certain acreage in times of high yields and favorable prices or to diversify the operation to maintain the financial solvency in times of declining returns.

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Table 1. Variable Production Costs per Acre for Corn, Cotton, and Soybeans Produced in Northeastern Louisiana, 2002-2011

Year	Corn	Cotton	Soybeans
2002	$201.57	$433.48	$112.19
2003	$230.69	$431.12	$117.16
2004	$213.20	$447.09	$115.34
2005	$253.31	$444.80	$120.18
2006	$290.34	$466.18	$114.34
2007	$280.31	$478.17	$134.23
2008	$342.70	$458.93	$143.63
2009	$494.50	$530.17	$215.49
2010	$446.36	$538.11	$326.22
2011	$441.29	$531.55	$305.47

Table 2. 2012 Estimated Parameters that Serve as the Mean Values for the Simulation Procedure

Parameter	Means Price per unit	Mean Yield per acre
Corn (CR)	$5.30/bu	150 bu
Cotton (CT)	$0.6765/lb	850 lbs
Soybean (SY)	$13.28/bu	40 bu
N Fertilizer	$0.63/lb	--
P Fertilizer	$0.70/lb	--
K Fertilizer	$0.51/lb	--
Diesel Fuel	$3.50/gal	--

Table 3. Simulation Results of Alternative Crop Mix Models in the Mississippi River Delta Region of Louisiana

Crop Mix No.	Corn	Cotton	Soybeans	GRW NRAVC/ac
		(percent of farm acres)		
1	100	0	0	$255.11
2	0	100	0	$50.60
3	0	0	100	$163.35
4	33	33	33	$157.00
5	50	50	0	$152.86
6	50	0	50	$210.23
7	0	50	50	$107.98
8	66	0	33	$225.17
9	66	33	0	$186.92
10	33	0	66	$195.25
11	33	66	0	$118.76
12	0	33	66	$127.09
13	0	66	33	$88.81

Table 4. Ranked Profitability of Selected Crop Mix Models in the Mississippi River Delta Region of Louisiana

Crop Mix Model (Identification No.)	GRW NRAVC/ac	Reduction in Return Level
100CR (1)	$255.11	--
66CR-33SY (8)	$225.17	$29.94
50CR-50SY (6)	$210.23	$44.88
33CT-66SY (10)	$195.25	$59.86
66CR-33CT (9)	$186.92	$68.19
100SY (3)	$165.35	$89.76
33CR-33CT-33SY (4)	$157.00	$98.11
50CR-50CT (5)	$152.86	$102.26
33CT-66SY (12)	$127.09	$128.02
33CR-66CT (11)	$118.76	$136.35
50CT-50SY (7)	$107.98	$147.14
66CT-33SY (13)	$88.84	$166.27
100CT (2)	$50.60	$204.51

Figure 1. Planted Acres in Northeast Louisiana for Corn, Cotton, and Soybeans, 2002-2011

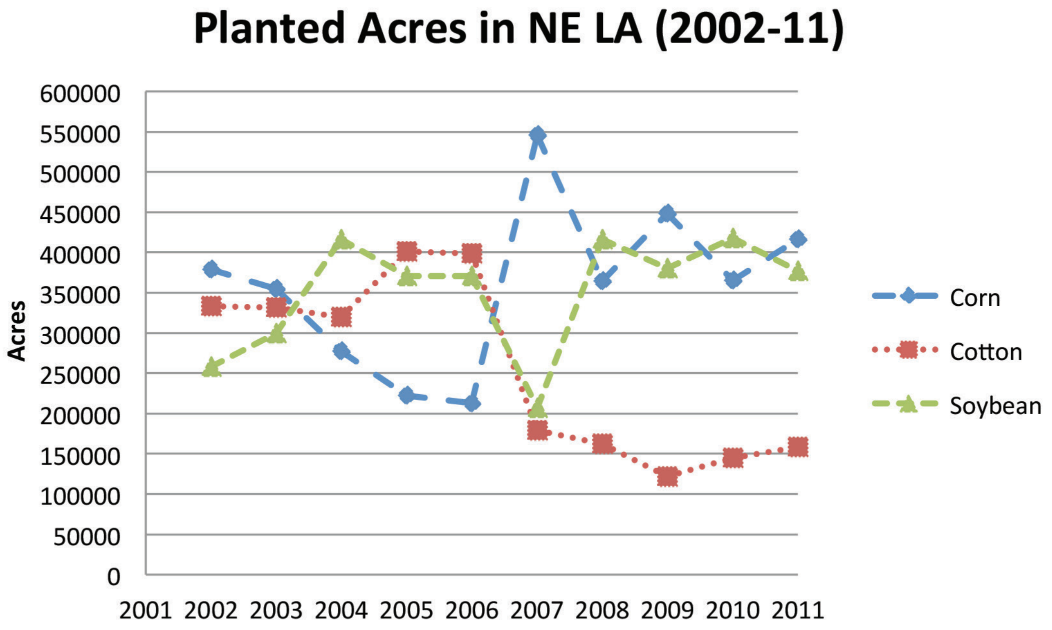

Figure 2. Fertilizer Unit Price per Pound for Nitrogen, Phosphate, and Potash in Louisiana, 2002-2011

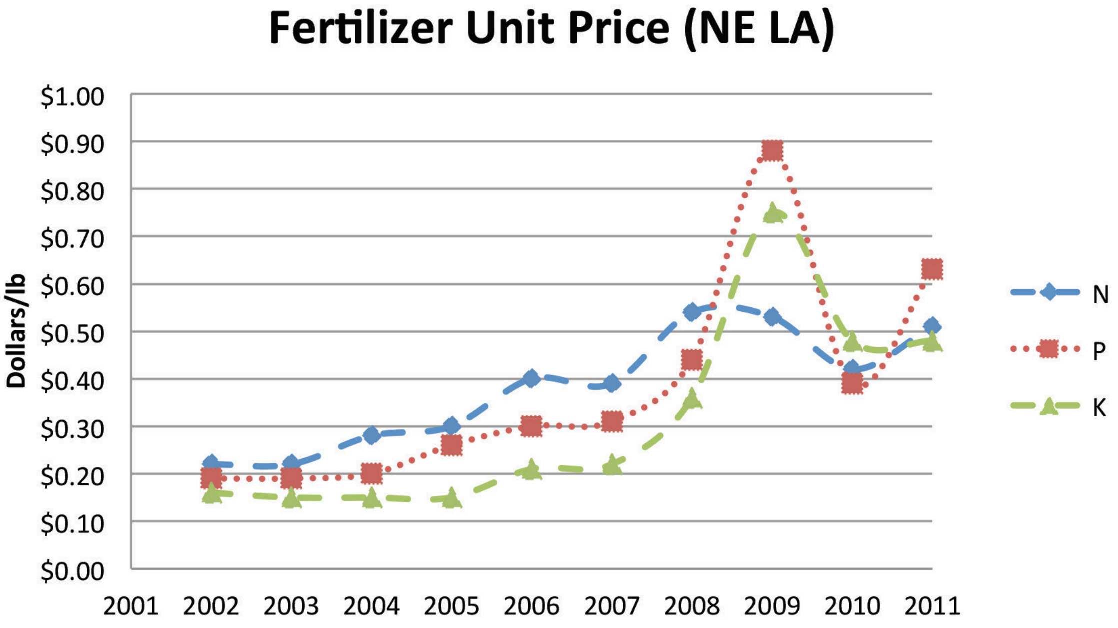

Figure 3. Farm Diesel Price per Gallon in Louisiana, 2002-2011

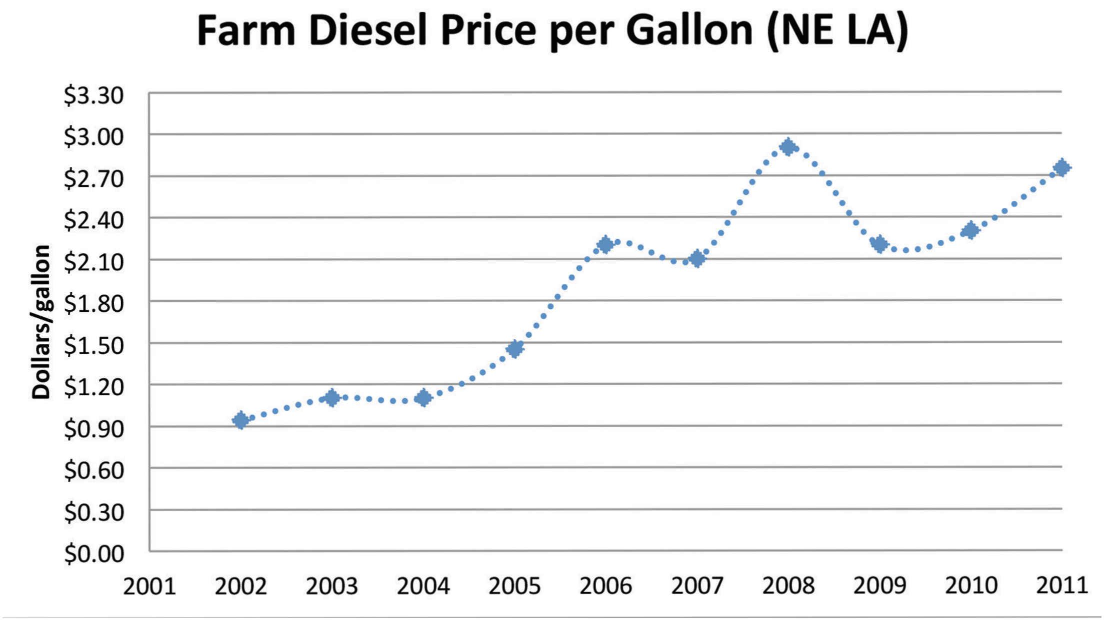

Figure 4. National Marketing Year Average Price Index for Corn, Cotton, and Soybeans

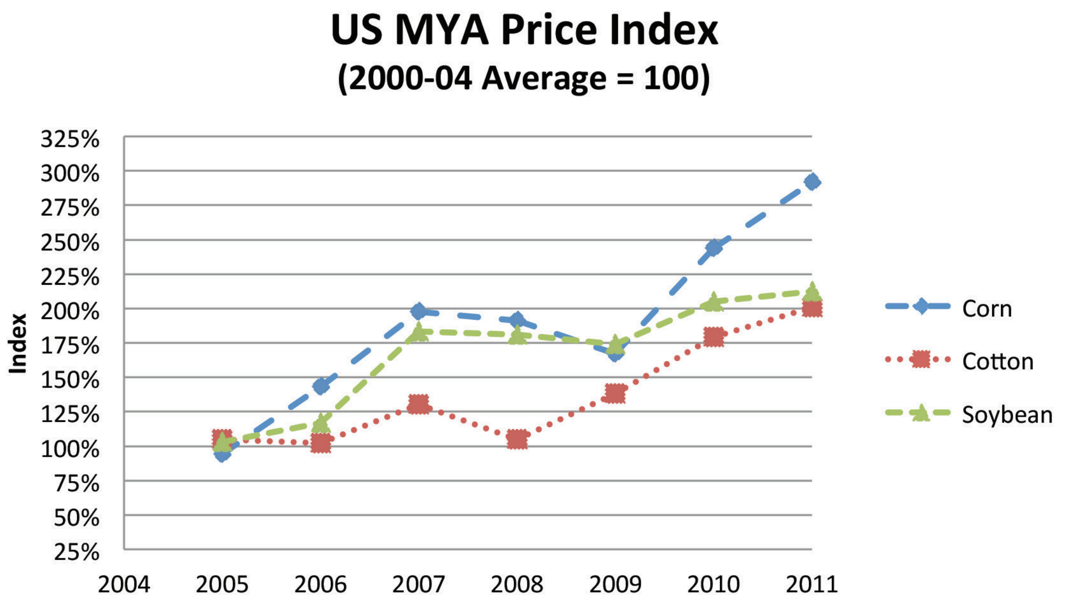

Figure 5. Variable Costs per Acre for Roundup-Ready (RR) Corn Produced in Northeastern Louisiana, 2012

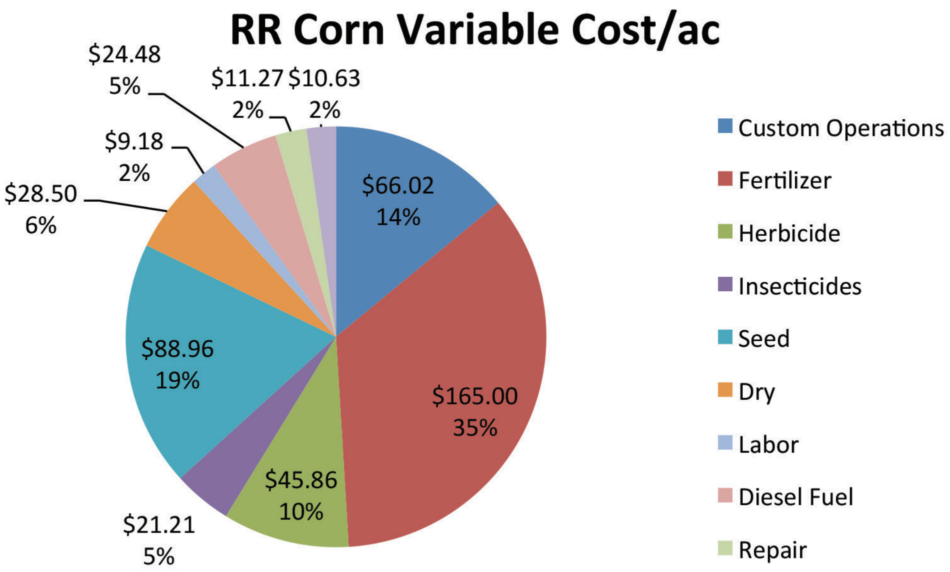

Figure 6. Variable Costs per Acre for Bollgard 2 Roundup Ready Flex (B2/RR Flex) Cotton Produced in Northeastern Louisiana, 2012

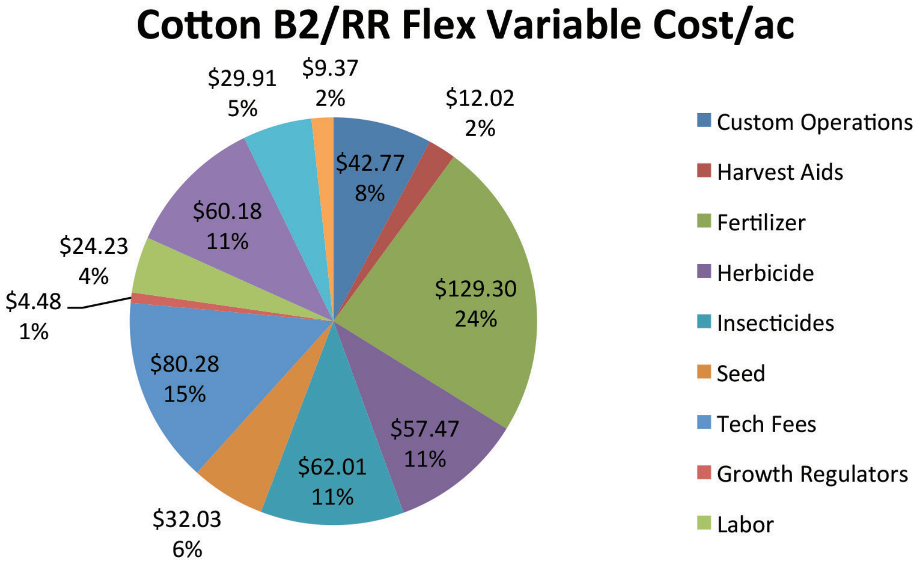

Figure 7. Variable Costs per Acre for Roundup Ready (RR) Soybeans Produced in Northeastern Louisiana, 2012