THE RESULTS OF SOYBEAN 2010: TRENDS IN MICHIGAN SOYBEAN PRODUCTION, 2005-2010

By

Angela Hobson

A Thesis

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Community, Agriculture, Recreation, and Resource Studies

2011

ABSTRACT

THE RESULTS OF SOYBEAN 2010: TRENDS IN MICHIGAN SOYBEAN PRODUCTION, 2005-2010

By

Angela Hobson

In 2005, the Michigan Soybean Promotion Committee (MSPC) and Michigan State University Extension (MSUE) launched *Soybean 2010*, a project to teach improved practices to producers. During the project, Michigan soybean growers were surveyed three times. The objective of this research was to conduct a survey of Michigan soybean growers to identify production practices, determine where producers go to find out agronomic information related to soybean production, and determine trends in Michigan soybean production practices by comparing results from the 2005, 2008, and 2011 surveys.

The results of the surveys show that respondents use seed/chemical suppliers, grower meetings, and MSU Extension for information. 27% of respondents report making a change as a result of *Soybean 2010*. The results of the surveys also show that average seeding rates have dropped, growers are switching from drills to planters, and they are using inoculants and fungicidal seed coatings in greater numbers. They are also moving away from 7.5 inch row widths. Overall, the practices of Michigan producers have moved closer to the recommendations of the MSPC and MSUE since 2005.

Acknowledgements

I would like to thank everyone who supported me through this process. To my family for their love, unstinting affection, reassuring presence, and the occasional cash "accidentally" left on the table.

To Dr. Murari Suvedi for guiding me and, above all, for giving me the opportunity to do this. I wouldn't be here without him.

To my committee members, Jennifer Rivera and Kurt Thelen, for their time and willingness to share their knowledge with me.

To Clipper and Buffy for adjusting to going out in snow over their heads.

I would also especially like to thank the Michigan Soybean Promotion Committee for the funding which made my education and thesis possible. And to Keith Reinholdt and Mike Staton for all of their help in steering a soybean novice through her initiation.

TABLE OF CONTENTS

LIST OF TABLES

Chapter One: Introduction

The *Soybean 2010* program was a research, education, and communication effort to assist Michigan producers in improving soybean yields and profitability. It was initiated by the Michigan Soybean Promotion Committee (MSPC) and Michigan State University Extension (MSUE) in 2005 in response to stagnant soybean yields in Michigan as compared to the increase in corn and wheat yields. From 1994 to 2004, the average corn yield in Michigan increased by 8.4% and the average wheat yield increased by 35.1%. In contrast, the yield for soybeans over that same period decreased by 8.7% (Suvedi, Thelen, Pennington & Takagi, 2005). It is also contrary to the national trend in soybean yields during that time; the national average yield for soybeans increased by 6.8% (Suvedi, Thelen, Pennington & Takagi, 2005). These trends are illustrated in Table 1.

Table 1: *Commodity Yields, National and Michigan*

		Michigan		**National Increase**
	1994 Yield (bu)	2004 Yield (bu)	Change (%)	%
Wheat	49.6	67.0	35.1	8.3
Corn	111.4	120.8	8.4	18.2
Soybean	36.8	33.6	-8.7	6.8

Note: Adapted from Suvedi, Thelen, Pennington & Takagi, 2005

Soybean 2010 published 25 fact sheets for growers on aspects of soybean production and profitability and issued press releases on relevant soy issues. The fact sheets were made available on the MSPC website. Mike Staton of MSU Extension organized a soybean yield contest to encourage growers to pay attention to yields and focus awareness on soybean production. Grower meetings were organized by the MSPC and MSUE and held in the off-season as forums for education on recommended production practices.

MSPC and MSUE recognized that the educational needs of Michigan farmers would change over time and that they would need to modify which practices were given the most attention in educational programs as growers learned and changed how they farmed. There was also a need to evaluate how well *Soybean 2010* was reaching and educating Michigan farmers. To meet both of these needs, a periodic evaluation process using a survey instrument was begun. Surveys were sent to 1,500 Michigan producers in 2005, 2008, and 2011 to gather information on current production practices, to understand how the growers viewed soybean production in Michigan, and to gauge the progress of *Soybean 2010*. For this paper, the survey results from these three years were compiled and examined for evidence of changes.

Objectives

The main objectives of this research project were to:

- Conduct a survey of Michigan soybean growers to identify production practices;
- Determine where producers go to find out agronomic information related to soybean production;
- Identify what producers think the problems and issues are contributing to lagging soybean production;
- Identify key areas for future research and educational programs intended to increase grower profitability; and
- Determine trends in Michigan soybean production practices by comparing results from the 2005, 2008, and 2011 surveys.

Structure of the Paper

The first chapter presents the significance and objectives of the research study along with a definition of terms. The methodology and statistical analysis are explained with an emphasis on the survey items relating to seed practices, information sources, and awareness of *Soybean 2010*. These topics are explored in greater detail in Chapters Three and Four. The second chapter presents the general survey findings. The first section describes how responses to the survey have changed over time, from 2005 to 2011. The second section describes the survey responses from the 63 producers who responded to the survey all three years. The third, fourth, and fifth sections describe how two groups, one high yielding and one low yielding, were generated and how their responses differed. Section three presents the data from the two yield groups in 2005, section four presents the data from 2008, and section five presents the data from 2011. The sixth section describes the results of a statistical analysis of the effect of a limited number of variables on average yield and number of acres farmed. The variables include tillage type and pest management. Chapters Three and Four are deeper explorations of sub-topics of the survey. Chapter Three focuses on seed and planting related production practices and was written for an audience in the crop management fields. Chapter Four focuses on the information sources used by growers and their interactions with the Soybean 2010 project and was written for an audience in the extension and outreach fields.

Significance of the Study

This study is a significant record of the *Soybean 2010* project. It summarizes the complete findings and work of the *Soybean 2010* project, and also documents the people and work which made it happen. This study serves as a record of the project for future reference and it documents the results for future inquiry. It also makes an in-depth analysis of some issues from Soybean

2010. The papers on the seed and planting practices of Michigan growers and on farmers' perceptions of *Soybean 2010* and information sources both offer a deeper look at the reasoning behind the survey questions and the responses. *Soybean 2010* generated a wealth of information and this compilation makes it available in a single location, in an accessible format, and a significant resource for future researchers, growers, and educators.

Terms

Stand: The stand of soybeans refers to the number of soybean plants which have established in a field. It is critical to establish a good stand to have good yields. Population is also used to refer to the stand of plants (Bennet, Hicks, Naeve, & Bennet, 1999).

Inoculation: The practice of coating soybean seed with Rhizobia bacteria prior to planting. These bacteria form a cooperative relationship with the soy plant, including nitrogen exchange (Bennet, Hicks, Naeve, & Bennet, 1999).

Drills and Planters: These planting devices cut the soil, drop a seed through a tube into the furrow, and cover it. Drills generally use fluted mechanisms to meter the seed and do not control depth of planting well. Planters are widely adjustable, generally use vacuum metering that places seed more accurately, and have better depth placement (Beuerlein, 2011).

Soybean cyst nematode (SCN): Soil-dwelling nematodes that damage soybean plants through the roots. The root damage causes stunted, weak plants and the number of nodules that mark good Rhizobia populations is reduced (Bennet, Hicks, Naeve, & Bennet, 1999).

Michigan Soybean Production

According to the MSPC, Michigan is the second most agriculturally diverse state in the U.S., outpaced only by the agricultural powerhouse state of California. In Michigan, soybeans were the third highest grossing commodity in 2009, increasing from $686.7 million in 2008 to $748.2 million (Kleweno, 2010). More than half of the counties in Michigan produced 79,600,000 bushels in 2009, placing the state 12th among the 31 states that produce soybean commercially (MSPC, 2011). Soybeans and soy products generated $419.7 million in exports in 2009, which is an increase of 50% since 1999 (MSPC, 2011). Like corn, the most valuable commodity produced in Michigan, soybeans can be processed into a number of products (Kleweno, 2010),. The Michigan Soybean Promotion Committee and the Soybean Checkoff program promote these products, such as soybean oil and soy ink, along with soybeans.

The Role of Soybean Promotion Committees

According to Williams, Capps, and Bessler (2009), checkoff programs for soybeans have existed since the 1950's. A small fraction of the price of each bushel sold was "checked off" and the monies were divided between state soybean associations and the national association to use to promote the industry. These programs were state administered until 1990 when the Farm Bill authorized a national soybean checkoff program, known as the United Soybean Board. In 1991, the Soybean Promotion, Research, and Consumer Information Act instituted mandatory checkoff of 0.5% of the price of every bushel for all soybean producers (Williams, Capps, & Bessler, 2009). The monies are pooled and divided among the states and the national checkoff board (Williams, Capps, & Bessler, 2009; MSPC, 2011).

In Michigan, the soybean checkoff program began in 1976 (MSPC, 2011) and continues today through the Michigan Soybean Promotion Committee and part of the national checkoff program. MSPC funds outreach initiatives to build a positive image of soybeans among the public,as well as research and communication programs to increase the production and profits of soybeans for soybean farmers. *Soybean 2010* was one of these checkoff programs. MSPC sponsored the evaluation of *Soybean 2010* providing the data reported in this thesis.

MSPC is similar to most state promotion committees in spending more funds on production research (26%) than on any other area (MSPC, 2011; Williams, Capps, & Bessler, 2009). The use of producer controlled funds to steer research is unusual in many academic environments where government and public bodies provide most of the funding (Lim, Shumway, Love, 2000). But research has shown that projects chosen and funded by checkoff boards can increase producers' profits at a greater rate than publicly funded projects (Lim, Shumway, Love, 2000). A government mandated evaluation in 2008 of the national soybean checkoff program found that the program had increased the size of the industry and returned over $6.00 for every dollar spent (Williams, Capps, & Bessler, 2009).

Methodology and Statistical Analysis

The first survey in 2005 was developed with technical assistance from the MSU Center for Evaluative Studies. The survey questions were developed by MSU faculty, MSU Extension personnel, and MSPC staff. After development, the survey was reviewed for reliability and validity by experts including Mark Seamon, Kurt Thelen, Mike Staton, Keith Reinholt, George Silva, Dennis Pennington, and Ned Birkey. The result was an approximately 3 page quantitative questionnaire with a mix of 49 multiple choice and short answers questions.

The 2005 survey was sent to a representative stratified sample of 1500 Michigan soybean producers. The Michigan Soybean Promotion Committee generated the sample through its mailing database and the sample was stratified by soybean acreage. The MSPC distributed and collected the completed surveys and sent the de-identified surveys to Michigan State for data entry, data analysis, interpretation, and report generation.

The 2008 and 2011 surveys utilized the same survey instrument except for minor modifications and the same data analysis framework as previous years. The only major change in question format was discarding the duplicate approach which asked respondents to report the same data twice, once for a high producing field and again for a low producing field. The 2008 and 2011 surveys asked for averages for variables such as yield, percent of weed control achieved, etc. The same 1500 producers were used as the sample. In 2008 and 2011, an incentive was offered to respondents who completed the survey. The cover letter informed recipients that they would receive a flash drive, worth approximately $10-20, for completing the survey and that it would be pre-loaded with a report of the results of the survey and soybean production instructional materials such as fact sheets.

Data was analyzed for statistical significance using SPSS software v 19. Descriptive statistics were generated to describe the population and inferential statistics were used to explore relationships and differences of soybean production practices by Michigan growers. Preliminary findings reports were given to the MSPC and summary reports were given to respondents.

280 soybean producers (18.7%) responded in 2005, 243 (16.2%) responded in 2008, and 198 producers (13.2%) responded to the 2011 survey. There were 32 producers in the dataset without ID numbers from 2005 and 2008 and they were deleted before the final numbers were computed. The final total number of responses was 698 (15.5%). There were 63 producers who responded to the survey all three years and 120 who responded to both 2005 and 2008. Overall, the response rate declined over time.

The de-identified survey data for all three surveys were coded, analyzed, and reported by Dr. Murari Suvedi and his graduate assistants. The MSPC generously agreed to release the data for use in research such as this paper and publications. Additionally, the Michigan State University Institutional Review Board classified this survey research as "Non-Human Subject/Research" and allowed its use in this paper. Thus, in 2011, the complete dataset was ready for analysis and was used to generate the results in this paper.

Chapters Three and Four are deeper explorations of sub-topics of the survey. The following sections detail the survey questions pertinent to those sub-topics. Brief backgrounds on the two topics, seed and planting related production practices and the information sources used by growers are included to provide context for the survey items.

Survey Questions Relating to Production Practices and Seed.

The survey asked 6 questions about seeding/planting practices. Respondents were asked to report the planting rate in seeds per acre, whether a planter or a drill was used, and the planting row width in inches. They were also asked how they measured application rate (seeds or pounds per acre), whether the planter/drill was recalibrated between seed varieties, and the average planting speed.

The 2011 survey also asked 6 questions about soybean seed. Respondents were asked how they selected varieties, the percentages of seed maturity groups used, and what type of seed (Food Grade, Roundup Ready, Low Sat, and Low Linolenic). They were also asked whether the seed was treated with fungicide, or inoculated, and if they control soybean cyst nematode (SCN) by seed selection. The choice of seed as it relates to harvest and sale, i.e. maturity group or type of seed, are not analyzed in this paper. The results of these questions are presented in the appendices.

Background on Production Practices Related to Seed.

Soybean 2010 recommended a number of specific changes to growers. Producers were told to 1) lower seeding rates, 2) decrease row widths, and 3) increase the use of fungicide coated seed and inoculants. The project also recommended to 4) measure seeding rates in seeds per acre rather than pounds per acre because the former is more precise (Staton, Thelen, & Silva, 2011; Staton, & Poindexter, 2011), 5) recalibrate the equipment when switching between seed varieties, and 6) to use planters in place of seed drills.

The recommendation to lower the seeding rate is based on data indicating that yields are not reduced by lower rates in northern climates (Chen & Wiatrak, 2011; Epler & Staggenborg, 2008; Rich & Renner, 2007). Soybean plants respond to lower densities by increasing branching and by having more pods per plant and/or more seeds per pod (Epler & Staggenborg, 2008, De Bruin & Pedersen, 2008). Yields can be maintained at lower seeding rates because yield is more attributable to the number of seeds and their weight rather than the number of plants in the field (De Bruin & Pedersen, 2008). It also increases economic viability by limiting the need to buy more of a costly input, genetically modified seed (Chen & Wiatrak, 2011; Epler & Staggenborg, 2008). The high seeding recommendations of the past may have been due to the low cost of seed

before the availability of modified seed (Epler & Staggenborg, 2008). MSPC and MSUE recommend planting 175,000 seeds per acre when planting with a drill in 7.5" rows. The seed rate falls to 150,000 seeds per acre when the row width increases to 15" and to 130,000 seeds when the width increases to 30" (Staton, Thelen, & Silva, 2011).

Recalibrating the planting device when switching between seed varieties is also recommended, because seed varieties vary in size, and recalibrating prevents seed waste and uneven populations (Staton, & Poindexter, 2011). MSUE and MSPC also recommend that growers use planters rather than drills for planting. Drills are less precise than planters and tend to leak seed, especially when pulled too quickly, contributing to uneven stands (Cox, Cherney, & Shields, 2010). Epler and Staggenborg (2008) attribute the historically high seeding rate recommendations to trials done with grain drills adjusted for wheat seed. An uneven population or stand may lead to yield loss (Bennet, Hicks, Naeve, & Bennet, 1999).

Row width is an important contributor to final yield (Chen & Wiatrak, 2011; Costa, Oplinger, & Pendleton, 1980; Epler & Staggenborg, 2008). Narrow rows provide weed control through an early and tight canopy shadeing out weeds (Yelverton & Coble, 1991; Bennet, Hicks, Naeve, & Bennet, 1999). However, the increased density has costs; the price of the extra seed and the increase number of plants lost to crowding or lodging must be taken into account when considering to narrow rows (Chen & Wiatrak, 2011; Costa, Oplinger, & Pendleton, 1980; Epler & Staggenborg, 2008). MSUE and MSPC recommend the use of narrow rows due to the associated increase in yields (Bertram & Pedersen, 2004; Costa, Oplinger, & Pendleton, 1980; Yelverton & Coble, 1991). Narrow rows have a width of 30 inches (76 cm) or less (Bertram & Pedersen, 2004; Cox & Cherney, 2011).

MSPC and MSUE also recommend the addition of seed treatments. They recommend that inoculants be used for all soybean plantings because research has shown significant yield increases of 1.3 bushels when inoculation is used on sites where soybeans have been produced previously (Schulz & Thelen, 2008). Inoculation is a seed treatment unique to legumes. The nitrogen fixing properties which are normally ascribed to the plants are actually the result of three species of Rhizobia bacteria (Chrispeels & Sadava, 2003). *Bradyrhizobiu mjaponicum* is the species specific to American soybean cultivars (Schulz & Thelen, 2008). The application of Rhizobia bacteria to the soybean seed increases the likelihood that the symbiotic relationship between the bacteria and the plant will occur (Bennet, Hicks, Naeve, & Bennet, 1999). The Rhizobia bacteria and the plant root hairs form nodules, allowing materials to flow back and forth (Chrispeels & Sadava, 2003). The bacteria take atmospheric nitrogen (N_2) and fix it into NH_4, which the soybean plant can use; the plant provides the bacteria with nutrients in the form of metabolites produced by photosynthesis (Chrispeels & Sadava, 2003). The Rhizobia bacteria are naturally occurring, but inoculation ensures that the soybean plant will have access to a sufficient population of the proper bacteria (Chrispeels & Sadava, 2003). Soybeans do not require Rhizobia bacteria to grow, but the plant will use soil nitrogen rather than the nitrogen the provided by the bacteria . This can lead to soil depletion, rather than the nitrogen increase that is a benefit of growing legumes in a crop rotation (Thelen & Schulz, 2011). The use of fungicide treated seed is also recommended when planting early or in Southwest Michigan where pythium is a problem (Staton, Thelen, & Silva, 2011).

The use of seed which has been genetically modified for resistance to the herbicide Round-Up is not closely analyzed in this manuscript. However, the ubiquitous use of seed that has been

genetically modified for resistance reported in the survey results indicates that herbicide application (timing and rates) is a major concern for growers. The narrow rows recommended to maximize yields also make cultivation for weed control difficult stressing the importance of herbicides (Wax & Pendleton, 1968). The popularity of genetically modified seed can be attributed to its many advantages, including reduced total herbicide application and herbicide runoff, easier use of conservation tillage, and increased reliance on less environmentally damaging herbicides (Culpepper and York, 2000).

Because timing is more critical as compared to the rate of application (as found in the popular herbicide glyphosate) or the brand of herbicide, surveys items did not ask respondents to name the herbicides applied to their fields or the rate of application (Payne & Oliver, 2000). But from the timing of the application, conclusions can be drawn concerning the type of product used. For example, glyphosate is a non-selective herbicide that is applied before emergence in most systems, but when applied in genetically modified systems, it is a post-emergent herbicide. Therefore, when respondents indicate that a post-emergent herbicide is used, it is likely to be glyphosate, thifensulfuron methyl, or chlorimuron ethyl. The ability to apply herbicide after the soybean seeds have emerged widens the time window for application. However, glyphosate and the other common products do not have any residual soil activity after application (Coulter & Nafziger, 2007), which means that weeds that emerge post-application must be dealt with separately. There are several strategies for dealing with post-application emerging weeds, such as re-applying glyphosate, delaying the first glyphosate application to allow for maximum weed emergence, or applying a different herbicide before seedling emergence and then following it with glyphosate after emergence (Coulter & Nafziger, 2007). However, there are drawbacks to these strategies. A second application of glyphosate adds to the costs of the crop and delaying

application can allow weeds to compete with the crop or allow weeds to grow past a stage where they are vulnerable to glyphosate (Grey, 2007, Payne & Oliver, 2000). A pre-emergent herbicide application coupled with a post-emergent glyphosate application allows the grower to delay glyphosate use without the drawbacks mentioned above. However, Johnson et al (2002) found yield reductions when a pre-emergent herbicide was applied first (Coulter & Nafziger, 2007). Residual herbicides are gaining favor in part because they provide an alternate mode of action which allows the grower to benefit from a pre-emergent application with greater weed control. The use of an alternate mode of action could also help stem the increase in glyphosate resistant weeds (Grey, 2007). Yield increases of 380 kg/ha were reported by Grey when use of a residual herbicide was included with glyphosate applications. The residual action of an herbicide, such as imazethapyr, when applied with the glyphosate maximizes weed control while minimizing the number of passes and does not require delaying according to Grey (2007).

Survey Questions about Information Sources and Awareness of Soybean 2010.

The 2011 survey asked growers to provide their sources of agronomic information and if they were aware of the *Soybean 2010* project. It also asked if the respondent had attended any of the *Soybean 2010* meetings, used any of the *Soybean 2010* materials like the website, hotline, or fact sheets, and whether they had changed any management practices as a result of what was learned from *Soybean 2010*.

Descriptive data were generated using SPSS v. 19 and analyzed using independent sample t-tests and paired sample t-tests, one-way Anova, and Pearson correlation. The overall dataset from the three survey years includes 63 respondents who participated in all three surveys. A separate longitudinal analysis of the 63 is included highlighting response differences as compared to the overall dataset.

Background on Information Sources and Awareness & Impact of Soybean 2010.

Soybean 2010 was a program established by the MSPC and MSUE with the goal of influencing the production choices of Michigan soybean farmers through communication and education. Therefore, competing sources of information were a concern and the surveys attempted to ascertain where else growers seek production information.

There is a divergence in the literature concerning growers' preference for print information versus face-to-face exchanges. Howell and Habron (2004) and Diekmann and Batte (2009) reported a preference for print media over personal exchanges. However, a number of studies have found that growers prefer interpersonal contact (Bruening, Radhakrishna, & Rollins, 1992; Lasley, Padgitt, & Hanson, 2001; Licht & Martin, 2007). These studies complement the findings of Howell and Habron (2004) and Diekmann and Batte (2009) because those researchers also found strong preferences for personal communication. According to Licht and Martin (2007), corn and soybean producers use media to gather general information and then use in-person means, such as Extension personnel, to evaluate what they have learned. Foltz, Lanclos, Guenther, Makus, and Sanchez (1996) found that Idaho dairy and potato farmers placed higher value on in-person sources like university specialists, but indicated that they preferred print sources like newsletters. The thicket of preference versus value versus actual use is difficult to decipher. In light of the divergence in the literature, this research focused on actual use of five information sources: grower meetings, media, Internet, seed/chemical suppliers, and MSU Extension.

The importance of Extension personnel and information relative to the importance of input suppliers like seed and chemical suppliers as an information source is an area of interest to the

MSPC and MSUE. While Alston & Reding (1998) found that Utah grain producers used Extension agents and chemical suppliers at nearly the same rate, Roseler, Chase, & McLaughlin (1994) concluded that direct Extension use is declining and it will increasingly need to reach dairy farmers by going through the nutrition companies which supply the farms. Foltz et al. (1996) also found that respondents rated independent and industry consultants as more reliable than public ones like Extension educators. However, farmers prefer to draw on multiple information sources, including university specialists and Extension educators (King & Rollins, 1999; Velandia et al., 2010).

The use of the Internet is also a key area of interest. According to the U.S. Department of Commerce (2011), 68% of U.S. households use broadband Internet. The rates of Internet use are lower for rural areas, but factors such as income and lack of interest were more important for determining use than geography (U.S. Department of Commerce, 2011). Howell and Habron (2004) found that Internet access did not increase the percentage of respondents interested in receiving information over the Internet. Bruening, Radhakrishna, and Rollins (1992) note the reluctance of farmers to embrace newer technology such as videocassettes. While cassettes are now largely obsolete, the general reluctance of farmers to adopt new, impersonal technologies appears to be intact. The relatively low use of Internet sources found in this research is similar to other research (Howell & Habron, 2004; Diekmann & Batte, 2009, Davis & Conley, 2011). Research has also found that producers with larger farms are more likely to rate the Internet highly as a source of information, but still found that less than 50% of farmers in Indiana use e-mail (Davis & Conley, 2011).

Chapter Two: Descriptive Summary of Soybean 2010

Section One: General Summary of Trends from 2005-2011

The average yield in 2011 was 44.5 bushels/acre. On average, the reported yields increased from 2005 to 2008. Table 3 describes the trend.

Table 2 *Average Soybean Yield in Bushels per Acre*

	2005			2008 (N=237)	2011 (N=197)
	High Producing Field (N=270)	Low Producing Field (N=255)	5 year average (N=248)		
Mean (s.d.)	45.8 (7.9)	35.3 (7.5)	39.7 (6.6)	43.3 (6.7)	44.5 (5.9)
Minimum	21	15	21	28	30
Maximum	70	55	61	62	62

The average acreage in 2011 was 482 acres. High-yielding producers in 2011 farmed an average of 430 acres and low-yielding producers averaged 303 acres. This is similar to data from 2008 which also found that larger operations had higher yields. In general, soybean acreage is increasing in Michigan. The average number of acres of soybeans planted has increased by 100 acres since 2005 as shown in Table 4.

Table 3 *Average Number of Acres of Soybeans in the Last 5 Years*

	2005 (N=256)	2008 (N=239)	2011* (N=195)
Mean	367.3	385.8	482.3
St. Deviation	379.1	373.9	631.8
Minimum	15	20	15
Maximum	2,500	3,000	6,000

*Outlier of 10,000 acres was removed

Table 5 demonstrates that the number of farmers using services for fertilizer, lime application, scouting, and soil sampling has increased since 2005. The percentage using soil sampling

services has nearly doubled from 32% to 61% in 2011. The percentage using fertilizer application services has also doubled, climbing from 21% to 40%. The use of lime application services increased from 36% to 54%. The use of scouting services increased from 14.3% to 17.7%. The percentage using harvesting services has dropped slightly from 11.8% to 10.6%. The use of planting services dropped from 4.6% to 3.0% with a spike in 2008 of 7.0%. The use of spraying services has remained steady since 2008 at 37%.

Table 4 *Custom Services Used*

	2005 (N=261)	**2008 (N=230)**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
Planting	12 (4.6)	17 (7.4)	6 (3.0)
Soil sampling	81 (31.0)	108 (47.0)	121 (61.1)
Harvesting	32 (12.3)	29 (12.6)	21 (10.6)
Pesticide applications**	79 (28.2)		
Scouting	36 (13.8)	39 (17.0)	35 (17.7)
Fertilizer applications	53 (20.3)	73 (31.7)	78 (39.4)
Lime applications	96 (36.8)	113 (49.1)	108 (54.5)
Spraying*		89 (38.7)	73 (36.9)
None*		47 (20.4)	25 (12.6)

*This item was not included in 2005. **This item was not included in 2008 or 2011.

Table 6 presents trends in seed selection. Selection of SCN resistance as a seed trait as increased from 29.3% to 50.0%. The use of specialty markets and market premiums saw similar increases in 2008 and decreases in 2011. Specialty market rose from 16.8% to 18.1% and then fell to 13.6%. Market premium rose from 16.4% to 18.5% and then fell to 12.6%. Reliance on other criteria remained steady. The use of Round-up Ready seed remains high at 70% and past performance on the farm is above 70% all three years. 46-47% of respondents rely on MSU variety trials and 41% select for disease resistance. The use of synchrony tolerant seed has increased from 3.9% to 7.6%.

Table 5 *Criteria for Selection of Soybean Varieties*

	2005 (N=261)	2008 (N=230)	2011 (N=198)
	Frequency (%)	Frequency (%)	Frequency (%)
MSU Soybean Variety Trials	120 (46.0)	96 (41.7)	94 (47.5)
Past Performance on Farms	166 (63.6)	162 (70.4)	150 (75.8)
Dealer Recommendation	201 (77.0)	158 (68.7)	138 (69.7)
Specialty Market	45 (17.2)	43 (18.7)	27 (13.6)
Market Premium	44 (16.9)	42 (18.3)	25 (12.6)
Disease Resistance	106 (40.6)	91 (39.6)	83 (41.9)
Soybean Cyst Nematode Resistance	76 (29.1)	107 (46.5)	99 (50.0)
Round-up Ready	196 (75.1)	176 (76.5)	141 (71.2)
Synchrony Tolerant (ST)	11 (4.2)	13 (5.7)	15 (7.6)

Soils and fertilizer information.

The majority of respondents, over 60% each survey, perform a soil test every 2-3 years (Table 7). Approximately 20% perform one every 4-5 years. Regular soil tests may indicate that growers are paying attention to the fertility of their soil. The increasing percentage of growers (72.5% in 2011) shown in Table 9 that use a custom blend fertilizer supports this conclusion. Shown in Table 8, respondents report use of the soil test information to apply phosphorous, potassium, and lime most frequently. The percentage applying micro-nutrients as a result of the soil test rose from 61.8% to 70.2% in 2011.

Table 6 *Frequency of Soil Test*

	2005 (N=246)	2008 (N=220)	2011 (N=194)
	Frequency (%)	Frequency (%)	Frequency (%)
Every year	14 (5.7)	19 (8.3)	13 (6.7)
2-3 Years	165 (67.1)	139 (60.4)	132 (68.0)
4-5 Years	60 (24.4)	46 (20.0)	43 (22.2)
6-10 Years	7 (2.8)	8 (3.5)	4 (2.1)
Seldom/rarely*		5 (2.2)	2 (1.0)
Never*		3 (1.3)	

*This item was not included in 2005.

Table 7 *Purpose of the Soil Test Information*

	2005 (N=261)	**2008 (N=230)**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
Phosphorous application	220 (84.3)	192 (83.5)	170 (85.9)
Potassium application	222 (85.1)	197 (85.7)	177 (89.4)
Micro-nutrients application	163 (62.5)	150 (65.2)	139 (70.2)
Lime application/ Adjusting the soil pH	222 (85.8)	206 (89.6)	183 (92.4)

Table 8 *Types of Fertilizer Used*

	2005 (N=256)	**2008 (N=225)**	**2011 (N=193)**
	Frequency (%)	Frequency (%)	Frequency (%)
A commercial blend	86 (33.6)	50 (21.7)	39 (20.2)
A customized blend	157 (61.3)	163 (70.9)	140 (72.5)
Both*		12 (5.2)	14 (7.3)
Other**	13 (5.0)		

*This item was not included in 2005. **This item was not included in 2008.

Table 10 describes the timing of fertilizer applications. The number of producers applying fertilizer in the fall, spring, and at planting has increased since 2005. Fall fertilizer rates have increased from 42% to 54%. Spring rates increased from 37% to 66% and at planting fertilization rates increased from 21% to 56%. The percentage applying one treatment bi-annually for both corn and soybeans has dropped from 15% to 8%.

Table 11 shows that phosphorus and potassium application rates have remained steady. Applications of boron, sulfur, and manganese have increased. Sulfur use has increased from 46% in 2005 to 62% in 2011 and manganese use increased from 60% to 68%.

Table 9 *Fertilizer Application Timing*

	2005 (N=258)	2008 (N=230)	2011 (N=198)
	Frequency (%)	Frequency (%)	Frequency (%)
Fall	101 (41.5)	102 (44.3)	106 (53.5)
Spring	94 (36.4)	135 (58.7)	131 (66.2)
At Planting	57 (22.1)	124 (53.9)	112 (55.6)
Post Emergence Foliar*		41 (17.8)	46 (23.2)
One Application Bi-annually for Soybean and Corn*		33 (14.3)	15 (7.6)

*This item was not included in 2005.

Table 10 *Nutrients Supplied by Fertilizers*

	2005 (N=261)	2008 (N=230)	2011 (N=198)
	Frequency (%)	Frequency (%)	Frequency (%)
Phosphorous	221 (81.2)	187 (81.3)	162 (81.8)
Potassium	229 (87.7)	203 (88.3)	183 (92.4)
Sulfur	117 (44.8)	111 (48.3)	122 (61.6)
Boron	66 (25.3)	68 (29.6)	82 (41.4)
Manganese	157 (60.2)	152 (66.1)	134 (67.7)
Foliar*		53 (23.0)	74 (37.4)
Nitrogen**	189 (67.5)		
Iron**	38 (13.6)		
Other	15 (5.7) e.g., agricultural calcium, copper, zinc, nutrients	19 (8.3) e.g., calcium, magnesium, zinc, lime, manure,	20 (10.0) e.g., calcium, magnesium, zinc, lime, manure,

*This item was not included in 2005. **This item was not included in 2008.

Table 12 describes how tillage practices have changed over time. The use of moldboard plows has decreased from 17% to 9% since 2005 and the use of field cultivators has increased from 43% to 51%.

Table 11 *Tillage Practices*

	2005 (N=261)		2008 (N=230)	2011 (N=198)
	High Producing Field Frequency (%)	Low Producing Field Frequency (%)	Frequency (%)	Frequency (%)
Chisel Plow	131 (50.2)	122 (47.1)	111 (48.3)	96 (48.5)
Moldboard Plow	45 (17.2)	34 (13.1)	25 (10.9)	18 (9.1)
V-Ripped	40 (15.3)	36 (13.8)	25 (10.9)	29 (14.6)
Deep Slots**	19 (7.3)	17 (6.55)	14 (6.1)	.
Disk	72 (27.6)	63 (24.3)	63 (27.4)	49 (24.7)
Field Cultivator	115 (44.1)	108 (41.6)	105 (45.7)	101 (51.0)
No-Till	144 (55.2)	148 (57.1)	153 (66.5)	117 (59.1)
Vertical Tillage*				32 (16.2)
Zone/Strip Tillage*				10 (5.1)
Other***			6 (2.6)	2 (1.0)

* This question was not asked in 2005 or 2008. **This option was not offered in 2011 ***Not included in 2005

Pest management information.

Herbicide application practices have changed as shown in Table 13. More producers are applying herbicide pre-emergence with residual activity, up from 13% in 2005 to 26% in 2011. The use of one application of glyphosate has decreased from 54% to 43%. Post-emergence application has dropped from 49% in 2005 to 15% in 2011. Most producers in each year report achieving 90% control of weeds or better.

Fungicide and insecticide applications have increased as shown in Table 16. The use of fungicides increased from 6.1% in 2005 to 34.2% in 2011. Insecticide applications also increased from 47.9% to 66%. The majority of producers are scouting their fields regularly with a small increase of 7% since 2005 (Table 14). The percentage of producers scouting for spider mites has doubled from 30% to 60% as shown in Table 15, but fewer are scouting for soybean rust, dropping from 37% in 2005 to 26% in 2011.

Table 17 presents methods of SCN control. The use of resistant seed varieties to combat SCN has increased since 2005, but the use of monitoring by testing has decreased. 46% of respondents used SCN resistant seed in 2005 with an increase over the years to 69% in 2011. The percentage using testing fell by half; from 11% in 2005 to 5% in 2011. The percentage using testing at all also fell; from 26% in 2005 to 20% in 2011. 70% of farmers continue to use crop rotation to combat SCN.

Table 12 *Herbicide Application*

	2005 (N=261)	**2008 (N=230)**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
Pre-plant	64 (24.5)	56 (24.3)	35 (17.7)
Pre-emergence* **	50 (19.2)	17 (7.4)	
Pre-emergence with residual activity*		30 (13.0)	51 (25.8)
Post-emergence	124 (47.5)	68 (29.6)	30 (15.2)
Two pass (Pre- and post program)	37 (14.2)	35 (15.2)	33 (16.7)
Glyphosate/ Round-up Ready (1 application)	141 (54.0)	95 (41.3)	86 (43.4)
Glyphosate/ Round-up Ready (2 applications)	113 (43.3)	135 (58.7)	92 (46.5)
No herbicide used**	6 (2.1)		

*This item was not included in 2005. **This item was not included in 2008 or 2011. ***This item was not included in 2011.

Table 13 *Field Scouting*

	2005	**2008**	**2011**
	Frequency (%)	Frequency (%)	Frequency (%)
Are field scouted on a regular basis?	(N=254)	(N=228)	(N=197)
Yes	189 (74.4)	188 (81.7)	162 (82.2)
Are field scouted by a crop consultant?	(N=255)	(N=228)	(N=195)
Yes	68 (26.7)	52 (22.6)	46 (23.6)

Table 14 *Purposes of Scouting Soybean Field*

	2005 (N=261)	**2008 (N=230)**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
White Mold	162 (62.1)	142 (61.7)	137 (69.2)
Septoria Leaf Spot	42 (16.1)	39 (17.0)	30 (15.2)
Soybean Cyst Nematode*		93 (40.4)	87 (43.9)
Spider mites	77 (29.5)	145 (63.0)	119 (60.1)
Sudden Death Syndrome*		61 (26.5)	74 (37.4)
Soybean Aphid	227 (87.0)	203 (88.3)	180 (90.9)
Grasshoppers	20 (7.7)	24 (10.4)	30 (15.2)
Soybean Rust*		85 (37.0)	52 (26.3)
Japanese beetle**	71 (25.4)		
Others*		9 (3.9)	12 (6.1)

*This item was not included in 2005. **This item was not included in 2008.

.

Table 15 *Insecticide and Fungicide Applications*

	2005	**2008**	**2011**
	Frequency (%)	Frequency (%)	Frequency (%)
Have applied insecticide in the past?	(N=261)	(N=229)	(N=197)
Yes	120 (46.0)	166 (72.2)	130 (66.0)
Have applied fungicide in the past?	(N=261)	(N=225)	(N=193)
Yes	17 (6.5)	52 (22.6)	66 (34.2)

Table 16 *Soybean Cyst Nematode Control*

	2005 (N=261)	**2008**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
Resistant Variety	118 (45.2)	150 (65.2)	137 (69.2)
Nematicide	1 (0.4)	2 (0.9)	1 (0.5)
Monitor Population (by testing for SCN)	28 (10.7)	6 (2.6)	10 (5.1)
Crop Rotation	206 (78.9)	167 (72.6)	145 (73.2)
Have not tested for SCN	67 (25.7)	50 (21.7)	39 (19.7)
Have tested, but don't have SCN	28 (10.7)	21 (9.1)	22 (11.1)
Do not monitor SCN**	43 (15.4)		

**This item was not included in 2008 or 2011.

Planting /harvesting information.

Shown in Table 18, 5% of producers in 2005 used Global Positioning Satellite technology. In 2011, 30% reported using GPS at planting. The group using GPS also reported significantly higher yields than those who do not, based on the 2011 data. In 2011, 59 farmers reported the use of GPS systems when planting and have an average yield of 46.73 bushels per acre. 136 farmers do not use GPS and have an average yield of 43.50 bushels per acre.

Table 17 *Use of GPS/ Guidance Systems When Planting*

	2005 (N=255)	**2008 (N=228)**	**2011 (N=196)**
	Frequency (%)	Frequency (%)	Frequency (%)
Yes	12 (4.7)	36 (15.8)	59 (30.1)

There is variation in the planting dates reported as shown in Table 19. Producers in 2011 reported the earliest planting dates; however, this does not mean that producers are uniformly planting earlier. The 2008 season was delayed by bad weather , affecting the planting dates reported. But producers are planting close to the beginning of May as MSUE and the MSPC recommend. The percentage reporting a uniform stand of plants has declined from 2005, dropping from 85.6% to 73.2% in Table 20. The percentage reporting a variable stand of plants has increased from 14.4% to 25.3%. The average number of plants in the stand (stand count) dropped from 170,514 plants in 2005to 154,327 plants in 2011 in Table 21. It is likely that this reflects the lowered seeding rates from 2005 to 2011.

Table 18 *Average Target Planting Date*

	2005		2008	2011
	High Producing Field (N=241)	Low Producing Field (N=232)	(N=228)	(N=179)
Mean (Average date)	May 8	May 12	May 9	May 6
Minimum (Earliest date)	April 1	April 1	April 7	April 15
Maximum (Latest date)	June 5	June 10	June 15	June 1

Table 19 *Rating of Average Stand Emergence*

	2005		2008 (N=233)	2011 (N=194)
	High Producing Field (N=239) Frequency (%)	Low Producing Field (N=241) Frequency (%)	Frequency (%)	Frequency (%)
Uniform	203 (84.9)	125 (51.9)	174 (74.7)	142 (73.2)
Variable	36 (15.1)	116 (48.1)	57 (24.5)	50 (25.3)
Both*			2 (0.9)	2 (1.0)

*This item was not included in 2005.

Table 20 *Average Stand Count*

	2005		2008 (N= 120)	2011 (N= 110)
	High Producing Field (N=107)	Low Producing Field (N=102)		
Mean	170,514	165,461	162,754	154,327
St. Deviation	19,572	20,149	20,772	20,224.5
Minimum	100,000	100,000	110,000	100,000
Maximum	210,000	210,000	225,000	200,000

Grower perceptions.

Shown in Table 22 below, the percentage of producers that see soybeans as a high value part of their system has increased from 63% in 2005 to 72% in 2011 and more report that yields are increasing. As shown in Table 23, they also see soybeans as requiring more management than in the past. In 2007, 38% of producers report that soybeans require a high level of management

versus 13% in 2005. The percentage of producers that think soybeans require a low level of management has fallen from 33% in 2005 to 4% in 2011. Table 24 shows that producers think yields are increasing.

Table 21 *Value of Soybean as Part of the Cropping System*

	2005 (N=257)	**2008 (N=227)**	**2011 (N=195)**
	Frequency (%)	Frequency (%)	Frequency (%)
High Value	160 (62.3)	159 (69.1)	141 (72.3)
Medium Value	89 (34.6)	63 (27.4)	51 (26.2)
Low Value	8 (3.1)	5 (2.2)	3 (1.5)

Table 22 *Level of Management Required For Soybean Production*

	2005 (N=257)	**2008 (N=227)**	**2011 (N=194)**
	Frequency (%)	Frequency (%)	Frequency (%)
High level of management	84 (32.1)	61 (26.9)	73 (37.6)
Moderate level of management	140 (54.5)	151 (66.5)	114 (58.8)
Low level of management	33 (12.8)	15 (6.6)	7 (3.6)

Table 23 *Perception of Soybean Yield over the Last Five Years*

	2005 (N=253)	**2008 (N=229)**	**2011 (N=190)**
	Frequency (%)	Frequency (%)	Frequency (%)
Remained the same	118 (46.6)	138 (60.3)	87 (45.8)
Increased	39 (15.4)	73 (31.9)	93 (48.9)
Decreased	96 (37.9)	18 (7.9)	10 (5.1)

Reported in Table 25, growers were asked to select all of the probable causes of yield reduction on their farm (The question was not asked in 2005). Over 70% chose type of soil both years. There were drops in the percentage selecting insects, stem rots, Round-up Ready yield drag, and

SCN. There was one increase, the percentage selecting planting date rose from 49.4% in 2008 to 64.6% in 2011. This may be due to the poor weather and delayed planting in 2008.

Table 24 *Grower Opinions on Probable Causes of Soybean Yield Reduction**

	2008	**2011 (N=198)**
	Frequency (%)	Frequency (%)
Type of Soil	170 (70.0)	142 (71.7)
Insects	166 (68.3)	115 (58.1)
Planting Date	120 (49.4)	128 (64.6)
White Mold	119 (49.0)	96 (48.5)
Soybean Cyst Nematode	118 (48.6)	84 (42.4)
Weed Pressure	106 (43.4)	82 (41.4)
Foliar Disease	92 (37.9)	75 (37.9)
Variety Selection	80 (32.9)	68 (34.3)
Herbicide Effectiveness	78 (32.1)	66 (33.3)
Stem Rots	74 (30.5)	52 (26.3)
Root Rots	73 (30.0)	58 (29.3)
Seed Quality	58 (23.9)	43 (21.7)
More Soybean in Soybean Acres	47 (19.3)	40 (20.2)
Roundup Ready	44 (18.1)	29 (14.6)
Seed Treatment	29 (11.9)	26 (13.1)
Breeding Delays in Yield	28 (11.5)	18 (9.1)
Increase of Soybean in Rotation	24 (9.9)	20 (10.1)
Lack of Agronomic Information	24 (9.9)	20 (10.1)
Increased Soybean Acres	15 (6.2)	11 (5.6)
Don't know where to get information	15 (6.2)	5 (2.5)
Excessive corn stover residue*		48 (24.2)

*This question was not asked in 2005. **This item is new in 2011.

Summary.

Yields are increasing for Michigan soybean farmers and now average 44.5 bushels an acre. The average number of acres has also increased since 2005. The number of farmers using services for fertilizer, lime application, scouting, and soil sampling has increased since 2005. Respondents'

seed selection criteria remained steady, with a heavy reliance on Round-up Ready seed and past performance on the farm. The increase in the number of respondents using SCN resistance as a criterion to select seed is in keeping with MSPC and MSUE recommendations.

There has been an increase in the number of growers who report valuing the soybean crop highly and that soybeans require a high level of management. There are a number of other indicators that support this. The growing use of custom blended fertilizer and more frequent application of fertilizer indicate that farmers spending more time and money on the soybean crop. As a corollary, the drop in the percentage who apply only one treatment for both corn and the following soybean crop also indicates that growers value the soybean crop more highly now. The increasing percentage of growers using an herbicide with residual activity, applying fungicides and insecticides, and scouting regularly also demonstrate an increased willingness to invest time and money in the soybean crop.

Section Two: Longitudinal data

The results and trends below are drawn from the 63 producers who answered all of the surveys all three years, 2005, 2008, and 2011. Since responses are from the same people over time a comparison of the data collected and analyzed increases the reliability of the findings and changes in practices over time.

On average, the reported yields increased from 2005 to 2008. The 2005 average was 40 bushels/acre and the 2011 average was 44.3 bushels/acre as shown in Table 26. In general, soybean acreage is increasing in Michigan. The average number of acres of soybeans planted has increased by 59 acres since 2005 as shown in Table 27.

Table 25 *Average Soybean Yield (Bushels/Acre)*

	2005		2005	2008 (N=61)	2011 (N=63)
	High Yield Field (N=63)	**Low Yield Field (N=62)**	**5 year average yield (N=59)**		
Mean	45.8	35.1	40.2	43.9	44.3
s.d.	8.0	7.6	7.2	6.9	5.8
Minimum	21	15	21.4	30	30
Maximum	66	50	55	62	58

Table 26 *Average Number of Acres*

	2005 (N=62)	2008 (N=62)	2010 (N=63)
Mean	356	379	415
Minimum	15	20	15
Maximum	1500	1300	1300

Reported in Table 28, the number of farmers using services for fertilizer, lime application, scouting, and soil sampling has increased since 2005. The percentage using soil sampling services has increased from 36.5% to 50.8% in 2011. The percentage using fertilizer application services has also increased, from 22.2% to 39.7%. The use of lime application services increased from 41.3% to 47.6%, but there was a spike in 2008 of 58.7%. The use of scouting services followed a similar pattern; it increased from 7.9% to 17.5% and then fell to 12.7%. The percentage using harvesting services remained the same, 12.7%, with a spike to 14.3% in 2008%. The use of planting services dropped from 4.8% to 1.6% with a spike in 2008 of 11.0%. The use of spraying services dropped from 39.7% in 2008 to 30.21% in 2011.

Table 27 *Types of Custom Services Used*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Planting	3 (4.8)	7 (11.1)	1 (1.6)
Soil sampling	23 (36.5)	33 (52.4)	32 (50.8)
Harvesting	8 (12.7)	9 (14.3)	8 (12.7)
Pesticide applications**	17 (27.0)		
Scouting	5 (7.9)	11 (17.5)	8 (12.7)
Fertilizer applications	14 (22.2)	20 (31.7)	25 (39.7)
Lime applications	26 (41.3)	37 (58.7)	30 (47.6)
Spraying*		25 (39.7)	19 (30.21)
None*		12 (19.0)	13 (20.6)

*This item was not included in 2005. **This item was not included in 2008 or 2011.

Table 29 presents the seed selection criteria results. Selection of SCN resistance as a seed trait as increased from 33.3% to 50.8%. The use of specialty markets and market premiums saw similar increases in 2008 and decreases in 2011. Specialty market rose from 12.7% to 15.9% and then fell to 9.5%. Market premium rose from 9.5% to 15.9% and then fell to 9.5%. The use of Round-up Ready seed remains high at 73%. Past performance on the farm declines all three years, but remains above 75%. Reliance on MSU variety trials dropped from 57.1% to 49.2%. The use of Synchrony tolerant seed has increased from 3.2% to 9.5%. The use of disease resistance is unchanged at 50.8%.

Table 28 *Criteria for Soybean Variety Selection*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
MSU Soybean Variety Trails	36 (57.1)	27 (42.9)	31 (49.2)
Past Performance on Farms	51 (81.0)	50 (79.4)	48 (76.2)
Dealer Recommendation	43 (68.3)	45 (71.4)	43 (68.3)
Specialty Market	8 (12.7)	10 (15.9)	6 (9.5)
Market Premium	6 (9.5)	10 (15.9)	6 (9.5)
Disease Resistance	32 (50.8)	30 (47.6)	32 (50.8)
Soybean Cyst Nematode Resistance	21 (33.3)	31 (49.2)	32 (50.8)
Round-up Ready	48 (76.2)	48 (76.2)	46 (73.0)
Synchrony Tolerant (ST)	2 (3.2)	3 (4.8)	6 (9.5)

Soils and fertilizer information.

The majority of respondents, over 60% each survey, perform a soil test every 2-3 years (Table 30). Approximately 20% perform one every 4-5 years. Regular soil tests may indicate that growers are paying attention to the fertility of their soil. The increasing percentage of growers (79.4% in 2011) that use a fertilizer which has been custom blended to their needs supports this conclusion (Table 32). Respondents report use of the soil test information to apply phosphorous, potassium, and lime most frequently in Table 31. The percentage applying micro-nutrients as a result of the soil test rose from 71.4% in 2005 to 76.2% in 2011.

Table 29 *Soil Testing Intervals*

	2005 N=60	2008 N=60	2011 N=61
	Frequency (%)	Frequency (%)	Frequency (%)
Every year	4 (6.7)	9 (15.0)	4 (6.6)
2-3 Years	39 (65.0)	36 (60.0)	42 (68.9)
4-5 Years	15 (25.0)	8 (13.3)	12 (19.7)
6-10 Years	2 (3.3)	5 (8.3)	2 (3.3)
Seldom/rarely*		1 (1.7)	1 (1.6)
Never*		1 (1.7)	

*This item was not included in 2005.

Table 30 *Purpose of the Soil Test Information*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Phosphorous Application	58 (92.1)	52 (82.5)	57 (90.5)
Potassium Application	57 (90.5)	54 (85.7)	57 (90.5)
Micro-nutrients Application	45 (71.4)	44 (69.8)	48 (76.2)
Lime Application/Adjusting the Soil pH	54 (85.7)	57 (90.5)	59 (93.7)

Table 31 *Types of Fertilizer Used*

	2005 (N=63)	2008 (N=61)	2011 (N=63)
	Frequency (%)	Frequency (%)	Frequency (%)
A commercial blend	24 (38.1)	12 (19.7)	10 (15.9)
A customized blend	35 (55.6)	47 (77.0)	50 (79.4)
Both*		2 (3.3)	3 (4.8)
Other**	4 (6.3)		

*This item was not included in 2005. **This item was not included in 2008.

Table 33 presents the timing of fertilizer applications. The number of producers applying fertilizer in the fall, spring, and at planting has increased since 2005. Fall fertilizer rates have increased from 47.6% to 55.6%. Spring rates increased from 34.9% to 61.9% and at planting fertilization rates increased from 17.5% to 55.6%. The percentage applying one treatment bi-annually for both corn and soybeans has dropped from 17.5% to 6.3%.

Table 32 *Time of Fertilizer Application*

	2005 N=63	2008 N=63	2011 N=63
	Frequency (%)	Frequency (%)	Frequency (%)
Fall	30 (47.6)	33 (52.4)	35 (55.6)
Spring	22 (34.9)	36 (57.1)	39 (61.9)
At planting	11 (17.5)	34 (54.0)	35 (55.6)
Post emergence foliar*		14 (22.2)	12 (19.0)
One application bi-annually for soybean and corn*		11 (17.5)	4 (6.3)

***This item was not included in 2005**

The nutrients applied by fertilizer are reported in Table 34. Phosphorus and potassium application rates increased by 3% since 2005. Applications of boron, sulfur, and manganese have increased. Sulfur use has increased from 57.1% in 2005 to 71.4% in 2011 and boron use increased from 27% to 39.7%. Manganese use remained steady at 74.6%. There was an increase in the use of other amendments, from 3.2% to 9.5%.

Table 33 *Nutrients Applied by Fertilizer*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Phosphorous	55 (87.3)	53 (84.1)	57 (90.5)
Potassium	60 (95.2)	59 (93.7)	62 (98.4)
Sulfur	36 (57.1)	32 (50.8)	45 (71.4)
Boron	17 (27.0)	17 (27.0)	25 (39.7)
Manganese	47 (74.6)	46 (73.0)	47 (74.6)
Foliar*		20 (31.7)	22 (34.9)
Nitrogen**	44 (69.8)		
Iron**	6 (9.5)		
Other	2 (3.2)	4 (6.3)	6 (9.5)

*This item was not included in 2005. **This item was not included in 2008 or 2011.

The use of moldboard plows has decreased from 15.9% to 9.5% since 2005 and the use of field cultivators has increased from 42.9% to 52.4% as seen in Table 35..

Table 34 *Tillage Type*

	2005		2008	2011
	High Producing Field Frequency (%)	Low Producing Field Frequency (%)	Frequency (%)	Frequency (%)
Chisel Plow	28 (44.4)	27 (43.5)	26 (41.3)	33 (52.4)
Moldboard Plow	10 (15.9)	6 (9.7)	6 (9.5)	6 (9.5)
V-Ripped	12 (19.0)	9 (14.3)	6 (9.5)	8 (12.7)
Deep Slots	7 (11.1)	6 (9.7)	5 (7.9)	
Disk	18 (28.6)	17 (27.4)	18 (28.6)	17 (27.0)
Field Cultivator	27 (42.9)	26 (41.9)	33 (52.4)	33 (52.4)
No-Till	34 (54.0)	30 (48.4)	42 (66.7)	37 (58.7)
Vertical Tillage*				13 (20.6)
Zone/Strip Tillage*				3 (4.8)
Other	1 (1.6)	2 (3.2)	4 (6.3)	1 (1.6)

* This question was not asked in 2005 or 2008. **This option was not offered in 2011

Pest management information.

Herbicide application practices have changed as shown in Table 36. More producers are applying herbicide pre-emergence with residual activity, up from 14.3% in 2005 to 28.6% in 2011. The use of one application of glyphosate has decreased from 63.5% to 49.2%. Post-emergence application has dropped from 54% in 2005 to 11.1% in 2011. Most producers in each year report achieving 90% control of weeds or better.

Table 35 *Timing and Rate of Herbicide Application*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Pre-plant	16 (25.4)	13 (20.6)	12 (19.0)
Pre-emergence$_1$	10 (15.9)	7 (11.1)	
Pre-emergence with residual activity*		9 (14.3)	18 (28.6)
Post-emergence	34 (54.0)	27 (42.9)	7 (11.1)
Two pass (Pre- and post program)	11 (17.5)	11 (17.5)	14 (22.2)
Glyphosate/ Round-up Ready (1 application)	40 (63.5)	29 (46.0)	31 (49.2)
Glyphosate/ Round-up Ready (2 applications)	26 (41.3)	37 (58.7)	25 (39.7)
No herbicide used**	2 (3.2)		

*This item was not included in 2005. **This item was not included in 2008 or 2011. 1This item was not included in 2011.

As reported in Table 39, fungicide and insecticide applications have increased. The use of fungicides increased from 4.8% in 2005 to 45.2% in 2011. The percentage applying insecticides also increased from 46% to 74.6%. The majority of producers are scouting their fields regularly with a small increase of 3.6% since 2005 (Table 37). As shown in Table 38, the percentage of producers scouting for spider mites has nearly tripled from 23.8% to 66.7%, but fewer are scouting for soybean rust, dropping from 38.1% in 2005 to 30.2% in 2011. The percentage scouting for white mold is high and increasing; it was 65.1% in 2005 and 74.6% in 2011. The same pattern is true for soybean aphid, increasing from 88.9% to 95.2%.

Table 36 *Fields Are Scouted on a Regular Basis*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Are field scouted on a regular basis?	(N=62)	(N=63)	(N=62)
Yes	48 (77.4)	55 (87.3)	51 (81.0)
Are field scouted by a crop consultant?	(N=62)	(N=63)	(N=63)
Yes	11 (17.7)	12 (19.0)	11 (17.5)

Table 37 *Purposes of Scouting Soybean Field*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
White Mold	41 (65.1)	43 (68.3)	47 (74.6)
Septoria Leaf Spot	12 (19.0)	13 (20.6)	13 (20.6)
Soybean Cyst Nematode*		23 (36.5)	25 (39.7)
Spider mites	15 (23.8)	44 (69.8)	42 (66.7)
Sudden Death Syndrome*		18 (28.6)	29 (46.0)
Soybean Aphid	56 (88.9)	59 (93.7)	60 (95.2)
Grasshoppers	4 (6.3)	7 (11.1)	12 (19.0)
Soybean Rust*		24 (38.1)	19 (30.2)
Japanese beetle**	15 (23.8)		
Others*		4 (6.3)	3 (4.8)

*This item was not included in 2005. **This item was not included in 2008.

Table 38 *Insecticides or Fungicides are Applied*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Have applied insecticide in the past?	(N=63)	(N=63)	(N=63)
Yes	29 (46)	48 (76.2)	47 (74.6)
Have applied fungicide in the past?	(N=63)	(N=62)	(N=62)
Yes	3 (4.8)	21 (33.9)	28 (45.2)

Methods to control SCN are reported in Table 40.The use of resistant seed varieties to combat SCN has increased since 2005, but the use of monitoring by testing has decreased. In 2005, 47.6% of respondents used SCN resistant seed and the percentage increases over the years to 74.6% in 2011. The percentage using testing fell by more than half, from 12.7% in 2005 to 4.8% in 2011. The percentage of farmers using crop rotation to combat SCN is steady at 81%.

Table 39 *Soybean Cyst Nematode Control*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Resistant Variety	30 (47.6)	41 (65.1)	47 (74.6)
Nematicide	0	1 (1.6)	0
Monitor Population (by testing for SCN)	8 (12.7)	2 (3.2)	3 (4.8)
Crop Rotation	51 (81.0)	53 (84.1)	51 (81.0)
Have not tested for SCN	24 (38.1)	14 (22.2)	15 (23.8)
Have tested, but don't have SCN	6 (9.5)	10 (15.9)	7 (11.1)
Do not monitor SCN**	9 (14.3)		

**This item was not included in 2008 or 2011.

Planting /harvesting information.

As presented in Table 41, the average width of a planting row has increased by nearly an inch, from 13.0" to 13.9" in 2011. When broken into categories, as shown in Table 42, there is an increase in the use of the middle widths; 22.6% report using a row width of 11"-22" in 2005 and 33.9% report using those widths in 2011. There is a decrease from 59.7% to 48.4% in the narrowest category and the percentage using the widest rows remains steady at 17.7%.

Table 40 *Width of Planting Row in Inches*

	2005 (N=62)	2008 (N=63)	2011 (N=62)
Mean	13.0	13.9	13.9
St. Deviation	8.1	8.3	8.0
Minimum	7.0	7.0	7.0
Maximum	30.0	30.0	30.0

Table 41 *Row Widths by Category*

	2005 (N=62)	2008 (N=63)	2011 (N=62)
	Frequency (%)	Frequency (%)	Frequency (%)
Less than 11"	37 (59.7)	32 (50.8)	30 (48.4)
11 to 22"	14 (22.6)	19 (30.2)	21 (33.9)
23" or more	11 (17.7)	12 (19.0)	11 (17.7)

Table 43 reports planter calibration trends. The changes in how planters are calibrated are slight, but contrary to the recommendations of the MSPC and MSUE. The seeds per acre decreased from 65.1% to 60.3% and the reported us of pounds per acre increased from 34.9% to 36.5%. A similar change reported in Table 44 is the decrease in the percentage who report recalibrating after changing seed varieties, 74.6% to 71.4%. This is also contrary to recommendations.

Table 42 *How Planter is Calibrated*

	2005 (N=63)	**2008 (N=63)**	**2011 (N=63)**
	Frequency (%)	Frequency (%)	Frequency (%)
Seeds per acre	41 (65.1)	44 (69.8)	38 (60.3)
Pounds per acre	22 (34.9)	18 (28.6)	22 (36.5)
Both*		1 (1.6)	2 (3.2)

*This item was not included in 2005.

Table 43 *Recalibrate when Changing Varieties*

	2005 (N=63)	**2008 (N=63)**	**2011 (N=63)**
	Frequency (%)	Frequency (%)	Frequency (%)
Yes	47 (74.6)	51 (81.0)	45 (71.4)

As shown in Table 45, 1.6% of producers in 2005 used Global Positioning Satellite technology when planting. In 2011, 25.4% reported using GPS at planting.

Table 44 *Use of GPS When Planting*

	2005 (N=63)	**2008 (N=63)**	**2011 (N=63)**
	Frequency (%)	Frequency (%)	Frequency (%)
Yes	1 (1.6)	7 (11.1)	16 (25.4)

Table 46 summarizes planting device trends. The use of drills is declining and the use of planters is rising. The percentage reporting use of both types is steady. There has been a decline in the average number of seeds per acre from 189,942 to 168, 621, as shown in Table 47.

Table 45 *Type of Planting Device (New Question in 2008)*

	2008 (N=63)	**2011 (N=198)**
	Frequency (%)	Frequency (%)
Drill	39 (61.9)	36 (57.1)
Planter	18 (28.6)	21 (33.3)
Both	6 (9.5)	6 (9.5)

Table 46 *Planting Rate in Seeds per Acre*

	2005 (N=52)	**2008 (N=56)**	**2011 (N=58)**
Mean	189,942	177,357	168,621
St. Deviation	18,495	36,169	26,638
Minimum	130,000	30,000	75,000
Maximum	225,000	300,000	210,000

There is variation in the planting dates reported in Table 48. Producers in 2011 reported the earliest planting dates; however, this does not mean that producers are uniformly planting earlier. But producers are planting close to the beginning of May as MSUE and the MSPC recommend

Table 47 *Average Target Planting Date*

	2005		**2008**	**2011**
	High Producing Field (N=56)	Low Producing Field (N=55)	(N=62)	(N=59)
Mean (Average date)	May 9	May 11	May 9	May 8
Minimum (Earliest date)	April 1	April 1	April 9	April 15
Maximum (Latest date)	June 1	June 5	May 30	May 30

In Table 49, respondents report a dramatic increase in the use of fungicide treated seed, jumping from 37.7% to 77.4%. Table 50 presents a similar increase in the percentage of inoculated acres, reaching 92.2% in 2011.

Table 48 *Seed Treatment with Fungicide*

	2005		**2008 (N=63)**	**2011 (N=62)**
	High Producing Field (N=61)	Low Producing Field (N=60)		
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Yes	23 (37.7)	23 (38.3)	34 (54.0)	48 (77.4)

Table 49 *Percentage of Soybean Acreage That Is Inoculated*

	2008 (N= 60)	**2011 (N=45)**
Mean	54.23	92.2
St. Deviation	47.68	18.9

Table 51 summarizes the respondents' rating of stand emergence. The percentage reporting a uniform stand of plants in Table 51 has declined from 2005, dropping from 82.8% to 65%. The percentage reporting a variable stand of plants has increased from 17.2% to 33.3%. The average number of plants in the stand (stand count) in Table 52 dropped from 166,000 plants in 2005 to 151,810 plants in 2011. It is likely that this reflects the lowered seeding rates from 2005 to 2011.

Table 50 *Rating of Average Stand Emergence*

Stand emergence	**2005**		**2008 (N=61)**	**2011 (N=60)**
	High Producing Field (N=58)	Low Producing Field (N=57)		
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Uniform	48 (82.8)	32 (56.1)	44 (72.1)	39 (65.0)
Variable	10 (17.2)	25 (43.9)	17 (27.9)	20 (33.3)
Both*			0	1 (1.7)

*This item was not included in 2005.

Table 51 *Average Stand Count*

Stand count	**2005**		**2008 (N=32)**	**2011 (N= 42)**
	High Producing Field (N=30)	Low Producing Field (N=29)		
Mean	166,000	156,586	160,313	151,810
s.d.	21,066	36,803	19,549	20,529
Minimum	100,000	18,000	115,000	100,000
Maximum	200,000	200,000	200,000	200,000

***Perceptions*.**

Growers were asked to select all of the probable causes of yield reduction on their farm and the results are summarized in Table 53. There were drops in the percentage selecting insects, Round-up Ready yield drag, and SCN. There was one increase, the percentage selecting planting date rose from 49.4% in 2008 to 64.6% in 2011. This may be due to the poor weather and delayed planting in 2008.

Table 52 *Probable Causes of Soybean Yield Reduction***

	2008 (N=63)	**2011 (N=63)**
	Frequency (%)	Frequency (%)
Type of Soil	43 (68.3)	46 (73)
Insects	47 (74.6)	40 (63.5)
Planting Date	31 (49.2)	43 (68.3)
White Mold	32 (50.8)	33 (52.4)
Soybean Cyst Nematode	31 (49.2)	33 (52.4)
Weed Pressure	28 (44.4)	25 (39.7)
Foliar Disease	30 (47.6)	32 (50.8)
Variety Selection	19 (30.2)	23 (36.5)
Herbicide Effectiveness	21 (33.3)	15 (25.4)
Stem Rots	17 (27)	18 (28.6)
Root Rots	20 (31.7)	23 (36.5)
Seed Quality	15 (23.8)	16 (25.4)
More Soybean in Soybean Acres	16 (25.4)	14 (22.2)
Roundup Ready	17 (27)	11 (17.5)
Seed Treatment	9 (14.3)	6 (9.5)
Breeding Delays in Yield	7 (11.1)	7 (11.1)
Increase of Soybean in Rotation	7 (11.1)	6 (9.5)
Lack of Agronomic Information	5 (7.9)	5 (7.9)
Increased Soybean Acres	4 (6.3)	6 (9.5)
Don't know where to get information	5 (7.9)	2 (3.2)
Excessive corn stover residue*		22 (34.9)

*This item is new in 2011. **Question was not asked in 2005

Tables 54 through 56 report the results of questions concerning the growers' perceptions of soybean management, value, and yield. The percentage of producers that see soybeans as a high value part of their system has increased from 58.1% in 2005 to 80.6% in 2011 and more report that yields are increasing. Respondents also see soybeans as requiring more management than in the past. 4% of producers in 2011 report that soybeans require a high level of management versus 9.5% in 2005. The percentage of producers that think soybeans require a low level of management has fallen from 30.2% in 2005 to 0% in 2011.

Table 53 *Value of Soybean as Part of the Cropping System*

Value	2005 (N=62)	2008 (N=63)	2011 (N=62)
	Frequency (%)	Frequency (%)	Frequency (%)
High Value	36 (58.1)	44 (69.8)	50 (80.6)
Medium Value	26 (41.3)	18 (28.6)	11 (17.7)
Low Value	62 (98.4)	1 (1.6)	1 (1.6)

Table 54 *Level of Management Required for Soybean Production*

	2005 N=63	2008 (N=63)	2011 (N=63)
	Frequency (%)	Frequency (%)	Frequency (%)
High level of management	6 (9.5)	24 (38.1)	29 (46.0)
Moderate level of management	38 (60.3)	38 (60.3)	34 (54.0)
Low level of management	19 (30.2)	1 (1.6)	0

Table 55 *Soybean Yield over the Last Five Years*

Yield	2005 (N=63)	2008 (N=63)	2011 (N=59)
	Frequency (%)	Frequency (%)	Frequency (%)
Remained the same	26 (41.3)	38 (60.3)	27 (45.8)
Increased	10 (15.9)	20 (31.7)	27 (45.8)
Decreased	27 (42.9)	5 (7.9)	5 (8.5)

Table 57 reports on the information choices of respondents. The results are very similar to the larger dataset. Chemical and other suppliers are the most favored source, followed by grower meetings, and Extension. Use of Internet sources reaches 25% in 2011.

Table 56 *Sources of Agronomic Information*

Source of Information	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
Grower Meetings	40 (63.5)	43 (68.3)	45 (71.4)
Media*		16 (25.4)	18 (28.6)
Seed/Chemical suppliers*		50 (79.4)	49 (77.8)
MSU Extension	34 (54.0)	39 (61.9)	35 (55.6)
Internet *		14 (22.2)	16 (25.4)
Agriculture Chemical or Fertilizer Supplier**	55 (87.3)		
Farm Publications (magazines, newspapers etc.)**	42 (66.7)		
Seed sales agronomist**	40 (63.5)		
Neighbor/coffee shop**	4 (6.3)		
Others	4 (6.3)		6 (9.5)

*This item was not included in 2005. **This item was not included in 2008 or 2011.

Section Three: Descriptive Analysis of Yield Groups, 2005

In 2005, the average soybean yield was 39.6 bushels per acre. The respondents in 2005 were divided into two groups based on the average yield. The high-yielding contains all respondents who reported a yield of 39.6 or higher. The low yield group is for anyone who reported a yield of 39.5 or below. Table 58 presents the total number in each group and the mean yield.

The high yield group averaged 44.2 bushels to the low yield group's 33.8 bushels. The high yield group also farmed more acres, with a mean of 396 acres, than the low yield group, with a mean of 344 acres. Table 59 presents the total number in each group and the mean acreage.

Table 57 *Soybean Yield (Bushels/Acre)*

	N	Mean (s.d.)
High yield group	141	44.15 (4.22)
Low yield group	107	33.81 (4.1)

Table 58 *Average Number of Acres*

	N	Mean (s.d.)
High yield	137	396.10 (369.32)
Low yield	106	343.89 (398.61)

The high yield group used a narrower planting row than the low yield. 60% of both groups reported using a width of less than 11". 27.2% of the high yield group used a width between 11" and 22" and 20.4% of the low yield group did. Only 12.5% of the high yield group used a width of 23" or higher compared to 20.4% of the low yield group.

Table 59 *Width of Planting Row*

	N	Mean (s.d.)
High yield	136	12.42 (7.53)
Low yield	103	13.6 (8.82)

Table 60 *Row Widths by Category*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=136	N=103
Less than 11"	82 (60.3)	61 (60.3)
11" – 22"	37 (27.2)	21 (20.4)
23" or higher	17 (12.5)	21 (20.4)

The high yield group planted slightly more seeds per acre than the low yield group. Both groups perform soil tests at roughly the same intervals. Slightly more of the low yield group test every 2-3 years (68.4%) than do in the high yield group (66.9%).

Table 61 *Planting Rate in Seeds per Acre*

	N	Mean (s.d.)
High yield	104	185336.54 (27095.52)
Low yield	76	183605.26 (23934.96)

Table 62 *Soil Testing Intervals*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=136	N=98
Every year	10 (7.4)	4 (4.1)
2-3 years	91 (66.9)	67 (68.4)
4-5 years	33 (24.3)	23 (23.5)
6-10 years	2 (1.4)	4 (4.1)

85% of the low yield group apply phosphorous versus 78% of the high yield group and 89.7% of the low yield group apply potassium versus 87.9% of the high group. The high yield group applies sulfur, boron, and manganese at a higher rate than the low yield group.

Table 63 *Nutrients Applied By Fertilizer*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=141	N=107
Phosphorous	110 (78.0)	91 (85.0)
Potassium	124 (87.9)	96 (89.7)
Sulfur	66 (46.8)	46 (43.0)
Boron	38 (27.0)	26 (24.3)
Manganese	88 (62.4)	60 (56.1)

The high yield group uses custom services at a higher rate than the low yield group. In particular, 35.5% use a soil sampling service and 46.1% use lime application services. But only 27.1% of the low yield group use soil sampling services and 28% use lime application services. Additionally, 25.5% of the high yield group use fertilizer application and only 15.9% of the low yield group do. 6% more of the high yield group use scouting services than the low yield group and 10% more of the high group use harvesting services.

Table 64 *Types of Custom Services Used*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=141	N=107
Planting	7 (5.0)	5 (4.7)
Scouting	24 (17.0)	12 (11.2)
Soil Sampling	50 (35.5)	29 (27.1)
Fertilizer Application	36 (25.5)	17 (15.9)
Spraying	40 (28.4)	30 (28.0)
Lime Application	65 (46.1)	30 (28.0)
Harvesting	23 (16.3)	7 (6.5)

Small percentages of either group use GPS in 2005. The percentage of high yield members who use it is twice that of the low yield group. A larger percentage of the low yield group uses no-till, 62.6% versus 51.8% in the high group. 54.6% of the high yield group use a moldboard plow and 43% of the low yield group do. Slightly more of the high yield group also use the chisel plow and disk.

Table 65 *Use of GPS When Planting*

Use of GPS when planting:	High yield group Frequency (%)	Low yield group Frequency (%)
	N=138	N=105
Yes	8 (5.8)	4 (3.7)

Table 66 *Tillage Type*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=141	N=107
Moldboard plow	25 (17.7)	17 (15.9)
Chisel plow	77 (54.6)	46 (43.0)
Disk	38 (27.0)	26 (24.3)
Field cultivator	60 (42.6)	46 (43.0)
No-till	73 (51.8)	67 (62.6)

65% of the high yield group calibrate their planters using seeds per acre versus 56.7% of the low yield group. 35% of the high yield group calibrate on pounds per acres versus 43.3% of the low yield group.

Table 67 *How Planter is Calibrated*

Planter calibration	High yield group Frequency (%)	Low yield group Frequency (%)
	N=140	N=104
Seeds per acre	91 (65.0)	59 (56.7)
Pounds per acre	49 (35.0)	45 (43.3)

Both groups scout fields regularly though a larger percentage of the high yield group (80.4%) do so than the low yield group (69.5%). Approximately similar percentages of both groups apply herbicides pre-plant and pre-emergence. A larger percentage of the high yield group (52.5%) applies herbicide post emergence than the low yield group (45.8). The high yield group also applies glyphosate in one application at a higher rate, 56% versus 50.5%. The low yield group reports applying glyphosate twice at a higher rate than the high yield group, 45.8% versus 42.6% for the high yield group. The low yield group also applies herbicide in a two pass process, pre and post emergence, more often than the high yield group, 15.9% versus 13.5% for the high group. 10.6% of the high yield group report applying fungicides and only 0.9% of the low yield group do. 49.6% of the high yield group apply insecticides and 43% of the low yield group do.

Table 68 *Fields Are Scouted on a Regular Basis*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=138	N=105
Yes	111 (80.4)	73 (69.5)

Table 69 *Timing and Rate of Herbicide Application*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=141	N=107
Pre-plant	37 (26.2)	27 (25.2)
Pre-emergence*	28 (19.9)	21 (19.6)
Post emergence	74 (52.5)	49 (45.8)
2 pass pre and post	19 (13.5)	17 (15.9)
1 glyphosate application	79 (56.0)	54 (50.5)
2 glyphosate applications	60 (42.6)	49 (45.8)

*Not asked in 2011

Table 70 *Insecticides or Fungicides are Applied*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=141	N=107
Insecticides	70 (49.6)	46 (43)
Fungicides	15 (10.6)	1 (0.9)

The high yield group relies more heavily on MSU Variety Trials, dealer recommendations, the demand from specialty markets, and market premiums than the low yield group. They also use disease resistance and Synchrony tolerance more. 67.3% of the low yield group uses past performance of a seed variety on the farm and 61.7% of the high yield group do. The low yield group also uses SCN resistance more often than the high yield group, 33.6% versus 26.2%.

Table 71 *Criteria for Soybean Variety Selection*

Soybean variety selection	**High yield group Frequency (%)**	**Low yield group Frequency (%)**
	N=141	N=107
MSU Variety Trials	67 (47.5)	47 (43.9)
Past performance on farm	87 (61.7)	72 (67.3)
Dealer recommendation	111 (78.7)	78 (72.9)
Specialty market	26 (18.4)	18 (16.8)
Market premium	28 (19.9)	16 (15.0)
Disease resistance	59 (41.8)	40 (37.4)
SCN resistance	37 (26.2)	36 (33.6)
RR ready	105 (74.5)	80 (74.8)
Synchrony tolerance	8 (5.7)	3 (2.8)

Section Four: Descriptive Analysis of Yield Groups, 2008

In 2008, the average soybean yield was 43.3 bushels per acre. The respondents in 2005 were divided into two groups based on the average yield. The high-yielding contains all respondents who reported a yield of 43.3 bushels or higher. The low yield group is for anyone who reported a yield of 43.2 bushels or below.

The high yield group averaged 48.7 bushels to the low yield group's 37.9 bushels. The high yield group also farmed more acres, with a mean of 454 acres, than the low yield group, with a mean of 322 acres.

Table 72 *Soybean Yield (Bushels/Acre)*

	N	Mean (s.d.)
High yield group	108	48.65 (4.23)
Low yield group	117	37.94 (3.84)

Table 73 *Average Number of Acres*

	N	Mean (s.d.)
High yield	107	453.72 (374.93)
Low yield	115	321.75 (375.25)

The high yield group used a wider planting row than the low yield group. More than 50% of both groups reported using a width of less than 11". 27% of both groups used a width between 11" and 22". 21% of the high yield group used a width of 23" or higher compared to 16% of the low yield group.

Table 74 *Width of Planting Row*

	N	Mean (s.d.)
High yield	105	14.51 (8.71)
Low yield	113	12.95 (8.15)

Table 75 *Row Widths by Category*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=105	N=113
Less than 11”	54 (51.4)	64 (56.6)
11” – 22”	29 (27.6)	31 (27.4)
23” or higher	22 (21.0)	18 (15.9)

The high yield group planted fewer seeds per acre than the low yield group. Both groups perform soil tests at roughly the same intervals. Slightly more of the low yield group test every 2-3 years (68.4%) than do in the high yield group (66.9%) and slightly more of the high yield group (7.4%) test every year than do in the low yield group (4.1%).

Table 76 *Planting Rate in Seeds per Acre*

	N	**Mean (s.d.)**
High yield	91	176527.47 (31207.40)
Low yield	96	179468.75 (24529.13)

Table 77 *Soil Testing Intervals*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=136	N=98
Every year	10 (7.4)	4 (4.1)
2-3 years	91 (66.9)	67 (68.4)
4-5 years	33 (24.3)	23 (23.5)
6-10 years	2 (1.4)	4 (4.1)

85% of the low yield group apply phosphorous versus 78% of the high yield group and 91% of the low group apply potassium versus 87% of the high yield group. The high yield group applies sulfur, boron, and manganese at a higher rate than the low yield group.

Table 78 *Nutrients Applied By Fertilizer*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=108	N=117
Phosphorous	85 (78.7)	99 (84.6)
Potassium	94 (87.0)	106 (90.6)
Sulfur	54 (50.0)	56 (47.9)
Boron	30 (27.8)	31 (26.5)
Manganese	78 (72.2)	72 (61.5)

The high yield group uses custom services at a higher rate than the low yield group. In particular, 53% use a soil sampling service and 55% use lime application services. But only 42% of the low yield group use soil sampling services and 45% use lime application services. Additionally, 32% of the high yield group use fertilizer application and 30% of the low yield group do. 5% more of the high yield group use scouting services than the low yield group and 3% more of the high group use harvesting services.

Table 79 *Types of Custom Services Used*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=108	N=117
Planting	8 (7.4)	7 (6.0)
Scouting	21 (19.4)	17 (14.5)
Soil Sampling	57 (52.8)	49 (41.9)
Fertilizer Application	35 (32.4)	35 (29.9)
Spraying	39 (36.1)	47 (40.2)
Lime Application	59 (54.6)	52 (44.4)
Harvesting	15 (13.9)	13 (11.1)

The percentages of either group using GPS in 2008 are small, but growing from 2005. The percentage of high yield members who use it is nearly three times that of the low yield group, 23.6% versus 8.5%. Equal percentages of the yield groups use no-till, 66.7% and nearly equal numbers use a moldboard plow, 11% versus 10%. 5% more of the high yield group also use the

chisel plow. A much larger percentage of the low yield group, 37%, use a disk plow than the higher yield group with 17%.

Table 80 *Use of GPS When Planting*

Use of GPS when planting:	**High yield group Frequency (%)**	**Low yield group Frequency (%)**
	N=106	N=117
Yes	25 (23.6)	10 (8.5)

Table 81 *Tillage Type*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=108	N=117
Moldboard plow	12 (11.1)	12 (10.3)
Chisel plow	55 (50.9)	53 (45.3)
Disk	18 (16.7)	43 (36.8)
Field cultivator	49 (45.4)	53 (45.3)
No-till	72 (66.7)	78 (66.7)

The nearly equal use of techniques between yield groups continues with planter calibration. 67% of the high yield group calibrate their planters using seeds per acre versus 69% of the low yield group. 30% of both yield groups calibrate on pounds per acres.

Table 82 *How Planter is Calibrated*

Planter calibration	**High yield group Frequency (%)**	**Low yield group Frequency (%)**
	N=108	N=115
Seeds per acre	72 (66.7)	79 (68.7)
Pounds per acre	32 (29.6)	35 (30.4)

Both groups scout fields regularly, though a larger percentage of the high yield group (89%) do so than the low group (76%). Approximately similar percentages of both groups apply herbicides pre-planting, pre-emergence, post emergence, and in two passes, one pre-emergence and one post emergence. A larger percentage (16%) of the high yield group applies an herbicide pre-emergence with residual activity than the low yield group (11%). The high yield group also

applies glyphosate in one application at a higher rate, 44% versus 36%, and applies glyphosate in two applications at a higher rate, 62% versus 56%. The percentage of both groups which apply insecticides is nearly equal, 73% of the high yield group and 72% of the low yield group. 31% of the high yield group report applying fungicides and only 16% of the low yield group do.

Table 83 *Fields Are Scouted on a Regular Basis*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=107	N=116
Yes	96 (88.9)	88 (75.9)

Table 84 *Timing and Rate of Herbicide Application*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=108	N=117
Pre-plant	28 (25.9)	28 (23.9)
Pre-emergence*	8 (7.4)	9 (7.7)
Pre- emergence with residual	17 (15.7)	13 (11.1)
Post emergence	31 (28.7)	36 (30.8)
2 pass pre and post	16 (14.8)	19 (16.2)
1 glyphosate application	48 (44.4)	45 (38.5)
2 glyphosate applications	67 (62.0)	65 (55.6)

*Not asked in 2011

Table 85 *Insecticides or Fungicides are Applied*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=107	N=116
Insecticides	78 (72.9)	84 (71.8)
Fungicides	32 (30.5)	19 (16.4)

The high yield group relies more heavily on MSU Variety Trials, past performance on the farm, the demand from specialty markets, and market premiums than the low yield group. The low yiel group relies more than the high yield group on dealer recommendations, disease resistance, Roundup Ready, and Synchrony tolerance. In particular, 83% of the high yield group uses past

performance of a seed variety on the farm versus 60% of the low yield group. Both yield groups use SCN resistance as a seed selection criterion at equal percentages, 47%.

Table 86 *Criteria for Soybean Variety Selection*

Soybean variety selection	High yield group Frequency (%)	Low yield group Frequency (%)
	N=108	N=117
MSU Variety Trials	48 (44.4)	47 (40.2)
Past performance on farm	90 (83.3)	70 (59.8)
Dealer recommendation	73 (67.6)	82 (70.1)
Specialty market	22 (20.4)	21 (17.9)
Market premium	21 (19.4)	20 (17.1)
Disease resistance	41 (38.0)	47 (40.2)
SCN resistance	51 (47.2)	55 (47.0)
RR ready	80 (74.1)	91 (77.8)
Synchrony tolerance	4 (3.7)	9 (7.7)

Section Five: Descriptive Analysis of Yield Groups, 2011

The average yield in 2011 was 44.5 bushels/acre. Producers with a yield of 51 bushels or more in 2011 are considered high-yielding. Low-yielding producers averaged 39 bushels or fewer per acre in 2011. The cutoff points were calculated by adding or subtracting one standard deviation from the mean yield for all respondents. The mean yield for high yielding producers was 55 bushels farming an average of 430 acres. The mean yield for low yielding producers was 35 bushels farming an average of 303 acres.

Table 87 *Avg. Soybean Yield (Bushels/Acre)*

	N	Mean (s.d.)
High yield	109	48.70 (3.88)
Low yield	87	39.32 (3.41)

Table 88 *Average Number of Acres*

	N	Mean (s.d.)
High yield	107	548.14 (764.05)
Low yield	86	399.78 (406.3)

The table below summarizes the average width of planter rows as reported by producers. The second table below divides the planter widths into pre-determined categories and summarizes the frequencies. High yielding producers use an average planter row width of 17.9 inches versus low yielding producers who use an average width of 15.5 inches. By category, a slight majority of the high yielders use a planter width from the middle category (41.7%) and equal numbers use the smallest and the widest planters. The largest percentage of the low yield group uses drills (42.9%), followed by the middle category with 35.7%, and the fewest number (21.4%) of low yielders use the largest planters.

Table 89 *Width of Planting Row*

	N	Mean (s.d.)
High yield	108	15.78 (8.64)
Low yield	86	14.12 (8.44)

Table 90 *Row Widths by Category*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=108	N=85
Drill: less than 11" wide	41 (38.0)	43 (50.6)
Planter: 15, 20, 22"	42 (38.9)	26 (30.6)
Planter: 28-30" wide	25 (23.1)	16 (18.8)

The high yielding group planted a lower rate of seeds per acre, 154, 750, than the low yielding group with 176,720. The high yield group also had a lower stand count.

Table 91 *Planting Rate in Seeds per Acre*

	N	Mean (s.d.)
High yield	99	168525.25 (28607.6)
Low yield	79	171151.9 (28691.59)

The vast majority of the high yield group (70%) test the soil every 2-3 years. 59% of the low yield group does the same. Smaller numbers of both groups test every 4-5 years. 58% of the high yielding group applies boron versus 32% of the low yield group. 75% the high yielding group applies sulfur versus 43% of the low yield group. 100% of the low yield group applies potassium versus 86% of the high yield group.

Table 92 *Soil Testing Intervals*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=108	N=85
Every year	8 (7.4)	5 (5.9)
2-3 years	77 (71.3)	54 (63.5)
4-5 years	21 (19.4)	22 (25.9)
6-10 years	1 (0.9)	3 (3.5)
Seldom/rarely	1 (0.9)	1 (1.2)

Table 93 *Nutrients Applied by Fertilizer*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=109	N=87
Phosphorous	92 (84.4)	69 (79.3)
Potassium	98 (89.9)	84 (96.6)
Sulfur	78 (71.6)	44 (50.6)
Boron	58 (53.2)	31 (35.6)
Manganese	73 (67.0)	61 (70.1)
Foliar	44 (40.4)	29 (33.3)

The high yield group tends to use custom services more than the low yielding group. Soil sampling is used by 75% of the high yielding group and by only 46% of the low yielding group.

Table 94 *Types of Custom Services Used*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=109	N=87
Planting	2 (1.8)	4 (4.6)
Scouting	21 (19.3)	14 (16.1)
Soil Sampling	70 (64.2)	51 (58.6)
Fertilizer Application	43 (39.4)	35 (40.2)
Spraying	43 (39.4)	29 (33.3)
Lime Application	60 (55.0)	48 (55.2)
Harvesting	8 (7.3)	11 (12.6)
None	15 (13.8)	10 (11.5)

A much higher percentage of the high yield group use GPS than the low yield. However, GPS is only used by approximately half of the high yield group members.

Table 95 *Use of GPS When Planting*

Use of GPS when planting:	**High yield group Frequency (%)**	**Low yield group Frequency (%)**
	N=107	N=87
Yes	42 (39.3)	16 (18.4)

The low yield group uses the moldboard plow, disk, and no-till with greater frequency than the high yield group. The high yielding group favors the chisel plow and field cultivator. No-till is generally associated with lower yields, but the data from these surveys only shows a 2-3 bushel decrease from no-till which would not place a grower in the lowest yield category.

Table 96 *Tillage Type*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=109	N=87
Moldboard plow	10 (9.2)	7 (8.0)
Chisel plow	66 (55.0)	36 (41.4)
Disk	18 (16.5)	31 (35.6)
Field cultivator	60 (55.0)	40 (46.0)
No-till	59 (54.1)	57 (65.5)

The vast majority of high yield growers use seeds per acre. The low yield group is more evenly split, but the majority favors pounds per acre.

Table 97 *How Planter is Calibrated*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=109	N=87
Seeds per acre	81 (74.3)	52 (59.8)
Pounds per acre	22 (20.2)	30 (34.5)
Both	6 (5.5)	5 (5.7)

Most growers scout regularly. A small percentage of the low yield group does not.

Table 98 *Fields Are Scouted on a Regular Basis*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=109	N=86
Yes	98 (89.9)	62 (72.1)

The low yield group applies a pre-plant herbicide at half the rate of the high yield group, 14% versus 29%. The low yield group applies more 2 pass herbicide (29) and more glyphosate (54%) than the high yield group. Overall, the low yield group applies slightly more herbicide than the high yield group.

Table 99 *Timing and Rate of Herbicide Application*

	High yield group Frequency (%)	**Low yield group Frequency (%)**
	N=109	N=87
Pre-plant	23 (21.1)	11 (12.6)
Pre- emergence with residual	33 (30.3)	17 (19.5)
Post emergence	17 (15.6)	13 (14.9)
2 pass pre and post	13 (11.9)	19 (21.8)
1 glyphosate application	51 (46.8)	35 (40.2)
2 glyphosate applications	40 (36.7)	51 (58.6)

The high yield group applies insecticides and fungicides at a higher rate than the low yield group. In particular, they apply more insecticide (71%) than the low yield group (54%).

Table 100 *Insecticides or Fungicides are Applied*

	N	High yield group Frequency (%)	N	Low yield group Frequency (%)
Insecticides	109	75 (68.8)	86	54 (62.8)
Fungicides	106	44 (41.5)	85	21 (24.7)

The high yield group uses several variety selection sources and criteria more than the low yielding group does. The high yield group uses past performance on farm and market premium more than the low yield group. A large percentage (88%) select seed for the specialty market versus only 11% of the low yield group. The low yield group chooses seed more often for SCN resistance and disease resistance than the high yield group.

Table 101 *Criteria for Soybean Variety Selection*

	High yield group Frequency (%)	Low yield group Frequency (%)
	N=109	N=87
MSU Variety Trials	53 (48.6)	41 (47.1)
Past performance on farm	87 (79.8)	62 (71.3)
Dealer recommendation	75 (68.8)	61 (70.1)
Specialty market	14 (12.8)	13 (14.9)
Market premium	15 (13.8)	10 (11.5)
Disease resistance	44 (40.4)	38 (43.7)
SCN resistance	52 (47.7)	47 (54.0)
RR ready	71 (65.1)	69 (79.3)
Synchrony tolerance	8 (7.3)	7 (8.0)

Section Six: Selective Statistical Analysis of Data

This section describes the results of a statistical analysis of selected variables and their result on yield or acreage. The data from all three years and all respondents is used for these analyses. The large number of variables from the survey made a complete analysis unwieldy, but those variables concerning tillage, herbicide, fungicide, and insecticide applications were of greatest interest to the MSPC and MSUE. Therefore, those variables were analyzed for their effect on yield and the number of acres farmed.

This survey and the data it generated are not comparable to traditional crop science studies which examine the effect of tillage systems or particular chemical applications on crop yields. However, the statistically significant relationships between farmer actions and crop yield or the number of acres owned do contribute to an understanding of Michigan farmer behavior. This analysis presents a clearer and more detailed picture of significant elements of Michigan soybean farmers' decisions and actions.

The results of the analysis of tillage types are reported in Table 103 and Table 104. There is a significant difference in acres farmed between those who use no-till and those who do not. Those who use no-till have more acres than those who do not. The analysis shows that there is a significant difference in the number of acres farmed between those who use a moldboard plow and those who do not. Smaller farms are much more likely to use a moldboard plow. There is also a significant difference in the number of acres farmed between those who use v-ripped tillage (approximately 16 inches deep) and those who do not, with larger farms using v-ripped tillage. There was also a significant difference in yield between those who use v-ripped tillage and those who do not. The higher yielding farms are more likely to use v-ripped tillage. There

was a significant difference in yield between those who use disk tillage and those who do not; the use of disk tillage is associated with lower yields.

Table 102 *Results of t-test of effect of tillage type on number of acres farmed*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Use of moldboard plow	Yes	85	257.7 (292.1)	-3.15 (675)	.002
	No	592	427.6 (484.2)		
Use of v-ripped tillage	Yes	90	632.61 (827.5)	5.02 (675)	.000
	No	587	371.54 (373.1)		
Use of no-till	Yes	407	470.45 (540.29)		
	No	270	309.47 (305.58)	4.45 (675)	.000

Table 103 *Results of t-test of effect of tillage type on yield*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Use of v-ripped tillage	Yes	93	43.60 (6.6)	2.06 (667)	.037
	No	576	42.03 (6.8)		
Use of disk tillage	Yes	174	40.47 (6.5)	-4.08 (667)	.000
	No	495	42.87 (6.7)		

Tables 105 and 106 describe the results of an analysis of herbicide, fungicide, and insecticide applications. The use of fungicide treated seed on acres farmed and yield are also examined.

There is a significant difference in yield between those who use a pre-plant herbicide and those who do not. Those who use a pre-plant herbicide have lower yields. There is a significant difference in yield between those who use an herbicide post emergence and those who do not; yields are higher for those who use an herbicide post emergence.

Both yields and acres farmed differ between those who apply herbicide in a 2 pass, pre and post emergence, system and those who apply Roundup once. Those who apply herbicide in a 2 pass, pre and post emergence, application have lower yields than those who do not. They also farm more acres than those who do not use a 2 pass system. The group which applies Roundup once has lower yields and farms fewer acres than those who do not apply Roundup once. There is a significant difference in yield between those who apply Roundup twice, with yields being significantly lower for those who apply twice.

There are significant differences in both yield and acres farmed between those who apply insecticides and those who do not. Those who apply insecticides farm larger acreages and have higher yields than those who do not apply them. There are also significant differences in both yield and acres farmed between those who apply fungicides and those who do not. Those who apply fungicides farm larger acreages and have higher yields.

Both yield and acres differ significantly between those who use fungicide treated seed and those who do not. The group that uses fungicide treated seed farms larger acreages and has higher yields than the group that does not.

Table 104 *Results of t-test of effect of herbicide, insecticide, and fungicide usage on number of acres farmed*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Herbicide: 2 pass, pre- and post-emergence	Yes	102	539.70 (443.4)	2.338 (454)	.020
	No	354	406.76 (522.50)		
Roundup: 1 application	Yes	318	358.41 (345.1)	-3.02 (558)	.003
	No	242	483.09 (621.3)		
Insecticides applied	Yes	410	490.62 (540.3)	5.93 (674)	.000
	No	266	277.61 (281.3)		
Fungicides applied	Yes	132	637.10 (716.6)	6.45 (666)	.000
	No	536	351.11 (365.2)		
Fungicide treated seed used	Yes	338	457.08 (555.7)	2.90 (657)	.004
	No	321	352.21 (341.9)		

Table 105 *Results of t-test of effect of herbicide, insecticide, and fungicide usage on yield*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Herbicide: pre - planting	Yes	154	41.90 (7.1)		
	No	331	43.67 (6.3)	-2.77 (483)	.006
Herbicide: post - emergence	Yes	220	41.19 (6.7)	-4.97 (542)	.000
	No	324	44.00 (6.3)		
Herbicide: 2 passes, pre- and post- emergence	Yes	103	42.16 (6.8)	-2.27 (455)	.024
	No	354	43.82 (6.5)		
Roundup: 1 application	Yes	312	42.05 (6.9)	-2.62 (552)	.009
	No	242	43.54 (6.3)		
Roundup: 2 application	Yes	332	42.35 (6.7)	-2.87 (528)	.004
	No	198	44.04 (6.4)		
Insecticides applied	Yes	407	43.13 (6.4)	4.20 (665)	.000
	No	260	40.91 (7.1)		
Fungicides applied	Yes	132	45.30 (5.5)	6.03 (658)	.000
	No	528	41.44 (6.8)		
Use of fungicide treated seed	Yes	338	43.95 (6.4)	7.11 (652)	.000
	No	316	40.33 (6.6)		

There are significant differences between those who use a GPS system at planting and those who do not. The group which uses a GPS system to guide planting farms larger acreages and has higher yields than the group which does not, as shown in Tables 107 and 108.

Table 106 *Results of t-test of effect of GPS system usage on yield*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
GPS	Yes	105	45.73 (5.8)		
	No	555	41.51 (6.7)	6.04 (658)	.000

Table 107 *Results of t-test of effect of GPS usage on number of acres farmed*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
GPS	Yes	105	685.53 784.7)	6.82 (665)	.000
	No	562	355.78 (361.9)		

The effect of the use of a chisel plow or field cultivator was also examined, but found to be not significant. Whether or not a farmer changed the calibration of the planting equipment between varieties was also found to be not significant. The results of these analyses are in the Appendix.

Eleven variables are associated with higher yields based on these tests. However, the link between a particular practice and higher yields is more properly an agronomic study than the survey study analyzed here. The relationship between the size of the farm and the practices used is of greater importance when examining what farmers choose to do. The surveys illuminate at least eight areas of significant difference based on the number of acres farmed. The traditional moldboard plow is used by smaller farms while v-ripping is more likely to be used by larger farms. No-till is another technique which is much more likely to be used by larger farms. This suggests that the newer practices are being adopted by larger farms as smaller ones maintain traditional practices. The use of modern GPS systems by larger farms likely indicates the role of money in adopting new practices. The pattern of herbicide application points to the linked resources of money and time. Those who have larger farms are more likely to apply herbicide twice which costs more money and time than a single application. Those who have smaller farms are more likely to choose the cheaper alternative of applying herbicide once. This may also suggest that smaller farms are more likely to have owners who have second jobs off the farm and that they need to minimize the time spent applying herbicides; the significant acreage differences between those who apply fungicides and insecticides and those who do not support this. The

larger farms are more likely to apply both fungicides and insecticides.

Chapter Three: Seed Trends in Michigan Soybean Production

Introduction

This chapter is a deeper exploration of the survey questions on production practices related to seeds and planting. The objective of this chapter is to identify the trends in the seed practices of Michigan soybean farmers since 2005, including seeding rate, row spacing, planting equipment, and seed treatments, and compare the trends to the recommendations of the MSPC and MSUE.

The purpose of the *Soybean 2010* project was to increase soybean yields by increasing adoption of better practices. To further that goal, surveys were sent to 1,500 Michigan producers in 2005, 2008, and 2011 to gather information on current production practices. The surveys included questions concerning the seeding rate per acre, the row spacing, the type of planting equipment, and seed treatments. The responses were compiled and examined for evidence of changes. The results were also compared to the recommendations of the MSPC and MSUE concerning seed practices.

Soybean 2010 recommended a number of specific changes to growers. Producers were told to (a) lower seeding rates, (b) decrease row widths, and (c) increase the use of fungicide coated seed and inoculants. The project also recommended to (d) measure seedling rates in seeds per acre rather than pounds per acre because the former is more precise (e) recalibrate the equipment when switching between seed varieties, and (f) use planters in place of seed drills (Staton, Thelen, & Silva, 2011; Staton, & Poindexter, 2011).

Methodology and Statistical Analysis

The first survey was developed in 2005 with technical assistance from the MSU Center for Evaluative Studies. The survey questions were developed by MSU faculty, MSU Extension

personnel, and MSPC staff. After development, the survey was reviewed for reliability and validity by experts in the field. The result was an approximately 3 page quantitative questionnaire of multiple choice and short answer questions.

The 2005 survey was sent to a representative stratified sample of 1500 Michigan soybean producers. The MSPC generated the sample through its mailing database and distributed the surveys. The sample was stratified by soybean acreage as recorded in that database. The MSPC collected the completed surveys and sent the de-identified surveys to Michigan State for data entry, data analysis, interpretation, and report generation. The 2008 and 2011 surveys utilized the same survey instrument except for minor modifications and the same data analysis framework as previous years. The only major change in question format was discarding the duplicate approach which asked respondents to report the same data twice, once for a high producing field and again for a low producing field. The 2008 and 2011 surveys asked for averages for variables such as yield, percent of weed control achieved, etc. Any other differences between questions asked in a certain year are noted in the tables. The number of total responses is 689, 261 soybean producers responded in 2005, 230 responded in 2008, and 198 producers responded to the 2011 survey. A small sample of producers, 63, responded to the survey all three years.

The survey section on Planting/Harvesting asked 14 questions. There were 6 questions about seeding/planting practices. Respondents were asked to report the planting rate in seeds per acre, whether a planter or a drill was used, and the row width in inches. They were also asked how they measured application rate (seeds or pounds per acre), whether the planter/drill was recalibrated between seed varieties, and the average planting speed.

The survey also asked 6 questions about soybean seed in two different sections: General and Planting/Harvesting. Respondents were asked how they selected varieties, the percentages of seed maturity groups used, and what type of seed (Food Grade, Roundup Ready, Low Sat, and Low Linolenic). They were also asked whether the seed was treated with fungicide, or inoculated, and if they control soybean cyst nematode by seed selection.

The overall dataset includes 63 respondents who participated in all three data collections. Their data was included in the overall analysis because respondents could have changed their answers over time and would not be redundant. A separate longitudinal analysis of the 63 is included when appropriate.

Seeding Rate

MSPC and MSUE recommend planting 175,000 seeds per acre when planting with a drill in 7.5" rows. The seed rate falls to 150,000 seeds per acre when the row width increases to 15" and to 130,000 seeds when the width increases to 30" (Staton, Thelen, & Silva, 2011). The recommendation to lower the seeding rate is based on findings that yields are not reduced by lower rates in northern climates (Chen & Wiatrak, 2011; Epler & Staggenborg, 2008; Rich & Renner, 2007). It also increases economic viability by limiting the need to buy more of an expensive input, genetically modified seed (Chen & Wiatrak, 2011; Epler & Staggenborg, 2008). The survey results indicate that seeds rates have dropped from an average of 184,165 in 2005 to 169,525 in 2010.

Evidence of a relationship between recommendations and yields.

The reported data also indicates that producers with the highest yields use lower seeding rates. The respondents in 2011 were divided into three categories based on yield. Producers who reported a yield of 51 bushels or more in 2010 are considered high-yielding. Low-yielding

producers averaged 39 bushels or fewer per acre. The cutoff points were calculated by adding or subtracting one standard deviation from the mean yield of 44.5 bushels per acres in 2011.

In 2010, the 20 farmers in the highest yield bracket planted a mean seed rate per acre of 154,750. The 134 farmers in the average yield bracket planted an average of 170,388 seeds per acre. The 25 farmers in the lowest yield bracket planted an average of 176,720 seeds per acre.

A Pearson correlation was calculated to examine the relationship between seed rate and yield. The correlation test showed that there is a weak negative correlation of -.170 between high seed rates and yield (n= 179, p= 0.05). The results support the recommendation to lower seeding rates to increase yield.

A one-way Anova test was also performed to test for differences in seeding rate for the three yield categories and demonstrated that the seed rate differed significantly as reported in Table 109. A Tukey post hoc comparison of the three groups indicated that seed rate differed significantly for the lowest yield category. High seeding rates were associated with the lowest yields.

Table 108 *ANOVA Test of Yield Relationship with Seed Rate in 2011*

Yield Category	**N**	**Mean Seed Rate (s.d)**	**F value (df)**	**Significance**
High	20	154750.00 (41771.15)	3.625 (2)	.029 (p<.05)
Average	134	170388.06 (24021.579)		
Low	25	176720.00 (35317.04)		
Total	179	169525.14 (28599.583)		

The results reported by respondents over three surveys indicate that they are following the recommendations of the MSPC and MSUE and that the yield increases correlate with the practice recommendations.

Evidence of adoption.

The strongest evidence for increased adoption of lower seeding rates comes from analysis of the 63 respondents who answered in 2005, 2008, and 2011. A paired samples t-test was performed to compare the 2005 seeding rates of these 63 respondents to their reported rates in 2005. There was a significant difference between the mean seeding rate of 2005 and the rate in 2011 as reported in Table 110. Seeding rates fell significantly from 2005.

Table 109 *Paired Sample t-Test 2005 and 2011 for Seeding Rate, Longitudinal Data*

Seeding Rates	**N**	**Mean (s.d.)**	**t (df)**	**Significance (2-tailed)**
2005	50	18934.0 (18584.2)	5.235 (49)	.000
2011	50	170820.0 (24360.1)		

Planter/Drill Calibration and Planting Equipment

MSPC and MSUE recommend recalibration of the planting device when switching between seed varieties, which vary in size, because it prevents seed waste and uneven populations (Staton, & Poindexter, 2011). MSUE and MSPC also recommend that growers use planters rather than drills for planting. Drills are less precise than planters and tend to leak seed, especially when pulled too quickly, producing uneven stands (Cox, Cherney, & Shields, 2010).

More farmers are calibrating their planters using seeds per acre rather than pounds per acre. The percentage using pounds per acre dropped from 38.3% in 2005 to 26.8% in 2011. The percentage using seeds per acre rose from 61.7% to 67.7% with a small increase of 3% in the number using both.

Respondents in 2005 were not asked whether they used planters or drills. However, because of the increase in the percentages of planters used in following years, this data was collected from farmers in the 2008 and 2011 surveys.. In 2008, 25% of respondents used planters and 64% used

drills. The remainder, 11%, used both. In 2011, 32% of respondents used planters and 55% used drills. 13% used both.

Row Width

MSUE and MSPC recommend that narrow rows (rows less than 30in (76 cm) wide)be used due to the associated increase in yields (Bertram & Pedersen, 2004; Costa, Oplinger, & Pendleton, 1980; Yelverton & Coble, 1991). Narrow rows provide weed control through an early and tight canopy, which shades out weeds (Yelverton & Coble, 1991; Bennet, Hicks, Naeve, & Bennet, 1999). However, the increased density has costs. The price of the extra seed and the plants lost to crowding or lodging must be taken into account (Chen & Wiatrak, 2011; Costa, Oplinger, & Pendleton, 1980; Epler & Staggenborg, 2008).

The average size of a row width has increased from 13" to 15" since 2005. In order to better understand how row widths are changing, the reported widths were divided into 3 groups as shown in Table 111. The three categories capture the most likely widths associated with drills and planters. The smallest category is 0-11", the middle category is 11-22", and the largest is for any width over 23". When divided by category, there is a drop in the number of producers using the smallest widths and an increase in the middle length category. There is also a small increase in the number using the largest widths.

Table 110 *Planter Row Widths 2005-2011*

Planter row width (inch)	**2005 (N=251)**	**2008 (N=220)**	**2011 (N=195)**
	Frequency (%)	Frequency (%)	Frequency (%)
Less than 11"	153 (58.6)	119 (54.1)	86 (44.1)
11 to 22"	59 (22.6)	60 (27.3)	68 (34.9)
23" or more	39 (14.9)	41 (18.6)	41 (21.0)

A t-test for equality of means demonstrated a significance difference between the planter widths used in 2005 and those used in 2011. The results shown in Table 112 support the previous finding of an average increase in the middle widths, from 13" to 15".

Table 111 *t-Test of Planter Row Widths in 2005 and 2011, Equal Variances Assumed*

Planter row width	**N**	**Mean (s.d.)**	**t (df)**	**Significance (2-tailed)**
2005	251	12.78 (8.07)	-2.758 (445)	.006
2011	196	14.96 (8.56)		

Seed Treatments

MSUE and MSPC recommend that inoculants be used for all soybean plantings because research has shown significant yield increases of 1.3 bushels per acre when inoculation is used on sites where soybeans have been produced previously (Schulz & Thelen, 2008). The use of fungicide treated seed is also recommended when planting early or in Southwest Michigan where pythium is a problem (Staton, Thelen, & Silva, 2011).

The percentage of acres with inoculated seed has risen from 56.61% in 2008 to 92.5% in 2011. This question was not asked in 2005. The use of fungicide seed treatments has risen from 33.9% in 2005 to 76.4% in 2011.

Seed Selection

MSUE and MSPC recommend five factors to be considered when selecting seed: yield, SCN resistance, disease resistance, standibility, and maturity (Staton, Thelen, & Silva, 2011).

The results of the seed selection survey questions are reported in Table 113. More farmers are selecting seed based on Soybean Cyst Nematode (SCN) resistance and Synchrony tolerance (ST). Synchrony is an herbicide produced by Dupont. In 2005, 29% of respondents chose SCN

resistant seeds as compared to 50% who chose them in 2011. The percentage choosing ST seeds doubled from 4% to 8%, but it remains a small percentage of overall. The percentage in other categories has not changed significantly.

Table 112 *How Soybean Varieties Are Selected*

	2005	2008	2011
	Frequency (%)	Frequency (%)	Frequency (%)
MSU Soybean Variety Trails	120 (46.0)	96 (41.7)	94 (47.5)
Past Performance on Farms	166 (63.6)	162 (70.4)	150 (75.8)
Dealer Recommendation	201 (77.0)	158 (68.7)	138 (69.7)
Specialty Market	45 (17.2)	43 (18.7)	27 (13.6)
Market Premium	44 (16.9)	42 (18.3)	25 (12.6)
Disease Resistance	106 (40.6)	91 (39.6)	83 (41.9)
SCN Resistance	76 (29.1)	107 (46.5)	99 (50.0)
Round-up Ready	196 (75.1)	176 (76.5)	141 (71.2)
Synchrony Tolerant (ST)	11 (4.2)	13 (5.7)	15 (7.6)

Conclusion

In general, the survey results demonstrate that the seed practices of Michigan producers are changing and moving closer to the recommendations of the MSPC and MSUE. Producers are lowering their seeding rates, using planters instead of drills, and coating seeds with fungicides and inoculants. Row widths are also changing. The overall increase in widths, from 13" to 15", and the decrease in the percentage of respondents using widths less than 11" likely indicate a move away from 7.5" drills and towards planters. This could mean that growers are using equipment that is calibrated for soybeans, rather than reusing corn or grain equipment.

The *Soybean 2010* project cannot be directly tied to the changing practices with this analysis, but yields and practices are moving in a positive direction. The future seed choices of Michigan farmers, especially concerning equipment choices, should continue to be tracked. Future surveys

should continue to ask whether planters or drills are used. A new question should be added to determine the most prevalent crop rotation. Those farmers growing wheat in rotation with soybeans would be expect to be more likely to use drills. If true, future education could be tailored for this audience.

Chapter Four: Information Source Use of Michigan Soybean Growers During Soybean 2010

Introduction

This chapter is an exploration of the survey construct focusing on sources of soybean information and producer awareness of *Soybean 2010*. The *Soybean 2010* program was a research, education, and communication effort to help Michigan producers improve soybean yields and profitability. As part of the project, surveys were sent to 1,500 Michigan producers in 2005, 2008, and 2011 to gather information on current production practices. The objectives of this chapter are to analyze the survey data for trends in (a) respondents' choices of soybean information sources, and (b) producer awareness of *Soybean 2010* and its implications on practice. As Extension turns to impersonal sources like the Internet to communicate with growers, it is important to examine how they choose information sources and how well Extension programs reach growers.

The survey results from questions concerning these constructs were compiled and examined for evidence of change. The architects of *Soybean 2010* define information sources as information obtained from state extension service, information generated and distributed at MSPC grower meetings, web-based publications, and information provided by chemical suppliers. Questions were intended to obtain baseline knowledge of information use as well as to measure change in use overtime.

Background

Soybean 2010 was an effort by the MSPC and MSUE to influence the production choices of Michigan soybean farmers through education. Therefore, the MSPC was interested in other,

competing sources of information and the surveys attempted to ascertain where else growers went for information.

There is a divergence in the literature concerning growers' preference for print information versus face-to-face exchanges. Howell and Habron (2004) and Diekmann and Batte (2009) reported a preference for print media over personal exchanges. However, a number of studies have found that growers prefer interpersonal contact (Bruening, Radhakrishna, & Rollins, 1992; Lasley, Padgitt, & Hanson, 2001; Licht & Martin, 2007). These studies complement the findings of Howell and Habron (2004) and Diekmann and Batte (2009) because those researchers also found strong preferences for personal communication. According to Licht and Martin (2007), corn and soybean producers use media to gather general information and then use in-person means, such as Extension personnel, to evaluate what they have learned. Foltz, Lanclos, Guenther, Makus, and Sanchez (1996) found that Idaho dairy and potato farmers placed higher value on in-person sources like university specialists, but indicated that they preferred print sources like newsletters.

An important personal source of information for producers is input suppliers. While Alston and Reding (1998) found that Utah grain producers used Extension and chemical suppliers at nearly the same rate, Roseler, Chase, and McLaughlin (1994) concluded that Extension will increasingly need to reach dairy farms by going through the nutrition companies which supply the farms. Foltz et al. (1996) also found that respondents rated independent and industry consultants as more reliable than public ones like Extension. Consequently, suppliers were included as an information source in this survey.

The use of the Internet is also a key area of interest. According to the U.S. Department of Commerce (2011), 68% of U.S. households use broadband Internet. The rates of Internet use are lower for rural areas, but factors such as income and lack of interest were more important for determining use than geography (U.S. Department of Commerce, 2011). Howell and Habron (2004) found that Internet access did not increase the percentage of respondents interested in receiving information over the Internet. Bruening, Radhakrishna, and Rollins (1992) note the reluctance of farmers to embrace newer technology such as videocassettes. While cassettes are now largely obsolete, the general reluctance of farmers to adopt new, impersonal technologies appears to be intact. The relatively low use of Internet sources found in this research is similar to other research (Howell & Habron, 2004; Diekmann & Batte, 2009, Davis & Conley, 2011). Research has also found that producers with larger farms are more likely to rate the Internet highly as a source of information, but still found that less than 50% of farmers in Indiana use e-mail (Davis & Conley, 2011).

Methods and Procedures

The first survey was developed in 2005 with technical assistance from the MSU Center for Evaluative Studies. The survey questions were developed by MSU faculty, MSU Extension personnel, and MSPC staff. After development, the survey was reviewed for reliability and validity by experts in the field. The result was an approximately 3 page quantitative questionnaire of multiple choice and short answer questions.

The 2005 survey was sent to a representative stratified sample of 1500 Michigan soybean producers. The MSPC generated the sample through its mailing database and distributed the surveys. The sample was stratified by soybean acreage as recorded in that database. The MSPC

collected the completed surveys and sent the de-identified surveys to Michigan State for data entry, data analysis, interpretation, and report generation. The 2008 and 2011 surveys utilized the same survey instrument except for minor modifications and the same data analysis framework as previous years. The only major change in question format was discarding the duplicate approach which asked respondents to report the same data twice, once for a high producing field and again for a low producing field. The 2008 and 2011 surveys asked for averages for variables such as yield, percent of weed control achieved, etc. Any other differences between questions asked in a certain year are noted in the tables. The number of total responses is 689, 261 soybean producers responded in 2005, 230 responded in 2008, and 198 producers responded to the 2011 survey. A small sample of producers, 63, responded to the survey all three years.

The 2011 survey asked growers where they go for agronomic information and if they were aware of the *Soybean 2010* project. It also asked if the respondent had attended any of the *Soybean 2010* meetings, used any of the *Soybean 2010* materials like the website, hotline, or fact sheets, and whether they had changed any management practices as a result of what was learned from *Soybean 2010*.

Descriptive data were generated using SPSS v. 19 and analyzed using independent sample t-tests. The overall dataset includes 63 respondents who participated in all three data collections. Their data was included in the overall analysis because respondents could have changed their answers over time and would not be redundant. A separate longitudinal analysis of the 63 is included when appropriate.

Sources of Information

From 2005 to 2011, there was little change in the preferences of Michigan soybean growers when choosing information sources. The results are reported in Table 114. The most popular source was seed and chemical suppliers (79.3%) and the second most popular source was grower meetings (75.8%). MSU Extension was the third most popular source (57.6%), followed by Internet (28.8%), media (24.7%), and other (9.1%). However, there were changes in the percentage of growers using certain sources. There was an increase in the use of grower meetings, rising from 56% in 2005 to 76% in 2011. There was also a significant increase in use of MSU Extension, rising from 49% to 58%. There was a slight increase in Internet use from 2008 to 2011 and a slight decrease in media use. The use of seed and chemical suppliers stayed the same.

Table 113 *Sources of Information for Respondents*

	2005	**2008**	**2011**
	Frequency (%)	Frequency (%)	Frequency (%)
Grower Meetings (2)	145 (55.6)	155 (67.4)	150 (75.8)
Media*		61 (26.5)	49 (24.7)
Seed/Chemical suppliers* (1)		182 (79.1)	157 (79.3)
MSU Extension (3)	129 (49.4)	127 (55.2)	114 (57.6)
Internet *		56 (24.3)	57 (28.8)

*This item was not included in 2005.

The size of a farm affects producers' use of information sources (Diekmann & Batte, 2009; Conley & Santini, 2007). Independent sample t-tests were used to examine the information use categories for significant differences in the number of acres owned. The t-tests reported in Table 115 showed three areas of significant difference by acreage: grower meetings, MSU Extension,

and Internet. Larger landowners were more likely to use grower meetings, MSU Extension, and the Internet for information.

Table 114 *Independent Sample t-Test of Information Source Use and Acreage*

Where do you go to get agronomic information?		**N**	**Acreage (s.d.)**	**t (df)**	**Significance (p<.05)**
Grower meetings	Yes	442	462.42 (516.1)	4.919* (648.3)	.000
	No	235	300.59 (335.7)		
MSU Extension	Yes	364	467.4 (511.9)	3.778* (668.9)	.000
	No	313	335.1 (399.4)		
Internet	Yes	111	530.9 (450.0)	3.09 (675)	.002
	No	566	381.8 (467.5)		

*Equal variances not assumed

Soybean 2010.

The 2005 survey did not ask respondents about *Soybean 2010* because it was the inaugural year. The results from 2008 and 2011 are reported in Table 116. Growers' awareness of the specific MSUE program, *Soybean 2010*, is similar to their use of extension materials in general. Nearly 60% of respondents use MSU Extension and the same percentage are aware of *Soybean 2010* by 2011. However, their use of *Soybean 2010* materials is much lower; 25% in 2008 and 39% in 2011 report using *Soybean 2010* materials. In 2008, 19% of respondents reported attending *Soybean 2010* programs with an increase to 30% in 2011. There was an increase reported in changed production practice due to *Soybean* 2010 from 2008 (18%) to 2011 (27%).

All categories saw a positive increase from 2008, but the 14% increase in use of program materials is most noteworthy as it indicates strong growth in the program's usage. Attendance and reported change due to the program also saw 10% increases.

Table 115 *Soybean 2010 Awareness and Use from 2008-2011*

	2008	2011
	Frequency (%)	Frequency (%)
Are you aware of the Soybean 2010 program?	(N=228) 121 (53.1)	(N=195) 117 (60)
Have you attended any of the programs sponsored by the Soybean 2010 program?	(N=227) 44 (19.4)	(N=196) 58 (29.6)
Have you used any of the materials (website, grower hotline, fact sheets, etc.) created by the Soybean 2010 program?	(N=224) 57 (25.4)	(N=191) 75 (39.3)
Have you changed any management practices on your farm as a result of what you learned from the Soybean 2010 program?	(N=212) 38 (17.9)	(N=184) 50 (27.2)

Further analysis by independent sample t-test found a significant difference between the acres owned by those who attended *Soybean 2010* programs and those who did not (Table 117). Larger landowners were more likely to report attendance at an event. No other significant differences between the acres owned by respondents reporting greater awareness, material use, or management change were found by t-test (data not shown).

Table 116 *t-Test of Awareness and Acreage*

Attended programs sponsored by Soybean 2010?		**N**	**Acreage (s.d.)**	**t (df)**	**Significance (p<.05)**
	Yes	101	559.5 (440.5)	2.89 (414)	.004
	No	315	390.6 (531.60)		

Longitudinal data.

The popularity of sources of information used by the 63 producers who answered all three years is similar to those used by the larger dataset and shown in Table 118. The most frequently used

sources in order of popularity are seed/chemical suppliers, grower meetings, MU Extension, media, and the Internet. The changes in information use differ from the overall dataset in several respects. The longitudinal data also shows an increase in the attendance at grower meetings, but the increase is much smaller, 9% versus 20% overall, but still statistically significant. The use of MSU Extension only increased by 1.6% and media use increased by a small amount rather than decreasing. The use of chemical and seed suppliers dropped by 1.6% in the longitudinal data versus a static 79% overall. The small increase in Internet use is similar to the overall dataset.

Table 117 *Sources of Information 2005-2011, Longitudinal Data*

Source of Information	**2005**	**2008**	**2011**
	Frequency (%)	Frequency (%)	Frequency (%)
Grower Meetings	40 (63.5)	43 (68.3)	45 (71.4)
Media*		16 (25.4)	18 (28.6)
Seed/Chemical suppliers*		50 (79.4)	49 (77.8)
MSU Extension	34 (54.0)	39 (61.9)	35 (55.6)
Internet *		14 (22.2)	16 (25.4)
Others	4 (6.3)		6 (9.5)

*This item was not included in 2005.

Independent sample t-tests were used to examine the information use categories for significant differences in the number of acres owned. The t-tests in Table 119 demonstrated a significant difference in the acreage sizes in three categories: grower meetings, MSU Extension, and Internet. As with the larger sample, respondents with larger farms favored these sources more.

Table 118 *t-Test of Information Source Use and Acreage Size*

Where do you go to get agronomic information?		N	Acreage (s.d.)	t (df)	Significance (p<.05)
Grower meetings	Yes	124	424.3 (331.6)	2.04 (185)	.043
	No	63	320.81 (322.7)		
MSU Extension	Yes	103	480.0 (360.0)	4.47 (181.6)*	.000
	No	84	278.7 (254.3)		
Internet	Yes	31	537.6 (377.8)	2.77 (185)	.006
	No	156	360.0 (314.5)		

*Equal variances not assumed

Soybean 2010 and longitudinal sample.

Shown in Table 120, a higher percentage of this longitudinal group than the entire dataset reports awareness of *Soybean 2010*, 66.7% vs. 60% in the overall set. However, it is worth noting that only 2/3 of respondents report awareness of *Soybean 2010*, even though this group has answered this survey three times. A higher percentage of the longitudinal group report using *Soybean 2010* materials, 58.3% vs. 39.3%. However, only 25.8% of the longitudinal dataset report attending events versus 29.6% overall. The percentages which report a change in management are very similar for both datasets and both show increases of 9-10%.

Table 119 *Soybean 2010 Awareness and Use 2008-2011, Longitudinal Data*

		2008	2011
		Frequency (%)	Frequency (%)
Are you aware of the Soybean 2010 program?	Yes	N=62 40 (64.5)	N=63 42 (66.7)
Have you attended any of the programs sponsored by the Soybean 2010 program?	Yes	N= 62 15 (24.2)	N=62 16 (25.8)
Have you used any of the materials (website, grower hotline, fact sheets, etc.) created by the Soybean 2010 program?	Yes	N=61 20 (32.8)	N=60 28 (58.3)
Have you changed any management practices on your farm as a result of what you learned from the Soybean 2010 program?	Yes	N=56 10 (17.9)	N=61 17 (27.9)

Analysis of the data using independent sample t-tests demonstrates a significant difference in awareness of *Soybean 2010* and program attendance based on acreage size and is reported in Table 121. Respondents with larger farms were more likely to be aware of *Soybean 2010* and attend programs. The greater awareness of *Soybean 2010* among larger landowners did not appear in the larger dataset.

Table 120 *t-Test of Awareness and Acreage*

		N	Acreage (s.d.)	t (df)	Significance (p<.05)
Aware of the Soybean 2010 program?	Yes	82	463.4 (348.9)	3.0 (101.3)*	.003
	No	42	291.0 (275.7)		
Attended programs sponsored by Soybean 2010?	Yes	31	581.3 (352.5)	3.57 (121)	.001
	No	92	343.2 (310.2)		

*Equal variances not assumed

Discussion

This survey did not group sources of information by method of delivery, but the two most used sources of information, seed/chemical suppliers and grower meetings, are both in-person sources. The third source, MSUE, encompasses in-person methods such as visits by Extension agents, though it could also include MSUE print materials. Non-personal methods such as media, including farm magazines, radio, and other mass communication means, and Internet were much less likely to be used.

According to Licht and Martin (2007), producers may use face-to-face contacts to vet information gathered from media sources. In this light, the low use of media found here might be explained as an indication of the greater value placed on personal exchanges, rather than as a rejection of media, print or otherwise.

The percentage of respondents that report attending *Soybean 2010* programs is lower than the percentage using the materials. This is at odds with a desire for more personal contact. These results may indicate that growers like face-to-face exchanges, but will turn to non-personal information sources when convenient. Regardless, respondents increased both their attendance at *Soybean 2010* programs and use of project materials.

The goal of *Soybean 2010* was to change how Michigan soybean growers farm and 27% of both sets of respondents reported making changes as a result of *Soybean 2010*.

Implications for Extension

Although this was a joint project with MSPC, the input and goals of MSU Extension were of central importance. The increase in the use of MSU Extension by growers is a positive

development as Extension educators are a direct source of knowledge based on the most recent university research. However growers also continue to rely heavily chemical and seed suppliers and MSEU may find disseminating new practices difficult when competing against others who may not be as aware. The preference for in-person exchange and a response which is specific to a grower's concerns probably plays a large role in the popularity of supplier information (Bruening, Radhakrishna, & Rollins, 1992; Lasley, Padgitt, & Hanson, 2001). The overall preference for personal communication and the low use of information from the Internet highlight the difficulty that Extension educators face when encouraging farmers to make use of electronic and Internet information. Respondents seem open to Extension efforts, but it remains to be seen whether Extension will be able to offer the expensive personal touch that producers prefer. But despite the difficulty, the respondents to this survey did indicate that they had made a change because of *Soybean 2010* and that percentage grew over time. Their responses indicate that Extension and university personnel still have a valuable role to play in disseminating knowledge to producers.

Chapter Five: Executive Summary

Introduction

The *Soybean 2010* program was a research, education, and communication effort to assist Michigan producers in improving soybean yields and profitability. It was initiated by the Michigan Soybean Promotion Committee (MSPC) and Michigan State University Extension (MSUE) in 2005 in response to stagnant soybean yields in Michigan as compared to the increase in corn and wheat yields.

Soybean 2010 published 25 fact sheets for growers on aspects of soybean production and profitability and issued press releases on relevant soy issues. The fact sheets were made available on the MSPC website. Mike Staton of MSU Extension organized a soybean yield contest to encourage growers to pay attention to yields and focus awareness on soybean production. Grower meetings were organized by the MSPC and MSUE and held in the off-season as forums for education on recommended production practices.

MSPC and MSUE recognized that the educational needs of Michigan farmers would change over time and that they would need to modify which practices were given the most attention in educational programs as growers learned and changed how they farmed. There was also a need to evaluate how well *Soybean 2010* was reaching and educating Michigan farmers. To meet both of these needs, a periodic evaluation process using a survey instrument was begun. Surveys were sent to 1,500 Michigan producers in 2005, 2008, and 2011 to gather information on current production practices, to understand how the growers viewed soybean production in Michigan, and to gauge the progress of *Soybean 2010*.

Objectives

The main objectives of this research project were to:

- Conduct a survey of Michigan soybean growers to identify production practices;
- Determine where producers go to find out agronomic information related to soybean production;
- Identify what producers think the problems and issues are contributing to lagging soybean production;
- Identify key areas for future research and educational programs intended to increase grower profitability; and
- Determine trends in Michigan soybean production practices by comparing results from the 2005, 2008, and 2011 surveys.

Methodology and Statistical Analysis

The first survey in 2005 was developed with technical assistance from the MSU Center for Evaluative Studies. The survey questions were developed by MSU faculty, MSU Extension personnel, and MSPC staff. After development, the survey was reviewed for reliability and validity by experts. The result was an approximately 3 page quantitative questionnaire with a mix of 49 multiple choice and short answers questions.

The 2005 survey was sent to a representative stratified sample of 1500 Michigan soybean producers. The Michigan Soybean Promotion Committee generated the sample through its mailing database and the sample was stratified by soybean acreage. The MSPC distributed and collected the completed surveys and sent the de-identified surveys to Michigan State for data entry, data analysis, interpretation, and report generation.

The 2008 and 2011 surveys utilized the same survey instrument except for minor modifications and the same data analysis framework as previous years. The only major change in question format was discarding the duplicate approach which asked respondents to report the same data twice, once for a high producing field and again for a low producing field. The 2008 and 2011 surveys asked for averages for variables such as yield, percent of weed control achieved, etc. The same 1500 producers were used as the sample. In 2008 and 2011, an incentive was offered to respondents who completed the survey. The cover letter informed recipients that they would receive a flash drive, worth approximately $10-20, for completing the survey and that it would be pre-loaded with a report of the results of the survey and soybean production instructional materials such as fact sheets.

Data was analyzed for statistical significance using SPSS software v 19. Descriptive statistics were generated to describe the population and inferential statistics were used to explore relationships and differences of soybean production practices by Michigan growers. Preliminary findings reports were given to the MSPC and summary reports were given to respondents.

280 soybean producers (18.7%) responded in 2005, 243 (16.2%) responded in 2008, and 198 producers (13.2%) responded to the 2011 survey. There were 32 producers in the dataset without ID numbers from 2005 and 2008 and they were deleted before the final numbers were computed. The final total number of responses was 698 (15.5%). There were 63 producers who responded to the survey all three years and 120 who responded to both 2005 and 2008. Overall, the response rate declined over time.

The de-identified survey data for all three surveys were coded, analyzed, and reported by Dr. Murari Suvedi and his graduate assistants. The MSPC generously agreed to release the data for

use in research such as this paper and publications. Additionally, the Michigan State University Institutional Review Board classified this survey research as "Non-Human Subject/Research" and allowed its use in this paper. Thus, in 2011, the complete dataset was ready for analysis and was used to generate the results in this paper.

Results

In general, the survey results demonstrate changes in the seed and planting practices of Michigan soybean growers that are compatible with the recommendations of *Soybean 2010*. They also demonstrate growing awareness of the project and continued growth in the number of growers reporting a change as a result of *Soybean 2010*. The longitudinal data are in line with the overall trends. The only area of difference is in planter calibration. The use of seeds per acre to calibrate planters dropped among the longitudinal group, but increased among the overall dataset.

General.

Overall, yields are increasing for Michigan soybean farmers and now average 44.5 bushels an acre. The average number of acres has also increased since 2005. The number of farmers using services for fertilizer, lime application, scouting, and soil sampling has increased since 2005. Respondents' seed selection criteria remained steady with a heavy reliance on Round-up Ready seed and past performance on the farm. The increase in the number of respondents using SCN resistance as a criterion to select seed is in keeping with MSPC and MSUE recommendations.

Soils/fertility.

There has been an increase in the number of growers who report valuing the soybean crop highly and that soybeans require a high level of management. There are a number of indicators that support these claims. The growing use of custom blended fertilizer and more frequent application of fertilizer indicate that farmers spending more time and money on the soybean crop. The

parallel drop in the percentage who apply only one treatment for both corn and the following soybean crop also indicates that growers value the soybean crop highly enough to apply additional fertilizer for it. Farmers are also planting earlier and they are using moldboard plows less while using field cultivators more.

Pest management.

The increasing percentage of growers using an herbicide with residual activity, applying fungicides and insecticides, and scouting regularly also demonstrate an increased willingness to invest time and money in the soybean crop. The majority of producers scout their fields regularly. Fungicide and insecticide applications have increased dramatically. The use of resistant seed varieties to combat SCN has increased since 2005, but the use of monitoring by testing has decreased. The majority of farmers continue to use crop rotation to combat SCN.

Herbicide application practices have changed. More producers are applying herbicide pre-emergence with residual activity. The use of one application of glyphosate has decreased and so has the use of post-emergence herbicide application. Pre-emergence applications indicate that the farmer is paying attention to good preparation of the soil and values the crop. The drop in post-emergent herbicide applications suggests that farmers are not simply relying on spraying for control of weeds after neglecting the field for several weeks.

Production practices and seed.

Producers are lowering their seeding rates, using planters instead of drills, and coating seeds with fungicides and inoculants. Row widths are also changing. The overall increase in widths, from 13” to 15”, and the decrease in the percentage of respondents using widths less than 11” likely indicate a move away from 7.5” drills and towards planters. This would mean that growers are

using equipment that is calibrated for soybeans, rather than reusing corn or grain equipment. The reported increase in planter use also supports this conclusion. Farmers are also calibrating their planting devices as seeds per acre rather than pounds per acre.

Information sources and perceptions.

Michigan soybean farmers' perceptions of the importance of soybeans have changed significantly. More farmers say that they see soybeans as a high value part of their farm system and say that it is a crop that requires a high level of management. The latter statistic is important because it reflects the management that farmers believe a crop merits. The actual level of management required by a soybean plant since 2005 has not changed, but farmers' perception of what kind of management is proportionate to its value has changed. More growers report that yields are increasing.

The results concerning information sources depict growing use of MSU Extension and grower meetings, but also a deep reliance on seed and chemical suppliers. This survey did not group sources of information by method of delivery, but the two most used sources of information, seed/chemical suppliers and grower meetings, are both in-person sources. The third source, MSUE, encompasses in-person methods such as visits by Extension agents, though it could also include MSUE print materials. Non-personal methods such as media, including farm magazines, radio, and other mass communication means, and the Internet were much less likely to be used.

The percentage of respondents that report attending *Soybean 2010* programs is lower than the percentage using the materials produced by the program. This is at odds with a desire for more personal contact. These results may indicate that growers like face-to-face exchanges, but will turn to non-personal information sources when convenient. Regardless, respondents increased

both their attendance at *Soybean 2010* programs (10.2%) and their use of project materials (13.9%).

Although this was a joint project with MSPC, the input and goals of MSU Extension were of central importance and the increase in the use of MSU Extension as an information source is a positive development. However, the reliance on chemical and seed suppliers is very significant and Extension agents are competing with input manufacturers to be heard. The preference for in-person exchange and a response which is specific to a grower's concerns probably plays a large role in the popularity of supplier information (Bruening, Radhakrishna, & Rollins, 1992; Lasley, Padgitt, & Hanson, 2001). The overall preference for personal communication and the low use of information from the Internet highlight the difficulty that Extension agents face when encouraging farmers to make use of low-cost electronic and Internet information. Respondents seem open to Extension efforts, but it remains to be seen whether Extension will be able to offer the expensive personal touch that producers prefer.

But despite the difficulty, the respondents to this survey did indicate that they had made a change because of *Soybean 2010* and that percentage grew over time by 9%. Their responses indicate that Extension and university personnel still have a valuable role to play in disseminating knowledge to producers. The goal of *Soybean 2010* was to change how Michigan soybean producers farm and the 27% of respondents who reported making changes as a result of *Soybean 2010* testify to its success.

Recommendations for Future Surveys and Research

Although *Soybean 2010* has ended, the education and communication efforts of the MSPC and MSUE continue through the new SMART (Soybean Management and Research Technology) program. Therefore, suggestions for improving the response rate of future evaluation surveys are

appropriate. The *Soybean 2010* surveys had 49 questions with numerous sub-questions. The total number of variables coded from the survey answers was over 160. The survey changed very little from 2005 and there were very few changes from 2008 to 2011 and no deletions.

The result is that questions that were no longer of interest to the MSPC or MSUE were left on the survey. Questions asking respondents to write in the cost of fungicide or insecticide use for the past year, for example, required effort on the part of the respondent to recall past expenditures and lengthened the survey, but there was little relationship between the answers and the interests of the MSPC and MSUE. Representatives of the MSPC asked that responses from these questions not be used in summative reports due to the perceived lack of utility. The overall length of the survey, and the effort required to complete it, is increased by questions that could be deleted without removing questions of value. Future surveys should be shorter and only questions of true interest should be included to increase the response rate (Scheuren, 2004).

Removing unneeded questions would allow more space for questions that are of interest to the MSPC and MSUE. The questions concerning information sources could be lengthened with more choices to add nuance to responses. Media could be either identified as "Print Media" or an explanation could be added to explain which media sources are included. The heavy use of suppliers as an information source is important and the types of suppliers, seed, fertilizer, or chemical, could be separated out to further understand their use. The use of MSU Extension is of interest and questions specific to reliance on Extension agents versus publications and other materials would help researchers understand how use of Extension is changing. Considering the invariable lack of use of Internet sources, it might be better to ask producers why they are

reluctant to use electronic media and how this situation could be changed than to continue asking if producers use the Internet. Demographic information such as age of respondent could be gathered, too.

Other states might also find a short survey which focuses on the variables most important to determining how closely actual production practices match recommended practices to be very useful. In addition to survey modification, I recommend the use of mailed reminders to increase the response rate, sending replacement surveys, and contacting non-respondents to learn why they did not respond. These measures can increase the response rate to 80% to 90%, which means that a smaller sample can be used. This will keep costs similar to the current situation with a large sample with a low response rate while improving the utility of the evaluation.

For further research, the relationship between yield, acreage, and GPS use would be interesting to explore. The survey data clearly links higher yields with owning more acres and the use of GPS. This relationship gives rise to questions about the role of land and wealth in Michigan soybean farming. Are larger landowners wealthier than smaller ones? If large landowners are more likely to use the recommended practices and have higher yields, is extension most beneficial to wealthier farmers? Or are these farmers more likely to have loans or insurance that require best practices? Does extension promote technologies which lead to consolidation? And is consolidation always financially beneficial to farmers? Why are the communication methods used, like websites and grower meetings, more appealing to larger farmers? The survey data collected may appear dry, but there are many, meatier questions touching on just how effectively Extension reaches its clientele behind the results.

Appendices

Appendix A: Chapter Two- Miscellaneous Tables

Section one tables.

Table 121 *Soybean Acres under Irrigation*

	2008* (N= 22)	**2011* (N=30)**
Mean	122.5	173.5
St. Deviation	111.7	184.6
Minimum	10	50
Maximum	500	1000

*Values of 0 were not included

Table 122 *Soil pH*

	2005 High Production (N=167)	**2005 Low Production (N=146)**	**2008 (N=204)**	**2011* (N=169)**
Mean	6.7	6.4	6.6	6.6
St. Dev.	0.5	0.6	0.4	.51
Minimum	4.0	4.0	5.9	5.0
Maximum	8.2	8.0	7.8	7.90

*Outlier of 2.1 was removed

Table 123 *Percent of Soybean Acres Drained*

Category of drainage	**2008**			**2011**		
	# of acres considered "poor" (N= 115)	# of acres considered "moderate" (N=193)	# of acres considered "well" (N=201)	# of acres considered "poor" (N= 98)	# of acres considered "moderate" (N= 147)	# of acres considered "well" (N=176)
Mean (S.D)	17.9 (15.9)	44.5 (29.4)	65.4 (26.5)	17.7 (13.6)	40.7 (25.9)	65.6 (27.9)
Mode	10	50	100	10.00	20.00[a]	100.00
Median	12	40	70	10.0000	30.0000	70.0000

Table 124 *Soybean Acres Considered Sufficiently Tile Drained*

	2008* (N=180)	2011* (N=164)
Mean	229.8	245.8
St. Deviation	254.1	261.8
Minimum	7	10
Maximum	2000	1400

*Values of 0 were not used

Table 125 *Soybean Acres with Manure Applied Annually*

	2008* (N=41)	2011* (N=56)
Mean	88.2	25.2
St. Deviation	87.8	23.5
Minimum	5	1
Maximum	300	100

*Values of 0 were not included

Table 126 *Percent of Weed Control Achieved*

	2005		2008 (N=231)	2011 (N=196)
	High Producing Field (N=267)	Low Producing Field (N=251)		
Mean	95.6	93.9	94.0	95.1
St. Deviation	6.7	8.3	7.5	5.5
Minimum	50	50	30	70
Maximum	100	100	100	100

Table 127 *Height of Weeds at the Post Emergence Time of Spray*

	2005		2008 (N=227)	2011 (N=189)
	High Producing Field (N=270)	Low Producing Field (N=254)		
Mean	2.13	2.17	3.5	3.2
St. Deviation	0.8	0.8	3.1	1.6
Minimum	1	1	0*	0*
Maximum	5	5	24	10

*When the answer was a range, the lowest number was used. Ex. 0-3 in, the 0 was used.

Table 128 *Cost of Insecticide and Fungicide Application per Acre*

	2008			
	Mean	S. D.	Minimum	Maximum
Cost of insecticide (N=133)	$11.8	5.3	$4	$35
Costs of fungicide (N=40)	$13.5	6.1	$4	$35
	2011			
	Mean	S. D.	Minimum	Maximum
Cost of insecticide (N=197)	$11.7	8.8	$2	$75
Costs of fungicide (N=193)	$13.4	5.6	$6	$31

Table 129 *Reasons for NOT Applying Fungicides*

	2005 (N=171)	**2008 (N=156)**	**2011 (N=198)**
	Frequency (%)	Frequency (%)	Frequency (%)
Cost of Production	28 (16.4)	26 (16.7)	18 (9.1)
Timing of application	28 (16.4)	15 (9.6)	13 (6.6)
Availability of applicator	5 (2.9)	5 (3.2)	5 (2.5)
Not needed*		110 (70.5)	63 (31.8)
Not at or above threshold for pest**	110 (64.3)		

*This item was not included in 2005. **This item was not included in 2008.

Table 130 *Crosstabulation: Use of Planting Device and Planter Row Width by Category*

2008		**Use of planting device**			**Total (%)**
		Drill (%)	Planter (%)	Both (%)	
Planter row width	Less than 11”	49.1	0.9	4.7	54.7
	11 to 22”	13.4	11.2	3.4	28.0
	23 or more”	2.2	12.1	3.0	17.2
	Total	64.7	24.1	11.2	100.0

2011		**Use of planting device**			**Total (%)**
		Drill (%)	Planter (%)	Both (%)	
Planter row width	Less than 11”	38.5	1.5	4.1	44.1
	11 to 22”	15.4	15.4	4.1	34.9
	23 or more”	0.5	15.9	4.6	21.0
	Total	54.4	32.8	12.8	100.0

Table 131 *Planting Speed (m.p.h.)*

	2005 (N=250)	2008 (N=237)	2011 (N=194)
Mean	5.2	5.2	5.1
St. Deviation	0.8	0.9	.95
Minimum	3	2	3.5
Maximum	10	10	15.0

Table 132 *Percentage of seed planted from each maturity group*

	2008			
	Average % of seed growers plant from 0-1 maturity group (N= 23)	Average % of seed growers plant from 1-2 maturity group (N=113)	Average % of seed growers plant from 2-3 maturity group (N=191)	Average % of seed growers plant from 3+ maturity group (N=49)
Mean (S.D)	16.1 (26.4)	56.9 (33.8)	77.7 (25.4)	27.7 (23.0)
Mode	5	50	85	25
Median	0	100	100	25

	2011		2011	
	Average % of seed growers plant from 0-1 maturity group (N= 8)	Average % of seed growers plant from 1-2 maturity group (N=90)	Average % of seed growers plant from 2-3 maturity group (N=168)	Average % of seed growers plant from 3 plus maturity group (N=41)
Mean (S.D)	50.6 (43.0)	47.9 (30.4)	75.5 (26.6)	37.8 (28.8)
Mode	10.00[a]	20.00[a]	100.00	20.00
Median	42.5	40	80	25

Table 133 *Types of Seed Used*

Percent of each type of seed used	2008			
	% of Food Grade (N= 39)	% of Roundup Ready (N=223)	% of Low Sat (N=7)	% of Low Linolenic (N=33)
Mean (S.D)	56.4 (35.8)	92.7 (17.6)	35.7 (46.8)	39.5 (27.0)
Mode	100	100	0	50
Median	50	100	5	50
Minimum	0	10	0	0
Maximum	100	100	100	100

Percent of each type of seed used	2011			
	% of Food Grade (N= 19)	% of Roundup Ready (N=177)	% of Low Sat (N=3)	% of Low Linolenic (N=8)
Mean (S.D)	71.1 (29.1)	95.5 (15.4)	46.7 (46.2)	58.8 (39.2)
Mode	100	100	20	100
Median	75.0	100	20	57.5
Minimum	20	20	20	10
Maximum	100	100	100	100

Table 134 *Average Harvest Date*

	2005		2008 (N=210)	2011 (N=162)
	High Producing Field (N=260)	Low Producing Field (N=248)		
Mean (Average date)	October 6	October 8	October 10	September 17
Minimum (Earliest date)	September 1	September 1	September 10	October 15
Maximum (Latest date)	November 10	November 15	December 1	November 11

Table 135 *Average Harvest Date by Category*

	2005		2008 (N=210)	2011 (N=188)
	High Producing Field (N=260) Frequency (%)	Low Producing Field (N=248) Frequency (%)	Frequency (%)	Frequency (%)
Before October 1	108 (41.5)	87 (35.1)	48 (22.9)	53 (28.2)
October 2 to November 19	152 (58.5)	161 (64.9)	159 (75.7)	134 (71.3)
After November 20	0 (0.0)	0 (0.0)	3 (1.4)	1 (0.5)

Section two tables.

Table 136 *Soil pH*

	2005 (N=42)	2008 (N=56)	2011 (N= 56)
Mean	6.7	6.6	6.6
St. Deviation	0.61	0.33	0.36
Minimum	4.0	5.9	6.00
Maximum	8.2	7.5	7.80

Table 137 *Soybean acres under irrigation*

	2008* (N= 6)	2011* (N=5)
Mean	91	146
St. Deviation	106.9	129.7
Minimum	10	50
Maximum	300	350

*Values of 0 were not included

Table 138 *Percent of Soybean Acres Drained*

	2008			2011		
	# of acres considered "poor" N=36	# of acres considered "moderate" N=52	# of acres considered "well" N=53	# of acres considered "poor" N=32	# of acres considered "moderate" N=46	# of acres considered "well" N=58
Mean (S.D)	17.8 (16.4)	44.2 (28.2)	62.1 (27.0)	17.2 (12.3)	39.7 (26.8)	66 (30.4)
Mode	10	50	100	10	20.0	100.0
Median	10.00	40.00	60.00	15.0	30.0	70.0

Table 139 *Soybean Acres Considered Sufficiently Tile Drained*

	2008 (N=45)	2011 (N=54)
Mean	232.3	223.5
St. Deviation	241.1	250.1
Minimum	10	10.00
Maximum	1235	1000.00

Table 140 *Soybean Acres with Manure Applied Annually*

	2008* (N=56)	2011* (N=13)
Mean	141.4	27.3
St. Deviation	123.5	26.3
Minimum	10	5
Maximum	300	100

*Values of 0 were not included

Table 141 *Percent of Weed Control Achieved*

	2005		2008 (N=63)	2011 (N=63)
	High Producing Field (N=60)	Low Producing Field (N=58)		
Mean	95.6	95.0	94.0	95.6
St. Deviation	7.0	7.8	8.4	5.3
Minimum	50	50	70	48
Maximum	100	100	100	100

Table 142 *Height of Weeds at the Post Emergence Time of Spray*

	2005		2008 (N=61)	2011 (N=61)
	High Producing Field (N=61)	Low Producing Field (N=30)		
Mean	2.03	2.07	4.3	3.0
St. Deviation	0.68	0.66	4.0	1.4
Minimum	1	1	1	1
Maximum	4	4	24	7

Table 143 *Cost of Insecticide and Fungicide*

	2008			
	Mean	S. D.	Minimum	Maximum
Cost of insecticide (N=34)	$13.2	6.6	$4	$35
Costs of fungicide (N=16)	$15.5	7.2	$6	$35
Costs			**2011**	
	Mean	S. D.	Minimum	Maximum
Cost of insecticide (N=37)	$13.0	12.1	$2	$75
Costs of fungicide (N=23)	$12	4.4	$6	$25

Table 144 *Reasons for NOT Applying Fungicides*

	2005 (N=63)	2008 (N=63)	2011 (N=63)
	Frequency (%)	Frequency (%)	Frequency (%)
Cost of Production	8 (20)	6 (9.5)	5 (7.9)
Timing of application	2 (5.0)	6 (9.5)	2 (3.2)
Availability of applicator	3 (7.5)	2 (3.2)	3 (4.8)
Not needed*		22 (34.9)	16 (25.4)
Not at or above threshold for pest**	27 (67.5)		

*This item was not included in 2005. **This item was not included in 2008.

Table 145 *Crosstabulation: Use of Planting Device and Planter Row Width by Category*

2008		**Use of planting device**			**Total**
		Drill (%)	Planter (%)	Both (%)	**(%)**
Planter row width	Less than 11”	46.0	1.6	3.2	50.8
	11 to 22”	15.9	9.5	4.8	30.2
	23 or more”	0	17.5	1.6	19.0
	Total	61.9	28.6	9.5	100
2011		Use of planting device			Total
		Drill (%)	Planter (%)	Both (%)	(%)
Planter row width	Less than 11”	43.5	1.6	3.2	48.4
	11 to 22”	12.9	14.5	6.5	33.9
	23 or more”	0	17.7	0	17.7
	Total	56.5	33.9	9.7	100

Table 146 *Planting Speed (m.p.h.)*

	2005 (N=63)	**2008 (N=63)**	**2011 (N=62)**
Mean	5.2	5.3	4.9
St. Deviation	0.91	0.87	0.63
Minimum	3.5	4	3.5
Maximum	10.0	10	7.0

Table 147 *Percentage of Seed Planted From Each Maturity Group fertilizer*

	2008			
	Average % of seed growers plant from 0-1 maturity group (N= 5)	Average % of seed growers plant from 1-2 maturity group (N=26)	Average % of seed growers plant from 2-3 maturity group (N=56)	Average % of seed growers plant from 3 plus maturity group (N=11)
Mean (S.D)	40 (44.9)	53.85 (27.0)	75.8 (27.3)	35.0 (24.5)
Mode	0	50	100	20
Median	20	50	82.5	25.0
	2011			
	Average % of seed growers plant from 0-1 maturity group (N= 4)	Average % of seed growers plant from 1-2 maturity group (N=32)	Average % of seed growers plant from 2-3 maturity group (N=51)	Average % of seed growers plant from 3 plus maturity group (N=12)
Mean (S.D)	75.0 (46.7)	55.5 (32.5)	70.6 (30.3)	44.6 (31.1)
Mode	100	100	100	100
Median	97.5	50.0	80.0	30.0

Table 148 *Types of Seed Used*

	2008			
	% of Food Grade (N= 6)	% of Roundup Ready (N=58)	% of Low Sat (N=2)	% of Low Linolenic (N=9)
Mean (S.D)	52.3 (37.8)	94.0 (16.0)	52.5 (67.2)	47.7 (24.8)
Mode	20	100	5	50
Median	36.5	100	52.5	50
Minimum	20	33	5	15
Maximum	100	100	100	100
	2011			
	% of Food Grade (N= 4)	% of Roundup Ready (N=57)	% of Low Sat (N=1)	% of Low Linolenic (N=2)
Mean (S.D)	61.3 (34.2)	96.1 (14.4)	100.0 (X)	70.0 (42.4)
Mode	20	100	100	40
Median	62.5	100	100	70
Minimum	20	25	100	40
Maximum	100	100	100	100

Table 149 *Average Harvest Date*

	2005		2008 (N=57)	2011 (N=53)
	High Producing Field (N=62)	Low Producing Field (N=61)		
Mean (Average date)	October 5	October 7	October 9	October 8
Minimum (Earliest date)	September 9	September 9	September 20	September 20
Maximum (Latest date)	November 1	November 1	November 1	November 10

Table 150 A*verage Harvest Date by Category*

	2005		2008	2011
	High Producing Field (N=62)	Low Producing Field (N=61)	(N=57)	(N=61)
	Frequency (%)	Frequency (%)	Frequency (%)	Frequency (%)
Before October 1	25 (40.3)	23 (37.7)	13 (22.8)	15 (24.6)
October 2 to November 19	37 (59.7)	38 (62.3)	43 (75.4)	45 (73.8)
After November 20			1 (1.8)	1 (1.6)

Section six tables

Table 151 *Results of t-test of effect of tillage type and planter calibration on number of acres*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Chisel plow	Yes	334	378.54 (448.6)	-1.52 (675)	.128
	No	343	433.22 (484.6)		
Field cultivator	Yes	315	411.56 (556.1)	.275 (675)	.783
	No	362	401.63 (374.9)		
Change calibration between varieties	Yes	501	424.29 (491.2)	1.72 (671)	.085
	No	172	353.19 (387.9)		

Table 152 *Results of t-test of effect of tillage type and planter calibration on yield*

		N	Mean (s.d.)	t value (d.f.)	Significance (p<.05)
Chisel plow	Yes	327	42.58 (6.6)	1.24 (667)	.216
	No	342	41.93 (6.9)		
Field cultivator	Yes	308	42.29 (7.1)	.161 (667)	.872
	No	361	42.21 (6.4)		
Change calibration between varieties	Yes	496	42.21 (6.7)	-.25 (662)	.801
	No	168	42.36 (6.9)		

Appendix B: Soybean 2010 Survey Instrument, 2011

Due to MSU Thesis formatting requirements, the pdf version of the original is not included. Please see the text version below or contact the MSPC for an original version of the survey.

Date: February 2011
To: Selected Producers of Soybeans
From: Andy Welden, Fellow Soybean Producer and MSPC President Andy
Re: FINAL Soybean 2010 Producer Survey

The Soybean 2010 project was initiated in 2004 as a collaborative effort of several organizations including the Michigan Soybean Promotion Committee (MSPC) and Michigan State University (MSU) after data analysis indicated soybean yields and profitability were not "keeping-up" with that of corn and wheat. To identify needed research, demonstration, and educational efforts needed to address this challenge, soybean producer surveys (similar to this one) were conducted in 2005 and again in 2008.

This FINAL Soybean 2010 producer survey is not only intended to evaluate the 2010 project but to use as a basis for new programming as we enter a new decade. The soybean checkoff values this feedback as we continue efforts for profitable soybean production.

The survey should take you no more than twenty minutes. The survey questions attempt to get straight to the issues and were designed to be "user friendly". Your response is completely voluntary, but important to future Michigan soybean production. Your responses will be kept confidential and will not be used for advertising or marketing solicitations or sold to private entities.

To show our appreciation, you will receive a SMaRT (successor to Soybean 2010) USB Flash Drive that is pre-loaded with a summary of the Soybean 2010 project for your reference. All you have to do is complete this survey and return it in the self-addressed,postage-paid return envelope by February 28, 2011.

Thank you in advance for your cooperation in returning the completed survey and being part of the group of producers involved in an effort to assure a viable soybean industry for Michigan.

FINAL Soybean 2010 Survey

State of the Production Systems for Michigan Soybeans

Dear Soybean Producer:

This FINAL Soybean 2010 producer survey is not only intended to evaluate the 2010 project but to use as a basis for new programming as we enter a new decade. The soybean checkoff values this feedback as we continue efforts for profitable soybean production. The survey will take only a short time to complete. Your participation is voluntary, but important to future Michigan soybean production. You may discontinue participation at any time. Your responses will be kept confidential, survey sheets are coded so we may provide follow up mailings in a effort to gather the data. The code will in no way identify you or your farm operation. All participants will receive a report of the summary of the survey findings regarding best soybean production practices in Michigan. The complete report is expected to be complete by July 2011. If you have questions regarding the survey questions or the purpose of this research, please contact the Michigan Soybean Promotion Committee in Frankenmuth.

General

1. What is the average number of acres of soybeans you planted in the last 5 years?
_____ Acres

2. What custom services have been used?
(check all that apply)
_____ Planting
_____ Scouting
_____ Soil Sampling
_____ Fertilizer Applications
_____ Spraying
_____ Lime Applications
_____ Harvesting
_____ None

3. How are soybean varieties selected? (check all that apply)
_____ MSU Soybean Variety Trials
_____ Past Performance on Farm
_____ Dealer Recommendation
_____ Specialty Market
_____ Market Premium
_____ Disease Resistance
_____ Soybean Cyst Nematode
Resistance
_____ Roundup Ready
_____ Synchrony Tolerant (STS)

4. What is your most prevalent crop rotation? _____

5. How many soybean acres do you irrigate? _____

Soils/Fertility

6. How often do you soil test your fields? _____

7. Do you use the soil test information for: (check all that apply)
_____ Phosphorous Application
_____ Potassium Application
_____ Micronutrient Application
_____ Adjusting the Soil PH

8. When applying fertilizer, do you use: _____ A commercial blend
_____ Customized blend to match soil fertility

9. What is your average soil pH?

10. When are fertilizers applied?

_____ Fall

_____ Spring

_____ At Planting

_____ Post Emergence Foliar

_____ One application bi-annually for soybean and corn

11. What percentage of your soybean acres are drained according to the following categories? (enter percent for each – should total to 100%)
_____ % Poor
_____ % Moderate
_____ % Well

12. How many soybean acres are sufficiently tile drained? _____

13. What nutrients have you supplied by fertilizer?
_____ Phosphorous
_____ Potassium
_____ Sulfur
_____ Boron
_____ Manganese

_____ Foliar
_____ Other:

14. What tillage practices do you use in your soybean production system?
(check all that apply)
_____Chisel Plow
_____Moldboard Plow
_____V-Ripped
_____Deep Slots
_____Disk
_____Field Cultivator
_____No-Till
_____Vertical Tillage
_____Zone/Strip Tillage

15. On average what percentage of your soybean acres annually have manure applied to them?
_____ %

«ID»

Pest Management

16. Which of the following herbicide application methods best match your management?
(check all that apply)
_____ Pre-plant
_____ Pre-emergence with residual activity
_____ Post-emergence (other than

Glyphosate)
_____ 2 pass Pre and Post program
_____ Glyphosate (1 application)
_____ Glyphosate (2 applications)

17. What % of weed control is usually achieved? _____ %

18. On average, how tall are weeds at the post emergence time of spray?
_____ inches

19. Are fields scouted on a regular basis? (at least once per month)
_____ Yes
_____ No

20. Are fields scouted by a crop consultant?
_____ Yes
_____ No

21. What insects and diseases do you scout for (check all that apply):
_____ White Mold

_____ Septoria Leaf Spot
_____ Soybean Cyst Nematode
_____ Spider mites
_____ Sudden Death Syndrome
_____ Soybean aphid
_____ Grasshoppers
_____ Soybean Rust
_____ Other (please list):

22. Have you applied foliar insecticides in the past?
_____ Yes
_____ No

A.
If yes, approximate cost per acre? _____
B. Targeted Pest(s):
_____

23. Have you applied foliar fungicides in the past?
_____ Yes
_____ No
A.
If yes, what is the approximate cost per acre?
_____ $/acre
B. Targeted pest(s):
C.
If not, what was the reason?
_____ Cost of product
_____ Timing of application
_____ Availability of Applicator
_____ Not needed

24. How do you control Soybean Cyst Nematode (SCN)?
(check all that apply)
_____ Resistant Variety
_____ Nematicide
_____ Monitor Population
_____ Crop Rotation
_____ Have not tested for SCN
_____ Tested, but don't have SCN

Planting/Harvesting

25. What is your row width: _____ Inches

26. Is your planter calibrated on: _____ Seeds per acre _____ Pounds per acre

27. Do you recalibrate when changing varieties?
_____ Yes
_____ No

28. Do you use a guidance systems when planting?
_____ Yes
_____ No

29. Do you use a:
_____ Drill
_____ Planter

30. What is your planting rate?
_____ Seeds per acre

31. What is your average planting speed? _____ m.p.h.

32. What is your average target planting date? _____

33. Please list the percentage of seed you plant from the following maturity group ranges (enter a percent for each category – should total to 100%)
_____ 0-1
_____ 1-2
_____ 2-3
_____ 3+

34. What type of seed do you plant? List the percentage for each type.
_____ Food Grade
_____ Roundup Ready
_____ Low Sat
_____ Low Linolenic

35. Is seed treated with fungicide?
_____ Yes
_____ No

36. What percentage of your soybean acreage is inoculated? _____ %

37. How would you rate your average stand emergence?
_____ Uniform
_____ Variable
Average stand count:_____

38. What is average harvest date?

39. What is average soybean yield?
_____ bushels/acre
«ID»

Perceptions

40. Yield reduction may be caused by:
(check all that apply)
_____ Herbicide Effectiveness
_____ Roundup Ready
_____ Insects
_____ Breeding Delays in Yield
_____ Type of Soil
_____ Increased Soybean Acres
_____ Increase of Soybean in Rotation
_____ More Soybean on Soybean Acres
_____ Weed Pressure
_____ Foliar Disease
_____ Stem Rots
_____ Root Rots
_____ Soybean Cyst Nematode
_____ Seed Quality
_____ Planting Date
_____ White Mold
_____ Seed Treatment
_____ Lack of Agronomic Information
_____ Variety Selection
_____ Don't know where to get information
_____ Excessive corn stover residue

41. What is the value of soybeans as part of your cropping system?
_____ High Value
_____ Medium Value
_____ Low Value

42. How much management is required for soybean production?
_____ High Level of Management
_____ Moderate Level of Management
_____ Low Level of Management

43. Over the past 5 years have your soybean yields:
_____ Remained Stable
_____ Increased

_____ Decreased

44. What do you see as the top 2 or 3 issues facing soybean growers?

45. Where do you go to get agronomic information?
_____Grower meetings
_____Media
_____Seed/Chemical Suppliers
_____Michigan State University Extension
_____Internet
_____Other (please list): _____
Soybean 2010

46. Are you aware of the Soybean 2010 project?
_____ Yes
_____ No

47. Have you attended any Soybean 2010 meetings titled "Overcoming the Barriers to Higher Soybean Yields"?
_____ Yes
_____ No

48. Have you used any of the materials (website, grower hotline, fact sheets, media, etc.) created by the Soybean 2010 project?
_____ Yes
_____ No

49. Have you changed any management practices on your farm as a result of what you learned from the Soybean 2010 project?
_____ Yes
_____ No
A. If yes, please specify:
«ID»

Thank you for participating in this vital survey! Please return this form in the stamped, self-addressed envelope provided.

References

References

Alston, D.G., & Reding, M.E. (1998). Factors influencing adoption and educational outreach of integrated pest management, Journal of Extension [On-line]. 36(3). Available: http://www.joe.org/joe/1998june/a3.html

Bennet, M. J., Hicks, D., Naeve, S., & Bennet, E. (Eds.). (1999). *The Minnesota Soybean Field Book*: University of Minnesota Extension Service.

Bertram, M., & Pedersen, P. (2004). Adjusting management practices using glyphosate-resistant soybean cultivars. *Agronomy Journal*, 96(2), 462-468.

Bruening, T. H., Radhakrishna, R. B., & Rollins, T. J. (1992). Environmental issues: farmers' perceptions about usefulness of informational and organizational sources. *Journal of Agricultural Education, 33*(2), 34-42. doi: **10.5032/jae.1992.02034**

Beuerlein , J. E. (2011). *Adjusting a grain drill for planting soybeans* (AGF-114-01). Retrieved from Ohio State University Extension website: http://ohioline.osu.edu/agf-fact/0114.html

Cartmell, D. D., II, Orr, C. L., & Kelemen, D. B. (2006). Effectively disseminating information to limited-scale landowners in the urban/rural interface. *Journal of Extension, 44*(1).

Chen, G. H., & Wiatrak, P. (2011). Seeding rate effects on soybean height, yield, and economic return. *Agronomy Journal, 103*(5), 1301-1307. doi: 10.2134/agronj2010.0427

Chrispeels, M. J., & Sadava, D. E. (2003). *Plants, genes, and crop biotechnology*. (2nd ed.). Boston: Jones & Bartlett Learning.

Conley, S., & Santini, J. (2007). Crop management practices in Indiana soybean production systems. *Crop Management*. Retrieved from PMN International website: doi:10.1094/CM-2007-0104-01-RS.

Coulter, J. A., & Nafziger, E. D. (2007). Planting date and glyphosate timing on soybean. [Article]. *Weed Technology, 21*(2), 359-366. doi: 10.1614/wt-06-025.1

Cox, W. J., & Cherney, J. H. (2011). Growth and Yield Responses of Soybean to Row Spacing and Seeding Rate. *Agronomy Journal, 103*(1), 123-128. doi: 10.2134/agronj2010.0316

Cox, W. J., Cherney, J.H., & Shields, E. (2010). Soybeans compensate at low seeding rates but not at high thinning rates. *Agronomy Journal*, 102(4), 1238-1243.

Culpepper, S., & York, A.C. (2000). Weed management in ultra narrow row cotton (*gossypium hirsutum*). *Weed Technology, 14*(1), 19-29.

Davis, V. M., & Conley, S. P. (2011). Characterizing extension value, computer technology and new media use of Midwest soybean growers. *Crop Management*. Retrieved from PMN International website: doi:10.1094/CM-2011-0628-01-RS.

De Bruin, J. L., & Pedersen, P. (2008). Soybean seed yield response to planting date and seeding rate in the upper Midwest. [Article]. *Agronomy Journal, 100*(3), 696-703. doi: 10.2134/agronj2007.0115

Diekmann, F., & Batte, M. T. (2009). Examining information search strategies of Ohio farmers. *Journal of Extension, 47*(6).

Epler, M., & Staggenborg, S. (2008). Soybean yield and yield component response to plant density in narrow row systems. *Crop Management* (September), CM-2008-0925-2001-RS.

Foltz, J., Lanclos, K., Guenthner, J., Makus, L., & Sanchez, W. (1996). The market for information and consultants in Idaho agriculture. *Agribusiness, 12*(6), 569-581.

Grey, T. L. (2007). Utility of residual herbicides in no-till double-crop glyphosate resistant soybean production. Online. Crop Management doi:10.1094/CM-2007-0122-01-RS.

Howell, J. L., & Habron, G. B. (2004). Agricultural landowners' lack of preference for Internet extension. *Journal of Extension, 42*(6).

Harder, D. B., Sprague, C. L., & Renner, K. A. (2007). Effect of soybean row width and population on weeds, crop yield and economic return. *Weed Technology, 21*(3), 744-752. doi: 10.1614/wt-06-122.1

Janovicek, K. J., Deen, W., & Vyn, T. J. (2006). Soybean response to zone tillage, twin-row planting, and row spacing. [article]. *Agronomy Journal, 98*(3), 800-807. doi: 10.2134/agronj2005.0231

Kleweno, D. D. National Agricultural Statistics Service, Michigan Field Office. (2010). *Michigan 2009-2010 highlights* (NR-10-76)

Lasley, P., Padgitt, S., & Hanson, M. (2001). Telecommunication technology and its implications for producers and extension services. *Technology in Society, 23*, 109-120.

Lim, H., Shumway, C. R., & Love, H. A. (2000). Research contributions from the soybean checkoff program. [article]. *Journal of Agricultural and Resource Economics, 25*(1), 128-146.

Lee, C. D. (2006). Reducing row widths to increase yield: why it does not always work. In W. J. Wiebold (Ed.), *Crop Management* (pp. 1-7).

Licht, M. A. R., & Martin, R. A. (2007). Communication channel preferences of corn and soybean producers. *Journal of Extension, 45*(6).

Michigan Soybean Promotion Committee (MSPC). About Us. Retrieved November 12, 2011, from http://www.michigansoybean.org/MSPCSite/AboutUS/aboutus.html

Michigan Soybean Promotion Committee (MSPC). (2011) *Soybeans impact Michigan's economy*. Retrieved December 11, 2011, from http://www.michigansoybean.org/MSPCSite/ 2011EconomicReport.pdf

Payne, S. A., & Oliver, S. R. (2000). Weed control in drilled glyphosate-resistant soybean. *Weed Technology*, *14*(2), 413-422.

Pedersen, P., & Lauer, J. G. (2004). Response of soybean yield components to management system and planting date. [article]. *Agronomy Journal, 96*(5), 1372-1381.

Rich, A. M., & Renner, K. A. (2007). Row spacing and seeding rate effects on eastern black nightshade (Solanum ptycanthum) and soybean. [article]. *Weed Technology, 21*(1), 124-130. doi: 10.1614/wt-04-220.1

Roseler, D.K., Chase, L.E. & McLaughlin, E.W. (1994). Information dissemination in dairy nutrition. Journal of Extension [On-line]. 32(1). Available: http://www.joe.org/joe/1994june/rb3.html

Scheuren, F. (2004). *What is a survey*. (2nd ed.). American Statistical Association. Retrieved from http://www.whatisasurvey.info?

Schulz, T. J., & Thelen, K. D. (2008). Soybean seed inoculant and fungicidal seed treatment effects on soybean. [article]. *Crop Science, 48*(5), 1975-1983. doi: 10.2135/cropsci2008.02.0108

Staton, M., & Poindexter, S. (2011). Calibrating drills for soybean production: Retrieved from Michigan Soybean Checkoff website: http://www.michigansoybean.org/MSPCSite/GrowerResources/FactSheets/CalibratingSoybeanDrills.pdf.

Staton, M., Thelen, K., & Silva, G. (2011). Checklist for Improving Soybean Yields. Retrieved from SMaRT Soybean Facts website: http://www.michigansoybean.org/MSPCSite/GrowerResources/ResearchPublications.html.

Suvedi, M., Thelen, K., Pennington, D., & Takagi, C. (2005). *A comparison of soybean production practices between above and below average yielding Michigan farms*. Informally published manuscript, Michigan State University, East Lansing, Michigan.

Thelen, K. & Schulz, T. (2011) Soybean Seed Applied Inoculation. Retrieved from SMaRT Soybean Facts website: http://www.michigansoybean.org/MSPCSite/GrowerResources/ResearchPublications.html.

U.S. Department of Commerce. (2011). *Exploring the Digital Nation: Computer and Internet Use at Home*. National Telecommunications and Information Administration [On-line]. Available at: http://www.esa.doc.gov/sites/default/files/reports/documents/exploringthedigitalnation-computerandinternetuseathome.pdf

Wax, L.M, & Pendleton, J.W. (1968). Effect of row spacing on weed control in soybeans. *Weed Science*, 16(4), 462-465.

Williams, G. W., Capps, O., Jr., & Bessler, D. A. (2009). Is the soybean checkoff program working? [Bulletin]. *Report - Agribusiness, Food and Consumer Economics Research Center, Department of Economics, Texas A & M University*(CM-01-09), viii + 94 pp.