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**Farmers' Willingness to Grow Sweet Sorghum as a Cellulosic Bioenergy Crop:
A Stated Choice Approach**

Jason Bergtold¹, Jason Fewell² and Jeffery Williams³

¹ Assistant Professor, 342 Waters Hall, Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506-4011, (785) 532-0984, bergtold@ksu.edu (contact person)

² Graduate Student, 342 Waters Hall, Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506-4011

³ Professor, 342 Waters Hall, Department of Agricultural Economics, Kansas State University, Manhattan, KS 66506-4011

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Farmers' Willingness to Grow Sweet Sorghum as a Cellulosic Bioenergy Crop: A Stated Choice Approach

Abstract

Biofuel production must increase to 36 billion gallons by the year 2022, according to government mandates. The majority of this fuel must be produced from “advanced” or second-generation biofuel feedstocks after 2015. Advanced biofuel feedstocks include annual crops such as sweet sorghum. Kansas farmers are poised to be major producers of sweet sorghum for biofuels. A stated choice survey was administered to Kansas farmers to assess their willingness to grow sweet sorghum for biofuels under various contracting scenarios. Results show that farmers are willing to grow biomass for bioenergy under contract and that insurance availability plays an important role in their decision.

Keywords: bioenergy, cellulosic, farm data, stated choice, sweet sorghum

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Introduction

The Energy Independence and Security Act of 2007 states, in part, that biofuel production must increase to 36 billion gallons by the year 2022. While first-generation biofuels (i.e., corn-based ethanol) can comprise a large share of biofuel production, the majority must be produced from “advanced” or second-generation biofuel feedstocks after 2015. Advanced biofuel feedstocks include agricultural residues, woody resources, municipal waste, algae, or other sources (U.S. Congress, 2007). As 2022 draws closer, the urgency of establishing a lignocellulosic biofuel industry becomes more pressing. Many questions still remain as to the viability of the industry in areas ranging from biomass production to storage and transportation to eventual biofuel processing.

A growing body of research concerning the production of biofuels has focused on the technical and economic feasibility, as well as the potential supply of alternative sources of cellulosic biofuel feedstocks (see De la Torre Ugarte et al., 2007; Gallagher et al., 2003; Graham, 1994; Graham et al., 2007; Heid, 1984; Perlack et al., 2004; Walsh et al., 2003; Nelson, et al., 2010). A significant short-coming of many of these (regionally-based supply) studies is that they provide a useful frame of reference, but do not examine the necessary economic and institutional conditions under which such a large-scale undertaking would be plausible (Rajagopal et al., 2007). It is not a question of whether the physical potential is there, but what are the contractual and market arrangements to provide the supply. That is, how likely is it that farmers are willing to adopt biofuel crops (e.g. switchgrass) with underdeveloped or nonexistent markets. Rajagopal

and Zilberman (2007) indicate that there still exists a need to understand the factors that lead to the adoption of biofuel technologies by farmers.

The timing, location and extent of adoption, as well as contractual, land tenure and farm demographic factors are still not well understood. Research in this area is very limited. Current studies include Anand et al. (2008); Bransby (1998); Hipple and Duffy (2002); Jensen et al. (2007); and Kelsey and Franke (2009). It is likely that farmers will supply cellulosic biofuel feedstocks only if a contract is offered by processors to produce or supply the feedstock and if the payoff from the enterprise is greater than any other possible land use (Rajagopal et al., 2007). Contractual arrangements will be affected by many factors, such as contract pricing, timeframe, acreage commitments, risk, timing of harvest, yield variability, feedstock quality, harvest responsibilities (e.g. custom harvesting), nutrient replacement, location of biorefineries, available cropping choices, technology, and conservation considerations (Altman et al., 2007; Epplin et al., 2007; Glassner et al., 1998; Larson et al., 2007; Stricker et al., 2000; Wilhelm et al., 2004). Given the lack of established markets for bio-energy crops and crop residues, contractual arrangements with individuals or groups of producers (e.g. via a cooperative) is likely necessary to ensure an adequate supply of feedstock in the long-term, which is a pre-requisite for a processor and/or bio-refinery to enter the market (Rajagopal et al., 2007; Epplin et al., 2007). The lack of knowledge concerning the potential adoption of cellulosic biofuel feedstock production by farmers in the Midwest and the necessary contractual arrangements to ensure an adequate long-term supply for processors and bio-refineries necessitates further research into these areas to be able to develop the necessary economic arrangements that will ensure adequate long-term supply for a biofuels market. In other words, scientists have yet to talk with farmers in-depth about the adoption and willingness to produce cellulosic biofuel feedstocks.

The purpose of this study is to examine farmers' willingness to produce sweet sorghum under alternative contractual, pricing, and harvesting arrangements. Sweet sorghum represents a high biomass yielding crop opportunity in the Midwest. In addition, these sorghum varieties provide an annual bioenergy crop option that could be rotated with conventional cash crops in the region. Assessment of farmers' willingness to adopt a sweet sorghum enterprise under different contractual arrangements is assessed using an enumerated field survey with stated choice techniques. The survey examines what contractual features farmers' prefer and their impact on the potential likelihood of a farmer adopting a sweet sorghum biomass enterprise. A stated choice approach following Louviere et al. (2000) is used to assess farmers' willingness to adopt and survey results are analyzed using a conditional logistic regression model with error components (Bhat, 1998; Greene, 2007).

Sweet Sorghum as a Bioenergy Crop

Sweet sorghum (forage sorghum) has been grown as livestock feed for many years. Its potential use as a bioenergy crop is a subject of much research across agricultural disciplines. Management of sweet sorghum is similar to grain and forage sorghum under dryland conditions. Biomass removal can involve chopping the plants into smaller pieces called billets (similar to forage harvesting) or it can be baled like corn stover for use by the refinery.

Expected biomass yields for sweet or photoperiod-sensitive sorghum range from 6 to 15 dry tons per acre, and can reach as much as 20 dry tons per acre depending on growing conditions, soil type, geography, etc. Prophet, et al. (2010) found yields over 12.5 dry tons per acre in trials in 2007 and 2008 in less than ideal growing conditions in Kansas. They also found that annual crops produced more usable biomass than perennial crops over the study period, which increases appeal of crops such as sweet sorghum for biofuels. Future biomass yields are

expected to increase with improvements in plant breeding and harvest technology, and upon further research. Biomass harvesting can be done by the farmer or by the biorefinery, and typically takes place in the late fall just before physiological maturity (Dooley, 2010).

Harvest may take place after a hard freeze to prevent additional drying costs, but total available dry matter decreases over time, thus reducing potential ethanol yield (Dooley, 2010). Biomass storage over long periods also affects potential ethanol yields. Uncovered sweet sorghum bales lose significant amounts of dry matter and have high enzymatic activity that reduces cellulose, hemicelluloses, and lignin in the biomass (Rigdon, et al., 2011).

Estimated costs for a sweet sorghum enterprise are similar to those for regular sorghum production. The annual average cost of production for a sweet sorghum enterprise range from \$240 to \$260 per acre (based on custom rates in Kansas) (Ag Manager.info, 2011). However, these do not take into account storage costs and potential spoilage and transportation costs. Opportunity costs may include a reduction in soil productivity and increased erosion, depending on the level of biomass removal.

Survey Methods and Data

A stated choice survey was administered from November 2010 to February 2011 in Kansas by Kansas State University and the USDA, National Agricultural Statistics Service (NASS) to assess farmers' willingness to produce cellulosic biomass in the form of corn stover, sweet sorghum, and switchgrass for bioenergy production under different contractual arrangements. A total of 485 farmers were contacted in northeastern, south central, and western Kansas to participate in the survey. These areas of Kansas were selected based on the number of farms growing corn and/or sorghum, as well as a mix of irrigated and dryland production. In each area, a random sample of approximately 160 farms over 260 acres in size and \$50,000 in

gross farm sales were selected from the USDA-NASS farmer list for each area of the state examined. Farmers already participating in USDA-NASS enumerated surveys (e.g. ARMS) were removed from the sample and replaced with another randomly drawn name. Prior to the survey entering the field, the stated choice component was field tested with focus groups at an annual extension conference hosted by the Department of Agricultural Economics at Kansas State University and then the entire survey was tested using face-to-face interviews with farmers in the targeted study areas of the state.

Potential participants were mailed a four page flier asking for their participation in the survey and providing information about cellulosic biofuel feedstock production on-farm one week prior to being contacted by USDA-NASS enumerators. USDA-NASS enumerators then scheduled one hour interviews with the farmers to complete the survey and stated choice experiments. Interviews, on average took 57 minutes to complete. Upon completion of the survey and receipt at the USDA-NASS office in Topeka, farmers were compensated for their time with a \$15 gift card. Of the 485 farmers contacted, 290 completed the survey and 38 were out-of-business, did not farm, or could not be located. Thus, the survey response rate was $(290/(485-38)) = 0.65$ or 65 percent. Of the 290 respondents who completed the stated choice experiment for sweet sorghum, 5 surveys were incomplete due to lack of responses on the experiment or refusal to answer demographic questions, leaving 285 usable surveys for this study.

After answering a number of questions about their farming operation, respondents were asked about their willingness to produce sweet sorghum as a cellulosic biofuel feedstock under contract. After this section of the survey, respondents were asked about biofuel feedstock

production preferences and perceptions; conservation on-farm and perceptions; risk management practices and perceptions; crop marketing practices; and demographics.

Farmer demographics taken from the 2007 U.S. Census of Agriculture (NASS, 2009) are used to determine whether the survey respondents are representative of Kansas farmers. Table 1 compares some of the demographics as reported by farmers in the survey to statewide numbers as recorded in the 2007 Census of Ag. The percentage of farmers who are white is the same for both the census and survey. A slightly lower average age is reasonable given our survey sampled larger farms that are likely operated by younger farmers. Average farm size and amount of rented land are considerably larger for our survey, but we chose farms over 260 acres in our sample, which eliminates many small, or hobby farms. More of the survey respondents are male than in the Census figures, but the size of the farms may explain this since larger farms are more likely to be operated by males. Average value of agricultural products found in the survey includes the value reported by the Census figures. The survey asked respondents to choose a range in which their agricultural value of sales fell, and the most oft chosen range matches Census of Ag figures.

Table 1. Comparison of Kansas farmer demographics to survey respondents

	2007 Census of Agriculture	Survey
Percent white	98.9%	98.9%
Age	57.7 years	55.9 years
Percent male principal operators	87.9%	95.9%
Average size of farm	707 acres	2147 acres
Average amount of rented land in farm	863 acres	1388 acres
Average market value of agricultural products	\$219,944	\$200,000 to \$399,999

Stated Choice Experimental Set-Up

A stated choice experiment was designed to assess farmers' willingness to enter into a contract with a bio-refinery or other biomass processor for producing sweet sorghum following Louviere et al. (2000) and Roe et al. (2004). Farmers were presented with information about sweet sorghum production and contract attributes before answering the stated choice questions (see Figure 1). Survey participants were then asked to consider five independent choice scenarios, where they were asked to select between two biomass contracts or an "opt out" option (see Figure 2 for one example scenario). Each contract option was unlabeled and had five attributes: (1) net returns above corn/sorghum production; (2) contract length; (3) biorefinery harvest; (4) insurance availability; and (5) government incentive payment.

The net returns above corn/sorghum production had 4 levels: 0%, 15%, 30% and 45%. A base value of \$50 for net returns from corn/sorghum production was provided to the farmers for all scenarios presented. This base level represents the average net returns from Kansas Farm Management Association Farms (KFMA) (2010) in the study region(s) for 2008/9. Given the ability of sweet sorghum to be rotated with other cash crops, it was thought that this bioenergy crop would likely replace corn or grain sorghum in a crop rotation. For the purpose of data analysis, this attribute was recoded into a dollar amount by multiplying the percentage increase by the \$50 base.

SECTION 2A

ANNUAL BIOENERGY CROP ROTATION OPTION: SWEET SORGHUM

This section of the survey will ask about farmers’ willingness to grow and supply sweet sorghum, which is an annual crop, to a biorefinery or intermediate processor (e.g. cooperative) through different contractual agreements. You will be asked to consider 5 scenarios. Each scenario contains three options: two contract options and one for “do not adopt.” The final option provides the option to “opt out” if the contracts presented are not favorable to you. In this case, you would be able to continue your regular crop rotation. Each contract will have different features, which include net returns per acre, contract length, a biorefinery harvest option, an insurance availability option, and a government incentive program option.

Sweet sorghum provides a bioenergy crop option that can be included in conventional cropping rotations. Management of sweet sorghum is similar to grain and forage sorghum under dryland conditions. Biomass removal can involve chopping the plants into smaller pieces called billets (similar to forage) or can be baled like corn stover for use by the refinery. Expected yields for sweet sorghum range from 6 to 12 dry tons per acre and are dependent upon climatic conditions. In the future, biomass yields are expected to increase with improvements in plant breeding and harvest technology. Biomass harvesting can be done by the farmer or by the biorefinery, and would take place in the late fall. The annual average cost of production for a sweet sorghum enterprise range from \$240 to \$260 per acre (based on custom rates in Kansas). In the following scenarios, the biorefinery will be responsible for long-term storage of biomass; a minimum acreage contract will be negotiated between the bio-refinery and farmer; and the contract will include an “Act of God” clause.

Each scenario presented will present different contractual options with the following features:

Contract Feature	Description
<p>Net Returns</p> <p><i>(for all features of the contract except the government incentive payment)</i></p>	<p>Represents the annual average expected <i>percentage</i> gain under the contract <i>above</i> the net returns associated with grain sorghum and/or corn production on your operation. As a reference point, net returns are expected to be around \$50 per acre on average in Kansas.</p> <p>For example, if crop returns are \$50/acre, a 10% return above \$50 per acre will be \$55/acre. This amount is received after all expenses are paid, including harvest and insurance, but does not include the government incentive payment.</p> <p>(Note: A level of 0% gain for this feature indicates that you would earn the same net returns on your farm from producing corn or grain sorghum.)</p>
<p>Contract Length</p>	<p>Represents the time commitment in consecutive years of the contractual agreement.</p>
<p>Biorefinery Harvest</p>	<p>“Yes” indicates the bio-refinery will harvest the biomass at their expense, and “No” means the farmer is responsible for harvest (including chopping into billets and transportation to the bio-refinery). Harvest charges are included in the net return percentage. That is, the charges are considered paid regardless of who harvests the biomass.</p>
<p>Insurance Availability</p>	<p>“Yes” indicates crop insurance is available, and “No” otherwise.</p>
<p>Government Incentive Payment</p>	<p>This incentive payment is provided at two levels for production of cellulosic biofuel feedstocks delivered to a bio-refinery. The incentive levels are either none (0) or 25 percent of the price per dry ton of biomass delivered to the refinery. The incentive received is in addition to the net returns above production.</p>

Figure 1: Information on Sweet Sorghum Production, Stated Choice Format and Contract Attributes Provided to Survey Respondents.

Sweet Sorghum Scenarios – For each scenario evaluate the contractual options and please rank the contract options in the order that you would prefer them with 1 = first choice, 2 = second choice, and 3 = third choice.

CONSIDER EACH SCENARIO INDEPENDENTLY.

Scenario 1:

		Contract A	Contract B	Option C
Contract Features	Net Return Above Sorghum/Corn Production (Base: \$50/ac)	15% Higher/year	45% Higher/year	Do Not Adopt
	Contract Length	2 Years	8 Years	
	Biorefinery Harvest	Yes	Yes	
	Insurance Availability	No	No	
	Gov. Incentive Payment	25%	25%	
Your Ranking (1-3)		2006 <input type="text"/>	2007 <input type="text"/>	2008 <input type="text"/>

Figure 2: Example of Stated Choice Question Format for Sweet Sorghum Choice Scenario

The second attribute was contract length and had 3 levels: 2 years, 5 years and 8 years. The increasing length of the contract represents the need of the refinery or biomass processor to mitigate risk by ensuring a long-term supply of biomass. The third attribute was a binary attribute (effects coded) for biorefinery harvest. This attribute provided the option to the farmer of having the biorefinery or intermediate processor harvest the biomass from the field and transport it to the refinery/processor. It was assumed that the cost of this practice was included in net returns. The fourth attribute was insurance availability, a binary attribute (effects coded) indicating if insurance crop insurance was available to purchase under the contract.

The final attribute was a government incentive payment that is similar to that provided under the Biomass Crop Assistance Program (BCAP) (Khana et al., 2010). The attribute has two levels: 0% and 25%. The level represents the match the government pays as a percentage of the price paid by the refinery for every ton of biomass produced and delivered. Furthermore, the incentive was not included in the net returns attribute described above. Given the use of

substantial subsidies to promote cellulosic biofuel production, this attribute plays an important role for policy analysis.

Each choice scenario presented to a respondent had two generically labeled contracts with the attributed levels randomly assigned and the choice of an “opt out” option. Following Louviere et al. (2000), a $(2^3 \times 3 \times 4)^3$ fractional factorial experimental design was used to develop 90 random choice sets in order to be able to identify all main effects and potential interaction effects between attributes and levels. The choice sets were then randomly assigned into 18 blocks, so that each respondent was faced with 5 choice scenarios. Thus, there were 18 versions of the survey. Of the 290 surveys, 12 to 20 of each version of the survey was completed.

Summary Statistics

Table 2 provides summary statistics for the average attribute levels for the respondents who selected the randomly assigned contract A or B as their first choice. The summary statistics for the entire sample for each contract option indicate that all the distribution of the attributes is relatively “even” across the choice sets. For example, about fifty percent of the contracts had the insurance option, while fifty percent did not. The only attribute biased toward the lower end was net returns above corn/sorghum production, which had lower increases in net returns on average. This may be more realistic with the adoption of new enterprise on-farm.

The total number of responses indicating the first choice as adopting a contract (either A or B), was 567. On average, contracts with slightly higher net returns, shorter contract lengths and with government incentives were chosen before those presented to the entire sample. This result is to be expected, and will be discussed in the conceptual model framework in the next section.

Table 2: Summary statistics of attribute levels for each randomly assigned contract type for the entire sample and those who chose Contract A or B as their 1st choice.

Attribute	Contract A				Contract B			
	Entire Sample (N = 1425)		1 st Choice (N = 276)		Entire Sample (N = 1425)		1 st Choice (N = 292)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Net Returns Above Corn/Sorghum Production	10.8	8.0	14.2	7.6	11.3	8.3	16.4	7.0
Contract Length	4.8	2.5	4.2	2.3	4.9	2.5	4.2	2.3
Biomass Harvest Option ^a	-0.013	1.0	0.13	1.0	-0.025	1.0	0.23	0.97
Insurance Availability ^a	-0.027	1.0	0.19	0.98	0.013	1.0	0.16	0.99
Gov. Incentive Payment	11.2	12.4	14.1	12.4	12.2	12.5	13.9	12.4

^a These binary attributes were effects coded.

Conceptual Model and Econometric Analysis

Following Roe et al. (2004), we assume that producers want to maximize expected discounted utility when choosing to enter into a contract to produce sweet sorghum versus produce corn or grain sorghum over time. Let producer's j 's expected discounted utility for contract option i be given by:

$$V_{j,i} = V(\Delta R_i(B_i, S_i), C_i, G_i, E_{j,i}) + \varepsilon_{j,i}, \quad (1)$$

where ΔR_i is the net returns above corn/grain sorghum production over time, which includes the costs associated with B_i , indicating if a biomass harvest option is part of contract i , and S_i , indicating if crop insurance is available. In addition, expected discounted utility is a function of C_i , or the length of the contract in years; G_i , or the level of government incentive payment, and $E_{j,i}$ is a vector of error components or alternative specific random individual effects included to account for choice situation invariant variation (i.e. the repeated choice set-up in the stated

choice experiment, correlation across alternatives, and unobserved preference heterogeneity). It is assumed that $E_{j,i}$ are mean zero and variance equal to one (Greene, 2007). The error term, $\varepsilon_{j,i}$ represents the nonsystematic part of expected utility that goes unobserved by the modeler and is distributed type I extreme value (Louviere et al., 2000).

For the purposes of this study we are primarily interested in examining the direct impact of the contract attributes on producers' willingness to adopt or enter into a contract. Following Roe et al (2004), we focus on the reduced-form representation of expected utility. The econometric model is based upon a main effects model with error components following Bhat (1998) and Greene (2007). That is, for producer j and contract i :

$$V_{j,i} = \beta_0 + \beta_1 \Delta R_i + \beta_2 C_i + \beta_3 B_i + \beta_4 S_i + \beta_5 G_i + \sum_j \theta_j E_{j,i} + \varepsilon_{j,i}, \text{ for } j=A, B \text{ or } C, \quad (2)$$

where θ_j represents the standard deviation of the error component or random effect associated with $E_{j,i}$. Given that the error components can enter into the expected utility for each contract choice, the model is able to capture correlations among contract or choice alternatives in the model, allowing the traditional IIA assumption of the classic conditional logistic regression model to be relaxed and for a more flexible model (Greene, 2007). Contract choices A and B represent the randomly assigned unlabeled contract choices presented in each choice scenario, while option C is the "opt out" or "do not adopt" option. Furthermore, as seen in Figure 2, option C has no attribute levels, thus $\beta = \mathbf{0}$, making $V_{C,i} = \theta_C E_{C,i} + \varepsilon_{j,i}$. Thus, the model is able to control for unobserved individual effects for "opting out." The error components for A and B show up in both utility functions for those generic choices to capture any correlation among the choices that may have arisen.

Given the usual desirability for higher returns and government incentives, we expect β_1 and β_5 to be positive. In addition, we would expect β_4 to be positive, given it is a risk

management tool, but this may depend on farmers' perceptions of the form in which the insurance may come. The sign for β_3 can be expected to go either way if farmers see the biomass harvest option as a cost-reducing measure or if they do not desire such an alternative as it invades on the sovereignty of their operation (i.e. others operating on their land). We expect β_2 to be negative, as most farmers have a short-term time horizon given current crop markets, making a long-term contract more undesirable, particularly in the early years of a developing market.

While each respondent ranked their choices, we only examine the first choice or one with highest likelihood of being chosen. Thus, equation (2) is modeled using a conditional logistic regression model with error components and the above stated restrictions following Greene (2007) and Hensher et al. (2005). NLOGIT 4.0 (Greene, 2007) is used to estimate the model, using simulated maximum likelihood with 1000 Halton draws using the BFGS Quasi-Newton Algorithm. Predicted probabilities, estimated marginal effects, and farmers' willingness to pay for alternative contractual features are calculated in a spreadsheet. Standard errors for all statistics using model results are calculated using the delta method following Greene (2003).

Results

Results will show the willingness of farmers to adopt these new enterprises and grow bioenergy crops. By using percentage net returns above those earned from typical crop production practices, a market price for biomass can be determined based on current market and production conditions, without putting a precise monetary value on the biomass. In addition, using the percentage net return above corn production will allow prices to "float" to levels that will truly entice farmers to adopt these bioenergy crops. The survey results will help formulate contract designs between biorefineries and farmers for these new enterprises. Policy makers and

the biofuel industry will benefit from the survey results because they will know whether farmers are willing to supply biomass, while realizing prices required for farmers to adopt. This biomass valuation method is useful because many farmers are unwilling to make a decision to grow biomass without knowing production costs and actual dollar returns. The method benefits biorefineries by helping them determine prices they can afford to pay for biomass by knowing how much farmers require to make it a worthwhile enterprise.

Table 3 contains estimates for a conditional logistic regression assessing farmers' willingness to produce sweet sorghum under contract subject to five contract attributes. As expected, net returns has a positive sign, indicating a higher likelihood of adopting a contract with higher net returns. Contract length has a negative sign, indicating longer contracts are less desirable for farmers than shorter contracts. The positive signs for biomass harvest option, insurance availability, and the government incentive payment also indicate farmers are more likely to participate in contracts with these attributes. Each of these coefficients is significant at the 1 percent level.

Table 3: Conditional Logistic Regression Results for Willingness of Producers for Contract Sweet Sorghum with a Biorefinery or Processor

Parameter	Estimated Coefficient	Standard Error	P-Value
Intercept	-2.9554	0.3466	0.0000
Returns Above Corn/Sorghum Production	0.1439	0.0079	0.0000
Contract Length	-0.3111	0.0253	0.0000
Biomass Harvest Option	0.5085	0.0718	0.0000
Insurance Availability	0.3718	0.0741	0.0000
Government Incentive Payment	0.0408	0.0064	0.0000
<i>Error Components</i>			
Contract A	2.3686	7.7069	0.7586
Contract B	1.7056	8.6095	0.8430
“Opt Out” Option (C)	3.2878	5.2166	0.5285
<i>Fit Statistics</i>			
Restricted Log-Likelihood	-1565.523		
AIC	1.21539		
McFadden Pseudo R ²	0.4526		

The error components of the random parameters logit take into account the weight of the uncertainty each respondent has on his/her decision and are unobservable (Hensher, Rose, and Greene, 2005). The error component is treated as a random variable and contains the individual-specific error term’s distribution, and other information not observed in the model (Hensher, Rose, and Greene, 2005). McFadden’s Pseudo R² indicates the data fits the model well.

Probability of Adoption

The probability of adoption follows the logit pdf,

$$P = \frac{e^{\beta'X}}{(1 + 2e^{\beta'X})}, \quad (3)$$

where P = probability of adopting a contract, and

$$\beta'X = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 \quad (4)$$

Figures 3 and 4 show the probability of a farmer adopting varying length contracts with and without insurance, respectively, as net return levels increase. Each graph shows the probability of adoption is greater for shorter contracts as farmers' uncertainty with producing bioenergy crops precludes their acceptance of long-term contracts. In Figure 3, when insurance is an option, farmers are more willing to produce the crops than when insurance is not available. Under the 2-year contract, there is about a 10% probability that farmers will enter into a contract when returns are about \$5 above typical crop production. As the returns increase to \$35 above typical crop production, farmers have about a 48% chance of accepting a 2-year contract. Figure 4 shows this probability falls to about 45% when insurance is not available. The difference between probabilities of adoption is lower when insurance is available than when it is not over the three contract lengths. The probability of adoption difference from 2- to 8-year contracts with insurance is approximately 9%, while without insurance, the difference increases to approximately 15% chance of adopting at \$35 per acre net return above normal crop production.

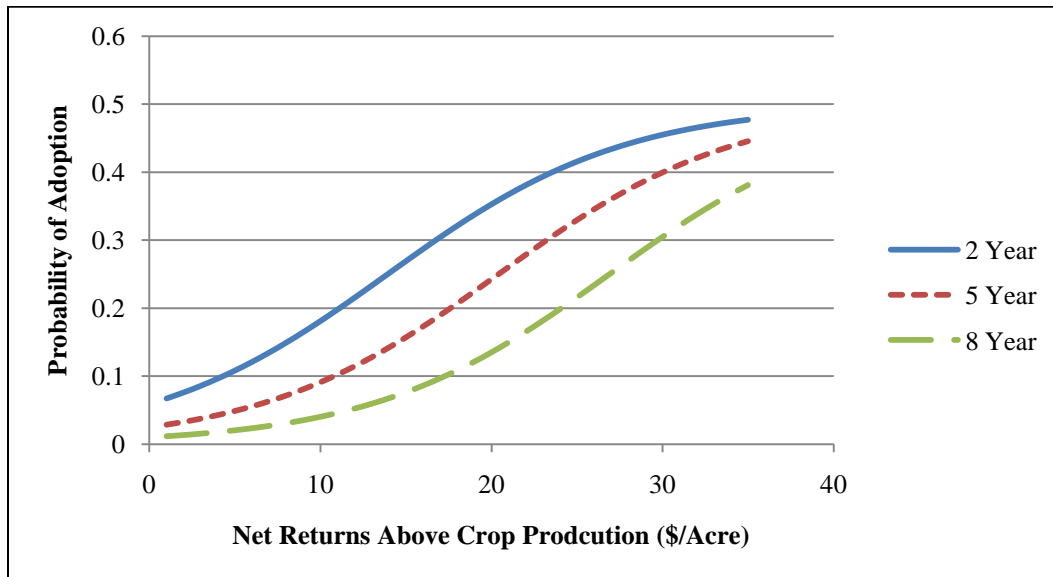


Figure 3. Probability of Contract Adoption for Sweet Sorghum For Different Levels of Net Returns and Contract Lengths with Insurance

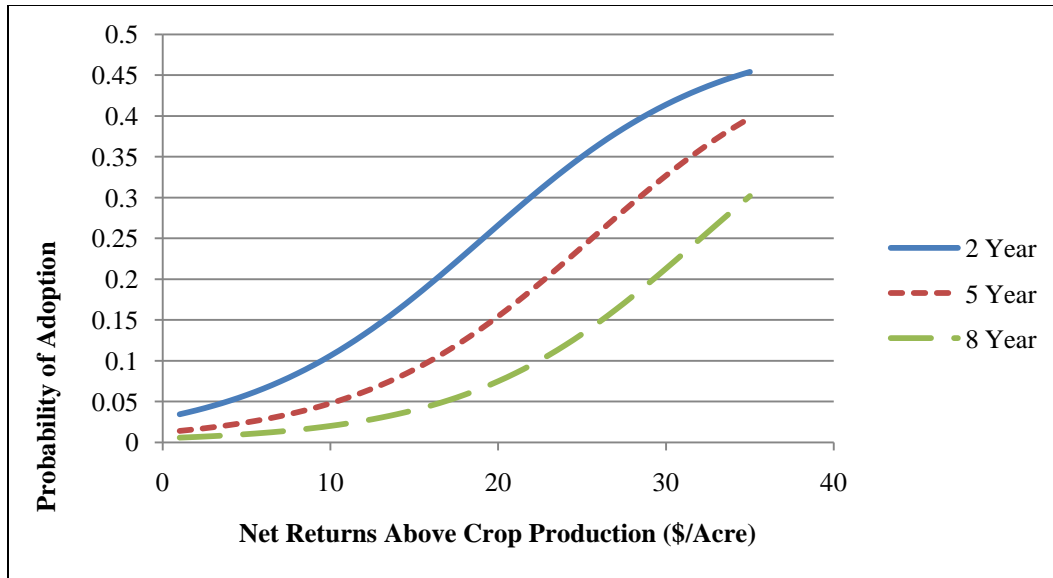


Figure 4. Probability of Contract Adoption for Sweet Sorghum For Different Levels of Net Returns and Contract Lengths with No Insurance

Marginal Effects

The marginal effects show the change in probability of adopting alternative contracts at varying net return levels. Using the probability, P , above, we find the derivative with respect to X_i , where i is the attribute of interest, here net returns, to find the marginal effect of a change in net returns on the probability of adopting a contract:

$$\begin{aligned}
 \frac{\partial P}{\partial X_1} &= P\beta_1 - 2P^2\beta_1 \\
 &= (P - 2P^2)\beta_1 \\
 &= P(1 - 2P)\beta_1
 \end{aligned}
 \tag{5}$$

Marginal effects of the probability of adoption under alternative net return scenarios with and without insurance are shown in Figures 5 and 6, respectively. The marginal effects show the decreasing marginal probability as net returns increase. The likelihood of adopting a 2-year contract with insurance in Figure 5 shows there is about a 0.018 percent chance a farmer will

adopt a 2-year contract with net returns at about \$13 over typical crop production, but that the likelihood of adopting an 8-year contract at the same net return level is 0.008.

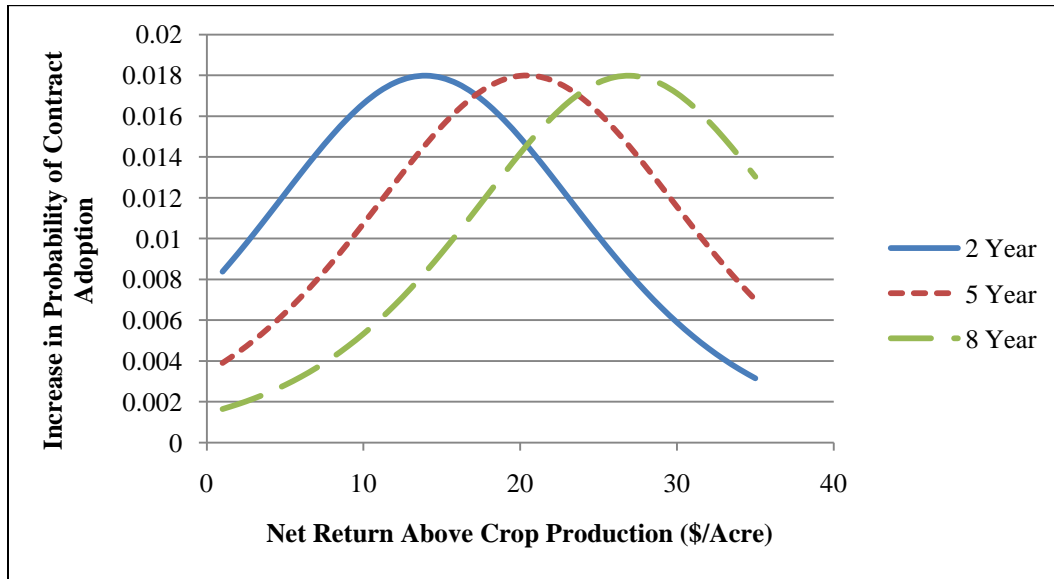


Figure 5. Marginal Effect of a \$1 Increase in Net Returns Above Crop Production for Different Length Contracts with Insurance

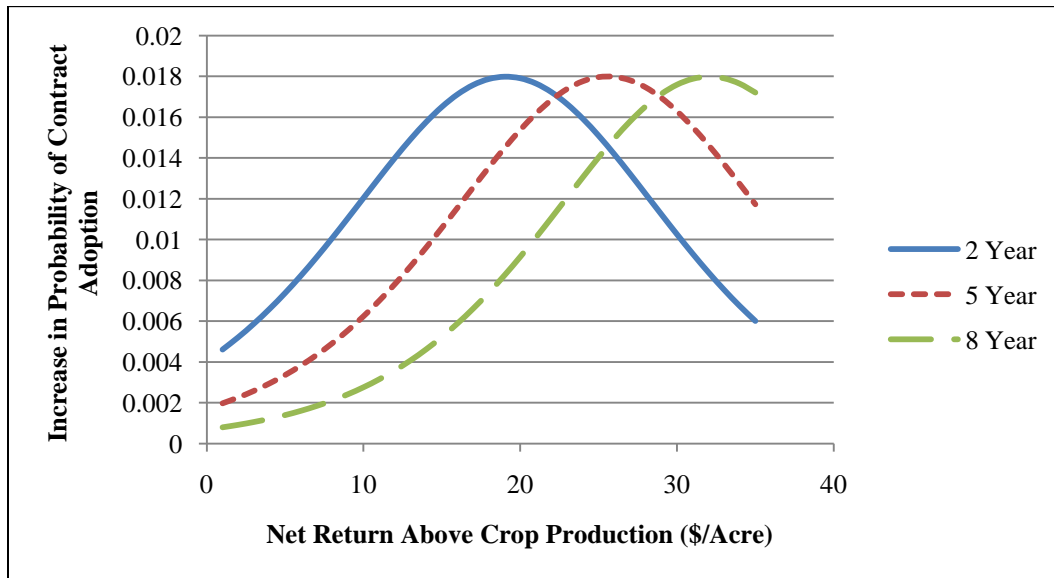


Figure 6. Marginal Effect of a \$1 Increase in Net Returns Above Crop Production for Different Length Contracts with No Insurance

The increase in probability of a farmer adopting a 2-year contract without insurance, as shown in Figure 6, is approximately 0.018 at a \$19 net return above typical crop production. Figures 5 and 6 closely resemble each other, only differing in the net returns required to adopt a specific contract, but at the same probability levels. The marginal effects capture the differences in adopting a contract with or without insurance at various net return levels.

Table 4 shows the calculated differences of the dollar amount required to convince a farmer to adopt a contract at different contract lengths with and without insurance. The probability that a farmer will choose a contract, Contract A or B, is 50%. At this level, the difference in net returns the farmer requires with or without insurance is \$5.17 per acre regardless of contract length.

Table 4. Net Return difference required for adoption of a contract at 50% probability

	2 years	5 years	8 years
Insurance	\$13.93	\$20.41	\$26.90
No Insurance	\$19.10	\$25.58	\$32.07
Difference	\$5.17	\$5.17	\$5.17

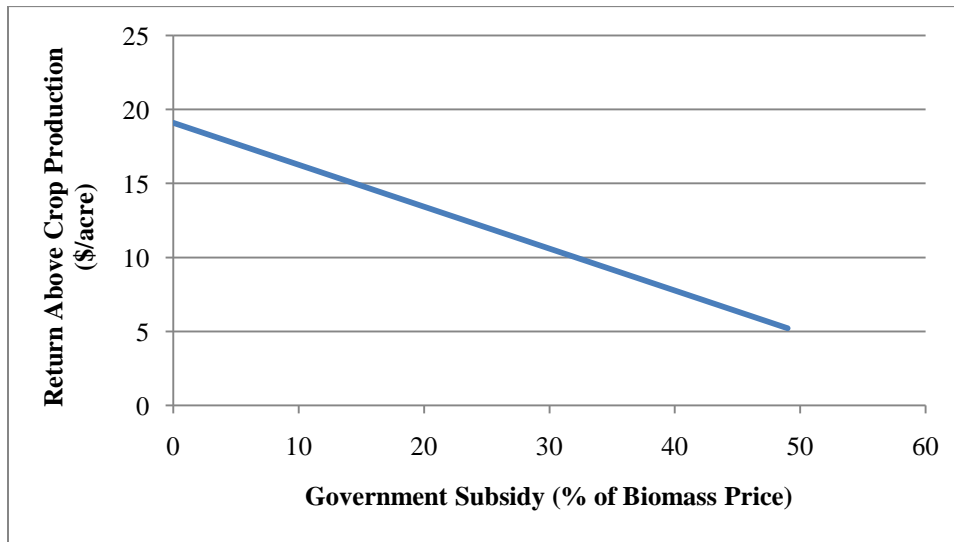


Figure 7. Net Returns Above Crop Production Required to Adopt At Different Government Subsidy Levels

Figure 7 shows the linear relationship between government subsidy as a share of biomass price and the net return above crop production needed for a farmer to grow sweet sorghum. As the government subsidy increases, the net return falls, until it reaches a point of \$5 per acre when the government subsidy paid above the price already paid for biomass is at about 50%.

Conclusion

Bioenergy crops are poised to have an important role in crop production on the Great Plains as farmers attempt to help meet the demands of new renewable fuels standards to produce “next generation” fuels. Sweet sorghum is a crop that is well-suited to planting in Kansas, but much uncertainty exists as to its viability and the willingness of farmers to grow alternative crops for biofuels. A stated choice survey was developed to assess farmers’ willingness to grow crops for biofuels. Results from the estimation showed that farmers are more willing to grow crops if net returns are relatively high and contract length is short. In addition, results show that farmers prefer an insurance option, similar to their existing crop insurance, and that a government subsidy on bioenergy crops has an inverse relationship with net returns to bioenergy crops.

Further research includes determining biomass prices that farmers and biorefineries can agree upon under differing contracts. Contract design will be one of the most important, yet most grueling aspects of establishing market prices for biomass. Farmers face much risk and uncertainty with growing new crops, especially when no market exists. Therefore, designing insurance contracts for biomass producers that are similar to existing crop insurance is necessary before widespread bioenergy crop adoption will occur on a large scale. USDA’s Risk Management Agency (RMA) must work with farmers and biorefineries to arrive at marketable insurance products.

References

1. Ag Manager.info (2011) "Crops: Production and Marketing." Online. Available at: http://www.agmanager.info/crops/budgets/proj_budget/decisions/
2. Altman, I., C.R. Boessen and D.R. Sanders. "Contracting for Biomass: Supply Chain Strategies for Renewable Energy." Paper presented at the Southern Agricultural Economics Association Annual Meeting, Mobile, Alabama, February 3 – 6, 2007. Online. Available at: <http://ageconsearch.umn.edu/bitstream/34907/1/sp07al01.pdf>.
3. Anand, M., J.S. Bergtold, P.A. Duffy, D. Hite, R.L. Raper and F.J. Arriaga. "Using Cover Crop Residues as a Biofuel Feedstock: Willingness of Farmers to Trade Improved Soil Conservation for Profit." Poster presented at the 30th Southern Conservation Agricultural Systems Conference and 8th Annual Georgia Conservation Production Systems Training Conference, Tifton, Georgia, July 29-31, 2008.
4. Bhat, C.R. (1998), "Accommodating Flexible Substitution Patterns in Multidimensional Choice Modeling: Formulation and Application to Travel Mode and Departure Time Choice", *Transportation Research Part B*, Vol. 32, No. 7, pp. 455-466
5. Boxall, P.C. and W.L. Adamowicz, "Understanding Heterogeneous Preferences in Random Utility Models: A Latent Class Approach," *Environmental and Resource Economics* 23(2002): 421 – 446.
6. Bransby, D.I. "Interest Among Alabama Farmers in Growing Switchgrass for Energy." Paper presented at BioEnergy '98: Expanding Bioenergy Partnerships, Madison, Wisconsin, October 4 – 8, 1998. Online. Available at: <http://bioenergy.ornl.gov/papers/bioen98/bransby1.html>.

7. De la Torre Ugarte, D.G., B.C. English and K. Jensen. "Sixty Billion Gallons by 2030: Economic and Agricultural Impacts on Ethanol and Biodiesel Expansion." *American Journal of Agricultural Economics*. 89(2007): 1290 – 1295.
8. Dooley, S. 2010. "Management Of Biofuel Sorghums In Kansas." M.S. Thesis, Kansas State University.
9. Epplin, F.M., C.D. Clark, R.K. Roberts and S. Hwang. "Challenges to the Development of a Dedicated Energy Crop." *American Journal of Agricultural Economics*. 89(2007): 1296 – 1302.
10. Gallagher, P.W., M. Dikeman, J. Fritz, E. Wailes, W. Gauthier and H. Shapouri. "Supply and Social Cost Estimates for Biomass from Crop Residues in the United States." *Environmental and Resource Economics*. 24(2003): 335 – 358.
11. Glassner, D.A., J.R. Hettenhaus and T.M. Schechinger. "Corn Stover Collection Project." Paper presented at BioEnergy '98: Expanding Bioenergy Partnerships, Madison, Wisconsin, October 4 – 8, 1998. Online. Available at: http://ergosphere.files.wordpress.com/2007/04/bio98_corn_stover.pdf.
12. Graham, R.L. "An Analysis of the Potential Land Base for Energy Crops in the Conterminous United States." *Biomass and Bioenergy*. 6(1994): 175 – 189.
13. Graham, R.L., R. Nelson, J. Sheehan, R.D. Perlack and L.L. Wright. "Current and Potential U.S. Corn Stover Supplies." *Agronomy Journal*. 99(2007): 1 – 11.
14. Greene W.H. (2003). *Econometric Analysis*, 5th ed., Prentice Hall: Upper Saddle River, NJ.
15. Greene, W.H. (2007). *NLOGIT Version 4.0: Reference Guide*. Plainview, NY: Econometric Software, Inc.

16. Heid Jr., W.G. *Turning Great Plains Crop Residues and Other Products Into Energy*, Agricultural Economic Report No. 523, Economic Research Service, U.S. Department of Agriculture, Washington, DC, 1984.
17. Hensher, D.A., J.M. Rose, and W.H. Greene. (2005). *Applied Choice Analysis: A Primer*. Cambridge UK: Cambridge University Press.
18. Hipple, P.C. and M.D. Duffy. "Farmers' Motivations for Adoption of Switchgrass." *In: J. Janich and A. Whipkey (eds), Trends in New Crops and New Uses*, Alexandria, VA: ASHA Press, 2002, p. 252 – 266.
19. Jensen, K., C.D. Clark, P. Ellis, B. English, J. Menard, M. Walsh and D. de la Torre Ugarte. "Farmer Willingness to Grow Switchgrass for Energy Production." *Biomass and Bioenergy*. 31(2007): 773 – 781.
20. Kansas Farm Management Association (2010). "Summary Reports by Region." Online. Available at: <http://www.agmanager.info/kfma/>
21. Khanna, M., X. Chen, H. Huang and H. Onal (2010). "Land Use and Greenhouse Gas Mitigation Effects of Biofuel Policies" *University of Illinois Law Review*, Forthcoming. Available at: <http://ssrn.com/abstract=1696004>
22. Kelsey, K.D. and T.C. Franke. "The Producers' Stake in the Bioeconomy: A Survey of Oklahoma Producers' Knowledge and Willingness to Grow Dedicated Biofuel Crops." *Journal of Extension*. 47(2009): Online. Available at: http://www.joe.org/Joe/2009february/pdf/JOE_v47_1rb5.pdf.
23. Larson, J.A., B.C. English and L. Lambert. "Economic Analysis of the Conditions for Which Farmers Will Supply Biomass Feedstocks for Energy Production." Final Report for Agricultural Marketing Center Special Projects Grant 412-30-54, Agricultural

- Marketing Resource Center, University of Tennessee, 2007. Online. Available at:
http://www.agmrc.org/media/cms/2007UTennProjDeliverable_9BDDFC4C2F4E5.pdf.
24. Louviere, J.J., D.A. Hensher and J.D. Swait. *Stated Choice Methods: Analysis and Application*. Cambridge, UK: Cambridge University Press, 2000.
25. National Agricultural Statistics Service, USDA. "2007 Census Publications." 03 February 2009. Online. Available at:
http://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1_Chapter_1_State_Level/Kansas/index.asp.
26. Nelson, R., M. Langemeier, J. Williams, C. Rice, S. Staggenborg, P. Pfromm, D. Rogers, D. Wang, and J. Nippert. "Kansas Biomass Resource Assessment: Assessment and Supply of Select Biomass-based Resources. Research report prepared for the Kansas Bioscience Authority, Olathe, KS, September, 2010.
27. Perlack, R.D., L.L. Wright, A.F. Turhollow, R.L. Graham, B.J. Stokes and D.C. Erbach. *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply*. Washington, DC: U.S. Department of Agriculture and U.S. Department of Energy, 2005.
28. Propheter, J.L., S.A. Staggenborg, S. Wu, and D. Wang. "Performance of Annual and Perennial Biofuel Crops: Yields during the First Two Years." *Agronomy Journal*. 102(2010): 806-814.
29. Rajagopal, D., S.E. Sexton, D. Roland-Holst and D. Zilberman. "Challenge of Biofuel: Filling the Tank without Emptying the Stomach?" *Environmental Research Letters*. 2(2007): Online. Available at: http://www.iop.org/EJ/article/1748-9326/2/4/044004/er17_4_044004.html.

30. Rajagopal, D. and D. Zilberman. "Review of Environmental, Economic and Policy Aspects of Biofuels." Policy Research Working Paper No. 4341. Sustainable Rural and Urban Development Team, Development Research Group, The World Bank. 2007. Online. Available at: <http://www.wilsoncenter.org/news/docs/worldbankSept.2007.pdf>.
31. Rigdon, A. R., D.E. Maier, P. Vadlani, and A. Jumpponen. 2011. "Evaluation of Composition and Enzymatic Activity Changes of Sorghum Biomass Under Various Storage Conditions." Poster presented at Kansas State University Bioenergy Symposium: Mapping Sustainable Bioenergy Opportunities in the central Great Plains--Feedstocks, Land Use, Markets, and Socio-economic Aspects. Manhattan, KS, April 27-28.
32. Roe, B., T.L. Sporleder and B. Belleville. (2004). "Hog Producer Preferences for Marketing Contract Attributes," *American Journal of Agricultural Economics* **86**(1): 115 – 123.
33. Stricker, J.A., S.A. Segrest, D.L. Rockwood and G.M. Prine. "Model Fuel Contract – Co-Firing Biomass with Coal." Paper presented at the Soil and Crop Science Society of Florida and Florida Nematology Forum, 60th Annual Meeting, Tallahassee, Florida, September 20 – 22, 2000. Online. Available at: <http://www.techtp.com/Cofiring/Model%20Contract%20Cofiring%20Biomass%20with%20Coal.pdf>.
34. Train, K.E. *Discrete Choice Methods with Simulation*. Cambridge, UK: Cambridge University Press, 2003, 334 pgs.
35. U.S. Congress, House of Representatives. "Energy Independence and Security Act of 2007. Title II-Energy Security Through Increased Production of Biofuels; Subtitle A—Renewable Fuel Standard." *U.S. Government Printing Office*. December 2007.

36. Walsh, M.E., D.G. de la Torre Ugarte, H. Shapouri and S.P. Slinsky. "Bionergy Crop Production in the United States." *Environmental and Resource Economics*. 24(2003): 313 – 333.
37. Wilhelm, W.W., J.M.F. Johnson, J.L. Hatfield, W.B. Voorhees and D.R. Linden. "Crop and Soil Productivity Response to Corn Residue Removal: A Literature Review." *Agronomy Journal*. 96(2004): 1 – 17.