ESSAYS ON EXTENSION EDUCATION AND FARMERS' ADOPTION OF OILSEEDS CROPS AND CONSERVATION PRACTICES

by

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M.S., Kansas State University, 2009

AN ABSTRACT OF A DISSERTATION

submitted in partial fulfillment of the requirements for the degree

DOCTOR OF PHILOSOPHY

Department of Agricultural Economics
College of Agriculture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2016

Abstract

Adoption of technological improvements are crucial to increase agricultural productiviy to help reduce poverty by obtaining higher farm incomes due to higher productivity and lower production costs. However, the introduction of new agricultural technologies has not always been successful or had diffuse adoption. Factors that determine farmers' adoption decisions are: 1) farm and farmers' characteristics; 2) technology attributes, and 3) the farming objective. Understanding these factors and how they affect adoption of new technologies on the farm is crucial to assure higher levels of adoption. The over all purpose of this thesis is to explore the adoption process of new technologies and practices by farmers. This is accomplished through three essays to meet the objectives of the thesis.

The purpose of the first essay was to evaluate whether or not farmers in the western U.S. are willing to grow specialized oilseed crops that could be used for certified hydrotreated renewable jet (HRJ) fuel production and incorporate them into existing wheat-based production systems under contract. Results indicate that providing oilseeds crops and contracts with desired attributes and features would positively affect farmers' decisions to incorporate oilseed crops into their rotation system. Preferred seed and contract attributes that may affect a farmer' adoption decision differ across different geographic regions of the U.S.

The second essay focused on identifying factors that impact participation and farmers' decision to adopt soil conservation and fertilization management practices for cassava producers in Thailand and Vietnam. Results indicate that asset ownership and cassava yield positively influence participation. Adoption of new practices was positively linked to farmers' participation in training activities, use of fish ponds (as a measure of alternative agricultural practices), presence of a nearby starch factory, and slope of the land.

Finally, the purpose of the third essay was to examine extension educators' characteristics that affect educators' selection decision of outreach methods in the U.S. This essay examines the diffusion process that impacts adoption of best management practices by farmers. The decision extension educators make for selecting a teaching method is affected by the relationship between the objectives of the learning process and the characteristics of the teaching method.

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Acknowledgement

I would like to express my sincere gratitude to some of the individuals at Kansas State University who guided and helped me during my doctoral study. I want to thank my major professors, Dr. Jason Bergtold and Dr. Timothy Dalton for their help, support, patience, and encouragement to complete this dissertation. Without their support and advice, I would not have completed this degree. I would also like to thank my supervisory committee members: Dr. Jeffrey Peterson, Dr. Alex Shanoyan, and Dr. William Blankenau.

I want to thank the faculty members in the Department who have contributed enormously to my learning and professional growth. Special thanks to Dr. Michael Boland, Dr. Vincent Amanor-Boadu, and Dr. Sean Fox. I would also like to express my gratitude to those in the Department for your support and friendship: Deana Foster, Judy Maberry, and Amanda Ericksen. Many thanks to my officemates: Seleise Barret, and Chuck Mickelsen for making the work environment so enjoyable all these years, and special thanks to Dr. Rich Llewelyn for taking the time to read my class papers and provide valuable comments.

A number of people at K-State have helped make my time here more enjoyable. Thank you to fellow graduate students for your support, encouragement, and your friendship. Special thanks to Elizabeth Canales and Verónica Pozo, your friendship and companionship made this journey enjoyable. I have great faith that we can accomplish a lot together yet. Thanks to Déborah Sánchez, Kara Ross, and Pedro Garay for your friendship and all your valuable advices. Special thanks to Koichi Yamaura for the support, friendship, and all the help during these years.

I would like to thank my family for their support during this ongoing endeavor. I wish to thank my parents and my sisters for supporting me in my career decisions. Many thanks for being an inspiration of hard work and tenacity. Many thanks to my brother-in-law, John Walker, for always being there for me and being a great support during this journey.

I would like to express my gratitude to the Fulbright Commission with whose generous support I was able to earn a Master’s degree, and to the German Government for the financial support to complete my Bachelor’s degree, which was the first step for this journey.

Finally, I would like to acknowledge the grants that made possible to conduct the project research that are now essays one and three. Primary funding for this project was provided through a specific cooperative agreement with the USDA, Agricultural Research Service (Project #5445-21660-002-07S) in conjunction with the Office of Naval Research. Additional funding was provided by USDA, NIFA Project # ILLW-2011-06476

Dedication

To my parents

Chapter 1 - Introduction

1.1 Motivation

The role of research and adoption of technological improvements are crucial to increase agricultural productiviy (Feder et al., 1985; Kassie et al., 2011; Nkonya et al., 1997). According to Becerril and Abdulai (2010), productivity-improving technologies help reduce poverty through direct and indirect effects. The most important direct effect is higher farm incomes due to higher productivity and lower production costs received by farmers who adopt the technology (Kassie et al., 2011). Indirect effects refers to lower food prices for consumers due to an outward shift in the supply curve (Kassie et al., 2011), and higher demand for on-farm labor (Becerril and Abdulai, 2010).

However, the introduction of new agricultural technologies has not always been successful or had diffuse adoption (Feder et al., 1985). Studies show that different factors can influence farmers' adoption decisions of new technologies. Understanding these factors may boost rates of adoption and facilitate the diffusion of new technologies and processes.

According to Kaliba et al. (1997), factors that determine farmers' adoption decision are divided into three major categories: 1) farm and farmers' characteristics; 2) technology attributes, and 3) the farming objective (e.g., subsistence versus profit maximization). The first category refers to farmers' characteristics such as age, education, attitudes towards the type of technology (e.g. conservation attitude), attitudes towards risk; and physical characteristics of the land such as slope, farm tenure arrangements, fertility, and other soil characteristics (Abdulai and Huffman, 2014; Asafu Adjaye, 2008; Feder et al., 1985). The second and third categories refer to the type of technology being offered and how well that technology addresses the needs of the farmers (Kaliba et al., 1997).

Abdulai and Huffman (2005) determined that household characteristics play a significant role in the diffision of new technology. They found that household heads' schooling , access to credit and farm size were significant variables affecting the adoption decision of cross-bred cows. Abdulai and Huffman (2014) also found that social networks as well as capital and labor constraints determine adiption of field ridging in rice.

Farmers' adoption decision is also affected by the variety of technologies being offered and specific attributes of the technology (Bellon et al., 2006; Edmeades et al., 2006; Smale et al., 2001). According to Adesina and Zinnah (1993), the main focus when studying technology adoption has been primarily household characteristics; however, the omission of relevant variables may lead to biased inference about adoption behaviors and incorrect policy conclusions and recommendations. Considering technological attributes as a factor that may affect the decision to adopt can lead to a better understanding of farmers' adoption behavior.

Edmeades et al. (2006) define variety attributes as the performance characteristics of plant varieties (or different technologies) as perceived and evaluated by farmers. Farmers, thus, maximize the utility based on multiple attributes of a crop (or new technology) produced based upon the attributes of the crop (or technology) rather than from the specific variety itself. From the farmer point of view, these attributes may be the ones that better respond to production constraints, satisfy consumption preferences and fulfill specific market requirements (Smale et al., 2001). According to Dalton (2004), failing to incorporate any of those attributes (e.g. production, consumption and market traits), or focusing on the wrong attribute, could lead to biased and inappropriate varietal (or technology) promotions.

Nkonya, et al. (1997) suggest that the efficacy of development programs highly depends on how extension educators and technical assistants involved in agricultural development understand and address the factors that affect technology adoption. Both formal and informal education play an important role in the development process, because it positively affects agricultural productivity and consequently farmers' welfare through the enhancement of human capital (Alene and Manyong, 2007; Asfaw and Admassie, 2004). Particularly, through the dissemination of useful and practical research findings (Ojha and Sinha, 2001), outreach and extension services help farmers develop new skills and enhance their ability of processing information and of making better decisions (Anderson and Feder, 2004; Wozniak, 1987).

1.2 Research Objectives

The purpose of this this dissertation is to study the adoption process of conservation technologies and new enterprises by farmers. This is accomplished by examining factors affecting farmers' decision to adopt oilseeds crops and conservation practices, and extension educators' decision to select outreach methods. Specifically, the objectives of this research are:

i) To examine farmers' willingness to adopt oilseed crops in wheat-based rotation systems in the U.S.

ii) To identify factors such as participation and farmers' and farm characteristics, and other socio-demographic factors that impact farmers' decision to adopt soil conservation and fertilization management practices, and

iii) To examine extension educators' characteristics that affect educators' decision when selecting outreach methods.

The following section presents an overview of the three essays that comprise this dissertation. The overviews present a summary of the methods used to meet the research objectives as well as some of the results that emerged from each research objective.

1.2.1 First Essay: Farmers' willingness to grow oilseeds as a biofuel feedstock for jet fuel: A latent class model approach

Oilseeds are increasing in interest as a feedstock crop for the production of renewable fuels because of their diverse oil compositional structure that provides optimal oil properties for certified hydrotreated renewable jet (HRJ) fuel conversion efficiency. Few studies have focused on determining farmers' behavior and attitudes towards their willingness to grow oilseeds for bio-jet fuel. Specifically, little is known about the farmers' willingness to produce oilseeds in the western region of the United States, as well as how oilseed characteristics can determine producer's willingness to grow oilseeds crops, and how crop producers respond to marginal changes in contract specifications.

Using data from a stated choice survey administered to non-irrigated wheat farmers in the western U.S., the objective of this study is to evaluate whether or not farmers are willing to grow specialized oilseed crops that could be used for HRJ production into existing wheat-based production systems under certain crop and contract attributes. This study seeks to explore the general insights regarding producer preferences over the attributes of oilseed contracts by determining oilseed variety characteristics and contract features that affect farmers' decision to adopt oilseeds into the rotation system and to determine farmers' willingness to pay to adopt oilseeds.

A latent class logit modeling framework is used to assess which variables and contract attributes are important for decision makers, as well as capturing heterogeneity across the survey population. Results indicate that providing oilseeds crops and contracts with desired attributes and features would positively affects farmers' decisions to incorporate oilseed crops into their rotation system. Preferred seed attributes that may affect in farmers' decision to incorporate the crop into the crop rotation differ from one geographic region to other.

1.2.2 Second Essay: Impact of participation in farmers' adoption of soil management and fertilization practices in Thailand and Vietnam

Some small-scale farmers in developing countries grow their crops primarily on marginal land, which is more susceptible to soil degradation, erosion, and low soil fertility. Starting in 1994, the International Center of Tropical Agriculture (CIAT) conducted a project, funded by the Nippon Foundation in Tokyo, Japan, to reduce soil erosion in cassava-based systems in Vietnam and Thailand to, ultimately, enhance cassava's productivity levels. Five different soil conservation and fertilization management practices (SCFMP) were promoted by the project: intercropping lines, hedgerow, contour ridging, farm yard manure, and chemical fertilizer use. SCFMP were offered using participatory research (PR) methodologies such as farmers' field schools, on-farm training, and field days.

Using a two-stage discrete choice modelling framework, this study tests the hypothesis that adoption of soil conservation practices is higher when using participatory research methodologies. In addition, the factors (e.g. households' characteristics) that influence the adoption decision of soil management practices will be determined.

Data was collected from eight sub-districts/communes in Thailand and Vietnam through semi-structured face-to-face interviews with sub-district and commune level representatives and focus groups with farmers. Data contain household characteristics such as gender, age, family composition, asset ownership, land holding, animal composition, and land/crop distribution. This information was elicited from 393 farmers from Vietnam and 439 farmers from Thailand. Additionally, comprehensive adoption data were collected. Baseline data was also collected before the CIAT program started.

Results indicate that asset ownership and cassava baseline yield positively influenced participation. This suggests that farmers with a higher capacity to invest are also more likely to participate in extension and training programs. Similarly farmers with higher cassava baseline yields are more interested in learning new agricultural practices because they may be more motivated to maintain their agricultural productivity and livelihood. Adoption of new practices is positively linked to farmers' participation in training activities, use of fish ponds (as a measure of alternative agricultural practices), presence of a nearby starch factory, and slope of their land.

Participation positively affects the use of more complex practices, which suggests that participatory methodologies can be used more intensively as more complex agricultural technologies are being promoted. More intensive training may not only help farmers get more familiar with agricultural technologies, but also help to develop their ability to adapt those technologies to their actual circumstances. Developing countries may benefit from the use of PR as these approaches help to increase adoption of technologies, which may improve productivity, farm income and well-being.

1.2.3 Third Essay: Extension educators' preferences on teaching methods: An ordered probit model with selection

Outreach and extension services play an important role in enhancing human capital in agriculture. Education and training provides farmers with the ability to adapt technologies to their own environment and needs, which results in higher rates of improved technology adoption, and higher productivity levels.

Factors that affect the impact of outreach and extension programs have been widely studied. Some studies have focused their efforts on understanding farmers' educational needs, their preferences and perceptions towards the different types of educational methods, and the effectiveness of educational methods on knowledge acquisition, while others have focused on identifying the challenges and alternatives of current educational methods, finding effective educational strategies for different types of audiences, as well as identifying extension educators' needs for information and training. Only a limited number of studies have been conducted to understand the methods those educators use to deliver information.

Under the hypothesis that educators tend to teach the way they prefer to learn, this study attempts to provide quantitative evidence on how extension educators' personal preferences and characteristics impact their teaching methods decisions. Specifically, the goals of this study are: 1) to identify extension educators' characteristics that affect their selection of different types of educational methods, and 2) to explain how extension educators' perception of farmers' reception affects this selection. Results from this study will help enhance learning among farmers by understanding educators' preferences for learning and teaching methods.

Using primary data collected through an electronic survey administered to outreach and extension educators in 10 western states of the U.S. on December, 2012, an ordered probit model corrected for selection bias is estimated. Various factors are believed to explain the use of learning methods by extension educators, including: education level, age, region, area of expertise, target group, perception on the farmers' use of information, and years of experience. Results indicate that extension educators' age did not affect the decision of using internet as a teaching method. Furthermore, the decision extension educators make for selecting a teaching method is affected by the relationship between the objectives of the learning process and the characteristics of the teaching method.

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Chapter 2 - Farmers’ willingness to grow oilseeds as a biofuel feedstock for jet fuel: A latent class model approach

2.1 Introduction

Production of alternative fuels such as ethanol and biodiesel has significantly increased since the beginning of the new millennium (Carriquiry et al., 2010; Taheripour et al., 2010; Zilberman et al., 2014). In the U.S., biodiesel production has increased from 9 million gallons in 2001 to 13.4 billion gallons in 2013 (EIA, 2012; EIA, 2013b). This expansion has been driven by a national priorities to reduce greenhouse gas (GHG) emissions and alleviate concerns about energy security, oil price volatility and dependence on foreign oil imports (Algieri, 2014; Carriquiry et al., 2010; Bankovic-Ilic et al., 2012; Hertel et al., 2010; Knothe, 2010).

The aviation industry is a substantial driving force in the biofuel industry. The demand for biojet fuel has increased due to the continued growth of air traffic and increased interest in reducing GHG emissions (Nygren et al., 2009). Both the commercial airline and the military aviation sectors have made considerable investment into the development and testing of alternative fuels, focusing on investigating fuel availability, low-cost and reliable fuel alternatives, and improved jet fuel efficiency (Dagget et al., 2006, Rosillo-Calle et al., 2012; Shonnard et al., 2010).

The production of alternative crops as feedstocks will likely be needed to meet the demand for biojet fuels. A number of different feedstocks can be utilized to produce biodiesel, and thus, biojet fuel. The most common sources of biofuel are: vegetable oils (edible and non-edible), animal fats, waste cooking oils and algae-based oils (Bankovic-Ilic et al., 2012). The use of edible oils such as soybean and canola oils for biodiesel production is being highly criticized, because it competes with these oils that are used for human consumption (Algieri, 2014; Bankovic-Ilic et al., 2012). Therefore, non-edible plant oils (e.g. rapeseed) have been investigated as a substitute for these crops, because they do not compete with oils for human consumption and their production costs are lower compared to edible oilseed crop varieties (Bankovic-Ilic et al., 2012). Non-edible oilseed plants can be produced on marginal lands and can be incorporated into existing crop rotations (Shonnard et al., 2010) such as small grain crops. Wheat-based cropping systems provide one such opportunity.

In the U.S., the predominant wheat production system has been wheat-fallow (WF) or wheat-summer crop-fallow (WSF); meaning that wheat producers have relied primarily on wheat production as their primary crop revenue stream. However, the introduction of reduced tillage and no-till systems for wheat production have made it possible to intensify (and diversify) production due to increases in soil moisture storage, replacing fallow periods with more frequent cropping. Although alternative rotation crops for wheat are limited, non-edible plant oils have been identified as a successful alternative to replace fallow periods without compromising existing agricultural land use for food production and enhancing economic and environmental sustainability of wheat production (Obour et al., 2015).

2.2 Objective

The purpose of this study is to evaluate farmers' willingness to adopt specialized oilseed crops under contract that are designated for hydrotreated renewal jet (HRJ) fuel production and can be incorporated into existing wheat-based production systems. This examination will assess producer preferences about oilseed varieties and contracts by determining how oilseed variety characteristics and contract features can affect farmers' adoption decisions using a stated choice experiment. Survey data is collected from a mail survey sent to wheat producers in ten western states of the U.S. The stated choice experiment data collected is then analyzed to using latent class conditional logistic regression models. The results from this research will help refineries and processors measure how marginal changes in contract provisions may alter producer acceptance and adoption. The biofuel industry will also benefit from information about the oilseed characteristics farmers need, as they can offer farmers crop varieties with desired characteristics that will work in local region. Finally, industry and policymakers can use these results as guidance to provide financial incentives and to promote adoption among farmers.

2.3 Background information

This section of the paper provides background on the biofuel industry and alternative oilseed crops that can be used as feedstocks to produce biojet fuel.

2.3.1 Biofuel Industry

The International Air Transport Association (IATA) has predicted a growth in global air traffic of 5% per year until year 2030 (Nygren et al., 2009; Rosillo-Calle et al., 2012). To fulfill the demand of jet fuel required to meet this predicted growth, Nygren et al. (2009) estimates that the percentage of aviation fuel would need to increase from 6.3% to 9.3% of crude oil production by 2030. However, the ability of crude oil production to keep pace with world demand for energy is not certain (Blakey et al., 2011; Dagget et al., 2006; Nygren et al., 2009).

Commercial aviation is responsible for 2 to 6 percent of total global carbon emissions (Blakey et al., 2011; Rosillo-Calle et al., 2012). This level is expected to increase as air traffic and energy consumption increase. To reduce GHG emissions, the IATA (2009) reports that the global aviation sector has set two important goals for the sector: (1) achieve carbon neutral growth, and (2) build a zero emission commercial aircraft within the next 50 years. These goals are to be accomplished through a four-pillar strategy: (i) improved technology, (ii) effective operations, (iii) efficient infrastructure, and (iv) positive economic instruments (IATA, 2009).

A main challenge for the aviation industry in meeting these goals has been finding "drop-in" fuels to replace petroleum–based fuels. That is, fuels produced from alternative feedstocks that do not require any modification to the equipment or infrastructure for their use (Bauen et al., 2009; Blakey et al., 2011), and meet high quality aviation standards (Bauen et al., 2009; Rosillo-Calle et al., 2012). These standards include: a high energy content; low freezing point; relight capability at altitude; low explosion risk; high specific heat capacity; low viscosity and high lubricity; good thermal and chemical stability; and safe for ground storage and handling (Blakey et al., 2011; Rosillo-Calle et al., 2012). Currently, only biodiesel-like fuels meet these requirements (Bauen et al., 2009; Rosillo-Calle et al., 2012; Tyner, 2012), along with having other advantageous properties, including: GHG emissions savings, low cost, sustainability, and potential speed of uptake (Bauen et al., 2009; Rosillo-Calle et al., 2012).

Although biodiesel and renewable jet fuels are produced using the same inputs, the production technology is different. Biodiesel is produced through a reaction with alcohol (EIA, 2012), whereas renewable jet fuels are typically produced by one of three ways. In the first method, a gasification and Fischer-Tropsch (FT) process is used to produce biomass-to-liquids (BTL) from woody energy crops, grasses, and municipal solid wastes (Bauen et al., 2009; Rosillo-Calle et al., 2012; Winchester et al., 2013); 2). The second method involves synthetic hydrocarbons (Bauen et al., 2009). The third and most popular method to produce biojet fuels is use of the hydrogenated ester and fatty acids (HEFA) process used to obtain hydrotreated renewable jet (HRJ) from vegetable oils and animal fats (Bauen et al., 2009; EIA, 2012; Kallio, 2014; Pearlson et al, 2013; Rosillo-Calle et al., 2012; Wilson et al., 2013; Winchester et al., 2013).

The potential for biofuels to replace petroleum-based jet fuel, decrease GHG emissions, and provide energy security is being investigated (Sims-Gallagher, 2013). This investigation stems from biofuels' current limited production capacity (especially biodiesel) considering the amount needed to meet jet fuel demand (Nygren et al., 2009). Increases in production of biofuels obtained primarily from grains, sugar crops and oilseeds are expected to raise the demand of feedstocks, which can lead to increase competition with food crops, higher commodity prices, and increased demand for land (Algieri, 2014).

Worldwide, edible oils are the main resource for biodiesel production, including biojet fuel, which leads to a global imbalance in the market (Bankovic-Ilic et al., 2012). The most preferred vegetable oils to produce biodiesel are canola oil in Canada, jatropha in India, rapeseed oil in Europe, and coconut or palm oil in tropical countries. Other oil crops used in lesser quantities are corn, cottonseed, peanut, sunflower, and safflower (Demirbas, 2007; Soriano and Narani, 2012).

In the United States (U.S.), soybean oil has historically been the largest biodiesel feedstock (Demirbas, 2007; EIA, 2012). During the 2012/2013 soybean marketing year (October to September), a total of 1.1 billion gallons of biodiesel was produced using 8,3 billion pounds of feedstock, of which 56% (4,6 billion pounds) was from soybean oil and the other 44% were supplied from canola oil, corn oil, palm oil, animal fats and recycled feeds (EIA, 2013a, EIA, 2013b). The share of soybean oil supply used for biodiesel production in the 2010/11 marketing year was 13.7% and it has increased dramatically to 24.6% and 22.9% for the 2011/12 and 2012/13 marketing years, respectively (USDA ERS, 2014).

Furthermore, the high demand for energy crops, and the consequent higher commodity prices, has led to two main land reallocations, which have had negative consequences. First, food crop land has been diverted into land for energy crop production, which results in a decrease in the supply of food crops, resulting in an increase in food prices (Carriquiry et al., 2010; Algieri, 2014). Second, forest and grass land is being converted for energy crop production, which leads to reductions in carbon sequestration and GHG emission savings from these lands (Carriquiry et al., 2010; Searchinger et al., 2008).

According to Bauen et al. (2009), GHG emissions savings greatly depend on the type of feedstock used to produce bio-jet fuels. Bauen et al. (2009) conducted a well-to-wake analysis to estimate GHG emissions and savings by analyzing the entire production chain of the fuel: feedstock production and the inputs used in production, feedstock transport, conversion process, and fuel transport, and co-products of biofuels. Also part of the analysis, extraction and refining of crude oil were estimated for petroleum derived jet fuel along with emissions from burning fuel in aircraft. Using petroleum based fuel GHG emissions as the baseline, results of the study indicated that GHG emissions of algae, forestry residues, woody crops and grasses, and tallow based fuels were significantly lower (< 10 g CO_2e/MJ fuel) compared to those of petroleum based fuels (87.5 g CO_2e/MJ fuel). Carbon dioxide (CO_2) savings ranged between 89% and 98%. Fuels based on conventional oil crops such as rapeseed, palm, and soybean oils had emissions between 40 and 70 g CO_2e/MJ fuel and CO_2 savings of only 20 to 54%. One exception was camelina-based fuels which had significantly lower emissions (13.5 gCO_2e/MJ fuel) and higher CO_2 savings (85%) compared to the petroleum based fuel baseline. The direct or indirect land use change impacts were not considered in the study.

The relatively high production costs for biojet fuels is another concern surrounding its utilization (Carriquiry et al., 2010). Approximately 80% of the cost of producing these biofuels is related to the cost of the feedstock (Demirbas, 2007; Bankovic-Ilic et al., 2012). Pearlson et al. (2013) report average jet fuel gate prices ranged from 0.12 to 0.80 $/L. The five-year average price for this type of fuel was 0.56 $/L, while the 20-year average was 0.28 $/L. In comparison, when soybean oil is used as a feedstock for biojet fuel production, fuel prices were significantly higher, ranging from 0.24 to 1.05 $/L. The five-year average price was 0.69 $/L and the 20-year average was 0.42 $/L. Winchester et al. (2013) state that between April 1990 and June 2012 the price of soybean oil exceeded the price of jet fuel, on average, by $1.19; and, by the year 2020, soybean oil prices are expected to exceed the price of jet fuel by $0.66.

In order to alleviate price, food, and land competition while still meeting the demand for jet fuel, production of biojet fuel will be needed using other alternative crops. Those alternative crops need to be non-food crops which can be potentially grown on marginal lands or as rotation crops during fallow periods on existing lands (Shonnard et al., 2010). The next subsection describes the characteristics of the oilseeds considered in this study and discusses the oilseeds' potential as bio jet fuel feedstocks.

2.3.2 Oilseeds crops for biofuel production

Soybean oil is the largest feedstock used in the U.S. for biodiesel production. However, this crop only ranks eighth on the list of best oil-yielding crops. Rapeseed (*Brassica napus*) ranks first on this list with yield levels of 122 gallons of oil per acre. Safflower has the fourth best yield at 80 gallons of oil per acre and mustard ranks seventh with 59 gallons of oil per acre (Kurki, et al, 2010). These oilseed crops also have significant crop rotational benefits. For instance, deep safflower and sunflower roots help break up hardpans and compacted soil, which improves soil conditions and crop productivity (Kurki, et al, 2010). Oilseed crops considered in the study included varieties of canola, mustard, camelina, flax, and safflower.

2.3.2.1 Canola (*Brassica napus L.*)

Canola is a type of rapeseed that has been bred to obtain oil with desirable characteristics for human consumption (Atkinson et al, 2006; Oplinger et al., 2014). Because both winter and spring varieties of canola have been developed, it is one of the few oilseed crops that can be cultivated in a wide range of areas across temperate zones (Atkinson et al, 2006; Kurki et al, 2010). Canola can perform well as a winter crop (Kandel and Berglund, 2011); however, it is less winter hardy than wheat and can be vulnerable to cold injury during severe winters (Kurki et al, 2010).

Canola can be grown under irrigation or dry-land, and in fields managed by no-till or conventional methods. Well-drained soils as well as good wheat and cotton land are ideal to maximize canola's performance (Jaeger and Siegel, 2008). Canola is typically produced in rotation with small grains, i.e., wheat, and grass seed. Both swathing and direct combining can be used to harvest canola (Atkinson et al, 2006; Nowatzki et al, 2011).

At maturity, canola seed contains 38 to 42% of oil (Oplinger et al., 2014). After oil extraction, the remaining meal is used as a protein supplement for livestock and poultry. Canola meal contains 35 to 38% of crude protein (Atkinson et al, 2006; Jaeger and Siegel, 2008) and about 12% of crude fiber (Atkinson et al, 2006). Expected seed yields ranges from 2,400 to 4,500 lb/acre for winter canola and 1,000 to 3,000 lb/acre for spring canola (Jaeger and Siegel, 2008). Expected oil yield is 122 gallons/acre (Kurki et al, 2010).

2.3.2.2 Camelina (Camelina sativa L.)

Because camelina has a high seedling frost tolerance and short production cycle, it has been considered as a promising new spring-sown rotational crop that can be adapted to crop rotations with small grains (Lafferty et al., 2009; McVay and Lamb, 2008). This is particularly good in marginal growing conditions due to its drought tolerance, water use efficiency, and high resistance to economically important pests such as flea beetles (Lafferty et al., 2009; McVay and Lamb, 2008). Because of these attributes, camelina has been considered as an alternative low-input-cost oilseed crop (Ehrensing and Guy, 2008).

Camelina can be swathed or direct combined (McVay and Lamb, 2008), as most of the cultivars are resistant to shattering (Ehrensing and Guy, 2008). Camelina oil has been used for cooking and fuel oil (McVay and Lamb, 2008) and the meal has been used in animal feed rations. Meal contains 45 to 47% crude protein, 10 to 11% crude fiber, and is low in glucosinolates (Ehrensing and Guy, 2008; McVay and Lamb, 2008). This crop has about 30 to 40% oil content (Lafferty et al., 2009; McVay and Lamb, 2008) and its expected yield is approximately 1,600 lb/acre with an estimated annual average production cost of $278.62 per acre.

2.3.2.3 Flax (Linum usitatissimum L.)

Oilseed flax can be adapted to a variety of climates and soil conditions. Flax's optimal performance is obtained when it is grown in cool climates and well-drained soils (Ehrensing, 2008b; Jaeger and Siegel, 2008). There are varieties of flax that are best suited for oil or fiber. Currently, the oil from flax has become more economically important than flax's fiber production (Ehrensing, 2008b). Flax seeds contains from 40 to 45% oil (Ehrensing, 2008b). Expected yields range from 2,000 to 3,000 lbs/acre for winter flax, and 1,800 to 2,400 lbs/acre for spring flax, provided it has received sufficient moisture. Production costs are approximately $391.43 per acre (Jaeger and Siegel, 2008).

2.3.2.4 Mustard varieties (Brassica spp.)

Three types of mustards are grown in North America: yellow (*Brassica hirta*), brown and oriental (*Brassica juncea*) mustard varieties (Oplinger et al, 2014). Mustard meal is high in glucosinolates, which makes it not suitable for livestock feed (Crockett et al, 2006; Oplinger et al, 2014). Yellow mustard is primarily a cool season crop (Wysocki and Corp, 2002), but can also be adapted to hot and dry conditions (Brown et al, 2005). This crop is commonly produced in a rotation with small grain cereals such as wheat (Brown et al, 2005; Oplinger et al, 2014). Mustards can be harvested by direct combining (Wysocki and Corp, 2002). Expected yields for yellow mustard ranges from 600 to 1,800 lbs/acre (Jaeger and Siegel, 2008) with an oil content of 27 to 35% (Oplinger et al, 2014; Peterson and Thompson, 2005). Expected oil yield is 59 gallons/acre (Kurki et al, 2010).

2.3.2.5 Rapeseed (Brassica napus.)

Rapeseed and canola are closely related members of the mustard family and they both are grown as oilseed crops (Ehrensing, 2008a). Rapeseed is grown as a source of erucic acid, which is not edible but is valuable in high-performance industrial lubricants. This crop also contains glucosinolates that provides rapeseed oil with a bitter taste (Ehrensing, 2008a). Canola was developed from rapeseed; however, anti-nutritional erucic acid and bitter glucosinolates that characterized rapeseed were removed (Buntin et al. 2010; Ehrensing, 2008a). Since 1956, the Food and Drug Administration (FDA) banned rapeseed oil for human consumption because it contains high amounts of erucic acid. Demand for rapeseed meal is low due to its high levels of glucosinolates, which depresses animal growth rates (USDA, 2016).

Both winter and spring varieties of rapeseed are available. Rapeseed and canola need to be grown apart to avoid seed contamination due to cross pollination (Frier & Roth, 2014). Both crops are preferred for biodiesel and biolubricant production, because their oil yield can double that of soybeans per acre at the same grain yield levels. However, rapeseed is the most common feedstock used for biodiesel (Frier & Roth, 2014).

2.3.2.6 Safflower (Carthamus tinctorious L.)

Safflower is a drought resistant crop that is well adapted to the western Great Plains (Armah-Agyeman et al., 2002; Boland, 2012). This crop can be planted in well drained, irrigated or dryland areas (Armah-Agyeman et al., 2002; Jaeger and Siegel, 2008). Given its deep root system, safflower can break up hardpans and compacted soils (Jaeger and Siegel, 2008; Kurki et al., 2010) to access areas of moisture deeper in the soil (Boland, 2012). These properties are especially beneficial when safflower is grown in rotation with other crops, such as small grains (Boland, 2012).

In the U.S., safflower has three major uses: oil, meal, and birdseed. Oil content ranges from 37 to 42% (Jaeger and Siegel, 2008). Safflower meal can be fed readily to livestock and poultry (Boland, 2012; Jaeger and Siegel, 2008). Its protein content reaches 24% (Armah-Agyeman et al., 2002; Boland, 2012). Expected yields range from 1,131 to 1,900 lb/acre and production costs are approximately $336.59 per acre (Jaeger and Siegel, 2008).

2.4 Data and survey methods

A stated choice survey was administered to 10,089 non-irrigated wheat growers to assess farmers' willingness to adopt specialized oilseed crops under contract that are designated for HRJ fuel production and can be incorporated into existing wheat-based production systems. The survey was designed by Kansas State University and conducted by the Iowa State University's Survey &

Behavioral Research Services (SBRS) unit. Eleven western states from the U.S. (California, Colorado, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, Texas, and Washington) were selected from three USDA Economic Research Service (ERS) Crop Production Regions: Pacific Northwest Fruitful Rim (California, Oregon, and Washington), the Prairie Gateway (Colorado, Kansas, Nebraska, Oklahoma, and Texas), and the Northern Great Plains (Montana, North Dakota, and South Dakota). According to the USDA ERS (2000), those regions are characterized for having a significant amount of wheat-based farming. The Prairie Gateway is the most important region in terms of wheat production in the U. S. (USDA ERS, 2000). By 1998, the Prairie Gateway and the Northern Great Plains regions account for 70 percent of total U. S. wheat production. However, these two regions are reported to have the lowest gross returns per acre in the country due to low yields (Ali, 2002).

The Pacific Northwest Fruitful Rim has a largest share of large and very large family farms and nonfamily farms (USDA ERS, 2000). From October to March, this region receives approximately two-thirds of the precipitation and stays fairly dry during the rest of the year (Olen et al., 2015). The Prairie Getaway region experiences wide extremes of both temperature and precipitation. This region is characterized for having bitterly cold air masses during winter and hot and humid summers. The Prairie is vulnerable to floods, severe thunderstorms, summer drought, heat, flooding, heat waves, and winter storms (Hatfield et al., 2015). The Northern Great Plains has largest farms (USDA ERS, 2000). Climate in this region is semi-arid with long, cold winters and short, hot summers. Land management is characterized by a mixture of dryland cropping systems and livestock production based on rangeland, pastures, and hay production (Sanderson et al., 2015).

Data of 10,089 wheat farmers from the 11 states where the study was conducted was purchased by Kansas State University from Farm Market ID (www.farmmarketid.com). These data included farmer's name, company's name, address, county, producer type, and telephone number (Larson and Fox, 2014). The survey was administered to all 10,089 wheat farmers in the sample.

The survey was mailed to farmers on April 2013. Reminder postcards were sent to non-responders 10 to 12 days after the first survey packets were mailed. A second survey packet was mailed 14 to 16 days after the remainder postcard was mailed (Larson and Fox, 2014). A total of 971 responses were received (a response rate of 9.7%). The low response rate may be attributed to the timing when the survey was administered. That is, there were two events that happened before the survey was sent, the presidential elections and the census of agriculture. These events demanded time from the farmers, becoming more difficult to motivate the farmer to provide information by taking the time to fill the survey out.

The survey questionnaire was organized in three sections. The survey gathered information on farmers' characteristics and management; information about oilseed feedstocks for bioenergy and farmers' willingness to grow a specialized bioenergy oilseed crop under contract; and information on crop adoption and perceptions towards biofuel feedstock production.

The statistical analysis was conducted for the three regions previously described. To determine whether the survey respondents are representative of farmers from each state, demographics reported by farmers in the survey are compared to the statistics from each state as reported in the 2007 Census of Agriculture (USDA, 2007). Table 2.1 shows the comparison between the state statistics and the farmers in the survey. For the Pacific and Great Plains regions, the percentage of farmers who are white is similar within all the regions and across respondents who completed the survey. The average age for farmers from the Pacific region is similar for both the census and the survey, but the average age of farmers in the census is slightly higher than the survey for the Prairie and Great Plains regions. The percentage of the male respondents is the same for both the census and the survey. Total sales from crop production are higher for all the regions when compared to the survey. This may due to the fact that the survey targeted wheat producers.

2.4.1 Stated Choice Experiment

The state choice experiment contains four contractual scenarios. Each contract has nine attributes. Four attributes are related to oilseed characteristics: shatter resistance, pest tolerance and herbicide resistance, winter hardiness, and extended window to direct combine. The remaining five attributes describe contract features: net returns, length of contract, crop insurance, cost share, and presence of an "Act of God" clause. These contract attributes were chosen based on a thorough literature review and the findings in the background section above. In addition, focused group interviews were conducted with farmers in each of the USDA ERS crop production regions to help facilitate the design of the stated choice experiment. The focus groups were held with 5 to 7 farmers to collect information about what crop and contract attributes they would find the most important when growing these crops and if they entered into a contract to produce these crops. Farmer participants were either considering adopting these crops; have produced oilseed crops; or have entered into a contract in the past to produce these crops. Focus groups were held in Kansas, North Dakota, Oklahoma and Washington during Fall 2012 and Winter 2013. The attributes used in the experiment represent the significant crop traits and contract attributes the participants felt were the most important. For crop variety attributes, shatter resistance, pest tolerance and winter hardiness were important for ensuring the viability and yield of the crop, while an extended direct combine window was important for flexibility of including oilseed crops in rotation with small grains.

Farmers indicated that the length crop insurance and net returns are highly important when considering the adoption of the crop (Fewell et al., 2016; Paulrud and Laitila, 2010; Smith et al., 2011). In addition, Bergtold et al. (2014) show that the length of contract, net returns, presence of crop insurance and financial incentives are important contract considerations in a similar context for production of cellulosic feedstocks for ethanol production. These attributes are further discussed in section 4.3 below.

Survey respondents are asked to consider each contractual scenario and choose if they would adopt a contract to grow oilseeds in rotation with wheat or “opt out”. Contract attributes were defined in the stated choice experiment and an example question is provided in Figure 1. In conjunction with the oilseed farmer survey, a supplemental information sheet was provided that highlighted the information about specific oilseed crops, costs and potential returns relative to wheat production.

As per the survey instructions, farmers were also asked to take into consideration that oilseed crops would be designated for HRJ fuel production and grown in rotation with spring or winter wheat under dry-land conditions. Net returns are explained in the survey as the expected percent gain above the net returns for producing an acre of wheat. Four levels of net return were considered: -5, 5, 15, and 25 percent above wheat net returns. The cost share attribute is described as the percentage of the input costs that the bio-refinery or processor agrees to pay. Three levels of the cost share attribute were considered in the survey: 0, 15, and 30 percent. Two levels are considered for contract length: 1 year or 3 years. The 3 year contract was considered because an oilseed crop is typically only rotated once every three years in a crop rotation with small grains. Oilseed characteristics, crop insurance, and the “Act of God” clause are binary attributes: 1= Yes (present) and 0=No (not present).

A (2^7 x 3 x 4) fractional factorial design was used to find the combinations needed to build the experiment based on the approach stated by Louviere et al. (2000). Fractional factorial designs are used instead of complete factorial designs to reduce the number of combinations to practical sizes (Louviere et al., 2000). PROC OPTEX was used in SAS to develop the design and blocking of choice sets. The D-optimality criterion was used to obtain the optimal design and a D-Efficiency score of 99.13 was obtained. The procedure developed 48 random choice sets which were randomly assigned into 12 blocks, i.e., 48 random choices divided by 4 contractual scenarios, which equates to 12 survey versions, which are randomized across survey respondents.

2.4.2 Summary Statistics

The majority of respondents choose the "opt out" option. On average, only 28.87% of the respondents were willing to grow an oilseed crop under contract for biojet fuel. Of the farmers willing to engage in such an enterprise from the Pacific Northwest region, 61% and 62.3% prefer oilseeds varieties resistant to shattering and harvesting by direct-combine, respectively. Of the farmers in this region, 52.8% and 51.6% prefer oilseed varieties with pest tolerance and winter hardiness attributes, respectively.

The majority of the adopters (61%) from the Prairie Gateway prefer harvesting using the direct-combine method and about half of the adopters prefer having varieties resistant to pests and shattering. Only 46% of the adopters from this region prefer winter hardened varieties of oilseeds. Similar results are obtained from the farmers from the Northern region.

All farmers willing to adopt any type of oilseed, regardless of region, prefer having shorter contract lengths. In fact, more than 52% of farmers prefer one-year over a three-year contract.

More than 57% of the farmers prefer having crop insurance and an “Act of God” clause included in their contracts, as well.

Farmers from the Pacific Northwest and Prairie Gateway primarily grow winter varieties of wheat, while farmers in the Northern Great Plains primarily grow spring wheat with some winter and durum varieties. For the Pacific Northwest a 5-year average yield of 77.3 bushels/acre and 58.5 bushels/acre of winter and spring wheat, respectively, was reported. Lower 5-year yield averages of winter wheat were reported in the other two regions: 42 bushels/acre in the Prairie Gateway and 49 bushels/acre for the Northern Great Plains. Farmers from the Prairie Gateway reported higher spring wheat 5-year yield averages, (74.6 bushels/acre) compared to 58.5 bushels/acre obtained by farmers from the Pacific Northwest and 41.5 bushels/acre by those from the Northern Great Plains.

When asked what crops they typically grow in their crop rotation before/after wheat, the majority of the farmers (> 39%) in the Pacific Northwest stated they follow a fallow-wheat-fallow cropping system. Fourteen percent of the farmers stated growing peas/beans before wheat and ten percent grow peas/beans after wheat. Crop rotation patterns appear less diverse in the Praire Gateway. Many of the farmers (over 45 percent of those surveyed) grow continuous wheat or have a wheat-fallow rotation. Other farmers in this region did rotate wheat with corn, sorghum, canola, peas, beans and other crops, but to a much lesser extent than the other regions. Farmers in the Northern Great Plains had more diversified crop rotations, growing wheat, corn, canola, peas and other crops before and after wheat. About 45% of the farmers reported having fallow periods in their crops rotations with wheat.

In all regions, canola is the most familiar oilseed crop with approximately half of the surveyed farmers, on average, reporting familiarity with canola. On average, 11% of farmers are familiar with flax and safflower, and farmers are the least familiar with pennycress. In addition to canola, farmers from the Pacific Northwest are also familiar with mustard varieties, but have are least familiarity with flax. Farmers in the North Great Plains are knowledgeable with canola, flax, safflower, and mustards. On average, the maximum acreage farmers are willing to initially allocate to grow any type of oilseed was 182 acres. Farmers from the Northern Great Plains are willing to initially allocate more land to grow oilseeds compared to other farmers in other regions.

2.5 Model

2.5.1 Expected Discounted Utility Model

The conceptual model presented in this study follows the approach by Roe et al. (2004). This approach assumes producers maximize expected discounted random utility when they choose to adopt oilseed crops into their crop rotation system. The expected discounted utility for producer i ’ when choosing contract j is:

$$V_{i,j} = V(R_j, A_j, C_j) + \varepsilon_{i,j}$$

where R_j is the oilseed return under contract j; A_j denotes a vector of oilseed attributes associated with contract j; C_j denotes a vector of features associated with contract j; and $\varepsilon_{i,j}$ denotes a random error term capturing the unobserved elements of expected utility. Oilseed attributes in A_j include shatter resistance, pest and herbicide resistance, winter hardiness, and extended direct combine window. Contract features included in C_j are contract length measured in years, crop insurance, percentage of cost share with a bio-refinery, and an “Act of God” clause.

2.5.2 Econometric Specification

A discrete choice latent class model (LCM) model is adopted, as a researcher will only observe if a farmer adopts contract *j* or not. Thus, the choice process is modeled as a binary choice process following a logistic regression framework. The latent class formulation assumes that a farmer's behavior depends on observable attributes and on latent heterogeneity that varies with factors that are unobserved by the researcher. In an LCM, farmers are implicitly sorted into a set of *Q* classes, but it is unknown which class contains any particular individual (Greene and Hensher, 2003).

Following Greene and Hensher (2003), the LCM asses the probability of farmer *i* from class *q* (*q*=1, 2, …, Q) choosing alternative (contract) *j* for choice situation *t* (t=1, 2, …T). That is, the model estimates:

$$P[farmer\,i\,chooses\,choice\,j\,in\,choice\,situation\,t \mid class\,q] = \frac{\exp(x'_{it,j}\beta_q)}{\sum_{j=1}^{J_i}\exp(x'_{it,j}\beta_q)} = F(i,t,j \mid q) \tag{1}$$

where x'_{it} is a matrix of contract is attributes for option j in choice situation *t* and β_q is a vector of coefficients for individuals in class *q*. The probability for the specific choice y_{it} made by a farmer i can be represented as:

$$P_{it|q}(j) = P(y_{it} = j \mid class = q) \tag{2}$$

The probability of a farmer being assigned to a particular class q is equal to joint probability of the sequence $y_i = [y_{i1}, y_{i2}, ..., y_{iT}]$, i.e. (Fewell et al., 2016):

$$P_{i|q} = \prod_{t=1}^{T_i} P_{it|q} \tag{3}$$

To estimate the probability of farmer i belonging to class q, Greene and Hensher (2003) suggest the traditional multinomial logistic discriminant:

$$H_{iq} = \frac{\exp(z_i^{'}\theta_q)}{\sum_{q=1}^{Q_i} \exp(z_i^{'}\theta_q)},\ q = 1,\ldots,Q,\ \theta_Q = 0 \tag{4}$$

where H_{iq} represents the latent class constant probability that classifies individual i into class q; z_i is a vector of observable characteristics of individual i, and θ_q is a vector of latent class parameters to be estimated. Thus, the probability that farmer i is will belong to class q is:

$$P_{iq} = \sum_{q=1}^{Q} H_{iq} P_{i|q}\ . \tag{5}$$

Following Greene & Hensher (2003), the model can be estimated using maximum likelihood. The log likelihood for farmer i belonging to class q and choosing alternative j is:

$$\ln L = \sum_{i=1}^{N} \ln P_i = \sum_{i=1}^{N} \ln[\sum_{q=1}^{Q} H_{iq} (\prod_{t=1}^{T_i} P_{it|q})]\ . \tag{6}$$

2.5.3 Empirical Estimation

To account for geographical differences, a separate regression was estimated for each region: Pacific Northwest Fruitful Rim (California, Oregon, and Washington), the Prairie Gateway (Colorado, Kansas, Nebraska, Oklahoma, and Texas), and the Northern Great Plains (Montana, North Dakota, and South Dakota). To estimate the model, we specify the following functional form for the expected discounted utility model. Farmers' willingness to adopt oilseeds into their crop rotation system under certain crop attributes and contract characteristics is estimated by the following empirical model:

$$V_{i,j} = \beta_0 + \beta_1 R_j + \sum_{s=1}^{4} \gamma_s A_{s,j} + \sum_{k=1}^{5} \delta_k C_{k,j} + \varepsilon_{i,j} \tag{7}$$

where j represents the alternative choice A or B per each scenario. Alternative A is a random contract on which oilseed attributes and contract characteristics are assigned randomly, while alternative B represents the "opt out" option.

The vector of variables A_j represents the oilseeds attributes that producers may prefer having when adopting the crop into their crop rotation system. These attributes included shatter resistance, pest resistance and herbicide tolerance, winter hardiness, and extended direct combine window.

Pod shattering refers to a characteristic on which pods split easily after maturity to facilitate seed dispersal. Shattering can cause a negative effect on yield as large amounts of seed can be lost in the field before and during harvesting (Morgan et al., 2000). Price et al. (1996) estimates 20% of seed yield lost due to shattering. Furthermore, volunteer plants that may result from the shed seeds may lead to light and nutrient competition with the crop next in the rotation as well as phytotoxic effects (Gan et al., 2008). The use of oilseed varieties resistant to shattering may help reduce yield loss, and avoid swathing (cutting of the stand to promote premature drying), which reduces harvesting costs as the use of desiccants and seed contamination are reduced and uniformity of the harvested seed is improved (Morgan et al., 2000).

Pest resistance and herbicide tolerance is a desired characteristic in a crop. The use of pest resistant varieties avoids yield losses from pest infestation and herbicide tolerant varieties allow the use of herbicides to fight other weeds without causing damage to the main crop. Brassica varieties are susceptible to diseases such as: Sclerotinia, Phytophthora root rot, Alternaria leaf spot, Pseudomonas bacterial blight (Armah-Agyeman et al., 2002; Kurki et al., 2010). The seedlings are also susceptible to damage caused by insects such as wireworms and cutworms. Grasshoppers and lygus bugs can also damage the crop (Armah-Agyeman et al., 2002). To reduce disease severity, plant certified seed is recommended.

Winter hardiness indicates the crop’s resistance to extreme low temperatures, which can injure the crop primarily by inducing ice formation between or within cells (Canola Council of Canada, 2011). Acclimation to cold temperatures, e.g., winter hardened varieties, can help oilseeds to cope with winter stress and avoid frost damage (Rapacz and Markowski, 1999).

Extended direct combine windows refer to a characteristic that allows maximizing yields by using proper harvesting. Oilseeds can be direct combined or swathed. Crops that have been desiccated or that are uniformly mature and relatively free of green weeds or Alternaria disease can be direct combine harvested. Swathing allows the crop to achieve uniform maturity before threshed. With swathing, the crop is cut and placed in rows directly on the cut stubble to accelerate the drying process and to ensure even ripening and reduction of seed losses from wind and hail. *Brassica rapa* varieties, i.e. canola, need to be swathed as it tends to ripen unevenly while *Brassica napus* varieties can be direct combined because they mature earlier and resist shattering (Canola Council of Canada, 2011).

Assuming producers are profit maximizers, the coefficients signs for shatter resistance, pest tolerance, and winter hardiness are expected to be positive because these attributes will help to maximize profits by reducing yield losses. The sign for the extended direct combine window coefficient is expected to be either positive or negative because both harvesting practices have advantages and disadvantages and preference may depend on the type of oilseed a farmer is willing to adopt.

The vector of contract characteristics C_j include: contract length, crop insurance, cost-share with a bio-refinery or processor, and an "Act of God" clause. Contracting involves risk sharing between buyers and sellers. One of the challenges in contracting is determining the appropriate risk premium accrued by participants, and how that is shared between the buyer and seller (Wilson and Dahl, 2009). The use of contracts to govern production and marketing has been increasing. However, contracting in small grains has not been common. Only about 12% of the production these grains are under contract (Wilson et al., 2007). Roe et al. (2004) asserts that contract features such as price windows, minimum delivery levels, and contract length can alter producer valuation of contracts. Findings have shown that as the length of the contract increases, the contract become less preferable (Fewell et al., 2016; Roe et al., 2004).

Crop insurance is an important tool to manage crop risks (Archer & Reicosky, 2009; Wilson et al., 2009). However, Wilson et al., (2009) states that the federal insurance program is beginning to experience challenges of insuring specialty crops with special quality traits (Wilson et al., 2009) for which there are few risk management tools available other than contracting. For insuring new or specialty crops, processor contracts are often a necessary condition (Diersen & Saleh, 2015). Little or no availability of crop insurance may limit the adoption of non-conventional oilseed crops (e.g. camelina, safflower) because farmers may not be willing to give up risk management tools inherent with growing established crops (Diersen & Saleh, 2015). The "Act of God" clause is a feature that allows farmers not to be obliged to deliver in case any situation covered by crop insurance (e.g. hail) occurs.

Because producers prefer having shorter term contracts, the coefficient for contract length is expected to be negative. Crop insurance and "Act of God" coefficients are expected to be positive because producers prefer having protection over unexpected situations. The signs for the cost share coefficient can be either positive or negative.

Producers and farm characteristics were used as independent variables in the LCM to characterize class membership. Table 2.3 displays the summary statistics along with an explanation of variables used in the LCM for each estimated latent class by USDA ERS crop production region. The "risk aversion" variable captures all farmers who believe are perceived by their neighbors as risk averse or cautious. Risk averse producers are usually less likely to adopt new technologies or practices that are perceived to increase risk (Pannell et al., 2006), making this an important independent variable to determine who would likely introduce oilseeds into a crop rotation. The independent variable "age" captures younger wheat producers; this is producers whose age ranges from 22 to 57 years old. Older producers are considered less likely to make changes in the crop rotation they already use (Fewell et al., 2016; Pannell et al., 2006). Farmers who attended college are captured by the education variable. More educated producers are more likely to decide introduce oilseed crops within their crop rotation system (Feder et al., 1985; Goodwin and Schroeder, 1994; Pannell et al., 2006). The "wheat land" variable accounts for the number of acres producers allocate to wheat production. Farmers who allocate larger number of acres to wheat are expected to be more willing to introduce oilseed crops in their rotation system to benefit from diversification. "Grow oilseeds" variable refers to the experience producers already have growing any type of oilseed crop. This is a binary variable where 1 indicates whether the producer has experience growing an oilseed crop and 0, otherwise. Farmers who already have experienced growing oilseed crops may be more willing to continue growing those or try another oilseed crop. Sales related to agricultural activities is a continuous variable that accounts for the total sales from agricultural activities. The higher the agricultural sales, the higher the likelihood a farmer may decide introduce oilseed crops to benefit from diversification.

"Work off-farm" is a binary variable where 1 represents farmers who work off farm. This type of farmers is less likely to adopt new practices because they do not fully depend on agricultural activities and may have less time to diversify into new crops. Percentage of land rented represents the amount of land farmers rent for the agricultural activity. Farmers who rent more land are less likely to adopt new practices (e.g. conservation practices), because of the investment needed. However, introducing an oilseed crop into a rotation system does not necessarily represent an investment; thus, the sign of the coefficient is more difficult to predict. The percentage of income from agricultural activities variable can help predict whether or not farmers will be willing to introduce an oilseed crop in the rotation system because the higher the dependence in agriculture, the highest the need for diversification.

Willingness-to-Pay for Crop and Contract Attributes

Farmers' willingness to pay (WTP) a premium for having specific oilseed attributes and contract features can be derived from the utility coefficients estimated in the LCM based on the following expression:

$$WTP_k = -\frac{\beta_k}{\beta_1}$$

where WTP_k is the farmer's willingness-to-pay for attribute k, β_1 is the marginal utility or estimate on the net returns attribute and β_k is the coefficient on the oilseed attributes (e.g. γ_s) and contract attributes (e.g. δ_k). Asymptotic standard errors can be estimated using the delta method (Greene, 2012).

2.6 Results

Estimation results for each LCM model estimated for each USDA ERS crop production region are provided in Table 2.2. Model fit statistics show a good fit. The McFadden's Pseudo-R^2 is 0.25, 0.28, and 0.23 for the Pacific, Prairie and Northern regions, respectively. LCM models were estimated with up to five latent classes. The model with the number of classes with the minimum Akaike Information Criterion (AIC) is chosen as the optimal fit (Hackbarth and Madlener, 2016; Zahabi et al., 2015).

2.6.1 Latent Class Assessment

Because of little variation, the individual specific variables impacting class membership used in each region were not the same. Both the Pacific and the Northern regions include age, education, risk behavior, number of acres allocated to wheat production, and experience growing oilseeds. Additionally, the LCM for the Pacific region includes the amount of sales related to agricultural activities while the Northern region includes working off farm, percentage of land rented, and percentage of the income from agricultural activities. The Prairie region includes only three variables: age, education, and risk behavior.

For all the regions, the optimal number of latent classes at which AIC was minimized was two. The estimated coefficients indicating the significant factors affecting class membership show that wheat producers from the Pacific region in class one are older, have a greater portion of land allocated to wheat production, and have lower farm sales. On average, farmers in latent class one from the Prairie region in class one are risk averse and have not earned a college degree. Farmers from the Northern Great Plains region in latent class one are risk averse, older, have attended college and have less amount of land allocated to wheat production.

Table 2.3 provides summary statistics for the explanatory factors used to estimate the latent classes for each crop production region. Summary statistics are provided for all explanatory factors even if they were not included in the LCM model (due to estimation issues) to assess and further interpret the latent classes. The LCM model assigns each farmer a probability of belonging to a specific class. For instance, when having two classes, class 1 contains farmers who show probabilities greater than 0.5 and class 2 contains farmers with probabilities less than 0.5. A t-test was conducted to determine if the differences between explanatory factors between classes 1 and 2 were significant or not.

For all regions, the majority of the farmers are assigned to class 2 (Table 2.3). The difference between the classes is significantly based on wheat land, sales, age, and risk aversion for the three regions. Additionally, education is statistically significant between classes for the Prairie region.

Compared to those from class one, farmers from the Pacific region in class two have less land allocated to wheat, which differs from the results obtained for the other two region, have more sales related to agricultural activities, are younger, have higher percentages of land rented, and are more risk averse. For the Prairie region, farmers in class two have more land allocated to wheat production, have more sales related to agricultural activities, are younger, have more percentage of land rented, work off farm, are more high educated, have experience growing oilseed crops, and are less risk averse. For the Northern region, farmers categorized in class two have more land allocated to wheat production, have more sales related to agricultural activities, are younger and less risk averse.

In general, farmers in class two are more likely to decide to introduce oilseed crops in the crop rotation because they are younger and the percentage of total sales related to agriculture is higher which means these farmers may find diversification as a way to decrease risk and increase total profits. Thus, for all regions, class one may be categorized as non-adopters and class two as adopters.

2.6.2 Crop and Contract Attributes on Oilseed Crop Adoption under Contract

Table 2.2 provides estimates of the coefficients for crop and contract attributes in the expected discounted utility function by latent class and crop production region. The estimated coefficients associated with the oilseeds attributes are as expected.

Shatter resistance is positive and statistically significant in both classes in the Prairie region and in class two from both the Pacific and the Northern region. The weather conditions of the Prairie region (e.g. hot and dry during summer) can help to increase the probabilities of shattering because high temperatures can accelerate the maturity level of the plant; therefore, it can be expected that wheat producers of both classes are interested on having this attribute in the oilseed crop. The Northern region is characterized by long and cold winters; thus, the probabilities of shattering could be lower than those from the Prairie region due to low temperatures. Regions with high humidity may have less need of shatter resistance varieties since humidity increases dampness of the pods which decreases shattering (Morgan et al., 2000).

Pest tolerance and herbicide resistance is positive and statistically significant in class two from both the Pacific and the Prairie regions and in both classes from the Northern region. Fungal diseases (e.g. Alternaria leaf spot) can cause serious losses during higher than normal rainfall seasons (Armah-Agyeman et al., 2002). Both regions, the Pacific and the Prairie are exposed to floods; thus, having varieties tolerant to pests could be very significant for those who are more likely to adopt. Winter hardiness is positive and statistically significant for class one from the Pacific region, both classes from the Prairie region, and class two from the Northern region. Farmers in the Prairie region face wide extremes of temperatures; which makes them more vulnerable to yield losses due to these extremes. Therefore, having varieties resistant to colder temperatures could be an important advantage for farmers willing to grow oilseed crops. This seed attribute may also provide farmers with the opportunity of late planting date. When using varieties which are not resistant to winter, late planting may compromise crop yield due to exposure to fall rains or fall frost (Armah-Agyeman et al., 2002).

Extended direct combine window is positive and statistically significant in both classes from the Pacific and the Northern regions. However, the coefficient for this attribute is negative and significant for farmers in class one from the Prairie region. This attribute needs crops reach maturity evenly as well as resistance to shattering. Both classes from the Prairie region reported the need of a shattering resistant attribute in the seed. Farmers from this region may not be interested in having extended direct combine window as they may prefer using swathing for harvesting the oilseeds crops to avoid shattering (or are used to or familiar with direct combining).

The significance and sign of contract features differed across crop production region, but the sign of each effect was usually as expected. Net returns are positive and significant for latent class two from the Pacific region and positive and significant for both classes from the Prairie and Northern regions. Considering that farmers are profit maximizers, these results were expected. Furthermore, according to Ali (2002) by year 1998, both regions, the Prairie Gateway and the Northern Great Plains reported the lowest gross returns per acre due to low wheat yields.

Therefore, increasing return through growing oilseeds may also explain both regions having positive and significant coefficients for this feature.

Length of contract is negative and statistically significant for all regions and classes. Farmers prefer less lengthy contracts (Fewell et al., 2016; Roe et al., 2004) because long-term contracts may reduce the ability of negotiate the conditions (e.g. delivery requirements).

Crop insurance is positive and statistically significant for class one from the Pacific region and class two from both the Prairie and the Northern regions. Because crop insurance is an important tool to manage crop risks, farmers may be more willing to adopt oilseed crops under the availability of this feature. Cost share is positive and statistically significant for class two from the Prairie region, but it is negative for class one from the Prairie region and for both classes in the Northern region. According to Ali (2002), custom harvesting and hauling for wheat production were most common in the Prairie region which may explain the result for class two. However, this region also reported having a cost advantage among all producing regions (Ali, 2002) because producers have the lowest costs per unit of expected yield. The last feature, “Act of God” clause was positive and significant for both classes from the Northern region and for class two from the Prairie region.

2.6.3 Willingness-to-pay for Crop and Contract Attributes

Farmers’ WTP estimates (Table 2.4) indicate the amount of additional net returns above wheat production a farmer would be willing to give up to produce oilseed crops with the given oilseed crop characteristics and given contract features. For all regions, respondents allocated in class two would be willing to pay up \$9.33, \$3.14, and \$4.37 of additional net returns per acre above wheat production, respectively, to produce a shatter resistant oilseed crop variable. Class one coefficients for this attribute were not significant for all regions.

Pest tolerance and herbicide resistance is another important attribute. Respondents categorized within class two reported to be willing to pay up to \$7.82, \$5.90, and \$5.03, for the Pacific, Prairie, and Northern regions, respectively. Furthermore, farmers in class one from the Prairie and Northern regions would also prefer varieties tolerant to pests. Farmers in class one from the Prairie region and in class two from the Northern region are willing to pay up to \$3.78 and \$7.10, respectively, for having a winter-hardy variety. Respondents from the Northern region prefer winter hard varieties due to the extreme weather conditions. A variety with this characteristic may help producers reduce yield losses due to frost damage.

Respondents in the Pacific region are willing to pay up to \$20.17 in class one and \$8.20 in class two to have varieties that allow combined harvesting while farmers from the Northern region are willing to pay up \$18.69 in class one and \$16.69 in class two. Only respondents in class two from the Prairie region will be willing to pay up to \$10.51 for having extended direct combine window, while farmers in class one from the same region are not willing to give up any amount of additional net return to grow a variety with this feature. These respondents were also willing to pay up \$38.18 for having a shatter resistance variable. This may indicate that class one respondents from the Prairie usually face shattering problems which does not allow combine harvesting.

For all three regions, latent class one respondents require \$16.31, \$14.28, \$20.05 per acre per additional contract year to adopt an oilseed crop contract, while respondents in class two will do so for \$6.70, \$5.19, and \$6.80, respectively. Farmers in class two were already categorized as adopters; thus, they may be willing to take more risk than those in class one. This may explain the difference between latent class one and two for this feature.

Respondents in class two for the Prairie and Northern region will be willing to give up to \$9.03 and \$11.01 of additional net return, respectively, for having crop insurance as part of the contract. Coefficients in both classes for these features from the Pacific region were not significant, while class one respondents from the Prairie region reported they are not willing to give up an additional amount of their net return for having this feature in the contract. For having a cost share feature in the contract, class two respondents from the Prairie and Northern regions are willing to pay up to $0.08 and $0.25.. Both class respondents from the Northern region and class one respondents from the Prairie region reported the need of an “Act of God” clause. These respondents will be willing to pay up to $20.38, $23.36, and $10.53, respectively, for having this clause in the oilseeds crop contract.

2.7 Conclusions

Oilseeds have a great potential to help reduce the U.S. dependence on non-renewable sources of energy and reduce GHG emissions. Farmers from 11 states were surveyed to assess their willingness to incorporate oilseeds into their crop rotation systems under alternative oilseed characteristics and contract scenarios. A set of latent class multinomial models were estimated to examine differences across farmer types and USDA ERS crop production regions.

For all the regions, the optimal number of latent classes was two. The estimated coefficients affecting class membership indicate that wheat producers from the Pacific region in class one are older, have a greater portion of land allocated to wheat production, and have lower farm sales, while farmers in the same class from the Prairie region in class one are risk averse and have not earned a college degree. Farmers from the Northern Great Plains region in class one are risk averse, older, have attended college and have less amount of land allocated to wheat production.

Results indicate that providing oilseeds with desired characteristics would positively affect farmers' decisions to incorporate oilseed crops into their rotation system. The desire of having these seed attributes may be primarily influenced by weather conditions in each region. Farmers in both classes from the Prairie region prefer shatter resistant varieties while only farmers in class two from both the Pacific and the Northern region prefer them. Pest tolerance and herbicide resistance positively affects class two from both the Pacific and the Prairie regions and in both classes from the Northern region. Winter hardiness is positive and statistically significant for class one from the Pacific region, both classes from the Prairie region, and class two from the Northern region. Extended direct combine window is positive and statistically significant in and negative for farmers in class one from the Prairie region.

Attractive contract features will positively affect farmers' decisions, as well. Net returns are positive and significant for latent class two from the Pacific region and positive and significant for both classes from the Prairie and Northern regions. For all regions, farmers showed preference for shorter-term contracts which providing them with more flexibility to negotiate contract conditions because long-term contracts may reduce the ability of negotiate the conditions (e.g. delivery requirements). Crop insurance is positive and statistically significant for class one from the Pacific region and class two from both the Prairie and the Northern regions. Cost share is positive and statistically significant for class two from the Prairie region, but it is negative for class one from the Prairie region and for both classes in the Northern region. "Act of God" clause was positive and significant for both classes from the Northern region and for class two from the Prairie region.

WTP estimates indicate that length of contract is the most important attribute in determining if a farmer will incorporate oilseed crops into the crop rotation. From the willingness-to-pay estimates it can be concluded that, for all regions, respondents allocated in class two would be willing to pay to produce a shatter resistant, and pest tolerant and herbicide resistant oilseed crop variety. Farmers in class one from the Prairie and Northern regions would also prefer varieties tolerant to pests. Farmers in class one from the Prairie region and in class two from the Northern region prefer having winter-hardy varieties. Respondents in both classes from the Pacific and Northern regions and in class two from the Prairie region prefer varieties that allow combined harvesting. Farmers in class one from the Prairie region will need compensation to accept this feature. For all three regions, class one will need a compensation for additional contract year to adopt an oilseed crop contract. Respondents in class two for the Prairie and Northern region prefer having crop insurance as part of the contract, while class one respondents from the Prairie region will need compensation to accept having crop insurance in the contract. Both class respondents from the Northern region and class one respondents from the Prairie region reported the need of an “Act of God” clause.

Because many of the oilseeds proposed to introduce in the farmers’ crop rotation are non-conventional, contracts are not well established yet and/or do not have a crop insurance feature or availability. Therefore, further research could be focus on determining how farmers’ risk attitude affects their willingness to adopt oilseed crops and how to build crop insurance for such specialty crops.

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Tables

Table 2.1 Comparison of select demographics between USDA, Economic Research Service Crop Regions and survey respondents

	Pacific Northwest		**Prairie Gateway**		**Northern Great Plains**	
	2007 Census of Agriculture	Survey	2007 Census of Agriculture	Survey	2007 Census of Agriculture	Survey
White (%)	93.00%	95.00%	98.00%	97.00%	98.00%	97.00%
Age	57.03	57.85	56.40	59.71	54.14	57.23
Male (%)	92.00%	92.00%	95.00%	95.00%	97.00%	95.00%
Total sales from crop production	80.00%	96.00%	65.00%	78.00%	74.00%	88.00%

Table 2.2 Estimation results for latent class logistic regression models by USDA Economic Research Service crop production region

Attributes	**Pacific Northwest**		**Prairie Gateway**		**Northern Great Plains**	
	Non-adopt	**Adopt**	**Non-adopt**	**Adopt**	**Non-adopt**	**Adopt**
Net returns	0.078	0.054 ***	0.456 *	0.077 ***	0.036 *	0.055 ***
	(0.062)	(0.017)	(0.268)	(0.007)	(0.021)	(0.010)
Shatter resistance	0.304	0.251 ***	8.697 *	0.121 **	0.185	0.120 *
	(0.362)	(0.084)	(4.468)	(0.053)	(0.136)	(0.072)
Pest tolerance and resistance	0.331	0.210 **	1.485	0.227 ***	0.367 **	0.138 *
	(0.4)	(0.088)	(1.020)	(0.053)	(0.152)	(0.074)
Winter hardiness	1.350 ***	0.020	8.640 **	0.145 ***	-0.117	0.195 ***
	(0.426)	(0.086)	(4.398)	(0.051)	(0.120)	(0.072)
Extended direct combine window	0.785 **	0.220 ***	-3.686 *	0.404 ***	0.334 **	0.457 ***
	(0.361)	(0.083)	(2.221)	(0.051)	(0.138)	(0.073)
Length of contract	-1.269 ***	-0.360 ***	-6.507 **	-0.399 ***	-0.717 ***	-0.373 ***
	(0.325)	(0.057)	(2.612)	(0.035)	(0.115)	(0.049)
Crop insurance	1.642 ***	0.106	-1.677	0.347 ***	0.159	0.302 ***
	(0.494)	(0.070)	(1.373)	(0.052)	(0.137)	(0.072)
Cost share	-0.017	-0.005	-0.996 *	0.006 *	-0.029 ***	0.014 ***
	(0.020)	(0.006)	(0.529)	(0.004)	(0.010)	(0.005)
Act of God	0.205	0.106	-0.336	0.405 ***	0.364 **	0.640 ***
	(0.326)	(0.087)	(0.828)	(0.051)	(0.145)	(0.071)
Class Probability						
Constant	3.703 *		-0.675 ***		-1.802	
	(2.037)		(0.208)		(1.559)	
Risk aversion (Risk averse & Cautious = 1)	-1.882		1.718 ***		6.071 **	
	(1.214)		(0.284)		(2.537)	
Age (22-57 = 1)	-4.370 **		0.006		-2.647 **	
	(2.111)		(0.009)		(1.140)	
Education (College = 1)	0.553		-0.849 ***		2.734 *	
	(1.101)		(0.269)		(1.490)	
Wheat land (acres)	0.002 *				-0.002 **	
	(0.001)				(0.001)	
Experience growing oilseeds (Yes = 1)	0.001				-0.073	
	(0.378)				(1.019)	
Sales related to ag activities	-1.172 **					
	(0.587)					
Work off-farm (Yes = 1)					-0.018	
					(0.658)	
% of land rented					0.029	
					(0.020)	
% of income from ag activities					0.002	
					(0.004)	
Model fit statistics						
Number of respondents		142		404		268
Number of respondents/class	48	94	164	240	124	144
Number of observations		568		1616		1072

Restricted log likelihood	-294.94	-805.07	-572.12
McFadden Pseudo R^2	0.25	0.28	0.23
AIC	1.127	1.024	1.118

Note: Asymptotic standard errors are reported in parentheses under each coefficient estimate. *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.

Table 2.3 Descriptive statistics by latent class for all regions

Variable	**Pacific Northwest**				**Prairie Gateway**				**Northern Great Plains**			
	Mean (Standard Error)		**Difference^{a}**		**Mean (Standard Error)**		**Difference**		**Mean (Standard Error)**		**Difference**	
	Non-adopt	**Adopt**			**Non-adopt**	**Adopt**			**Non-adopt**	**Adopt**		
	N= 48	**N= 94**			**N= 164**	**N= 240**			**N= 124**	**N= 144**		
Wheat land	1246.80	851.66	395.14	**	554.96	734.27	-179.31	***	1113.48	1887.70	-774.22	***
	(165.02)	(88.33)	(170.71)		(36.69)	(47.27)	(64.74171)		(91.75)	(151.20)	(183.09)	
Sales	528,260.00	1,015,426.00	-487,164.70	***	390,993.80	678,829.80	-287,836.00	***	503,384.10	918,664.2	-415,280.40	***
	(82274.46)	(85410.60)	(135091.70)		(49570.43)	(49376.51)	(72408.37)		(54553.88)	(70969.32)	(91459.00)	
Age	65.93	53.57	12.36	***	63.36	55.76	7.60	***	60.04	53.94	6.11	***
	(1.46)	(1.09)	(1.87)		(0.95)	(0.72)	(1.17)		(1.00)	(0.95)	(1.38)	
% of income from ag activities	84.70	83.08	1.62		70.82	74.86	-4.03		75.00	74.61	0.39	
	(3.13)	(2.33)	(3.96)		(2.58)	(3.55)	(4.84)		(2.81)	(2.72)	(3.93)	
% of land rented	49.50	65.53	-16.03	**	45.87	57.44	-11.57	***	45.01	47.05	-2.03	
	(5.46)	(3.63)	(6.41)		(3.02)	(2.09)	(3.55)		(3.08)	(2.66)	(4.05)	
Work off-farm	0.37	0.45	-0.08		0.42	0.58	-0.17	***	0.50	0.49	0.01	
	(0.07)	(0.05)	(0.09)		(0.04)	(0.03)	(0.05)		(0.46)	(0.04)	(0.06)	
Education	0.76	0.67	0.09		0.43	0.64	-0.21	***	0.63	0.54	-0.02	
	(0.06)	(0.05)	(0.08)		(0.04)	(0.03)	(0.05)		(0.04)	(0.04)	(0.06)	
Gender	0.93	0.99	-0.05	*	0.94	0.99	-0.05	***	0.04	0.06	-0.02	
	(0.08)	(0.04)	(0.01)		(0.05)	(0.02)	(0.01)		(0.02)	(0.02)	(0.03)	
Experience growing oilseed	0.10	0.17	-0.07		0.30	0.56	-0.26	***	75.01	74.62	0.39	
	(0.05)	(0.04)	(0.06)		(0.04)	(0.03)	(0.05)		(2.81)	(2.72)	(3.93)	
Risk aversion	0.10	0.23	-0.13	*	0.47	0.15	0.32	***	0.06	0.01	0.06	***
	(0.05)	(0.04)	(0.07)		(0.04)	(0.02)	(0.04)		(0.02)	(0.01)	(0.02)	

Note: *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.
a. Difference was estimated using a t-test

Table 2.4 Farmers' willingness to pay estimates

Attribute	**Pacific Northwest**		**Prairie Gateway**		**Northern Great Plains**	
	LC1	**LC2**	**LC1**	**LC2**	**LC1**	**LC2**
Shatter resistance	-7.807	-9.335 **	-38.184	-3.137 **	-10.343	-4.369 *
	(10.245)	(4.060)	(27.659)	(1.391)	(8.174)	(2.661)
Pest tolerance and resistance	-8.517	-7.819 **	-6.518 *	-5.899 ***	-20.556 *	-5.034 *
	(9.313)	(3.800)	(3.599)	(1.438)	(11.038)	(2.695)
Winter hardiness	-34.702	-0.734	-37.933	-3.782 ***	6.559	-7.102 **
	(22.783)	(3.220)	(27.114)	(1.379)	(8.152)	(2.713)
Extended direct combine window	-20.171 *	-8.196 **	16.185 **	-10.511 ***	-18.692 *	-16.687 ***
	(12.124)	(3.897)	(7.445)	(1.595)	(11.366)	(3.448)
Length of contract	16.312 **	6.702 ***	14.284 ***	5.192 ***	20.047 **	6.796 ***
	(6.948)	(2.178)	(4.234)	(0.645)	(9.533)	(0.977)
Crop insurance	-42.205	-3.959	7.361 **	-9.025 ***	-8.915	-11.007 ***
	(30.194)	(3.393)	(3.661)	(1.547)	(8.430)	(2.855)
Cost share	0.224	0.101	2.187 ***	-0.080 *	0.808 **	-0.251 ***
	(0.217)	(0.112)	(0.230)	(0.0410)	(0.336)	(0.071)
Act of God	-5.279	-3.935	1.477	-10.531 ***	-20.376 *	-23.362 ***
	(8.513)	(3.350)	(3.604)	(1.569)	(11.763)	(4.639)

Note: Asymptotic standard errors are reported in parentheses under each coefficient estimate. *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level **of significance.

Figure 2.1 Stated choice experiment - Example

	Characteristics	**Description**	**Scenario**			
			1	**2**	**3**	**4**
Oilseed Characteristics	Shatter resistance	The oilseed has improved shatter resistance	No	Yes	Yes	Yes
	Pest tolerance and resistance	Varieties have traits that provide herbicide and insect resistance	No	No	Yes	No
	Winter hardiness	Winter varieties are more resistant to winter weather	No	Yes	No	Yes
	Extended direct combine window	Oilseed has an extended window to direct combine and not swath	No	No	No	Yes
Contract Features	Net returns	Expect percent gain above the net returns for producing an acre of wheat	25%	5%	25%	5%
	Length of contract	The time commitment in consecutive years of the contract	1 Year	3 Years	1 Year	1 Year
	Crop insurance	Crop insurance is available in the market for this crop	Yes	Yes	No	No
	Cost share	Biorefinery or processor agrees to cover a percentage of the input costs	30%	15%	15%	30%
	"Act of God"	The contract includes an "Act of God" clause	Yes	No	No	Yes
	I would probably be willing to grow an oilseed crop under contract for this scenario		1=Yes 2=No	1=Yes 2=No	1=Yes 2=No	1=Yes 2=No

Chapter 3 - Impact of participation in farmers' adoption of soil management and fertilization practices in Thailand and Vietnam

3.1 Introduction

International cooperation programs aim to disseminate agricultural technologies and practices to small-scale farmers coping with a lack of technology, economic resources, agricultural policies, and environmental adversities. Before the 1970's, conventional methodologies were widely used by these programs. These conventional methodologies used research and extension processes where decisions were made by scientists, without taking farmers' points of views or considerations directly into account, limiting their effectiveness and adoption of new technologies. In response, participatory research (PR) approaches were developed. These approaches integrate farmers' opinions and representation with researchers' knowledge during the research, development and dissemination phases for new technologies (Lilja and Ashby, 2001).

Studies have documented that, compared to conventional approaches, PR approaches increase adoption rates of new technologies by farmers (Ashby and Lilja, 2004; Bellon, 2001; Roothaert et al., 2005). PR approaches increase the efficiency of the diffusion process of new technologies (Godtland et al., 2003; Kaaria et al., 2005; Paris et al., 2008); are more cost effective to end-users as transactions costs are reduced (Figueroa and Valdivia, 2008; Ortiz et al., 2008); increases farmer productivity (Monyo et al., 2001; Weltzien et al., 2001); and helps to improve farm income (Figueroa and Valdivia, 2008; Mansuri and Rao, 2003). In addition, PR approaches improve institutions' cost-benefit ratios (Björkman and Svensson, 2007; Ceccarelli et al., 2001; Feder et al., 2004a); build farmers' capacity to make better decisions, (Figueroa and Valdivia, 2008; Friis-Hansen, 2005; Hellin et al., 2008); empowers people, builds social capital, and strengthens governance (Friis-Hansen, 2005; Mansuri and Rao, 2003); facilitates farmers' learning (Horton, 2008); enhances research, extension and development process efficiency (Hellin et al., 2008; Mansuri and Rao, 2003; Paris et al., 2008); improves farmers' knowledge (Reed, 2008); and promotes genetic diversity (Bellon and Morris, 2002; Smale et al., 2003). This approach decreases the distance between research and the target environment, as the PR approach allows on-farm research under real conditions as opposed to conventional on-station research and experimentation that is done under more ideal conditions (Bellon and Morris, 2002; Ceccarelli et al., 2001; Reed, 2008).

In contrast, Rola et al. (2002), Feder et al. (2004b) and Mauceri et al. (2007) find that there are no significant differences in knowledge between participants who were involved in participatory extension programs to introduce integrated pest management practices and those who did not, rejecting the hypothesis of knowledge gains and rates of dissemination of technologies for farmer participants. These discrepancies in research findings, as well as the concern about higher costs of implementing participatory programs, emphasizes the need for more evidence of PR's role and impact on international cooperation programs' aims. Johnson et al. (2003) affirm that there is a lack of impact and cost analysis about using PR over conventional approaches. Findings about impacts of the PR approach may help to redefine the use of this approach as part of existing extension programs, potentially helping to provide the additional benefits previously mentioned.

3.2 Objective

Using data from a cassava project in Thailand and Vietnam, the purpose of this study is to analyze whether or not participation in training activities affects the decision of farmers to adopt new technologies. Specifically, this study aims to: 1) determine households and social characteristics that affect Thailand and Vietnam farmers' decision to participate in a cassava project where technologies were transferred using participatory methodologies: field days, on-farm trial, and/or farmers' field schools; and 2) find the determinants of farmer's adoption of soil management and fertilization practices. This study analyzes participation using a Logit Model corrected for self-selectivity since farmers are exposed to the decision of whether or not to participate. Adoption of new agricultural practices is a multi-choice decision. Thus, a multinomial logit model is used to analyze farmers' choice of adopting different bundles of the different practices assessed.

3.3 Background Information

3.3.1 Role of agricultural technology on agricultural growth, poverty reduction and income improvement

Economic growth, poverty alleviation, and environmental sustainability are three critical issues in economic development theory that need to be understood in order to develop strategies that ultimately help individuals escape poverty traps (Bravo-Ureta, et al., 2010; Mendola, 2007). Consequently, governments, international donors, and multilateral banks have implemented programs to improve the income of rural areas in developing countries (Bravo-Ureta, et al., 2010). According to the World Bank (2008), 75% of the people who live with less than a-dollar-a-day, live in rural areas. The majority of them are employed or self-employed in agriculture, which explains the close relationship between agricultural growth, rural development, and poverty reduction (Minten & Barrett, 2008). Agricultural growth is widely considered as the most effective means to address poverty in developing countries (Dadi et al., 2004; Feder et al., 1985; Kassie et al., 2011; Mendola, 2007; Simtowe et al., 2012). Mendola (2007) suggests that development programs should pay more attention and allocate more resources to the development of agriculture in those countries.

Some small-scale farmers in developing countries grow their crops primarily on marginal lands, which have limited agricultural potential because they are usually located in hillside and dryland areas. These conditions make this type of land more susceptible to soil degradation, erosion, and low soil fertility. Consequently, farmers are more likely to experience decreased crop productivity (Wollni et al., 2010). Thus, agricultural productivity is an important challenge that needs to be addressed (Kassie et al., 2011; Simtowe et al., 2012), in order to meet the demand of growing populations; changes in preferences and quality of life (Noltze et al., 2013); and to improve the livelihoods of farmers through income growth (Wollni et al., 2010).

The role of research and adoption of technological improvements are crucial to increase agricultural productiviy (Feder et al., 1985; Kassie et al., 2011). According to Becerril and Abdulai (2010), productivity-improving technologies help reduce poverty through direct and indirect effects. The most important direct effect is higher farm incomes, resulting in higher productivity and lower production costs for farmers who adopt new technologies (Kassie et al., 2011). Indirect effects result from lower food prices for consumers due to an outward shift in the supply curve for crops with more efficient technology and lower production costs (Kassie et al., 2011), as well as higher demand for on-farm labor (Becerril and Abdulai, 2010).

3.3.2 Challenges for adoption of new agricultural technologies

Farmers' adoption of new agricultural technologies is essential to achieve economic growth in developing countries where a significant amount of resources have been allocated to provide technical assistance and education to agricultural producers (Feder et al., 1985; Nkonya et al., 1997). The introduction of many new technologies has not always met with success (Feder et al., 1985). Studies show that there are many factors that influence farmers' adoption decisions and help explain heterogeneity and differences among farmers to help further explain their adoption behavior. Understanding these factors may help improve rates of adoption and facilitate the diffusion of new technologies.

According to Kaliba et al. (1997), factors that determine farmers' adoption decisions are divided into three major categories: 1) farm and farmers' characteristics; 2) technology attributes, and 3) farming objective. The first category refers to farmers' age, education, attitudes towards the type of technology being considered (e.g. conservation attitude); and physical characteristics of the land such as slope, farm tenure arrangements, fertility, permeability, or water holding capacity (Abdulai and Huffman, 2014; Asafu Adjaye, 2008; Feder, et al., 1985). The second and third characteristics refer to the type of technology being offered and how well that technology addresses the needs of the farmers (Kaliba et al., 1997).

Kassie et al. (2015) find risk is an important factor that determines adoption. They state that empirical evidence indicates that farmers exhibit decreasing absolute risk aversion, implying that farmers are averse to downside risk, especially to unexpectedly low yields. Soule et al. (2000) affirms that non-economic factors (e.g. local water quality problems) also plays an important role in determining whether or not farmers will adopt a new technology. According to Abdulai & Huffman (2014), low rates of adoption can be explained by constraints such as lack of credit, information barriers, risk aversion, and environmental and institutional factors. For instance, if the technology is labor intensive, farmers facing labor or liquidity constraints may decide not to adopt the technology. Nkonya et al. (1997) suggest that the efficacy of development programs depends on how extension educators and technical assistants involved in agricultural development understand and address the factors that affect technology adoption. Furthermore, the effective involvement of farmers can help determine appropriate criteria for cropping-system valuation; farmers' needs and preferences; improved methods of dissemination and extension; and feedback (Adebayo and Oladele, 2013).

3.3.3 Participatory methodologies

Small-scale farmers are challenged to quickly respond to an environment of high competitiveness, rapid urbanization and market integration. They need to learn production and market strategies that allow them to maximize profits while providing consistent quality and quantity of their produce to the market (Devaux et al., 2007; Horton, 2008). In addition, each community presents unique physical and human characteristic (e.g., groups of farmers, soil characteristics). For instance, in the dry areas of Africa, the need could be to find a drought resistant variety of barley (Ceccareli et al., 2001), while in the high hills of Honduras, the main concern could be to find new technologies to prevent soil erosion (Johnson et al., 2003). Hence, integrating farmers in agricultural research can help assure that new technologies are obtained to meet farmers' local needs, to ultimately accelerate the development process.

In order to expose farmers to an active, efficient and specific learning process to assure adoption of new technologies, a number of PR approaches have been developed that are tailored to the field or problem of concerns and the target audience. Alternative PR approaches, include:

3.3.3.1 Farmers Field Schools (FFS)

This is a group-based learning process, initially developed to promote Integrated Pest Management (IPM). The main focus is promoting learning by discovery, which includes hands-on training activities such as zoos and the use of field experiments to compare IPM strategies with farmer's practices (Ortiz et al., 2004).

3.3.3.2 On-farm trials

On-farm research is an approach designed to provide more confidence in current management practice or to help identify whether or not the technology needs any change (Ketterings et al., 2012).

3.3.3.3 Field Days

A less participatory methodology used to transfer new technologies to farmers is field days which have been designed to introduce growers and agricultural professionals to new technologies and techniques (Heiniger et al., 2002). Farmers would come together to share details of on-farm research and demonstration of how those technologies are used and applied, as well as learn from each other (Ketterings, et al., 2012).

3.3.4 Soil agricultural and fertilization management practices and cassava production

To keep pace with food demand for growing populations and limited arable land, use of continuous cropping systems is a common practice in many areas (Asafu Adjaye, 2008; Baidu-Forson, 1999; Teklewold et al., 2013). However, this system has led to loss of soil fertility, salinization, lower water quality, watershed degradation and other forms of land degradation, resulting in reduced agricultural productivity (Khanna, 2001; Noltze et al., 2012; Solís et al., 2007; Teklewold et al., 2013; Willy & Holm-Müller, 2013). Wollni, et al. (2010) reports that approximately 54% of total agricultural land worldwide is located in dryland and hilly areas. This situation not only makes these lands more susceptible to land degradation, desertification and crop yield decline, but also increases crop production costs in the long run (Willy & Holm-Müller, 2013). Consequently, more conservation agricultural technologies and practices are needed in order to increase agricultural productivity without compromising the sustainability of crop production (Baidu-Forson, 1999; Noltze, et al., 2013).

Extension services have often focused on increasing crop yields; however, not enough attention has been paid to maintain the natural resource base (Wollni, et al., 2010). The use of land-enhancing tecnologies and agricultural practices can help improve soil quality, soil water holding capacity, and control of diseases and pests (Baidu-Forson, 1999; Kassie, et al., 2015) by reducing the impact conventional farming has on the environment (Adebayo and Oladele, 2013). Soil conservation and fertilization management practices have been proposed to improve the efficiency of cropping systems in a sustainable way. These practices respond to the challenges farmers face in different environments (Noltze et al., 2013).

Cassava production is important in Vietnam and Thailand and is primarily produced under smallholder farming systems. The International Center for Tropical Agriculture (CIAT in Spanish) conducted a project from 1994 to 2003 that aimed to control erosion and maintain soil fertility in cassava-based systems in Vietnam and Thailand (Agrifood Consulting International, 2004). The CIAT cassava project introduced five conservation practices: chemical fertilization, contour ridging, hedgerows, intercropping, and manure use. The expectation is that cassava farmers who adopt these practices, can help to mitigate the negative impacts of soil degradation on crop yields and environment by improving soil quality. Details about the specific practices are given below.

3.3.4.1 Chemical fertilization

This type of fertilization refers to the conventional use of mineral fertilizers to improve crop yields. These types of fertilizers are usually costly, compared to the use of manure; however, the release of nutrients is faster than that when using organic manure (Riley, 2016).

3.3.4.2 Contour ridging

This is an effective tillage practice for controlling soil erosion and increasing crop yield (Liu et al., 2015) by reducing run-off (Juan et al., 2015). This tillage management approach is widely used throughout the world especially in arid and semi-arid regions and on sloping land (Juan et al., 2015).

3.3.4.3 Farm yard manure

This practice consists of applying manure (organic matter) to the field to enhance plant growth (Senkondo et al., 2014). Adding organic matter in the soil improves soil properties (Senkondo et al., 2014), and increases soil organic carbon (Riley, 2016).

3.3.4.4 Hedgerows

Hedgerows are linear plantings or remnants of shrub or low tree species, which run along edges of agricultural fields (Wilkerson 2014). They can help prevent or reduce soil erosion, provide or support ecosystem services and native species habitat, and may also enhance landscape connectivity for native species (Marshall and Moonen, 2002). If managed appropriately, hedgerows can function as barriers to plant invasion (Wilkerson, 2014)

3.3.4.5 Intercropping

This is a cropping pattern in which two or more crops are being grown simultaneously in the same field during the same growing season (Anil et al., 1998; Fan et al., 2016). Anil et al. (1998)

describes four types of intercropping: mixed, row, strip, and relay. Different from row intercropping, on which at least one crop is arranged in rows, the mixed system does not have row arrangements. Under the strip intercropping system, two or more crops are being grown in different strips. Strips need to allow independent cultivation and interaction among crops. Relay intercropping is the only system in which crops are not necessarily grown in the same season. Under this system, two or more crops are grown in relay, but with the growth cycles overlapping to some degree. Stoltz and Nadeau (2014) determine that a maize-faba bean intercropping system results in higher protein content and lower residual soil mineral nitrogen after harvest compared to mono-cropped maize.

The intercropping system has many advantages over mono-cropping. Latati et al. (2016) associates an increase in biomas and grain yield with higher levels of nitrogen fixation ability provided by beans when using a bean-maize intercropping system. Hu et al. (2016) suggest that the strip intercropping maize-wheat system combined with conservation tillage and straw mulching can significantly increase yields, improve the use efficiency of limited water resources in arid areas, and lower carbon emission from farming. Anil et al. (1998) states that the use of energy-rich and protein-rich forage systems (e.g. maize-soybean) may lead to higher protein value rations to feed animals, making feed costs lower.

3.4 Data

Data were collected during the execution of the CIAT Cassava Project in Vietnam and Thailand. This project aimed to test and develop soil conservation practices using farmer participatory research (FPR) methodologies in order to improve soil fertility and reduce erosion in cassava fields in Vietnam and Thailand. Starting in 1994, the cassava project was funded by the Nippon Foundation in Tokyo, Japan.

According to Agrifood Consulting International (2004), a participatory rapid rural appraisal (PRRA) team collected data through a face-to-face interview from eight sub-districts / communes in Thailand and Vietnam through semi-structured face-to-face interviews and questionnaires with sub-district and commune level representatives and PRRA focus groups with groups of farmers. This information was provided from 393 and 439 farmers from Vietnam and Thailand, respectively; which makes a total of 832 farmers interviewed. Furthermore, baseline data were gathered before the CIAT program started.

Data contains variables including household characteristics such as gender, age, family composition, asset ownership, land holding, animal composition, and land/crop distribution. There is also information on adoption of soil conservation and fertilization management practices as well as the type of participatory activity in which a farmer decided to participate. Descriptive statistics for select variables are presented in Table 3.1.

The CIAT Cassava Project PR-based program offered farmers three types of training for the proposed soil conservation and fertilization management practices: field days, farmers' field schools, and on-farm trials. The CIAT project focused on use and adoption of the following soil conservation and fertilization management practices (SCFMP) by farmers: intercropping, hedgerows, farm yard manure, chemical fertilizer use, and contour ridging. In order to facilitate data analysis, SCFMP were grouped in three categories: 1) biological, 2) fertilization, and 3) contour ridging. The biological category refers to intercropping and hedgerows practices; farm yard manure and chemical fertilizer belong to the fertilization category, and the third one refers to contour ridging.

3.5 Conceptual Framework

Farmers are exposed to a sequence of decisions in the CIAT project, which can be viewed in stages. In the first stage, farmers have to decide whether or not to participate in training activities and how many to participate in. Farmers will participate in training activities if the utility obtained from doing so is greater than the utility from not participating. That is:

$$U_{i,a} > U_{i,b} \tag{1}$$

where: $U_{i,j} = x_i \beta_j + \varepsilon_{i,j}$ for $j = a$ (participate), b (not participate) and U_{ij} is the utility of farmer i who decides to participate and x_i are the exogenous variables which affect farmers' decision.

Since farmers are exposed to a set of soil conservation and fertilization management practices, they can adopt a bundle of practices that include all or any subset of the soil conservation and management practices offered. Thus, the adoption decision must take this into account because if, for estimation purposes, each adoption decision is treated independently, then valuable economic information may be lost (Cooper, 2003). A joint adoption framework provides a more accurate measure of the effect of factors determining farmers' adoption decisions, as well as being able to capture the total effect of adopting more than one alternative (Bergtold and Molnar, 2010; Birungi and Hassan, 2010; Wu and Babcock, 1998).

The second stage of the model, then takes into account the joint adoption framework, conditional on if the farmer participated in training. It is assumed that farmers will choose to adopt a bundle of practices when training has occurred. Thus, the stages are viewed as simultaneous. Conditional on training, a farmer will choose to adopt one or a combination of SCFMP as a bundle as long as the utility obtained when doing so is higher than that obtained from adopting any other bundle of SCFMP. That is (Birungi and Hassan, 2010):

$$U_{ik} > U_{il};\ \forall\ k \neq l$$

where $U_{ik} = x_i\beta_k + \varepsilon_{ik}$ is the utility of farmer *i* who decides to adopt the k^{th} bundle of management practices, *l* represents any other bundle of management practices, and x_i are a set of exogenous variables which affect the farmer's decision to adopt.

3.6 Empirical Model

The proposed conceptual framework gives rise to a two stage model. The first stage of the model examines if a farmer will participate in one of the training activities or not, which is based on their utility. The utility is assumed to be a function of exogenous variables. Empirically this model is given as:

$$Bipart_i = \beta_0 + \beta_1 Gender_i + \beta_2 Nadult_i + \beta_3 Ownership_i + \beta_4 Yield_i + \varepsilon_i, \qquad (1)$$

where $Bipart = \begin{cases} 1\text{, if farmer } i \text{ participates in training} \\ 0\text{, otherwise} \end{cases}$, ε_i is a zero mean IID error term, and the variables are defined in Table 3.1. Assuming that ε_i is distributed extreme value Type 1, the empirical model given by (1) can be estimated as a standard logit model.

For the first stage a binary variable of participation was created where '1' indicates whether farmers participated in at least one of the training activities and '0', otherwise. Gender, number of adults in household, asset ownership, and cassava yield are expected to explain the probability of farmers to participate in training activities. Asset ownership is a continuous variable representing the number of assets a farmer owns. It explains farmers' willingness to invest. The yield variable is a continuous variable that represents the cassava yield produced before the CIAT program started. Both variables are expected to have a positive impact on participation in training since farmers who are willing invest may be more willing to learn about their investments prior to making the investment. Those who produce more cassava may be eager to learn new practices to enhance their production levels.

The second stage of the model assesses a farmer's adoption decision given participation in training. A farmer can choose to adopt a number of different bundles of practices amongst the SCFMP. Given the reduced classification of practice proposed in the data section, these include: F= Fertilization only, B = Biological only C = Contour Ridging only, BF = Biological and Fertilization only, CF = Contour Ridging and Fertilization, BC = Biological and Contour Ridging, and BCF = Biological, Contour Ridging and Fertilization. The utility from adopting a given bundles is a function of explanatory factors and is empirically given by:

$$Madopt_{i,k} = \alpha_{0,k} + \alpha_{1,k}Country_i + \alpha_{2,k}\hat{B}ipart_i + \alpha_{3,k}Nadult_i + \alpha_{4,k}Land_i + \alpha_{5,k}FishPond_i + \alpha_{6,k}TLU_i + \alpha_{7,k}Slope_i + \alpha_{8,k}Poverty_i + \alpha_{9,k}StarchFactory_i + \varepsilon_{i,k} \qquad (2)$$

where $Madopt_{i,k}$ is a binary variable equal to 1 if the farmer adopts bundle k (e.g. F, B, C, BF, CF, BC, BCF, or none), $\varepsilon_{i,k}$ is a zero mean IID error term, and the set of explanatory variables is described in Table 3.1. Given that $Madopt$ can be made into a polychotmous index of the bundles of SCFMP and assuming the error terms are distributed extreme value for all *k*, the model given by equation (2) can be estimated as a multinomial logistic regression model.

For the second stage, a multinomial adoption variable was created. SCFMP were grouped in three categories: 1) 'biological' referring to intercropping and hedgerows practices; 2) farm yard manure and chemical fertilizer belong to ‘fertilization’ category, and 3) contour ridging which is a dummy variable, where ‘1’ indicates whether the farmer adopted the practice and ‘0’ otherwise. The three groups are modeled jointly. Seven different conservation practices were identified; however, the ‘biological only’ (B), ‘contour ridging only’ (C) and ‘contour ridging and biological’ (CB) were dropped and the associated probabilities of adoption assumed to be equal to zero, given not enough observations were provided in the dataset to identify the parameter estimates (α) for equation (2) for these categories.

For the explanatory factors explaining adoption, ‘Fish pond’ is a dummy variable equal to ‘1’ if farmers produce fish on their farms and ‘0’, otherwise. The tropical livestock unit (TLU) is a continuous variable used to describe livestock numbers of various species as a common unit that is generated using exchange ratios (Jahnke, 1982). Therefore, it captures the total quantity of livestock farmers possess. In this case, TLU = cattle*1.12+ buffalo*1.7+ goat*0.1+ pig*0.1+ poultry*0.008 (Dalton et al., 2007). It is hypothesized that farmers who produce fish are more skilled than those who do not. Farmers who have more livestock will have manure and may show interested in learning how to use manure. Thus, both variables are expected to have a positive effect on adoption of SCFMP.

The ordered variable ‘slope’ is used to represent land characteristics; in this case, ‘0’ refers to flat terrains, ‘1’ to the undulating, and ‘2’ to the hilly ones. Poverty is an ordered variable where ‘0’ refers to poor farmers, ‘1’ to those on the average, and ‘2’ to the ones who are better-off. Finally, starch factory is a dummy variable where ‘1’ indicates the presence of a cassava starch factory close to the village and ‘0’, otherwise. Higher levels of slope and poverty are expected to have positive effects on adoption of SCFMP. Farmers producing in more adverse conditions (e.g. hilly land) may find more benefits of using hedgerows or contour ridging than those producing under lower levels of adversity (e.g. flat terrain). Furthermore, better-off farmers may be more likely to invest in new practices and to include fertilizers in their cassava production.

Country is a dummy variable equal to ‘1’ for farmers from Thailand and ‘0’ for those from Vietnam. Land is a continuous variable which indicates the amount of land farmers dedicate to cassava production. Finally, to model the simultaneity between participation in training in stage one and adoption of a bundle of SCFMP, the fitted probability, $\hat{B}ipart_i$, is used to model the impact of training following Dalton et al. (2011).

3.7 Results

Results are presented by stage and shown in Tables 3.2 to 3.5.

3.7.1 Stage One: Participation in Training

Model estimates for the logit model estimating the probability of a farmer participating in training are provided in Table 3.2. Associated marginal effects are presented in Table 3.3 with asymptotic standard errors calculated following the delta method (Greene 2007). The asset ownership and the cassava production variables were the only two statistically significant explanatory variables impacting the probability of farmers to participate in at least one of the activities offered. At a 10% level of significance, if farmers increase their asset ownership by one level, it will result in 5% increase in the probability of participation. An increase of one unit in cassava yield will increase the probability of participating in training by 1.2%. These results support the hypothesis of better off farmers or ones willing to invest will tend to participate more in extension activities, including training. Johnson et al. (2003) asserts that participation is voluntary; however, it takes time which means which means that the poorest may not be able to afford it. Furthermore, many participatory methodologies could require some investment. Tripp et al. (2005) reported that poorer farmers were excluded from a farmers' field school program in Zanzibar due to their "little physical and financial buffer for experimentation".

Furthermore, it is expected that farmers who more productive are producing cassava will be more interested in learning new agricultural practices that help them to further improve or maintain their productivity. Goodwin and Schroeder (1994) found that participation rises as farm size increases and suggested that returns to a fixed educational investment are likely to be greater for producers managing larger farms.

3.7.2 Stage Two: SCFMP Bundle Adoption

Estimation results for the multinomial logistic regression model of adoption of SCFMP bundles is provided in Table 3.4. Given the limited interpretability of coefficient estimates in this model, marginal effects for the explanatory variables with associated asymptotic standard errors are presented in Table 3.5. Asymptotic standard errors are calculated using the delta method (Greene, 2007).

Results indicate that farmers who participate in some type of training were 74.96% less likely to use only fertilization only, but 66% more likely to use a bundle of biological and fertilization management practices with contour ridging (BCF), which is considered as the most complex bundle to adopt as it requires more knowledge about soil conservation practices and fertilization. These results are as expected since training activities were designed to teach farmers principles of fertilization in order to avoid soil degradation due to over-dosage of fertilizers, as well as to integrate different conservation practices taking into consideration their own local conditions. These results also agree with Dalton et al. (2007) who find that participation becomes more helpful as the complexity of new techniques increases. Bundle BCF is also considered as the most intense bundle because it contains a higher number of practices offered. Therefore, participation not only impacts positively in the adoption of more complex bundles but also on the adoption of a higher number of practices offered. As a result, programs that use participatory methodologies, although more costly, may be more effective because adoption and intensity of adoption is higher due to the participation factor.

The determinants that have more influence on adoption of bundles of SCFMP are country characteristics, participation, and other production activities (i.e. domestic animals, fish pounds), soil characteristics, market institutions (i.e. cassava factory). As shown in Table 3.5, marginal effects indicate that farmers from Thailand were 13.11 and 22.29 % more likely to adopt fertilization practices only and a combination of contour ridging and fertilization management, respectively; while being 16.41% less likely to adopt a combination of biological, contour ridging, and fertilization conservation practices. In addition farmers were 20.03% less likely to adopt biological and fertilization practices compared to those farmers from Vietnam.

Soil characteristics of soil are significant determinants of a farmer's decision to adopt SCFMP. For instance, as the degree of slope increases on a farmer's land, it is 14% and 13% more likely to adopt a combination of biological, contour and fertilization practices (BCF), and biological and fertilization practices (BF), respectively. Thus, farmers producing on marginal lands are more likely to implement soil conservation practices as they are more interested in benefiting from them.

Higher number of adults in a household increases the probability of using fertilization only by 4% and reduces in the probability of using a combination of biological and fertilization practices by 0.13%. An additional acre of land increases the probability of using only fertilization by 0.15%

and reduces the probability of using a combination of all practices (BCF) by 0.06%. These results could be because more landed farmed means higher investment and greater amount of labor.

The presence of a starch factory increases the probability to adopt the bundle of all practices by 17.41% while it reduces the probability of using fertilization only. As expected, the close presence of a factory close to their village motivates cassava producers to implement new agricultural practices since reduction of risk when marketing and better prices will pay off the investment allocated on the implementation and maintenance of those practices with a stronger local market. These results agree with Dalton et al. (2011) findings. Their study maintains that participation and the presence of a starch factory close to the village are important determinants for adoption of soil conservation practices. However, these differ from those findings from Birungi and Hassan (2010) study where they found that poverty negatively correlates with participation and adoption. In this particular case, the results for poverty were not significant.

Other production activities (i.e. fish pounds) positively correlate with adoption of soil conservation practices. Farmers who own fish pounds are 14% more likely to adopt a combination of BCF soil conservation practices than those who do not own fish ponds. According to Genius et al. (2006), having alternative agricultural activities (diversification) may decrease farmers' risk, which is associated with less uncertainty on future yields and thus farm income, which results on a higher level of adoption. Furthermore, farmers who own fish ponds are considered as more specialized and it is possible that higher-skilled farmers are more likely to adopt the new technology (Feder et al., 1985).

3.8 Conclusions

Small-scale farmers in developing countries grow their crops primarily on marginal land, which is more susceptible to soil degradation, erosion, and low soil fertility. The International Center of Tropical Agriculture (CIAT) conducted a project to reduce soil erosion in cassava-based systems in Vietnam and Thailand. Five different soil conservation and fertilization management practices were promoted by the project: intercropping lines, hedgerow, contour ridging, farm yard manure, and chemical fertilizer use. SCFMP were offered using participatory methodologies such as farmers' field school, on-farm training, and field days as tools to increase levels of adoption. Because SCFMP alternatives are a simultaneous decision, a two-stage discrete choice modeling framework was used to: 1) explain the determinants that affect participation in extension/ training activities, and 2) explain the determinants that affect adoption of SCFMP.

Results indicate that participation is positively influenced by asset ownership and cassava yield. This indicates that farmers with higher willingness/capacity to invest are also more likely to participate in extension programs. Similarly farmers with higher cassava baseline yields are more interested in learning new agricultural practices because they may be more motivated to maintain their agricultural productivity and livelihood. Adoption of new practices is positively linked to farmers' participation in training activities. Results indicate that as the complexity of new technologies introduced increases, participation becomes a more powerful tool that increases farmers' willingness to adopt new practices. This was evidenced by the positive influence of training on the adoption of more complex bundles of SCFMP. Furthermore, participation impacts on the intensity of adoption; this is, the number of practices adopted increases significantly when farmers participate in training activities.

Results suggest that participatory methodologies can be used more intensively as more complex agricultural technologies are being promoted. More intensive training may not only help farmers to become more familiar with new technologies, but also develop their ability to adapt those technologies to farmers' actual circumstances. Although many studies have raised concern about the high costs of PR, researchers and extension educators could consider the use of PR as complexity of technologies increase. This is, the more complex the technology, the more participatory the outreach method needs to be. Furthermore, the intensity of adoption, measured in the number of practices adopted by farmers increases due to participation. This means that development programs may be more effective when using PR. Developing countries may benefit from the use of PR, because the use of PR may increase not only the adoption rate but also the intensity of adoption of new agricultural technologies, improving productivity, farm income and agricultural households' well-being.

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Tables

Table 3.1 Statistics and description of variables

Variable	**Mean**	**Std.Dev.**	**Definition**
Country	0.5622	0.4964	Vietnam = 0, Thailand = 1
Bipart	0.3213	0.4673	Participation (Yes = 1, No = 0)
Partic	0.9665	1.5256	Ordered Variable 1=
SCFMT	1.7590	1.17425	Soil Conservation and fertilization management practices (None=0, Fertilization = 1, Biological+Contour Ridging+Fertilization = 2, Biological+Fertilization = 3, Contour Ridging+Fertilization = 4)
Gender	0.1995	0.3999	Male = 0, Female = 1
Nadult	2.8233	1.2355	Number of adults in a household (continuous variable)
Nchild	1.5475	1.0694	Number of children in a household (continuous variable)
Land1	26.7791	31.6199	Number of hectares dedicated to cassava production (ha)
Yield1	4.2113	3.8289	Cassava baseline yield (tons/ha)
Fish	0.3936	0.4889	Fish pound production (Yes = 1, No = 0)
TLU	2.4360	5.3096	Total land unit (units/ha)
Own	3.3039	1.3923	Active assets ownership (Categorical variable Less ownership = 1, More ownership = 6)
Slope	1.6345	0.4819	Slope of land (Flat = 0, Undulating = 1, Hilly = 2)
Poverty	1.0000	0.4602	Poor = 0, Average = 1, Better-off = 2
Factory	0.7296	0.4445	Presence of an starch factory closer to the village (Yes = 1, No = 0)
Project	0.4391	0.4966	Presence of the project in a village (Yes = 1, No = 0)

Note: Number of observations is 747

Table 3.2 First stage parameter estimates for participation in farmers participatory research (FPR)

Variable	Coefficients	
Constant	-1.949	***
	(0.299)	
Gender	-0.052	
	(0.206)	
Number of adults	0.085	
	(0.064)	
Asset ownership	0.216	***
	(0.060)	
Cassava yield	0.056	**
	(0.022)	
Log likelihood	-456.943	
Chi squared	24.098	
McFadden Pseudo R^2	0.026	

Note: *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.

Table 3.3 First stage marginal effects estimates for participation in farmer participatory research (FPR)

Variable	Coefficients	
Gender	-0.011	
	(0.04299)	
Number of adults	0.018	
	(0.01357)	
Asset ownership	0.046	***
	(0.01271)	
Cassava yield	0.012	**
	(0.00468)	

Note: *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.

Table 3.4 Second stage parameter estimates for adoption of soil conservation and fertilization management practices (SCFMP)

Variable	F		CF		BF		BCF	
Constant	-0.268		-3.781	***	-1.911	**	-5.842	***
	(0.693)		(0.97117)		(0.88224)		(0.985)	
Country	-0.026		2.037	***	-1.905	***	-1.670	***
	(0.361)		(0.58859)		(0.45705)		(0.452)	
Participation	1.085		-0.599		5.149	*	8.177	***
	(2.462)		(2.99597)		(3.06097)		(3.012)	
Number of adults	0.031		-0.086		-0.249		-0.138	
	(0.134)		(0.1663)		(0.16898)		(0.169)	
Land	0.031		-0.001		0.008		-0.007	
	(0.134)		(0.00874)		(0.00824)		(0.010)	
Fish pond	0.004	**	1.771	***	1.173	**	2.807	***
	(0.008)		(0.54552)		(0.56321)		(0.559)	
TLU	1.214	*	0.244	**	0.249	**	0.229	*
	(0.507)		(0.12367)		(0.12446)		(0.128)	
Slope	0.240	**	1.590	***	2.383	***	2.744	***
	(0.321)		(0.42178)		(0.43454)		(0.460)	
Poverty	1.541	***	1.786	***	1.188	***	1.474	***
	(0.377)		(0.4898)		(0.44421)		(0.46189)	
Starch factory	-0.755	**	-0.116		-1.102	**	1.111	**
	(0.372)		(0.52596)		(0.45433)		(0.54484)	
Log likelihood							-779.555	
Chi squared							544.372	
Mc Fadden Pseudo R^2							0.259	

Note: *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.

Note: F= Fertilization, BCF = Biological, Contour Ridging and Fertilization; BF = Biological and Fertilization, CF = Contour Ridging and Fertilization.

Table 3.5 Second stage marginal effects estimates for the adoption of soil conservation and fertilization management practices (SCFMP)

	None	F	CF	BF	BCF
Country	0.009	0.130 ***	0.214 ***	-0.206 ***	-0.147 ***
	(0.128)	(0.114)	(1.273)	(-0.943)	(-0.811)
Participation	-0.082	-0.655 **	-0.256	0.373	0.620 ***
	(-0.676)	(-0.328)	(-0.869)	(0.978)	(1.951)
Number of adults	0.001	0.041 **	-0.005	-0.026 **	-0.011
	(0.092)	(0.180)	(-0.151)	(-0.610)	(-0.296)
Land	0.001	0.001	-0.0004	0.001 *	-0.001 *
	(0.092)	(0.030)	(-0.103)	(0.149)	(-0.247)
Fish pond	-.99564D-04 ***	-0.105 **	0.037 *	-0.025	0.146 ***
	(-0.069)	(-0.064)	(0.155)	(-0.080)	(0.563)
TLU	-0.053 **	0.006	0.001	0.002	-0.0002
	(-0.542)	(0.021)	(0.032)	(0.045)	(-0.005)
Slope	-0.009 ***	-0.281 ***	0.034	0.141 ***	0.154 ***
	(-0.782)	(-0.278)	(0.227)	(0.730)	(0.959)
Poverty	-0.056 ***	0.056	0.031	-0.033	0.002
	(-1.454)	(0.087)	(0.332)	(-0.267)	(0.020)
Starch factory	0.020	-0.153 ***	0.038	-0.072 **	0.166 ***
	(0.377)	(-0.173)	(0.293)	(-0.426)	(1.188)

Note: *,**,and *** indicates statistical significance of an explanatory factor or attribute at the 10, 5 and 1 percent level of significance.

Note: F= Fertilization, BCF = Biological, Contour Ridging and Fertilization; BF = Biological and Fertilization, CF = Contour Ridging and Fertilization.

Chapter 4 - Extension educators' preferences on teaching methods: an ordered probit model with selection

4.1 Introduction

Both formal and informal education play an important role in the development process. It positively affects agricultural productivity and consequently farmers' standard of living through the enhancement of human capital and management (Anderson and Feder, 2007; Huffman, 2001). This enhancement occurs through the dissemination of useful and practical research findings. Outreach and extension services help farmers develop new skills and enhance their ability to process information, helping them to make better decisions (Anderson and Feder, 2004; Ojha and Sinha, 2001; Wozniak, 1987).

The link between research and farmers is strengthened by extension and outreach services due to their two-way role. First, extension educators disseminate researchers' innovations to farmers in terms they can understand (Anderson and Feder, 2004); and second, they provide researchers with information about actual farmers' needs, as well as their attitudes towards and perceptions of innovations they had already been exposed to (Evenson, 2001). When educating farmers, extension efforts enable farmers to better understand the production process and the benefits the introduction of new technologies and best management practices may provide. This understanding may increase not only farmers' adoption rate of these technologies (Anderson and Feder, 2004; Evenson, 2001; Ojha and Sinha, 2001), but their capacity to adapt them to their own environment and situation, as well (Anderson and Feder, 2004).

Anderson and Feder (2004) find that both: 1) farmers' socio-economic characteristics; and 2) extension educators' method of delivery will affect the impact of extension and outreach programs, because both factors drive the way farmers manage their operations and adopt new innovations. Although communication tools provide the information educators aim to distribute, the extension process can fail if such information does not answers the audience's needs using the most effective method (Carter and Batte, 1994; Monroe and Oxarat, 2011). Therefore, understanding how extension educators deliver information and how farmers accept it can be crucial to accomplish extension and outreach programmatic goals.

The first factor has been addressed by a wide number of studies for which the main focus has been to understand farmers' attitudes and management, as well as different socio-economic characteristics on the effectiveness of the extension process. These studies have examined the educational needs of farmers (Ricard et al., 2008; Trede and Whitaker, 1998); determined the preferences farmers have towards different types of educational methods (Franz et al., 2010; Radhakrishna et al., 2003; Shaw et al., 2012); their perceptions of those methods (Eckert and Bell, 2005; Eckert and Bell, 2006; Ngathou et al., 2006); and the effectiveness of educational methods on knowledge acquisition (Benavente et al., 2009; King, 1999; Wagenet et al., 2005).

The majority of studies have aimed to identify the challenges of and potential alternatives to current educational methods, to find effective educational strategies for different types of audiences (Benavente et al., 2009; Lakai et al., 2012; Marra et al., 2012; Strong et al., 2010), as well as to identify extension educators' level of knowledge of specific topics and needs for information and training (Bailey et al., 2014; Germain and Ghosh, 2013; Gibson and Hillison, 1994; Kluchinski, 2012; Miller and Miller, 2009; Radhakrishna and Martin, 1999).

When studying different educational and delivery methods, the main focus has been allocated to explaining farmers' preferences towards those methods (Franz et al., 2010). Only a few studies have been conducted to understand the preference for and factors affecting extension educators' choices concerning delivery methods. Many of these studies do not provide an extensive analysis of how extension educators decide on the type of methods they use to deliver information and why they prefer those methods. Because educators tend to teach the way they prefer to learn, allocating more efforts on explaining extension educators' behavior when choosing different types of delivery methods could be important to close the gap between farmers' learning styles and extension' teaching preferences (Davis, 2006).

4.1 Objective

The purpose of this study is to identify the determinants of extension educators' decision when selecting a delivery method and to assess educators' perception of the effectiveness of these methods. This study attempts to provide quantitative evidence using data from an online survey of extension and outreach educators in the western U.S. about the delivery methods the educators use and how they perceive them. Using ordered probit models with selection; the paper provides information about how extension educators' personal preferences of learning impact their selection of teaching and delivery methods. Results will help enhance learning among farmers by understanding educators' preferences of learning and teaching methods. Such understanding will support the development and delivery of more effective educational and extension programs.

4.2 Background information

4.2.1 Educational and Delivery Methods

Extension programs are designed to provide the learner with: 1) experiential opportunities, 2) mechanisms to reinforce existing knowledge, and 3) opportunities to integrate new information with existing knowledge and skills (Guion, 2006). Based on these three extension objectives, Guion (2006) defines the following categories under which delivery methods can be grouped:

1. *Experiential:* The methods in this category are used to gain experience with the provided information through experiential opportunities. Some methods in this group are: case study, field day, games & role play, interactive CD/video/audio, interactive workshop, on-farm test, practicum, play, and demo skills.
2. *Reinforcement:* Methods designed for the reinforcement objective help educators strengthen the information they initially provided to farmers, as well as keep them motivated for continued learning. Articles (EDIS/journal), newspaper articles, fax or e-mail messages, home study kits, leaf lefts or flyers, newsletters, fact sheets, notebooks, and posters are among the methods under this category.
3. *Integrative:* Methods in this category allow the audience to clarify, discuss, and gain a greater understanding of the information, as well as combine new information with existing information. Integrative methods are: brainstorming, buzz groups, conferences, conventions, forums, institutes, meetings, panels, seminars, symposia, teleconferences, telephone TA, personal visits, and office visits.

When selecting delivery methods, extension educators should consider three factors: 1) clientele, 2) subject matter, and 3) desired change (Cole, 1981). Consideration of the clientele means educators must know and understand the farmers' socio-economic characteristics and preferences as these will affect their learning ability. Radhakrishna et al. (2003) found that older and/or retired landowners preferred traditional delivery systems such as newsletters, publications, and field tours rather than high technology-driven systems and formal classes. The author concluded that video and internet may not be effective delivery methods when attempting to reach older and/or retired landowners. Franz et al. (2010) studied preferences for learning and delivery methods among farmers. They found that farmers want extension educators to provide cutting edge and relevant research-based information translated into lay terms, as well as to help them understand how to apply such information. The authors concluded that extension educators' should consider producers' level of education, geographic location, and farming experience when considering delivery methods. However, this study considered only farmers' opinions without any discrimination by age, level of education or other farmers' or educators' characteristics.

The second factor extension educators need to be aware of is the subject matter. That is, educators need to take into consideration the level of difficulty of the subject to be taught relative to the audience. Feder et al., (2004) found that farmers consider other farmers to be the most important source of agriculture information, but prefer more specially targeted or trained sources (e.g. extension educators or industry agents) as the complexity of the message increases. Mauceri et al., (2007) studied integrated pest management (IPM) techniques used in potato production. IPM techniques are relatively complex and therefore require sufficient knowledge acquisition for successful implementation to occur. The complexity of the IPM message can affect which method of diffusion will have the greatest impact. More complex messages include knowledge of the pest life cycle, understanding the use of traps and monitoring of pest populations, use of systemic versus protectant pesticides, and use of different active ingredients to prevent buildup of resistance in pests. Other messages can be understood with minimum explanation, such as early harvest, crop rotations, and use of resistant varieties.

The last significant factor to be considered when selecting a teaching method is identifying the desired change, which requires that extension educators define the goal(s) they wish to achieve through the extension process. Strong (2012) states that to identify what the learner will be able to do as a result of the learning experience, educational objectives need to be written that focus on three points: performance, conditions, and criterion. Performance details what the learner will be expected to do. Conditions outline the circumstances under which performance will occur. Criterion indicates the level a learner must perform at in order to be considered acceptable. Program outcomes must be evaluated by educational organizations to address program accountability. To illustrate the theory, Strong (2012) examined an innovative delivery method with a robust learning theory for constructing learning objectives. This method was expected to improve learning in the Master Goat Producer (MGP) program in Texas and Tennessee. The objective was to incorporate educational objectives in the marketing session of MGP based the cognitive domain approach (knowledge, comprehension, application, analysis, synthesis, and evaluation). Incorporating the cognitive approach, Strong (2012) concludes that adult participants were more confident on their ability to define, discuss, utilize, analyze, and synthesize goat production marketing plans had been increased; however, they showed less confidence about evaluation. Strong (2012) also concluded that older participants had more difficulty to learn than the younger attendants.

King (1999) compared three educational methods, namely: a slide set, pamphlet, and a combination of slide set and pamphlet. The goal of the study was to identify the most effective and efficient method of the three for educating farmers about soil sampling. Results indicated that the methods (slide set and/or pamphlet) used in this study were effective for providing facts and concepts concerning soil sampling. Learning and retention of facts and concepts in both immediate and delayed knowledge were similar for all methods. Farmers preferred group-paced instruction (extension meetings, workshops with a pamphlet, and one-on-one instructions) for learning about soil sampling. Overall, the three educational programs proved to be relevant, appropriate, easy to understand, and maintained the interest on the subject. Wagenet et al. (2005) considered that the lack of effective environmental education and the need for a better interface between citizens' knowledge about the environment and how best to use that knowledge. An educational concept was needed that connects environmental education with environmental policy and management. Therefore, an education program comprising six television programs; a radio series; Web-based materials; and information supplied to libraries was developed. Results did not strongly support the effectiveness of using local public television as an environmental education tool, watching the television programs did not result in significant changes in environmental knowledge or commitment. However, results on radio and library information were not presented.

Findings from the studies in this section reinforce the need to modify delivery systems to fit the demographic characteristics of the intended audience and to guide extension educators and specialists choosing teaching methods that are more suitable to farmers' preferences and needs. This paper contributes to this literature by helping to explain extension educators' decisions concerning educational and delivery methods, the factors that impact their choice of delivery method, and their factors influencing their perceptions about the effectiveness of those methods.

4.3 Data and Summary

An online survey was offered to extension personnel, agribusinesses, seed dealers, agricultural consultants, researchers and government agency personnel. The questionnaire was emailed to 7,612 extension and outreach personnel across ten states in the western U.S. on December, 2012. A total of 989 responses were received (13% of response rate). A total of 143 observations were dropped from the dataset since they did not contain needed information about outreach extension methods.

The objective of the survey was to gather information about current outreach practices, delivery methods, and teaching methods. The questionnaire contained 34 questions organized in three sections. The first section gathered information on job background and demographics; the second requested information about outreach and extension methods currently used by the respondents; and the third section focused on assessing current knowledge and perceptions respondents have about bioenergy feedstocks and biofuel markets.

Three outreach sectors were identified: 1) extension and research, 2) government, and 3) agribusiness. The first sector contains all of those who work as state or county extension educators, as well as university, government or industry researchers. The government sector refers to extension educators and personnel who work in the U.S. Department of Agriculture. Finally, seed suppliers or dealers, chemical dealers, crop consultants, certified crop advisors and other agribusiness were grouped under the agribusiness sector. The 10 western states surveyed were grouped into three regions (Table 4.1): the Pacific Northwest Fruitful Rim, the Prairie Gateway, and the Northern Great Plains region. Prairie Gateway was the region with the highest response rate, obtaining 51% of the total responses. Kansas, Colorado, and Nebraska were the states with the highest response, representing 17%, 10.64%, and 10.17% of the total responses, respectively.

The lowest rate corresponds to the Pacific Northwest Fruitful Rim region where California and Oregon contributed only 1.18% each, of the total responses obtained.

4.3.1 Dependent and Independent Variables

Variable description and descriptive statistics for dependent and independent variables are reported in Table 4.2.

4.3.1.1 Dependent variables

This study examines some of the common dissemination and teaching methods used by extension educators that have been mentioned in the literature. These methods include: internet, news media (newspaper, TV, radio), and trader, farmer of commodity magazine, magazines, newsletters, extension publications, research publications, websites, other university sources, federal agencies, USDA/ ARS, state ag, farm organizations, commodity organizations, seed company publications, other industry publications, product documentation, and local agribusinesses. This paper focuses on the use of the internet, news media, and trader/farmer/ commodity magazines, only. Data limitations prevent robust estimation of the other models. On the survey, extension educators reported the methods they use and were asked to rank how effective they perceive the method to be on a 5 point Likert scale, where 1 is the least effective and 5 is the most effective source. The survey also had an option to indicate if the extension educator had not used the source before. Thus, a binary variable was also obtained for the use of the source; this is, 1 indicates the educator has used the source and 0, otherwise. Table 4.2 reports descriptive statistics for the ordered and binary dependent variables in the study.

4.3.1.2 Independent variables

Variables affecting extension educators' decision of using an educational method are grouped into three categories: educators' socio-demographic factors, extension environment, and educational method characteristics.

Socio-demographic factors evaluated are: experience, gender, age, and education. Experience is a continuous variable and refers to the number of years the educator has been working as an educator. More experienced educators may be less likely to try new educational methods because the methods they already use fulfill their needs. Age is a continuous variable which could help explain the methods educators chooses because older educators may be less likely to use high technological educational methods (i.e. internet), preferring more conventional methods. This hypothesis is based on studies at the farmer level where has been found that older learners have less preference for high technological learning methods. Gender is a binary variable. Education is a variable that describes whether the educator has college degree or any graduate degree. It is expected that educators holding higher degrees of education may be more willing to try other types of educational methods because, as learners, they have been more exposed to other type of methods.

The extension environment category refers to those characteristics that explain the type of work the educator is involved with, the expertise required in this type of work, and the geographical area where the educator is located. The variables in this category are: region, position, and expertise. Three USDA Economic Research Service (ERS) Crop Production Regions were defined: Pacific Northwest Fruitful Rim, the Prairie Gateway, and the Northern Great Plains and surveyed states were allocated to each region. These regions are classified according to patterns that define agriculture specialization which may also define the teaching methods educators need to use (USDA Economic Research Service, 2000).

The position variable refers to educators' affiliation: government, extension and research, and agribusiness. These affiliations may be related to the objectives of the extension programs which could define the type of methods the educator uses. Expertise refers to the main agricultural specialization educators spend more time teaching: crop production, finance and marketing, and livestock. Depending on the specialization, educators may need to use specific methods of teaching. The last category refers to the characteristics of the type of method which is primarily related to the goals of the teaching program.

4.3.2 Survey Summary

Most survey respondents had a bachelor, masters, or doctoral degree. Between 6 and 8 percent of the respondents have taken graduate course work and less than 7 percent stated they have a vocational, associates, or high school degree.

For all regions, the majority of respondents considered crop production as their primary area of expertise. This area involves activities such as: agronomy and soils, horticulture, pesticides and integrated plant management, production management, and livestock production. A very low percentage of respondents were involved in business, marketing, and/or finance and insurance activities.

As shown in Table 4.3, on a Likert scale from 1 (strongly disagree) to 5 (strongly agree), respondents were asked what agricultural stakeholders they frequently work with in their positions. Showing averages greater than 3.4 (between indifferent to strongly agree), respondents in both the agribusiness and the extension and research sectors affirmed they frequently work with farmers and agribusiness, while those in the government sector work mainly with farmers. Only respondents in the agribusiness sector in the Pacific region and those in the extension and research sector in the Northern Great Plains affirmed to work with commodity groups, showing a mean greater than 3.5.

Respondents were asked to assess the effectiveness of different outreach and delivery methods. Summary statistics to these questions are provided in Table 4.4. Extension educators and other outreach personnel ranked university extension publications, internet, and newsletters between somewhat effective and very effective, showing a mean higher than 2.7, on average (Table 4.4). Research experiment station publications and federal agricultural agencies were sources considered effective to very effective (mean higher than 3) by the extension/research and government sectors, respectively. The least effective sources were perceived to be seed company publications, farmers' organizations, and other industry publications (Table 4.4).

Respondents were asked to rank the top three events they attend to learn about agricultural production. Summary statistics to these questions are provided in Table 4.5. Conferences, meetings, and field days were the events most frequently ranked, showing more than 46% of the surveyed population in each region attending. Furthermore, between 20 to 40% of this population ranked extension websites, on-farm demonstrations, and interactive workshops as events extension educators and other outreach personnel attend to gather agricultural information. Seed company events and university classes were the least used events.

Regarding outreach methods, extension educators where asked to rank the sources and events they frequently use to provide agricultural information to farmers. Table 4.6 shows that, overall, more than 50% of the respondents per region ranked field days and fact sheets as the sources they most frequently used. Extension educators working in the area of extension and research also considered seminars and community education events as sources/events they frequently use for outreach to farmers, while the government sector ranked soil and water conservation district and USDA related events as important. The agribusiness sector provides information through industry-sponsored, commodity groups/grower association, and/or crop consultant/certified crop advisor events. Radio/TV, state department of agriculture programs, and programs on bioenergy were the least frequently ranked events.

4.4 Model and Estimation

An ordered probit model is considered appropriate for this study due to the ordinal categorical nature (i.e. Likert scale) of the dependent variables (e.g. internet) being assessed. The approach presented in this paper follows the modeling approach proposed by McKelvey and Zavoina for the analysis of ordered, categorical, non-quantitative choices, outcomes, and responses (Greene and Hensher, 2010).

As explained by Greene and Hensher (2010) and Greene (2012), the empirical model is based on an underlying latent model. The empirical model is assumed to measure an extension educator's perceived effectiveness of a delivery or teaching method. Call this perception y_i^*. It is then assumed that the perceived effectiveness is a linear function of a set of explanatory factors or independent variables (as identified in section 3.1), i.e.:

$$y_i^* = \beta' x_i + \varepsilon_i, \ \ i = 1, \ldots, n \qquad (1)$$

where β is a vector of coefficients, x_i is a vector of explanatory variables, and ε_i is an IID mean zero stochastic error term. Given that y_i^* cannot be readily measured or observed, what is observed is the response y_i, which is measured on a Likert scale. The latent model given by equation (1) can then be modeled by as a discrete choice model, where y_i^* is discretized using a censoring mechanism, i.e.:

$y_i = 0 \; if \;\; y_i^* \le \mu_0$

$y_i = 1 \, if \;\; \mu_0 < y_i^* \le \mu_1$

$y_i = 2 \;\, if \;\; \mu_1 < y_i^* \le \mu_2$

...

$y_i = J \;\, if \;\; \mu_{J-1} < y_i^* \le \mu_J$

where J represents the number of ordinal categories, and μ_j is an unknown threshold parameter to be estimated for $j = 0,...,J$. The observed response y_i of category J is observed when the underlying continuous response y_i^* falls in the $J-th$ interval. The probability of observing the $J-th$ interval or response $y_i = j$ is given by (Greene, 2012):

$$\Pr ob[y_i = j \,|\, x_i] = \Pr ob[\varepsilon_i \le \mu_j - \beta' x_i] - \Pr ob[\varepsilon_i \le \mu_{j-1} - \beta' x_i] \qquad j = 0, 1, ..., J.$$

Assuming ε_i is normally distributed across gives rise to the ordered probit model, giving rise to the following specification for the probabilities of observing y_i:

$\Pr ob(y_i = 0 \,|\, x_i) = \Phi(-x_i ' \beta)$

$\Pr ob(y_i = 1 \,|\, x_i) = \Phi(\mu_1 - x_i ' \beta) - \Phi(-x_i ' \beta)$

$\Pr ob(y_i = 2 \,|\, x_i) = \Phi(\mu_2 - x_i ' \beta) - \Phi(\mu_1 - x_i ' \beta)$

…

$\Pr ob(y_i = J \,|\, x_i) = 1 - \Phi(\mu_{J-1} - x_i ' \beta)$

where Φ represents the respective cumulative distribution function. The model requires having $u_J > \mu_{J-1}$ for all the probabilities to be positive.

The model developed in this study attempts to explain extension educators' decision in choosing a learning method by taking into account: 1) extension educators' characteristics and 2) learning methods' characteristics. Extension educators' choice of learning method is observable as long as the educators reported having used the method; however, there exist cases in which educators have not used the method and no observation is made about its perceived effectiveness. To take account of this, an ordered probit model with selection or Heckman ordered probit approach is utilized to estimate the model (Greene, 2012; Lhuillery, 2011). The method estimates the model in two stages. The first stage assess if extension educator *i* uses method *j*. That is:

$$Use_{i,j} = \beta_0 + \sum_{k=1}^{4} \beta_k agent_i + \sum_{l=5}^{6} \beta_l area_i + \sum_{m=7}^{8} \beta_m perception_i + \varepsilon_{i,j}, \qquad (2)$$

where $Use_{i,j}$ a binary variable that represents whether or not educator is i have used method j. This is, variable $Use_{i,j}$=1 if educators i have used method j, and 0 otherwise. Independent variables were grouped into three categories: agent, area, and perception. The $agent_i$ category contains those variables that describe educator i personal characteristics, such as age, education, years of experience in the position, and gender. Based on the studies conducted at the farmers' level, older educators would be less likely to use high technology methods, such as internet (Franz et al., 2010; Radhakrishna et al., 2003; Strong, 2012). Educators with higher level of education are expected to use more innovative and modern methods because they have been more exposed to a plethora of teaching methods and would be more willing to try newer and more modern teaching methods. The variable years of experience in the position refers to the number of years the educator has been in the same position (this variable does not refers to the number of years the educator has worked as an educator). Educators with longer tenure may be less willing to try more modern and high technology methods. They may prefer continue using the methods they already know and believe are already effective. The gender variable expects to capture whether or not it makes a difference when deciding a teaching method. There are not expectations on signs for this variable.

Category $area_i$ represents variables that describe the type of position educator i is involved with. In the survey, educators were asked to describe what groups they directly work with. The groups were farmers, agribusiness, and commodity groups. Educators working directly with farmers may need to use methods that allow visualization or practicing the topics being taught. The agribusiness and commodity groups may also need visualization and practice; however, these groups may be more risk taker and allow educators to use high technology methods.

Finally, the $perception_i$ category refers to three variables that describe perception of educator i towards the utility target audience. Educators were asked how much use they believe farmers, agribusiness and commodity groups give to the information they receive from them, where 1 indicates educator i perceives farmers/agribusiness/commodity groups use the information provided and 0, otherwise. These variables may capture the motivation educator i has to continue searching for innovative ways to teach. If educator i perceives the information provided is important (and, therefore, used) to the target area, the probabilities of using teaching method j may increase.

The second stage measures the perceived level of effectiveness, which is conditional on the use of the practice as given by the model in equation (2). The second stage is modeled as:

$$(Y_{i,j} \mid Use_{i,j} = 1) = \beta_0 + \sum_{k}^{4} \beta_k agent_i + \sum_{l=5}^{6} \beta_l region_i + \sum_{m=7}^{8} \beta_m position_i + \sum_{m=9}^{10} \beta_m \exp ertise_i + \sum_{n=11}^{12} \beta_5 method_j + \varepsilon_{i,j},$$

where $Y_{i,j}$ is a categorical variable that indicates the perception of effectiveness educator i has of method j. Perception is provided only when educator i has used the method j; this is, when $Use_{i,j}$ =1.

As explained above, three factors are usually considered when selecting a teaching method: 1) clientele audiences, 2) subject matter, and 3) desired change (Cole, 1981). The model in this study assesses the first factor using extension educators' characteristics, represented in the equation as $agent$. Because educators tend to teach the way they prefer to learn (Davis, 2006), educators' perceptions on how farmers like to learn may be impacted their own demographic characteristics. Thus, their demographic characteristics (e.g. age, experience, education, and education) are expected to help explain their decision when selecting a teaching method. As explained above, variables age, education, and experience will help explaining the use of method j by educator i because those variables define whether educator i is more likely to take risks or has been exposed to other type of teaching methods. The second factor, represented in the equation by $region$, is assessed using the geographical area on which the extension educators provide services. This category refers to three U.S. regions: Pacific Northwest, Prairie Getaway, and Northern Great Plains. Each region has a different level of agricultural specialization, which may define the teaching methods educator i will be willing to use. Only the Pacific and the Prairie region were included in the model to avoid singularity. The category $method$ contains teaching methods' characteristics and is used in the model to assess the third factor; this is, categorizing each method as experiential, reinforcement or integrative will provide an insight of the objective the educator wants to accomplish after the training. Estimation of the model is performed in LIMDEP using the

ORDERED command, which utilized a full information maximum likelihood method to estimate the model (Greene, 2012).

4.5 Results and Discussions

Results of the ordered probit models with selection for each delivery method examined are presented in Table 4.7. Estimates for the first stage examining the probability of using a particular method are given in the selection equation portion of the table, while estimates of factors impacting perceived effectiveness are shown in the top portion of the table. Model fit statistics are provided at the bottom of the Table 4.7.

***Internet*:** For the selection equation, parameter estimates for experience, age, work with farmers, work with agribusiness and perception that farmers use the information are positive and statistically significant. This means that older and more experienced educators are more likely to use internet, which is different from what was expected. Extension educators who work with farmers and agribusiness are also more likely to use internet compared with those who work with commodity groups. Perception that farmers use the information provided may also increase the probability of using internet as a teaching method.

For the second stage equation, parameter estimates for age and integrative methods were positive and statistically significant. Older extension educators tend to be more satisfied when using internet. This result is different from what was expected since it was hypothesized that older educators would be more reluctant to use high technology delivery methods, based on farmers' level studies. Radhakrishna, et al. (2003) found that longleaf pine landowners in South Carolina preferred newsletters, publications, and field tours. However, internet was the least preferred delivery method, which may be due to the significant negative correlation between age and technology delivery systems found in their study. Franz, et al. (2010) recommend the use of the internet as a delivery method with farmers who utilize it.

Furthermore, if the need is to use integrative methods, internet may be the source more likely to be chosen. Bailey et al. (2014) found that internet was the most common source used to find university, extension, and other academic sources for credible information. Bailey et al. (2014) found the most common barrier faced when searching for information was lack of time. Because internet a source on which information for any type of subject is available, extension educators find internet as an effective source for gathering information.

News media (newspaper, TV, and radio)**:** Selection equation indicates that educators who work with farmers and agribusiness are more likely to use news media to transfer information. Also, perception of agribusiness using the information provided may increase the probability of using this method.

Second stage estimates for gender, age, education and for the Pacific Northern region were positive and statistically significant. These results indicate that older extension educators with higher level of education as well as females consider news media as an effective source to gather information. However, extension educators whose position is related to extension and research or are involved with the government consider this source less effective. Bailey et al. (2014) suggest that when gathering information, cost is the least important factor when evaluating information sources, while trustworthiness and quality are the most important. Thus, extension educators may not find this source as effective as internet due to the credibility of the source. Finally, this source is less likely to be used when the objective for the learners is to provide with some type of experience or training; that explains the negative sign of the experiential variable. Franz, et al. (2010) examined the learning methods farmers prefer and compared them with the preferred teaching methods of extension educators and specialists. This study found that farmers preferred learning methods were: hands-on, demonstrations, farm visits, field days, discussions, and face-to-face. Farmers showed a mixed preference towards online-methods, newsletters, books/manuals, on-farm tests, meetings, and lectures. Radio was the least preferred method. Kelsey and Franke (2009) determined Oklahoma's producers knowledge about crops dedicated to biofuel production. They found that 75% of the producers were familiar with the biofuel industry and noted that the two sources they used the most to learn about biofuels were TV/ news media and newspapers. Kelsey and Franke (2009) concluded that mass media is an effective tool for communicating national priorities and new innovations. Nelson and Trede (2004) found that extension educators prefer the use of problem-solving situations involving primarily mental activity and with the development of production agriculture skills.

***Trade, farmer or commodity magazines*:** Selection equation indicates that educators who work with farmers and agribusiness are less likely to use news media to transfer information. Also, perception of farmers and agribusiness using the information provided may decrease the probability of using this method.

Second stage estimates for gender and crop production resulted positive and statistically significant. Extension educators involved with crop production consider this source effective. However, there are no other estimates that indicate this could be a preferred source to gather or transfer information. Besides credibility and quality, Bailey et al. (2014) found that sources for professional use, extension educators prefer the source having the following characteristics: accessibility, timeliness, familiarity and prior success, and cost. Although accessible, familiar, and inexpensive, trade, farmer or commodity magazines may not be timeliness. Kelsey and Franke (2009) determined that besides TV/news media and newspapers, producers learned about biofuels in farm magazines and publications as well as on the internet, making mass media an important tool to provide information to producers.

4.6 Conclusions

Outreach and Extension services play an important role in enhancing human capital. Extension educators help farmers adapt technologies to their own environment and needs which increases the rates of adoption of improved technologies and consequently raises productivity levels. However, outreach and extension programs are affected by farmers and their socio-economic characteristics and the way extension educators deliver information to farmers. Using data collected through an electronic survey administered to extension and other outreach educators in 10 western states of the U.S., a series of ordered probit model corrected for selection bias were estimated to explain the extension educators' characteristics that influence their decision of the type of educational methods they use to transfer agricultural information.

Various factors are believed to explain the use of learning methods by Extension educators, including: education level, age, region, area of expertise, target group, perception on the farmers' use of information, and years of experience. Results indicate that different from what was expected, older extension educators tend to be more satisfied when using internet. Furthermore, internet is a source more likely to be chosen as an integrative method. Because internet a source on which information for any type of subject is available, extension educators find internet as an effective source for gathering information. News media (newspaper, TV, radio) is considered an effective source to gather/transfer information by older extension educators with higher level of education as well as females. However, extension educators involved in extension and research or with the government consider this source less effective. Similarly, news media is less likely to be used when the objective for the learners is to provide with some type of experience or training. Finally, only extension educators involved with crop production find trade, farmer or commodity magazines an effective source.

Extension educators' age did not affect in the decision of using internet as a teaching method. As technology advances, it is expected that older people may fell behind; however, results indicate that age may not be a barrier for using more complicated teaching methods. Furthermore, the decision extension educators make for selecting a teaching method is affected by the relationship between the objectives of the learning process and the characteristics of the teaching method. More education on the teaching methods, their characteristics may prove effective to enhance the accomplishment of the extension programs.

Although this study sheds light on what characteristics affect in the decision of selecting teaching methods, more research needs to be done to help explain how extension educators' perception of farmers' reception affects this selection, as well as how much affect the barriers extension educators face on the decision of teaching methods.

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Tables

Table 4.1 States classification in regions

Pacific Northwest Fruitful Rim N=130	Prairie Gateway N=433	Northern Great Plains N=255
California	Colorado	Minnesota
Idaho	Kansas	Montana
Oregon	Nebraska	North Dakota
Washington	Oklahoma	South Dakota
	Texas	

Table 4.2 Descriptive Statistics of Dependent and Explanatory Variables

Variable	Mean	Std. Dev.	Definition
Dependent variables			
Internet- binary variable	0.95	0.22	Source to obtain information (1= Source used; 0= Do not use)
Internet- ordered variable	1.90	1.03	Source to obtain information (1= Do not use -5= Very effective)*
News media (newspapers, TV, radio)- binary variable	2.92	1.14	Source to obtain information (1= Do not use -5= Very effective)
News media (newspapers, TV, radio)- ordered variable	0.86	0.35	Source to obtain information (1= Source used; 0= Do not use)
Trade, farmer or commodity magazines- binary variable	0.86	0.34	Source to obtain information (1= Source used; 0= Do not use)
Trade, farmer or commodity magazines- ordered variable	2.75	1.16	Source to obtain information (1= Do not use -5= Very effective)
Independent variables			
Experience	15.56	11.64	Number of years educator has been working in that position (continuous variable)
Gender	0.28	0.45	Extension educators' gender (binary variable: 1= Female; 0= Male)
Age	46.24	11.91	Extension educators' age (continuous variable)
Education	0.50	0.50	Extension educators' education level (binary variable: 1= Grad studies; 0= Undergrad studies
Pacific Northwest	0.16	0.37	Region extension educators works: 1= Pacific Northwest; 0 = Otherwise
Prairie Getaway	0.53	0.50	Region extension educators works: 1= Prairie Gateway; 0 = Otherwise
Northern Great Plains	0.31	0.46	Region extension educators works: 1= Northern Great Plains; 0 = Otherwise
Extension & Research	0.30	0.46	Extension educators' position: 1= Extension & Research; 0= Otherwise
Government	0.60	0.49	Extension educators' position: 1= Government; 0= Otherwise
Agribusiness	0.10	0.29	Extension educators' position: 1= Agribusiness; 0= Otherwise
Crop Production	0.56	0.50	Extension educators' area of expertise: 1= Crop production; 0= Otherwise
Finance & Marketing	0.17	0.38	Extension educators' area of expertise: 1= Finance & Marketing; 0= Otherwise
Livestock	0.27	0.45	Extension educators' area of expertise: 1= Livestock; 0= Otherwise
Experiential	0.80	0.40	Educational method type: 1= Experiential; 0= Otherwise
Reinforcement	0.97	0.16	Educational method type: 1= Reinforcement; 0= Otherwise
Integrative	0.98	0.14	Educational method type: 1= Integrative; 0= Otherwise
Work with farmers directly	0.82	0.38	Binary variable: 1= Educator works with farmers directly; 0= Otherwise

Work with agribusiness	0.72	0.45	Binary variable: 1= Educator works with agribusiness directly; 0= Otherwise
Work with commodity groups	0.47	0.50	Binary variable: 1= Educator works with commodity groups directly; 0= Otherwise
Perception: Farmers use the información	0.83	0.38	Perception: 1= Farmers use the information; 0= Otherwise
Perception: Agribusiness use the information	0.65	0.48	Perception: 1= Agribusiness use the information; 0= Otherwise
Perception: Commodity groups use the information	0.67	0.47	Perception: 1= Commodity groups use the information; 0= Otherwise

* Likert scale: 1= Do not use; 2= Not effective, 3= Somewhat effective, 4= Effective, 5= Very effective

Table 4.3 Target groups and reception of information perception

Perception	Stats	Pacific Northwest			Prairie Gateway			Northern Great Plains		
		Ext & Res	**Gov**	**Agbus**	**Ext & Res**	**Gov**	**Agbus**	**Ext & Res**	**Gov**	**Agbus**
I frequently work directly with farmers in my position	Mean	3.91	4.11	4.40	3.80	4.16	4.64	4.30	4.40	4.69
	Std. Dev	1.32	1.23	0.97	1.25	1.31	0.87	1.07	1.07	0.66
I frequently work directly with agribusiness in my position	Mean	3.44	2.81	4.40	3.55	3.20	4.18	3.85	3.32	4.33
	Std. Dev	1.35	1.12	0.97	1.21	1.22	0.98	1.09	1.09	0.76
I frequently work directly with commodity groups in my position	Mean	3.15	2.50	3.67	2.90	2.37	3.05	3.52	2.50	2.68
	Std. Dev	1.38	1.02	1.32	1.27	1.10	1.31	1.19	1.12	1.07
Farmers use the extension and outreach information I provide in making their decisions	Mean	3.76	3.66	4.30	3.81	3.75	3.60	4.00	3.97	3.89
	Std. Dev	1.14	0.92	0.67	0.99	0.96	1.03	1.00	0.88	0.79
Agribusiness use the extension and outreach information I provide in making their decisions	Mean	3.20	2.79	4.63	3.48	2.91	3.08	3.60	2.98	2.96
	Std. Dev	1.26	1.00	0.52	0.92	0.96	0.87	1.00	1.05	0.96
Commodity groups use the extension and outreach information I provide in making their decisions	Mean	3.23	3.02	4.25	3.46	3.04	3.18	3.73	3.18	3.23
	Std. Dev	1.31	1.01	0.71	0.91	0.94	0.98	1.04	1.05	0.99

Likert Scale: 1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly agree

Table 4.4 Effectiveness of information sources extension educators and other outreach personnel use to obtain crop-related information as measured through a Likert scale

Information Sources	**Stats**	**Pacific Northwest**			**Prairie Gateway**			**Northern Great Plains**		
		Ext & Res N=63	**Gov N=57**	**Agbus N=10**	**Ext & Res N=127**	**Gov N=258**	**Agbus N=48**	**Ext & Res N=64**	**Gov N=161**	**Agbus N=30**
Internet	Mean	3.39	3.23	3.60	3.33	3.22	3.28	3.37	3.26	3.07
	Std. Dev.	0.82	0.75	0.70	0.68	0.74	0.77	0.66	0.74	0.80
News Media (Newspapers, TV, Radio)	Mean	2.06	2.36	2.56	2.40	2.56	2.13	2.44	2.51	2.28
	Std. Dev.	1.03	0.76	0.88	0.80	0.76	0.70	0.77	0.82	0.96
Trade, Farmer of Commodity Magazines	Mean	2.52	2.57	2.70	2.52	2.64	2.69	2.65	2.67	2.48
	Std. Dev.	0.85	0.74	0.82	0.86	0.79	0.76	0.64	0.75	0.95
Newsletters	Mean	2.79	2.72	3.00	2.66	2.76	2.55	2.71	2.66	2.76
	Std. Dev.	0.85	0.64	0.82	0.92	0.76	0.76	0.85	0.76	0.74
University Extension Publications	Mean	3.40	2.96	3.10	3.30	3.14	2.78	3.38	3.06	2.76
	Std. Dev.	0.79	0.77	0.99	0.81	0.75	0.94	0.79	0.76	0.91
Research Experiment Station Publications	Mean	3.25	2.68	3.22	3.03	2.85	2.62	3.31	2.78	2.72
	Std. Dev.	0.87	0.73	0.83	0.89	0.87	0.96	0.81	0.90	0.96
University Bioenergy Websites	Mean	2.78	2.26	2.40	2.52	2.24	2.00	2.52	2.18	1.92
	Std. Dev.	0.98	0.71	1.14	0.90	0.79	0.98	0.83	0.81	0.76
Other University Sources	Mean	2.96	2.50	2.44	2.64	2.56	2.34	2.74	2.50	2.44
	Std. Dev.	0.87	0.69	1.24	0.77	0.79	0.76	0.81	0.82	0.75
Federal Agricultural Agencies (USDA-NRCS, USDA-FSA)	Mean	2.69	3.00	2.75	2.72	3.22	2.38	2.48	3.20	2.24
	Std. Dev.	0.98	0.94	1.04	0.90	0.79	0.96	0.93	0.86	0.83
USDA Online Newsrooms, ARS Agricultural Research Magazine	Mean	2.55	2.41	2.00	2.43	2.52	1.94	2.17	2.56	2.04
	Std. Dev.	0.95	0.76	1.10	0.96	0.86	0.87	0.75	0.82	0.55
State Agricultural Agencies	Mean	2.60	2.50	2.90	2.52	2.48	2.13	2.43	2.42	2.23
	Std. Dev.	0.80	0.80	0.99	0.87	0.80	0.66	0.80	0.80	0.95
Farm Organizations (e.g. Farm Bureau)	Mean	2.17	2.38	2.43	2.35	2.28	2.08	2.25	2.20	2.09
	Std. Dev.	0.81	0.79	0.98	0.90	0.79	0.90	0.80	0.78	0.90
Commodity Organizations	Mean	2.44	2.55	3.00	2.28	2.10	2.16	2.48	2.05	2.32
	Std. Dev.	0.82	0.67	0.93	0.78	0.80	0.90	0.75	0.78	0.85
Seed Company Publications	Mean	2.26	2.56	2.43	2.26	2.22	2.59	2.27	2.22	2.43
	Std. Dev.	0.79	0.84	1.13	0.85	0.73	0.82	0.65	0.81	0.97
Other Industry Publications	Mean	2.27	2.36	2.50	2.20	2.07	2.48	2.24	2.13	2.38
	Std. Dev.	0.67	0.70	0.97	0.80	0.65	0.78	0.64	0.71	0.86
Product Documentation or Instructions	Mean	2.33	2.50	2.70	2.54	2.31	2.63	2.54	2.24	2.57
	Std. Dev.	0.83	0.80	1.16	0.82	0.77	0.90	0.87	0.80	0.77
Local Agribusinesses	Mean	2.44	2.68	3.11	2.49	2.41	2.48	2.56	2.48	2.50
	Std. Dev.	0.81	0.64	1.05	0.90	0.75	0.70	0.81	0.81	0.97

Likert Scale: 1=Not effective, 2=Somewhat effective, 3=Effective, 4=Very effective

Table 4.5 Events extension educators and other outreach personnel attend to obtain crop and other agricultural production-related information.

Information events	Stats	Pacific Northwest				Prairie Gateway				Northern Great Plains			
		Ext & Res	Gov	Agbus	Total	Ext & Res	Gov	Agbus	Total	Ext & Res	Gov	Agbus	Total
		N=63	N=57	N=10	N=130	N=127	N=258	N=48	N=433	N=64	N=161	N=30	N=255
Field days	NR	33	41	6	80	73	180	27	280	32	120	13	165
	%	52.38	71.93	60.00	61.54	57.48	69.77	56.25	64.67	50.00	74.53	43.33	64.71
Conferences	NR	36	20	9	65	86	120	30	236	41	75	22	138
	%	57.14	35.09	90.00	50.00	67.72	46.51	62.50	54.50	64.06	46.58	73.33	54.12
Meetings	NR	31	25	5	61	60	122	38	220	36	74	23	133
	%	49.21	43.86	50.00	46.92	47.24	47.29	79.17	50.81	56.25	45.96	76.67	52.16
Extension websites	NR	25	24	4	53	47	94	8	149	24	43	4	71
	%	39.68	42.11	40.00	40.77	37.01	36.43	16.67	34.41	37.50	26.71	13.33	27.84
On-farm demostrations	NR	15	14	2	31	33	89	10	132	13	60	10	83
	%	23.81	24.56	20.00	23.85	25.98	34.50	20.83	30.48	20.31	37.27	33.33	32.55
Interactive workshops	NR	11	15	-	26	15	60	6	81	14	50	3	67
	%	17.46	26.32	-	20.00	11.81	23.26	12.50	18.71	21.88	31.06	10.00	26.27
Seminars/ Lectures	NR	10	10	2	22	26	26	7	59	8	19	5	32
	%	15.87	17.54	20.00	16.92	20.47	10.08	14.58	13.63	12.50	11.80	16.67	12.55
Web-based forums	Freq	8	3	1	12	10	22	4	36	2	8	4	14
	%	12.70	5.26	10.00	9.23	7.87	8.53	8.33	8.31	3.13	4.97	13.33	5.49
University classes	NR	7	2	1	10	11	4	1	16	7	7	1	15
	%	11.11	3.51	10.00	7.69	8.66	1.55	2.08	3.70	10.94	4.35	3.33	5.88
Seed company events	NR	1	2	-	3	2	8	10	20	1	6	5	12
	%	1.59	3.51	-	2.31	1.57	3.10	20.83	4.62	1.56	3.73	16.67	4.71

NR= Number of people who ranked that source

Table 4.6 Sources and events extension educators use the most to provide crop related information to farmers

Outreach sources and events	Stats	Pacific Northwest				Prairie Gateway				Northern Great Plains			
		Ext & Res	Gov	Agbus	Total	Ext & Res	Gov	Agbus	Total	Ext & Res	Gov	Agbus	Total
		N=63	N=57	N=10	N=130	N=127	N=258	N=48	N=433	N=64	N=161	N=30	N=255
Fact sheets	NR	37	46	7	90	83	197	29	309	41	123	20	184
	%	58.73	80.70	70.00	69.23	65.35	76.36	60.42	71.36	64.06	76.40	66.67	72.16
Newsletters	NR	18	17	3	38	42	95	25	162	17	56	14	87
	%	28.57	29.82	30.00	29.23	33.07	36.82	52.08	37.41	26.56	34.78	46.67	34.12
Programs on bioenergy	NR	7	7	-	14	14	18	2	34	6	9	2	17
	%	11.11	12.28	-	10.77	11.02	6.98	4.17	7.85	9.38	5.59	6.67	6.67
Interactive website	NR	12	13	2	27	24	53	6	83	12	18	8	38
	%	19.05	22.81	20.00	20.77	18.90	20.54	12.50	19.17	18.75	11.18	26.67	14.90
Radio/ TV	NR	1	-	-	1	15	24	2	41	2	8	1	11
	%	1.59	-	-	0.77	11.81	9.30	4.17	9.47	3.13	4.97	3.33	4.31
Field days	NR	32	34	6	72	69	161	28	258	30	101	18	149
	%	50.79	59.65	60.00	55.38	54.33	62.40	58.33	59.58	46.88	62.73	60.00	58.43
Interactive workshops	NR	19	24	2	45	25	87	13	125	32	77	8	117
	%	30.16	42.11	20.00	34.62	19.69	33.72	27.08	28.87	50.00	47.83	26.67	45.88
Seminars	NR	29	10	6	45	53	53	19	125	24	41	10	75
	%	46.03	17.54	60.00	34.62	41.73	20.54	39.58	28.87	37.50	25.47	33.33	29.41
Community Education Events	NR	33	14	1	48	64	84	16	164	40	51	9	100
	%	52.38	24.56	10.00	36.92	50.39	32.56	33.33	37.88	62.50	31.68	30.00	39.22
County, State, and Ag Representative Fairs	NR	18	13	-	31	25	64	7	96	14	30	4	48
	%	28.57	22.81	-	23.85	19.69	24.81	14.58	22.17	21.88	18.63	13.33	18.82
Industry- sponsored events	NR	11	10	4	25	40	26	34	100	18	28	23	69
	%	17.46	17.54	40.00	19.23	31.50	10.08	70.83	23.09	28.13	17.39	76.67	27.06
Commodity Groups/ Grower Association events	NR	23	12	5	40	51	32	19	102	28	25	14	67
	%	36.51	21.05	50.00	30.77	40.16	12.40	39.58	23.56	43.75	15.53	46.67	26.27
Farm service agency/ Farm bureau events	NR	3	6	1	10	14	35	5	54	1	20	2	23
	%	4.76	10.53	10.00	7.69	11.02	13.57	10.42	12.47	1.56	12.42	6.67	9.02
State Department of Agriculture programs	NR	13	5	1	19	13	35	3	51	6	19	2	27
	%	20.63	8.77	10.00	14.62	10.24	13.57	6.25	11.78	9.38	11.80	6.67	10.59
USDA/NRCS, USDA/RMA, USDA/FSA	NR	11	36	3	50	22	203	7	232	18	128	4	150
	%	17.46	63.16	30.00	38.46	17.32	78.68	14.58	53.58	28.13	79.50	13.33	58.82
Soil and water conservation district	NR	13	37	2	52	20	162	2	184	13	114	3	130
	%	20.63	64.91	20.00	40.00	15.75	62.79	4.17	42.49	20.31	70.81	10.00	50.98
Crop consultant/ Certified crop advisor programs	NR	9	9	8	26	43	28	35	106	16	18	19	53
	%	14.29	15.79	80.00	20.00	33.86	10.85	72.92	24.48	25.00	11.18	63.33	20.78
Other events	NR	8	7	-	15	6	10	2	18	10	5	1	16
	%	12.70	12.28	-	11.54	4.72	3.88	4.17	4.16	15.63	3.11	3.33	6.27

NR= Number of people who ranked that source

Table 4.7 Estimates of the ordered variable with selection for use of learning method

Variable	**Internet**		**News media (newspapers, TV, radio)**		**Trade, farmer or commodity magazines**	
Constant	0.172		-0.168		1.196	***
	(0.455)		(0.326)		(0.442)	
Experience	0.00031		-0.005		-0.002	
	(0.006)		(0.006)		(0.006)	
Gender	0.120		0.391	***	0.371	***
	(0.108)		(0.102)		(0.109)	
Age	0.012	**	0.012	**	0.003	
	(0.005)		(0.006)		(0.005)	
Education	0.116		0.222	**	0.155	
	(0.103)		(0.103)		(0.111)	
Region: Pacific Northwest	0.012		0.012	*	0.003	
	(0.005)		(0.006)		(0.005)	
Region: Prairie Gateway	-0.157		0.264		0.099	
	(0.141)		(0.151)		(0.152)	
Position: Extension & Research	-0.045		-0.070	*	-0.022	
	(0.096)		(0.095)		(0.108)	
Position: Government	-0.236		-0.332	**	0.029	
	(0.164)		(0.167)		(0.173)	
Expertise: Crop production	0.057		0.093		0.189	*
	(0.102)		(0.098)		(0.102)	
Expertise: Finance & Marketing	-0.056		-0.201		0.054	
	(0.146)		(0.137)		(0.144)	
Method: Experiential	0.080		-0.242	**	0.080	
	(0.122)		(0.120)		(0.125)	
Method: Integrative	1.226	***	-0.602		-0.330	
	(0.142)		(0.995)		(0.768)	

Selection equation

Variable	**Internet**		**News Media (Newspapers, TV, Radio)**		**Trade, Farmer or commodity magazines**	
Experience	0.014		0.004		0.008	
	(0.009)		(0.007)		(0.008)	
Gender	0.397	**	0.077		0.172	
	(0.177)		(0.135)		(0.136)	
Age	-0.013		0.002		0.002	
	(0.009)		(0.007)		(0.007)	
Education	0.532	***	0.044		0.260	*

	(0.188)		(0.124)		(0.143)	
Work mainly with farmers	0.138		0.329	*	-0.361	*
	(0.244)		(0.173)		(0.192)	
Work mainly with agribusiness	0.567	***	0.558	***	-0.297	**
	(0.219)		(0.149)		(0.144)	
Perception: farmers use information	0.432	*	0.107		-0.560	*
	(0.249)		(0.185)		(0.306)	
Perception: agribusiness use information	0.381	*	0.307	**	-0.510	*
	(0.227)		(0.152)		(0.288)	
Threshold						
Threshold 1	0.932		-1.128		-0.555	
	(0.930)		(1.106)		(0.840)	
Threshold 2	2.243		0.156		0.846	
	(0.931)		(1.092)		(0.837)	
Threshold 3	3.293		1.404		2.113	
	(0.937)		(1.083)		(0.838)	
Log likelihood	-815.835		-983.369		-984.464	
Rho	0.443		0.545		0.062	

Note: Asymptotic standard errors are reported in parentheses under each coefficient estimate. *,**, and *** indicates statistical significance of an explanatory variable at the 10, 5 and 1 percent level of significance.