An industry needs assessment of competencies in precision agriculture
by Rick A Perleberg

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Agricultural Education
Montana State University

Abstract:
The purpose of this study was to identify those competencies which precision agriculture professionals perceived as needed by industry as well as how those competencies relate to importance in hiring. The study area was limited to the states of Idaho, Montana, North Dakota and South Dakota.

This descriptive study followed the needs assessment model outlined by Borich (1980). Weighted Discrepancy (WD) scores were generated under this model; however, they were modified to indicate a relative importance in hiring coupled with the overall need of industry for an identified competency. This statistic has significance in identifying the training needs of individuals entering the precision agriculture industry as it relates to bearing on being hired. WD scores identified the most important vocational and career competencies considered by industry professionals when hiring people to work in precision agriculture applications.

A survey was mailed to individuals identified as population segments by utilizing the design identified by Dillman (1978). Eighty-eight competency statements, grouped into 4 categories were measured using two Likert-type scales, one measuring respondent perceptions of the need of industry for that competency and the second measuring respondent perceptions on the importance those competencies had in hiring individuals to work in precision agriculture applications.

Variations of responses between demographic groups were analyzed using a Mann-Whitney test. A Cronbachs's alpha test for reliability was conducted to test for survey instrument reliability. No significant variations between demographic groups were found and the survey instrument was determined to be reliable.

The data from this study have significant implications upon both industry and education alike. Industry has identified those specific and unique competencies related to precision agriculture applications as well as quantifying the importance that each of those competencies has when considering hiring individuals to work in precision agriculture applications. Educational institutions need to react to the voice of industry in order to be dynamic in their curricula as well as meet the needs of prospective employees in the precision agriculture industry. The data in this study outline those identified competencies as well as determine their importance in industry hiring situations.

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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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Date July 27, 1999

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ABSTRACT

The purpose of this study was to identify those competencies which precision agriculture professionals perceived as needed by industry as well as how those competencies relate to importance in hiring. The study area was limited to the states of Idaho, Montana, North Dakota and South Dakota.

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CHAPTER ONE

THE PROBLEM

Introduction

In this last decade of the Twentieth century, we find ourselves in the midst of the information age. Computer technologies are ever improving and the methods in which these technologies utilize information that applies to production agriculture situations are reaching incredible measures. The National Research Council (NRC), in the 1997 publication Precision Agriculture in the 21st Century: Geospatial and Informational Technologies in Crop Management, identified three potential effects of precision agriculture:

> First, widespread adoption of precision agriculture may affect employment opportunities in rural communities. Second, precision agriculture may affect the structure of agriculture, particularly the distribution of farm sizes. Third, more efficient and precise use of fertilizers , pesticides, and other purchased inputs may alleviate environmental spillovers from agriculture. (p. 79)

With these predictions come exciting opportunities for production agriculturists. Satellite technologies have paved the way for precision farming. The NRC (1997) defines precision farming as "a management strategy that uses information technologies to bring data from multiple sources to bear on decisions associated with crop production" (NRC, 1997, p. 17). The gathering of data from remote sources used in conjunction with computer technologies can limit field variability while decreasing inputs as well as promote beneficial stewardship of production lands.

When the desire to produce more product on the same amount of land is coupled with the need to decrease inputs, the production agriculture industry faces other, potentially more important, dilemmas. The 1980's saw the rise of environmental awareness by the general public. As a nation, many questioned the farming practices of many production agriculturists. While some allegations of poor stewardship of American soils were unfounded and simply the result of an uninformed or under informed public crying for environmental safety, some of the allegations were true. Not all producers had the best interest of the environment in mind, they were simply concerned with the bottom line: Money in the bank.

"Policy makers have been intrigued with the concept (of site specific management) because it facilitates environmental stewardship and offers the potential to minimize environmental risks from agricultural activities" (J.S. Schepers, et al., 1998, p. 316). By applying treatments to production areas on an "as needed" basis relating to the sub-meter needs of the soil, producers can better accommodate the potential environmental impacts of their inputs. The need to apply fertilizers and pesticides at rates aimed to meet average field needs is no longer necessary. Precision agriculture applications can accommodate the site specific needs of management units.

The implementation for any of the modes of precision agriculture applications will require several specific things from the agriculture industry as a whole. One of these many things is a shift in paradigms by the producer as to how they approach the management of their operations. Gathering, organizing and analyzing the data that are collected by producers will drive how they manage the crops they produce.

The technologies, although experimental in nature, which are available today have the potential to net farmers greater profits while maintaining cognizant stewardship of their land. In being a cognizant steward of their land, each producer must weigh many factors relating to production, finances and the environment. The challenge is; however, how does one implement such technologies? How will the people who operate within these technologies be trained? Who will train them and what, exactly, will need to be taught?

Precision agriculture applications, including GPS/GIS information technologies, can offer producers the edge as to increased yields and decreased inputs resulting in greater profits. The National Research Council (1997) wrote:

> In the 21st century, agriculture professionals using information technologies will play an increasingly important role in crop production and natural resource management. It is imperative that educational institutions modify their curricula and teaching methods to educate and train students and professionals in the interdisciplinary approaches underlying precision agriculture. (p. 104).

In order to prepare for the future of agricultural production, modern employees must not allow themselves to be left without the training necessary for success in this and related fields such as natural resource management, biology, wildlife management, earth and environmental sciences.

Statement of Purpose

The purpose of this study is to determine the competencies that individuals working with precision agriculture applications will need to possess in order to be functional contributors in crop production situations in the states of Montana, North Dakota, South Dakota and Idaho. Also, the perceived importance of these competencies were identified by industry professionals when considering an individual for hire to work in the precision agriculture field.

Need for Study

The new world order has brought about a global economy. Tandem to the global economy is the ever-increasing need for domestic producers of agricultural products to gain an edge in the market place. Producers have little to say as to international policy on trade. Even when their voice is heard, the wheels of international agriculture trade policy grind slow and unsteady. Whereas producers cannot necessarily affect market prices, they can affect the amounts that they produce and also control the inputs to those crops in order to improve on the return over input ratio.

In addition to marketing issues, environmental issues that stem from agricultural production practices have an impact on how producers make decisions related to their crops. Site specific management (SSM) allows producers and crop consultants the opportunity to apply varied amounts of product according to specific needs of each soil in a given field. With SSM, environmental impacts of agricultural inputs can be reduced.

"Precision Agriculture may simultaneously improve farm profitability and reduce environmental spill over from agriculture" (NRC, 1997, p. 13).

In order for precision agriculture to be widely adopted and implemented, prospective employees will need skills for understanding and analyzing spatially variable data. They will also need training to be effective in on-site applications of precision agriculture.

Independent and cooperative consulting firms must also seek continuing education about precision agriculture application technologies. These firms will be called upon to interpret data collected on client's farms and will be responsible for aiding in the decision making process. The wealth of information that is held by the farmers will be enhanced by the utilization of information technologies. However, consultants and farmers need training as to the actual processes of implementing these technological advances.

Cutting edge technologies need trained individuals to implement these technologies and realize them to their full potential. A technology without a technician is like a light bulb without electricity-- a great idea but by itself is worthless. The energy driving these technologies related to precision agriculture is qualified and competent technicians.

"The Professional societies associated with agriculture, biology, earth sciences, and environmental sciences could provide guidance in identifying necessary course work for new professionals and additional training for existing personnel" (NRC, 1997, p. 6).

Although some community colleges and universities have begun to address the needs of industry as they relate to precision agriculture technologies within their respective curricula, most have not. Perhaps the reason why those needs have not been addressed within the curricula could be that those needs are not clearly defined. Moreover, perhaps those needs are changing at a rate much faster than that of contemporary curriculum development.

If the skills and competencies related to precision agriculture applications can be identified and organized into cohesive and prudent categories, then curricula can be developed to meet the industry need. In contrast, if educational public facilities graduate qualified individuals who cannot effectively enter the workforce at a level to which they can serve as viable employees, then that institution is not serving the public to the capacity at which it was designed to operate. The result will be a deficit in trained production agriculture technicians. By identifying the skills and competencies that these graduates need as well as the perceived needs of industry, this researcher hopes to build the foundation for curricula development for precision agriculture, education and industry.

Objectives

In order to fulfill the purpose of this study, the following objectives have been identified:

(1) Identify the perceived need of precision agriculture industry professionals for specific and unique competencies in precision agriculture applications; and

(2) Determine the specific competencies related to precision agriculture applications and their perceived importance for individuals to possess those competencies when being considered for hire.

Definitions

Site Specific Management (SSM) -- the ability to apply inputs, such as fertilizers, based on the needs of individual areas within a field, rather than making uniform applications across the entire field (Wilkerson, 1996, p.5)

Global Positioning Systems (GPS) – navigational system consisting of a constellation of 24 satellites that send and receive radio signals to determine locations on earth.

Geographic Information Systems (GIS) – computer systems and software that organize data into cohesive formats and render geospatial analysis opportunities from the data gathered.

Differential GPS (DGPS) – GPS coordinates that have undergone correction for ionospheric and atmospheric conditions. More accurate than GPS, it utilizes known locations (way points and base stations) to correct GPS signals and produce sub meter accuracy of coordinate.

Internet – a global connection of interconnected local, mid level, or world-wide networks (ES-USDA & ECOP. 1991).

Production Unit – area where crops are produced.

Management Unit – specific areas within production units that have varying characteristics as compared to other areas within the same production unit.

Real Time – relates to actual readings at a specific point in time for a particular area's characteristics.

Spatial Data – data collected over expanses of land.

Biomass – levels of organic matter relating to living tissues in crops.

Assumptions

This study was developed on the following assumptions:

1. Precision Agriculture is an up and coming industry revolution that will require trained individuals to perform specific, technical tasks related to these new technologies.
2. Site specific management and the precision agriculture applications that accommodate those management methods have the potential to be widely adopted practices. Those practices will, eventually, become commonplace in the agriculture industry.
3. The utilization of information technologies can aid in the decision making process of on farm situations.
4. There are specific and unique competencies related to precision agriculture that can be identified.
5. Industry personnel can identify the importance of precision agriculture competencies.

Limitations

This study was limited to:

1. The survey population will have geographic limits that are delineated by the participant states of the Upper Midwest Aerospace Consortium (Montana, Idaho, North Dakota and South Dakota).
2. The time at which the survey will be administered falls in the month of June, 1999.
3. Participants will be limited to those who are service providers for precision agriculture or producers utilizing the concepts of precision agriculture.

CHAPTER 2

Review of Literature

The literature review was approached as three inter-related areas that affect the researcher's study. Literature review pertaining to 1) precision agriculture technologies about site specific management (SSM) and precision agriculture applications, 2) information about the development of conducting needs assessments, 3) specific skill and competency identification for SSM and precision agriculture application. Little is published about the specific competencies related to precision agriculture application.

The infancy of precision agriculture and the ever changing and improving nature of the skills do not lend themselves to actual literature review from a variety of reliable sources. So in order to review published material, the researcher utilized articles from professional journals and industry specific publishers of precision agriculture information.

In addition to the industry manuals and professional periodicals, the researcher has utilized telephone interviews with faculty from various community colleges and universities in order to gain an understanding of curricula construction and delineation of competencies to create objectives for courses.

Precision Agriculture Technologies

Global Positioning Systems (GPS) are the backbone to many precision farming applications. The necessity to know where one is on a given production unit, and to be able to gather and analyze data for a given area, is paramount to Site Specific Management (SSM).

GPS was developed by the Department of Defense as a means to simplify and add accuracy to navigation. The system consists of 24 satellites that orbit the earth and have the capacity to send and receive radio signals. In order to determine a given location, the system operates in a sequence of events. Jeff Hurn, author of "GPS, A Guide to the Next Utility", has identified these basic steps and categorized them into five factors that all relate to the operation of GPS satellites and receivers. "(1) The basic idea of satellite ranging, (2) measuring your distance from a satellite, (3) getting perfect timing, (4) knowing where a satellite is in space, and (5) ionospheric and atmospheric delays." (Hurn, 1993, p. 14-47)

The distance to a satellite can be determined by how long it takes a radio signal to reach the ground receiver from the satellite. The assumption is made that the satellite and the receiver are both generating the same pseudo-random code at the same exact time. The distance is determined by evaluating the length of time it takes for the code to get to get the receiver and comparing how late its pseudo-random code was compared to the receiver's code.

The accuracy of satellite time is the key to how well GPS operates. The satellites are equipped with atomic clocks, which remain extremely accurate over extended periods of time. While the clocks on board the satellites remain ever constant, receiver clocks are an entirely different matter. Errors in receiver clock accuracy are corrected by the use of complex trigonometric equations and by the utilization of three measurements from satellites in order to determine a single location.

The three measurements are actually a series of measurements from three different satellites. Three satellites are necessary for a three dimensional identification of location. A fourth measurement from a fourth satellite rules out any "out of line" measurements. A fourth measurement is necessary for "real-time" data collection and therefore requires receivers with four channels, one devoted to each satellite making measurements. Real time measurements are necessary for nearly all precision agriculture equipment. Richard F. Dunn Jr., writing for "The Precision Agriculture Buyers Guide" (1998, pg. 46), stated that selection of a yield monitor will allow you to "make observations and flag the information to a GPS location during harvest ... to rote weed patches, wet spots, thin stands and other trouble areas from the combine cab". Accurate, real-time data collection is essential to the future of SSM and precision farming.

The calculations that are performed in order to determine position require knowledge of the exact whereabouts of the satellites in space. GPS satellites orbit the earth at 10,900 miles above the surface. This distance allows for accurate prediction of their orbits; therefore, contributing to the accuracy of measurement. Any variation from the normal orbit pattern is monitored closely by the Department of Defense. So, one can be assured that the watchful eye of the United States military can only add to the precise performance of these satellites. If the monitoring by the Department of Defense wasn't enough, each satellites is equipped with monitors to record and send data constantly in regard to the maintenance of orbit consistency. (Morgan & Ess, 1997, p. 10)

Although much of the potential error that can occur with GPS equipment is addressed and corrected by technologies and the application of complex mathematical formulas, some error sources are more difficult to eliminate. A layer of earth's outer atmosphere, the ionosphere, is composed of electronically charged particles. These electronically charged particles can affect the speed at which light travels. Ionospheric error is corrected by applying the average effect of the ionosphere upon the speed of light with correction equations. Problematic; however, is the fact that not every day in the ionosphere is average; as a result, this is a potential source of error.

The earth's atmosphere is also a potential source of error. The weather, where all meteorological variations occur, can not be controlled nor corrected for. The advantage is, however, the error that occurs from this type of inconsistency is minimal. This minimal inconsistency is approximately 1 – 20 feet.

Yet another source of error is the result of "Dilution of Precision" (DOP). The DOP is influenced by the relative positions of the satellite. Position refers to horizontal, vertical, time and geometric measurements. (Trimble, 1996). Computer analysis of orbits makes DOP error less likely to occur and project planning may dictate the hours at which the greatest amount of DOP is present; therefore, allowing producers or consultants a better idea of when they should be utilizing these technologies.

In order to gain the sub meter accuracy necessary for some production operations, differential GPS (DGPS) is utilized. DGPS is more accurate than non-corrected GPS coordinates. DGPS employs the use of a known location (base station, way point) and "calculates the combined error in the satellite range data" (Hurn, 1993). The results of DGPS are more accurate locale data that can be incorporated into on site decision making as to the micro-management of production areas. The union of GPS and precision farming implements is a necessary relationship for SSM in addressing yield variability within fields, as well asother existing field condition data. Carr, et al (1991) determined that "applying different fertilizer treatments to contrasting soils in a field can generate greater returns than applying a field-average fertilizer treatment". Precision agriculture machinery and GPS/GIS technologies give producers the upper hand in management of their fields. Gathering and recording data and then analyzing that set of data specific to varied field conditions, as to the prescribed amounts of fertilizers, can decrease input costs. The variable rate application of product is an example of the union of GPS/GIS technologies and precision agriculture hardware.

Information drives precision agriculture applications. GPS is a tool by which the information can be gathered, organized and customized to site specific units. Another tool for utilizing information technologies is remote sensing equipment. Remote sensing, as described by Johannsen, Carter and Willis (1998, p.13), can provide precision agriculture by the following three advantages:

(1) Much greater detail of an individual field

(2) Much more precisely defined colors or delineation of variations of vegetation, residues or surface soils

(3) Repeat viewing of the same scene every 2 – 7 days

As a result of their findings, they conclude that the use of satellite imagery as an application of precision agriculture can provide a greater availability of data. It also provides a greater variation of the types of data and a more timely acquisition of that can impact site decisions.

The utilization of information technologies, as they apply to precision farming practices, has the potential for broad-based adoption. Although the technologies are emerging and evolving before the eyes of agriculture industry, broad-based adoption will hinge, most likely, on economic factors (NRC-1997). The cost of implementation of SSM and its tools (precision agriculture equipment) will need to be "outstripped by the economic gains of the practice" (NRC 1997). There are several practices or farm implements that all relate to SSM as methods of precision farming. The first, variable rate controllers allow for varied application rates of a given input (seed, fertilizer, pesticide) for a pre-determined field condition. The precise location of the pre-determined field condition is determined another implement – the GPS receiver.

GPS receivers allow producers to determine the location of a given field condition (moisture, pH, NPK values, pest populations) at a given point in time by collecting data from that area and integrating them into a GIS (Geographical Information System) application. The union of GPS and GIS technologies aid in the decision making process by creating maps or data tables that give site specific information for a particular point at the time the data was collected within the production unit.

Field data recorders give producers the ability to note field conditions on a real-time basis. By utilizing Differential GPS (DGPS) coordinates, the information is transferred to a computer off site for analysis in mapping software programs. Differentially corrected GPS signals have sub-meter accuracy and build information that is more specific than plain GPS readings.

Navigational systems are yet another application of precision agriculture methods. By watching a monitor that is located in the cab of the tractor, the operator can run the machine in electronically controlled swaths. This technology allows the operator to make applications of inputs or perform specific field operations. The use of GPS and DGPS signals are utilized in this system as well. Signals are transmitted to a receiver located on the tractor and the machine position is displayed on the in-cab monitor in relation to the field.

Yet another component of precision agriculture are information networks. Information networks give producers an up to the minute report on weather forcasts, market reports and other important information that can aid in the decision making process. All of this information can be accessed by the producer via the World Wide Web (Internet), in familiar surroundings of home or an on-site office.

Also included as an application of precision agriculture are the technologies of precision irrigation systems. Precision irrigation systems can all but eliminate the necessity of multiple applications of herbicides or liquid fertilizers by applying precisely controlled amounts of product that has been combined with the irrigation water according to site specific information gathered previously. By eliminating the necessity for multiple treatments by fertilizer or pesticide equipment, inputs are minimized which result in decreased expense to the producer.

While decreased inputs of product result in lower costs of production, there is yet another benefit to applying SSM techniques. Environmental issues relating to the over-application of pesticides and fertilizers can all but be eliminated by utilizing SSM strategies in conjunction with precision agriculture applications.

One indicator of plant health is the amount of chlorophyll present in the leaves of the plant. Chlorophyll metering can sense the actual amount of chlorophyll present in a given plant population. This application of precision agriculture, when compared to test strips with a known (adequate) amounts of soil nutrients, can aid in making decisions as to fertilizer inputs in a given area.

The use of satellite imagery that utilizes infrared or black and white images of a field during various stages of crop development is yet another precision agriculture technique. Along the same line as chlorophyll metering, satellite imagery can indicate biomass. When images of the same area taken at a different time are compared to recent images, producers can gather information as to particular inputs or treatments necessary for the site specific areas within that crop production unit.

The National Research Council in "Precision Agriculture in the 21st Century" (1997), outlined the existing conditions that describe contemporary precision agriculture applications. "While its precise dimensions continue to evolve, the following features characterize most precision agriculture applications in use or under development:

- Data capture tends to be electronic, automated, and relatively inexpensive.
- Data capture can occur more frequently and in more detail.
- Information either captured as a part of field operations or purchased externally, can be considered separate inputs into the production operation. (It is also a feature of integrated pest management and sustainable agriculture concepts.)
- Data interpretation and analysis can be more formal and analytical.
- Scientific decision rules are applicable to actual farming operations.
- Implementation of the response can be more timely and more site specific.
- Performance of alternative management systems can be quantitatively evaluated."(p. 18)

The specific skills related to features described have not been addressed. A cohesive and comprehensive set objectives to meet existing industry needs has not been as of yet. Some community colleges and universities have, in fact, developed curricula that are attempting to meet the industry need for trained individuals competent with precision agriculture concepts and skills.

Evolving technologies need trained people.

> Precision agriculture services may be provided directly (i.e., for custom hire) or may be purchased in the form of hardware and software products embodying those services, or as combination of products and services. In all likelihood, both forms of obtaining precision agriculture services will coexist, with exact combination depending on such factors as the size of operation, the technical expertise of the operator, and the density of the local market for services. (NRC, 1997, p. 89)

Assuming that the coexisting of these two populations will occur, we are left with the dilemma of training or re-training those individuals. The first step in the training process is to identify just what needs to be taught.

The researcher has not found a nationally adopted list of skills and competencies relating to precision agriculture applications. Therefore, this lack of concrete identification necessitated the purpose of this study.

The specific skills and competencies were derived from interview and survey instrumentation, but the determination of need perceived by industry followed the model designed by G.D. Borich (1980). The initial step was to list competencies related to precision agriculture. These competencies were derived from industry, private sector, and educational faculty survey.

Where Borich (1980) suggested that the competencies be checked against pre-existing activities of potential students, this study used industry personnel rather than potential students. The researcher predetermined the competencies within different regions of the United States, but did not attempt that within the states utilized in this study. Borich's model will delineate the backdrop for the methodology portion of this thesis.

Stufflebeam, et.al (1985) determined that:

> Needs assessment is a process that helps one to identify and examine both values and information. It provides direction for making decisions about programs and resources .... Needs assessment can be part of community relations, facilities planning and consolidation, program development and evaluation and resource allocation. (p.xiii)

In order for industry to adjust to cutting edge technologies, the educational needs of precision agriculture industry must be addressed. Defined by Tyler (1971) as the gap between the desired and the actual, needs are categorized into 3 areas: concepts, skills or values. "Concepts relate directly to learners' thinking and understanding of the behavior and its impacts, and whether learners can move beyond the level of skill they receive in the educational setting (Knerr, 1996, p.12).

Skills, as defined by Tyler (1971) are identified as either specific or general. In order to maintain accuracy in a needs assessment, both specific and general skills relating the subject area must be identified.

In 1992, Mims, Novak, Simpson and Davis developed the conclusion that "easing the pain of adopting new technology is not easy, but careful attention to user's needs will prevent adoption failure or sluggish adoption" (p. 672). It is imperative that accuracy in skill and competency identification takes place and that the true need of the precision agriculture industry be considered.

Specific Skills and Competency Identification

The researcher, in mid October conducted telephone interviews with educational professionals who taught precision agriculture courses. The effect of conversations was that the need for widely adopted curricula rests upon the educational institution's diligence towards innovative production practices. Production practices that utilize satellite technologies, applications in variable rate technologies, SSM conceptual production practices, and the utilization of precision farming equipment are some examples of those innovative production practices (Brase, 1998).

In interviewing Terry Brase, one of the instructors from Hawkeye Community College in Iowa, the researcher discovered that a panel of experts, all utilizing precision agriculture applications, was selected as a panel to develop the curriculum for the college. The group initially identified all the skills and competencies related to cohesive units for instruction. Thus, curriculum design began and eventually became implemented at Hawkeye Community College (D. Adkisson, et al, 1998).

The curricula developed from the DACUM meetings is currently on line and available to participant schools. The instructional materials include units covering such topics as GPS, GIS, Data Collection techniqus, Data Analysis, Product Generation and various Agricultural Technology applications.

Another model for identifying skills and competencies was developed by Ohio's Division of Vocational and Career Education. Ohio's Competency Analysis Profile (OCAP) "contains units (with and without sub units) competencies and competency builders that identify the occupational, academic and employability skills needed to enter a given occupation or occupational area" (OCAP profile, p. i) The OCAP profile further analyzes the competencies by creating three levels: core, advancing and futuring. The OCAP lists are the cumulative result of yet another panel. This panel was made up of employers within the given skill areas who are directly involved in the industry.

CHAPTER 3

Methodology

In order to meet the purposes of this study, the following methods and procedures will be developed. The chapter will be separated into five sections. These sections will be: 1.) Population Description, 2.) Instrument Design, 3.) Data Collection Methods, 4.) Data Analysis Procedures, and 5.) Summary.

This is a descriptive study of the competencies related to precision agriculture applications. It is the intention of this study to provide an up-to-date description of those competencies perceived by agriculture industry professionals to be significant for employment in precision agriculture applications.

Population Description

Those individuals to be identified as population segments will be bound by the following criteria:

1. Employed in an agricultural industry trade that utilizes GPS/GIS technologies and or precision farming hardware or software applications.
2. Located within, and limited to, the states of Montana, Idaho, North Dakota, or South Dakota.

3. Professional crop and chemical consultants utilizing precision agriculture hardware and concepts for production agriculture purposes.

The researcher attempted to identify at least 100 individuals to constituted the population for the sake of this study. The potential respondents were identified from professional and telephone interviews of educational and precision agriculture industry professionals. The researcher also identified potential respondents from the Upper Midwest Aerospace Consortium (UMAC) mailing list. A total of 94 individuals were identified for the study.

Wyoming was omitted from the study due to a lack of identifiable individuals who fir the respondent characteristics in order to be included as a population segment. The researcher contact University and Community college staff as well as Cooperative Extension staff in attempts to identify potential segments for population inclusion. In addition, individuals who were registered on the UMAC phone list were contacted. Through these attempts, the researcher was still unable to find sufficient numbers to include Wyoming as a participant state.

Instrument Design

The researcher utilized the survey procedures established by Dillman's (1978) Total Design Method (TDM). The content of the instrument was a combination of findings from literature review, professional correspondence, and telephone interviews conducted by the researcher. The major categories for the survey, as well as the specific identification of competencies were compiled by the 1st week of May, 1999.

The survey consisted of two, 5-point Likert-type scales that applied to one identified competency. (See Appendix A). One scale measured the perceived *Importance in Hiring* an individual with the identified competency and the other scale measured the *perceived need* of having that competency as related to the precision agriculture industry and employment.

On the *Importance in Hiring* column, one corresponded with low importance of an individual possessing this particular competency; a rating of two signified a moderately low level of importance; a rating of three signified moderate importance; four signified moderately high importance; and a rating of five signified a high level of importance in hiring an individual who possessed that particular competency. The second scale measured the *perceived need* of that competency to precision agriculture applications with one signifying low need; two signifying moderately low need; three signifying moderate need; four signifying moderately high need; and 5 signifying high need of that competency to precision agricultural industry applications. General demographic data were collected as well.

Data Collection Methods

The data for this study will be collected using a mailed survey instrument in a two page survey form. (Appendix A). The survey instrument for this study was developed from both personal interviews conducted by the researcher, as well as literature review for this study. Terry Brase of Hawkeye Community College in Waterloo, Iowa was an integral part of the survey design. Mr. Brase cooperated with the researcher by sharing the content from meetings about the Precision Agriculture Degree Program at Hawkeye Community College. In addition to the results of those meetings, Mr. Brase allowed the researcher to view the curricular materials that were developed for area High School Agricultural Education programs. These curricular materials contained objectives for competencies in precision agriculture applications and survey competency statements were derived from some of those materials.

In addition to Mr. Brase, Dr. James Durfey, Professor of Agriculture and Food Science at Washington State University was interviewed. Dr. Durfey was integral in the development of the four categories identified in the survey instrument.

Consistent with Dillman's (1978) Total Design Method (TDM), the researcher mailed a postcard notifying respondents that they were to receive a survey for the study in the near future. Postcards were mailed on May 20, 1999 (Appendix B).

The first mailing of the survey instrument (Appendix A) with a cover letter (Appendix C) was mailed May 28, 1999. The first follow-up cover letter (Appendix D) with another copy of the survey was mailed on June 7, 1999. The final mailing, along with a cover letter (Appendix E), was sent June 23, 1999.

A pilot test of the survey was conducted, but the returns from the pilot test were not returned to the researcher in time to implement suggested changes. Item #17, *Read and interpret OD yield maps*, from the Synthesis and Interpretative Skills category was omitted from the data analysis after the pilot test was returned. As well as the change due to pilot testing concerns for clarity, a number of respondents either did not respond or claimed that they did not understand the statement. Therefore, the researcher decided to omit that competency statement from data analysis. Those changes suggested were not significant to the main content of the survey. Simple wording suggestions on two competencies were made; however, those competencies would not have been significantly different in their meanings. The change would have been for clarification only.

Demographic data were collected so that a profile of respondent characteristics could be developed. Analysis of these demographic groups indicated minimal variations between demographic groups in each of the survey competency statements.

The demographic groups are identified in Appendix A. Job title information was collected to distinguish between production oriented respondents and service providing respondents.

Additional information about duration of employment, gender, age, educational level achieved, number of years working with precision agriculture applications, percentage of time spent utilizing precision agriculture software, equipment or applications was collected. Respondents were also asked if they desired to see the results of this study.

Data Analysis Procedures

Data Analysis was conducted using SPSS© statistical software, as well as Quattro Pro©. The surveys were scanned using Remark© software and data entered into spreadsheet form for further analysis.

Following Borich's model, the importance rating minus the likelihood of hiring ratings produced a discrepancy score for each competency. The discrepancy scores were weighted by multiplying the average level of importance by the discrepancy score for each skill or competency. This will result in a weighted discrepancy (WD) score. Any WD score above zero indicated that there is a perceived need for training in this area or a relative level of importance as perceived by the respondent. This score yielded important quantitative data that suggested the need for educational entities to include these skills and competencies into existing curricula or to develop new courses to address these skills and competencies.

Also where Borich (1980) focused the results of the discrepancy scores directly back to the population studies, this is not the case for this study. Respondents of the survey instrument did not directly benefit from training directed to that particular position.

The modification of Borich's(1980) model for needs assessment yielded significant WD score indicators of those competencies that are not only needed by industry, but are also important in hiring. It is a specific statistic that related directly to the employability of a given competency.

"The needs assessment model is essentially a self-evaluative procedure, which relies on teachers' judgements about their own performances" (Borich, 1980, p. 42). This statement inferred that those who are directly involved in the occupation can best identify the needs for extended training in that particular applications. It is under this premise that the respondent population was identified for this study. While the respondent population for this study did not actually receive the training needs that they identify, they are the best judges of what training is needed.

"The Mann-Whitney test evaluated the hypothesis that two independent groups have been drawn from the same population" (Glass & Hopkins, 1996, p. 303). In order to be sure that the demographic groupings did not independently exist within the population for the study, the Mann-Whitney test was conducted using the respondent mean responses for each competency statement. This lends statistical support that the population is in fact heterogeneous.

"A measure must have some reliability if it is to have any validity" (Glass & Hopkins, 1996, p. 577). The Cronbach's alpha test for reliability is a good estimate of parallel form reliability for tests. To ensure that the researcher did not gather data that was generated out of measurement error, the coefficients form Cronbach's alpha were analyzed for each competency statement as well as the total coefficient for each category of the survey instrument. If a Cronbach's Alpha coefficient of 1.00 is found, there is perfect agreement between the two demographic groups when responding to identical competency statements. "For research purposes, a useful rule of thumb is that reliability should be at least .70 and preferable higher (Frankel & Wallen, 1996, p. 163).

A Cronbach's Alpha-Reliability analysis was conducted on each of the four categories. Category #1, *Software and Basic Computer Proficiencies*, reported a reliability coefficient of .9594. The second category which tested competencies relating to Component Hardware proficiencies, reported a reliability coefficient of .9835. Synthesis and Interpretation Skills, category #3, reported a reliability coefficient of .9770.

Category #4, Field Operations/ Applications, reported a reliability coefficient of .9724. These coefficients indicate that the test instrument was reliable in each of the four categories individually. The survey instrument had an overall Cronbach's Alpha-Reliability coefficient rating of .9731, thus indicating overall reliability of the survey instrument.

Summary

The methodology portion of this thesis will stand as the foundation for gathering, compiling, and analyzing the data that met the objectives of the study. The survey design facilitated data collection and with the data analysis tool (SPSS), the researcher devised a list of competencies that industry deems as important to precision agriculture operations. The use of weighted discrepancy scores yielded results that clearly identified the perceived importance of all identified competencies related to precision agriculture applications as well as their importance in hiring.

CHAPTER 4

Results of the Study

The study was designed to identify the competencies that industry deemed as important in hiring perspective employees for precision agriculture jobs. Further, the study was designed to reveal specific competencies related to precision agriculture applications. The results of the study are presented in 8 sections: 1) Demographic data, 2) perceived level of need by industry, 3) perceived importance of individuals possessing those competencies when considered for hiring, 4) priority of mean weighted discrepancies related to competencies, 5) differences within group according to demographic factors, 6) comments provided by respondents, and 7) summary.

Demographic Data

Ninety-four surveys were mailed to individuals in the Upper Midwest Aerospace Consortium member states with the exception of Wyoming. The remaining states included Idaho, Montana, North Dakota, and South Dakota. Of those 94 surveys mailed, 7 were returned in the initial mailing as undeliverable. Return addresses, or "address changed" stamps allowed the researcher to contact 3 of those 7 and thus solidify the population number at 90.

The explanation in Table 1 delineates the return rates from two subgroups within the respondent population. As possible source of variations in responses, the researcher separated those respondents into two demographic groups for sake of response analysis and reporting of response rates.

Data in Table 1 indicate 26 of the population had returned the survey prior to the mailing of the second questionnaire. Eleven respondents responded late second mailing.

Table 1. Return Rates for Respondents.

Response Group	Early Responders	Late Responders	Percent Returned
Service Provider	17	5	24.4
Producer	9	6	16.7
Total $_{n=37}$	26	11	41.1

A Mann-Whitney U test was conducted on the responses of the early and late responders. The same procedure was applied to service providers and producers (See Table 2). There was no significant difference in the mean responses for all competency statements when tested at the .05 probability level. In concurrence with the researcher's major advisor and data analysis, it was determined that there was no significant difference between early and late responders. Thus, the two groups were grouped to produce a total sample of 37 respondents.

Table 2. Distribution of Employment Type Held by the Respondents.

Type of Employment	n	%
Service Provider	22	59.5
Production	15	40.5

Table 2 data reveal that 59.5% (22) of the respondents were service providers, while 40.5% (15) of the respondents were involved in production. A Mann-Whitney analysis was performed on these two groups and those competency statements that tested significantly different are reported in Table 20. Of the 37 respondents, 36 (91.9%) were male and 3 (8.1%) were female. Table 3 identifies the number and percentages of respondents when separated by gender.

Table 3. Distribution of Gender in Respondent Group.

Gender	n	5
Male	34	91.9
Female	3	8.1

Table 4 delineates the distribution of respondents by age. Six (16.2%) respondents were between the ages of 24 -35 years of age. Those respondents between the ages of 36-45 years numbered 15 (40.5%) and made up the greatest proportion of respondents. Twelve (32.5%) of the respondents were between the ages of 46-55, making up the second largest proportion of the respondent group. Respondents 56 and older numbered 3 (8.1%) and made up the smallest proportion of respondents. One individual chose not to enter his/her age in the demographic data information section. This accounts for the decreased n (n = 36) for this table.

Table 4. Distribution by Age of the Respondents.

Age (in years)	n	%
24-35	6	16.2
36-45	15	4.05
46-55	12	32.5
56 and older	3	8.1
Missing	1	2.7

The data complied in Table 5 identifies the proportion of respondents by highest level of education that respondents have received. A Bachelor's degree was the greatest proportion of respondents educational level at 17 (47.2%). Six (16.7%) respondents had a high school diploma as their highest level of education.

Table 5. Distribution by Highest Levels of Respondents' Education.

Degree Held	n	%
High School Diploma	6	16.7
Associate	3	8.3
Bachelors	17	47.2
Masters	5	13.9
PhD	4	11.1
Missing	1	2.8

Masters degree recipients numbered 5 (13.9%). 3 (8.3%) individuals had achieved an Associate degree. Doctorate (PhD) recipients within the respondent group numbered 4 (11.1%). One individual did not respond, accounting for the n = 36 for respondent group size. When those with a high school diploma were subtracted from the total (37-6), it revealed that 83.3% (31) held a post secondary degree.

Table 6 information identifies the distribution of respondents' experience working with precision agriculture hardware, equipment, or software applications. Respondents with 0 -3 years experience numbered 16 (43.2%). Eighteen (48.6%) respondents had 4-7 years of experience. Only 3 (8.2%) respondents had accrued 8 or more years of experience with precision agriculture technology and applications.

Table 6. Distribution of Experience Working with Precision Agriculture Hardware, Equipment or Software.

Number of years	n	%
0-3	16	43.2
4-7	18	48.6
8 or more	3	8.2

The distribution of time that respondents devote to precision agriculture equipment or applications is identified in Table 7. Thirteen (35.1%) individuals dealt with equipment or applications in precision agriculture less than 9% of their time working in this area. Five (13.5%) respondents worked with the applications between 10 - 19% of their time on the job. Six (16.3%) respondents reported time devotion to precision agriculture technologies between 20 to 29% of their time. No respondents reported working at the 30 - 39% level. One (2.7%) respondent identified that he/she utilized the technologies or equipment between 40 - 49% of the time. Similarly, one (2.7%) individual reported at the 50 - 59% level. Three (8.1%) respondents reported utilization at the 60 - 69% level. The second largest group of respondents reported that they devote 70% or greater of their work time to precision agriculture equipment or applications with 8 (21.6%) individuals responding.

Table 7. Distribution of Respondents by Time Devoted to Working with Precision Agriculture Equipment or Applications.

Percent of time	n	%
0-9	13	35.1
10-19	5	15.5
20-29	6	16.0
30-39	0	0
40-49	1	2.7
50-59	1	2.7
60-69	3	8.1
70 or more	8	21.6

Perceived Level of Need by Industry

The first objective of this study was to identify the specific competencies related to precision agriculture and their perceived need to industry as identified by industry professionals. An initial review of each category competency item is presented in Tables 8, 9, 10 and 11. An analysis of the means and standard deviation for each competency item in the four categories of Software and Basis Computer Proficiencies, Component Hardware Proficiencies, Interpretation and Synthesis, and Field Operation is provided.

Respondents were asked to identify the perceived need by industry for trained individuals with each particular competency in all four categories. A response of 1 indicated a low need and a response of 5 indicates a high need in Tables 8-15. Competencies are arranged such that they correspond to the mean Weighted Discrepancy (WD) scores reported in Tables 16-19.

Table 8. Industry Need for Software and Basic Computer Proficiencies.

Question	Mean	Standard Deviation
Utilize GIS software to create layouts	4.19	0.81
Export date in different file formats	4.30	0.85
Utilize GIS software to create maps	4.41	0.76
Use prescription software for site specific farming applications	4.24	1.06
Integrate multiple software applications to perform specific operations	4.22	0.85
Use e-mail to communicate with producers, suppliers and colleagues	4.19	0.84
Operate soil sampling and recording software	3.70	1.08
Understand various file formats	4.14	0.86
Utilize GIS software to create graphs	3.65	1.13
Utilize basic PC and/or Mac applications for databases	4.00	0.99
Download data from the Internet	3.81	1.00
Utilize basic PC and/or Mac applications for word processing	3.83	1.10
Perform basic functions with GPS integrated software	4.17	0.87
Utilize GIS software to create bar charts	3.60	1.17
Utilize basic PC and/or Mac applications for spreadsheets	4.00	1.00
Navigate through the Internet	3.80	1.11

Table 8 reveals the mean and standard deviation (SD) for software and basic computer proficiencies. The means range from 4.41 to 3.60 and SD range from .76 to 1.17. The ability to *utilize a GIS software to create bar charts* was the lowest ranking item. Based on the Likert-type scare used, all competencies in this area are needed as revealed by the means for each item. The mean responses for individual competency statement scores indicate that the *utilization of Geographic Information Systems (GIS) to create maps* is deemed the highest need for trained individuals in agriculture industry with a mean of 4.41 and SD of 0.76.

Table 9 presents data that indicates the mean of need by industry for individuals possessing competencies in component and hardware proficiencies of precision agriculture equipment. The means range from 4.35 to 3.02 with SD of .75 to 1.44. The competency with the mean of 4.35, had the lowest SD of .75. The competency with the lowest mean of 3.03, had the highest SD of 1.44. The highest ranked competency was *operate Global Positioning System (GPS) hardware devices* (4.35), while the lowest was *make welding repairs on equipment* (mean=3.02).

In analyzing the data, there is a distinct break in the competency identification with electronics and computer related items located in the upper half of the mean values and hydraulic or other mechanical competencies located in the lower half of the mean values.

Table 9. Industry Need for Component Hardware Proficiencies.

Question	Mean	Standard Deviation
Install a variety of computer components	4.00	0.87
Troubleshoot electronic systems	3.84	1.01
Identify various types of hydraulic pumps and their components	3.43	1.28
Operate GPS hardware devises	4.35	0.75
Explain and apply hydraulic standards	3.57	1.19
Troubleshoot yield monitors	3.94	1.10
Define basic hydraulic terminology	3.65	1.09
Calibrate yield monitors	4.03	1.04
Identify and properly connect various hydraulic fittings	3.49	1.15
Troubleshoot hydraulic systems	3.38	1.19
Install, read, or explain real time sensors	4.08	1.01
Identify and recognize hydraulic motors and their components	3.24	1.23
Identify, analyze and read hydraulic sensors	3.41	1.19
Safely operate sprayer equipment	3.90	1.24
Perform routine repairs on hydraulic systems	3.30	1.29
Explain and identify electronic standards	3.54	1.14
Identify and troubleshoot hydraulic valves	3.27	1.23
Safely operate fertilizer spreaders	3.78	1.22
Use variable rate seeders	4.27	0.99
Have a working knowledge of heavy equipment	3.46	1.12
Troubleshoot pneumatic systems	3.13	1.16
Install yield monitors	3.68	1.13
Safely operate variable rate spreaders	3.73	1.17
Read cab monitors for field positions	3.94	1.15
Perform basic identification of pneumatic system components	3.21	1.16
Understand electronics terminology	3.95	0.94
Make welding repairs on equipment	3.02	1.44
Make general repairs on machinery	3.46	1.32
Recognize connection continuity	3.68	1.03
Perform basic maintenance operations on equipment	3.51	1.35

Table 10 shows the mean values and standard deviations for synthesis and interpretation. The mean values range from 4.46 to 3.78 indicating a high need for these competencies. The highest mean with the lowest SD is identifying the competency to *verify data integrity* (4.46). In contrast, the lowest mean (3.7) competency of read and interpret raster surfaced yield maps, has the second lowest SD of 1.13.

Table 10. Industry Need for Synthesis and Interpretative Skills.

Question	Mean	Standard Deviation
Develop prescriptions for soil amendments	4.08	1.11
Develop prescriptions for pest management purposes	4.00	1.20
Recognize effects and determine causes	4.38	0.83
Read and interpret common yield maps	1.30	0.85
Interpret soil sample analyses and various soil data	4.23	1.12
Interpret various maps and data projections	4.30	0.85
Verify data integrity	4.46	0.73
Recognize valid data	4.46	0.80
Integrate maps and soil samples	4.19	1.00
Establish cropping time lines	4.11	1.07
Review and utilize historical data specific to various producer situations	4.27	1.02
Interpret crop yield information	4.22	0.75
Read and interpret raster surfaced yield maps	3.70	1.13
Read and interpret remotely sensed images and aerial photographs	3.94	0.94
Analyze production related problems	4.35	0.95
Read and interpret vector point yield	3.78	1.00

The mean values and standard deviations for field operations/applications are reported in Table 11. The means range from 4.68 to 3.43. The high and low mean values for the corresponding competencies share that relationship with the standard deviation for each, with the low being .63 for the high mean value, and 1.20 for that of the low mean value.

Table 11. Industry Need for Field Operations/Applications Competencies.

Question	Mean	Standard Deviation
Organize field testing protocols and complete using various techniques	3.95	0.97
Identify common, regional common and noxious weeds	4.22	0.79
Generate prescriptions for weed control requirements	4.00	1.11
Recognize plant response to various rates of applied product	3.92	0.98
Recognize plant response to various types of insect related impacts	3.89	0.99
Collect field histories	3.95	1.00
Identify/recognize stages of plant growth	4.24	0.89
Generate prescriptions for fertilizer requirements	4.02	1.09
Recognize plant response to various rates of moisture	3.89	0.94
Generate prescriptions for insect control requirements	3.84	1.07
Perform sampling techniques to collect agronomic data on soils	3.95	1.00
Identify common, regional agronomic insects	3.84	1.01
Calibrate seeders, fertilizer applicators, and equipment	4.05	1.00
Perform sampling techniques to collect agronomic data on protein	3.70	1.10
Set up grid mapping formats for data collection	3.70	1.18
Transfer data from desktop computer to applicator	4.24	0.89
Use DGPS to collect geo-referenced positions	4.24	0.93
Organize agronomic data	4.19	0.78
Perform sampling techniques to collect agronomic data on chlorophyll levels	3.43	1:20
Discuss requirements with applicators	4.28	1.07
Perform sampling techniques to collect agronomic data on plant response rates	3.60	1.04
Utilize variable rate technology for site specific farming applications including seeder, and fertilizer applicators	4.24	1.01
Navigate using light bars and GPS guidance systems	3.73	1.12
Perform sampling techniques to collect agronomic data on crop moisture	3.62	1.14
Establish cooperative working relationships with customers, co-workers and supervisors	4..68	0.63
Communicate effectively with customers, peers and supervisors	4.62	0.68

Coupled high at the top of the values at 4.68 and 4.62 are the competencies to *establish cooperative working relationships with customers, co-workers, and supervisors*, and to *communicate effectively with customers, peers and supervisors*, respectively.

Perceived Importance of Individuals Possessing Competencies for Hiring

The second objective of the study is to the specific competencies related to precision agriculture applications and their perceived importance to individuals being hired to jobs in this field. In tables # 12 - 15, the mean value and standard deviations for each competency are reported.

Table 12. Importance of Software and Basic Computer Proficiencies Competencies for Hiring of Individuals.

Question	Mean	Standard Deviation
Utilize GIS software to create layouts	3.97	1.12
Export data in different file forms	3.92	1.09
Utilize GIS software to create maps	3.81	1.08
Use prescription software for site specific farming applications	3.79	1.25
Integrate multiple software applications to perform specific operations	3.79	1.23
Use e-mail to communicate with producers, suppliers and colleagues	3.76	1.23
Operate soil sampling and recording software	3.76	1.32
Understand various file formats	3.76	1.09
Utilize GIS software to create graphs	3.66	1.16
Utilize basic PC and/or Mac applications for databases	3.62	1.14
Download data from the Internet	3.62	1.21
Utilize basis PC and/or Mac applications for word processing	3.60	1.09
Perform basic functions with GPS integrated software	3.51	1.21
Utilize GIS software to create bar charts	3.38	1.38
Utilize basic PC and/or Mac applications for spreadsheets	3.32	1.40
Navigate through the Internet	3.32	1.18

Table 12 identifies the mean and SD values for the *Importance* ratings from respondents for competencies relating to software and basic computer proficiencies. The high mean value was 3.97 and the low 3.32. The highest had a relatively high SD at 1.21. The SD values ranged from 1.08 to 1.40. Similar to the ranking order of Need means, *Utilization of GIS software to create layouts* ranked high with a mean value of 3.97. The author notes that as a whole these competencies were rated lower for importance than they were for need (3.97 to 3.32 and 4.41 to 3.60). The lowest ranking mean was that of *Navigate through the Internet* and *Utilize PC and/or Mac applications for spreadsheets* with means of 3.32 and a standard deviation of 1.18 and 1.40 respectively.

Component Hardware Proficiencies mean values and standard deviations are reported in Table 13. The high mean is value reported at 4.00 and the low at 2.76. Standard Deviations range from 0.96 to 1.5. Data indicated that these corresponding areas are perceived to be a high need for industry as well as important (4.0) in being considered for hiring.

Table 14 reports the mean and SD values of responses relating to Category #3, Synthesis and Interpretive Skills. The lowest high mean value is reported in this category (3.95) relating to importance levels. Means ranged from 3.95 to 3.14 aid SD value ranged from 1.34 to 1.13. Similar top end groupings of mean values are reported in this table compared to that of Table 10, the corresponding need table of mean values and SD.

Table 13. Importance of Component Hardware Proficiencies for Hiring of Individuals.

Question	Mean	Standard Deviation
Install a variety of computer components	3.46	1.10
Troubleshoot electronic systems	3.35	1.25
Identify various types of hydraulic pumps and their components	3.57	1.37
Operate GPS hardware devises	3.98	1.07
Explain and apply hydraulic systems	3.11	1.37
Troubleshoot yield monitors	3.54	1.30
Define basic hydraulic terminology	3.22	1.23
Calibrate yield monitors	3.68	1.22
Identify and properly connect various hydraulic fittings	3.08	1.38
Troubleshoot hydraulic systems	2.97	1.30
Install, read or explain real time sensors	3.78	1.28
Identify and recognize hydraulic motors and their components	2.84	1.26
Identify, analyze and read hydraulic sensors	3.03	1.30
Safely operate sprayer equipment	3.57	1.37
Perform routine repairs on hydraulic systems	2.92	1.40
Explain and identify electronic standards	3.19	1.22
Identify and troubleshoot hydraulic valves	2.90	1.30
Safely operate fertilizer spreaders	3.46	1.38
Use variable rate technology equipment	4.00	1.15
Have a working knowledge of heavy equipment	3.14	1.32
Troubleshoot pneumatic equipment	2.79	1.32
Install yield monitors	3.38	1.32
Safely operate variable rate seeders	3.46	1.35
Read cab monitors for field position	3.70	1.27
Perform basic identification of pneumatic system components	2.92	1.30
Understand electronics terminology	3.76	1.28
Make welding repairs on equipment	2.76	1.53
Make general repairs on machinery	3.24	1.40
Recognize connection continuity	3.49	1.20
Perform basic maintenance operations on equipment	3.35	1.46

Table 14. Importance of Synthesis and Interpretative Skills Competencies for Hiring of Individuals.

Question	Mean	Standard Deviation
Develop prescriptions for soil amendments	3.95	1.20
Develop prescriptions for pest management purposes	3.92	1.21
Recognize effects and determine causes	3.92	1.19
Read and interpret common yield maps	3.76	1.28
Interpret soil sample analyses and various soil data	3.73	1.22
Interpret various map and data projections	3.70	1.22
Verify data integrity	3.70	1.13
Recognize valid data	3.65	1.23
Integrate maps and soil samples	3.62	1.32
Establish cropping time lines	3.62	1.13
Review and utilize historical data specific to various producer situations	3.57	1.34
Interpret crop yield information	3.43	1.19
Read and interpret raster surfaced yield maps	3.32	1.25
Read and interpret remotely sensed images and aerial photographs	3.27	1.26
Analyze production related problems	3.24	1.32
Read and interpret vector point yield	3.14	1.29

Field operations and application competency means and standard deviation are reported in Table 15. Response means range from 4.49 to 3.05 and S.D. values range from .93 to 1.35. *Establish working relationships with customers, co-workers, and supervisors* and *communicate effectively with customers, peers and supervisors* reported the highest mean of 4.49. The lowest means were reported from the *ability to identify common, regional agronomic insects* (3.05).

Table 15. Importance of Field Operations and Applications Competencies for Hiring of Individuals.

Question	Mean	Standard Deviation
Organize field testing protocols and complete using various techniques	3.24	1.01
Identify common, regional common and noxious weeds	3.68	1.00
Generate prescriptions for weed control requirements	3.43	1.26
Recognize plant response to various rates of applied product	3.35	1.18
Recognize plant response to various types of insect related impacts	3.32	1.18
Collect field histories	3.41	1.24
Identify/recognize stages of plant growth	3.76	1.04
Generate prescriptions for fertilizer requirements	3.54	1.24
Recognize plant response to various rates of moisture	3.41	1.11
Generate prescriptions for fertilizer requirements	3.38	1.16
Perform sampling techniques to collect agronomic data on soils	3.51	1.07
Identify common, regional agronomic insects	3.05	1.33
Calibrate seeders, fertilizer applicators and equipment	3.70	1.05
Perform sampling techniques to collect agronomic data on protein	3.32	1.30
Set up grid mapping formats for data collection	3.32	1.25
Transfer data from desktop computer to applicator	3.92	1.12
Use DGPS to collect geo-referenced positions	2.92	1.16
Organize agronomic data	3.87	1.11
Perform sampling techniques to collect agronomic data on chlorophyll levels	3.05	1.33
Discuss requirements with applicators	3.98	1.14
Perform sampling techniques to collect agronomic data on plant response rates	3.30	1.24
Utilize variable rate technology for site specific farming applications	4.00	1.05
Navigate using light bars and GPS guidance systems	3.46	1.35
Perform sampling techniques to collect agronomic data on crop moisture	3.35	1.30
Establish cooperative working relationships with customers, co-workers and supervisors	4.49	1.07
Communicate effectively with customers, peers and supervisors	4.49	0.93