Summer 7-2021

# The Importance of Communication Skills to Independent Crop Consultants

Lindsay Overmyer
*University of Nebraska-Lincoln*, lindsay.overmyer@huskers.unl.edu

# THE IMPORTANCE OF COMMUNICATION SKILLS TO INDEPENDENT CROP CONSULTANTS

by

Lindsay M. Overmyer

A Doctoral Document

Presented to the Faculty of

The Graduate College at the University of Nebraska

In Partial Fulfilment of Requirements

For the Degree of Doctor of Plant Health

Major: Plant Health

Under the Supervision of Professor Gary L. Hein

Lincoln, Nebraska

August, 2021

# THE IMPORTANCE OF COMMUNICATION SKILLS TO INDEPENDENT CROP CONSULTANTS

Lindsay M. Overmyer, DPH

University of Nebraska, 2021

Advisor: Gary L. Hein

Independent crop consulting companies provide services to farmers by scouting (i.e., collecting field observations of plants and pests) and developing management recommendations for individual fields. In production agriculture, independent crop consultants (ICCs) are professionals who are independent of product sales. They are knowledgeable in many disciplines including plant pathology, entomology, weed science, plant science, economics, water management, and soil science. However, ICCs must also have extensive communication skills to communicate to their audience of field scout(s), farmers, industry professionals, and government officials. The goal of this document is to examine how ICCs use their communication skills and how they can refine and strengthen their communication skills.

Communication is an important life skill, involving knowledge or information transfer to produce an outcome. Communication concepts and models can be applied to interpersonal communication between ICCs and their audience (Chapter 1). Communication between the field scout and ICC primarily occurs during the field training process for the scout. Educational methods of experiential learning and scaffolding can be applied to this field training process (Chapter 2). Interviews with farmers explored the motivations and values of farmers that aid the ICC in communicating management recommendations to farmers (Chapter 3). These interviews emphasized farmers have individual goals, motivations, values, and communication

styles, in which an ICC must adapt to develop a trusting relationship. Independent crop consultants are also instrumental in the agricultural social system by bridging knowledge transfer between farmers, industry professionals, and government officials (Chapter 4).

## ACKNOWLEDGMENTS

First, I would like to thank my committee members Drs. Robert Wright, Tamra Jackson-Ziems, and Gary Hein. Thank you for providing support through this program and providing feedback on this document. Dr. Hein, thank you for seeing the potential in me and encouraging me to join the program in 2017. I would also like to thank Kelly White, administrative assistant of the DPH program who has been so helpful in helping me put words on the page of this document.

The Doctor of Plant Health (DPH) Program would not exist without the collaboration among the Departments of Entomology, Plant Pathology, Agronomy, and Horticulture. Through my time here, I have enjoyed learning from experts and fellow graduate students in these departments. The integration of these disciplines is critical to learn and think systemically for management approaches. Current DPH students and alumni have been instrumental in my understanding of class concepts; from our whiteboard brainstorming sessions, “debrief” sessions, to learning about agriculture and horticulture across the nation. I truly appreciate the support and conversations with current DPH students and alumni. Our supportive nature in the DPH office has allowed me to blossom into the agricultural professional I am today.

I want to thank Catlin Goodwin for introducing me to Morgan MathisonSlee, a Ph.D. candidate in the Department of Community Sustainability at Michigan State University. Collaborating with Morgan on chapter 3 was a very valuable experience on learning how to conduct social science research and analyze qualitative data. Catlin, thank you for providing your social science and educational background which also has aided me in the direction of this document.

I want to thank my family for their continuous support throughout this process, especially my parents, Alan and Jude, and my brother Austin Overmyer. It has been challenging to be away from the farm but thank you for encouraging me to pursue my passion for learning more about agriculture.

To all, thank you for your provoking thoughts, challenging my thoughts, and inspiring the words and thoughts in this document. Lastly, those who have said not to quit even when challenges arose – thank you! To future DPH students reading this do not quit. Keep going, reach out if you need someone to talk to.

TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# CHAPTER 1

# THE PROCESS OF COMMUNICATION AS IT APPLIES TO INDEPENDENT CROP CONSULTANTS

## Introduction

Communication is a vital life skill and can impact nearly every aspect of a person's life. The majority of our day is spent communicating; from ordering a cup of coffee, to visiting with friends and family, to building business relationships. Understanding the basic aspects of the communication process can help you become a better communicator and avoid some of the frustrations that can come from miscommunication. Throughout my journey working in agriculture, I have come to realize that without adequate communication, ineffective knowledge transfer can limit the adoption of new agricultural innovations.

Being raised on a grain and livestock farm, my passion for agriculture has been evolving from a young age. My passion increased as I became active in my local 4-H club and later with the National FFA Organization. Through participating in the FFA soil judging contest, I found that I wanted to pursue a career in agriculture. My perspective from being raised on a farm gave me the awareness that farmers deal with a vast number of problems on a daily basis, from fixing equipment to marketing crops and everything in between. A farmer does not have the time to study all the details of what farming involves, but a network of people can contribute to make a farmer successful in his or her operation. Hence the need for crop consultants to help farmers make decisions by sharing their agronomic knowledge, experience, and perspective, thus reducing the burden on the farmer.

Independent crop consultants (ICC) are professionals who are independent of product sales and knowledgeable about the production of agricultural crops on topics ranging from plant pathology, entomology, weed science, plant science, economics, water management, and soil science (Figure 1.1) (Post 1988). In the United States, many independent crop consulting businesses provide their services to farmers. These services include scouting and developing management recommendations for individual fields. Several examples of these companies are Agrimanagement Inc. (Yakima, Washington), Centrol Crop Consulting, Inc. (Twin Valley, Minnesota), Crop Quest Agronomic Services (Dodge City, Kansas), and Glades Crop Care Inc. (Jupiter, Florida), Servi Tech (Dodge City, Kansas), and Todd Ag Consulting (Plainview, Texas).

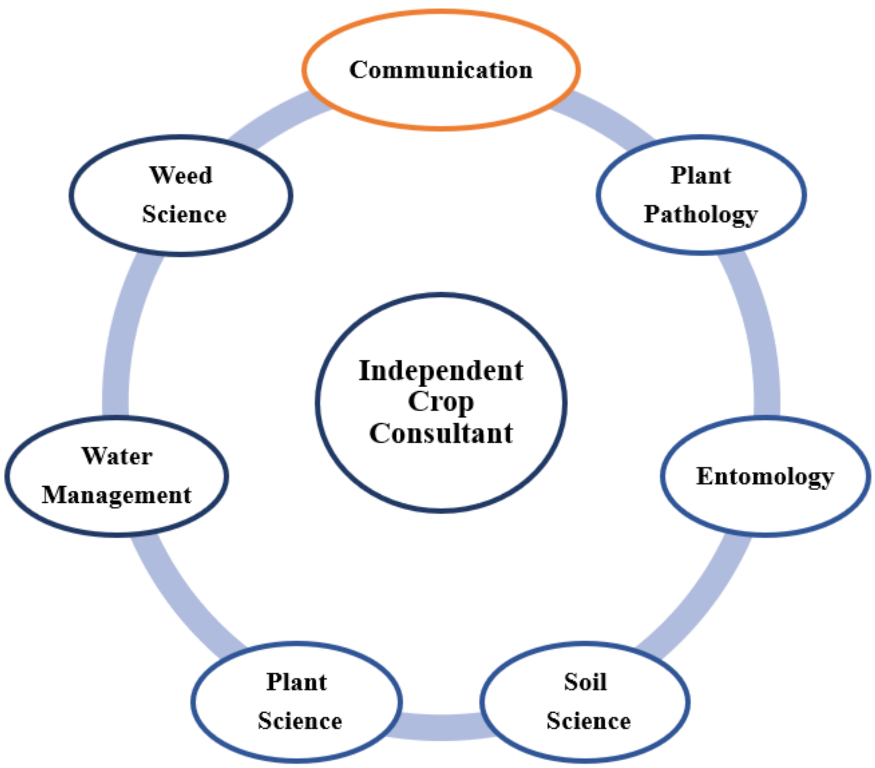



Figure 1.1. Disciplines of an independent crop consultant (ICC).

The primary audiences that ICCs interact and communicate with regularly include field scouts, farmers, industry professionals, and government officials (Figure 1.2). Field scouts are individuals who work alongside the ICC to collect field data and make observations to report back to the consultant. Often field scouts are interns during the summer. The term scout is not universal across the U.S. as some refer to field scouts as crop scouts, field men, scouts, or samplers. These individuals are invaluable to the ICC, and if they are not trained well in collecting observational data, ICCs will not have reliable information to make the best recommendations. An ICC must also network with industry professionals (e.g., Universities, Extension) to obtain a working knowledge about new technology and regulations that can impact crop production in their region and influence their recommendations to farmers. For example, if a new plant disease is discovered, working relationships among ICCs, Extension, and government agencies will ensure proper steps are taken to protect the food production system.

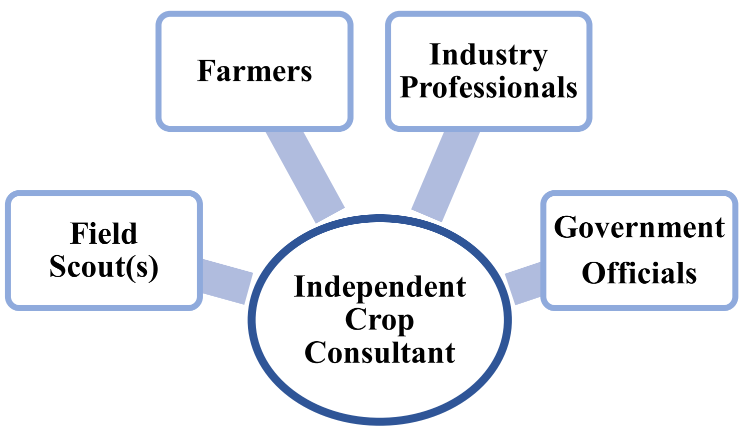



Figure 1.2. Primary audience of independent crop consultants (ICCs).

Independent crop consultants must have an interdisciplinary knowledge of agricultural disciplines as previously mentioned; however, they must also have extensive communication skills (Figure 1.1). The goal of this document is to examine how ICCs can refine and strengthen their communication skills. ICCs must build strong relationships with their farmer clientele to make tailored crop recommendations. These recommendations are specific for the farmer's operation and situation, but the recommendation (i.e., the message) also needs to be spoken or written in a way that resonates with the farmer. Independent crop consultants use communication techniques and teaching techniques without even knowing it. This document is written from the perspective of an ICC and investigates how they communicate to their primary audiences. The perspective presented here has arisen through discussion and input from experienced crop consultants and farmers and my observations from several internships along with personal work experiences (i.e., North Central Agricultural Research Station at the Ohio State University, Luckey Farmers Inc. in Ohio, Crop Production Services in Ohio, Centrol Crop Consulting in North Dakota, Agrimanagement Inc. in Washington, and the Vector Ecology Lab at the University Nebraska-Lincoln).

## Communication Levels

Communication is a process between individuals involving knowledge or information transfer to produce an outcome that is understood by both the sender and receiver (Telg and Irani 2012). Components of this process include a source, message, receiver, and feedback. The source or sender creates the message (i.e., the "what") and encodes it so the receiver will understand. The source also determines the channel or how to communicate the message (e.g., voice, telephone, visual aids, television, radio, mass media, print media). Finally, the receiver (i.e., audience) receives and decodes the message and provides feedback to the source. An effective communicator must understand and be efficient at implementing the aspects of this communication process.

In the communication process, it is important to understand the level of social organization at which the message is being communicated. There are multiple levels of communication from intrapersonal communication to mass communication (Figure 1.3). Mass communication can be defined as "one of the processes of communication at the society-wide level" (McQuail 1987). Descending on the communication process in society pyramid, the number of examples (i.e., cases) of communication increases because with mass communication one source of information is delivered to a large audience of receivers. Below mass communication is public (e.g., institutional, organization) communication where someone communicates directly to a sizable audience (Telg and Irani 2012). The main difference between these two levels of communication is the scale or number of people who are receiving the message.

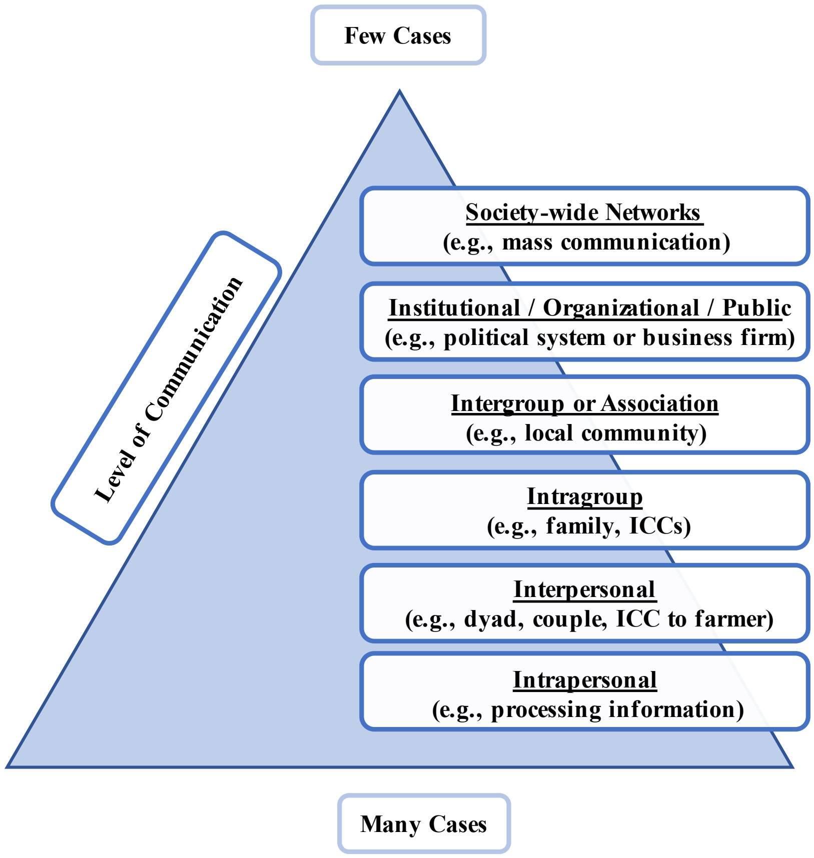



Figure 1.3. Pyramid of communication processes in society (adapted from McQuail 1987).

At the intergroup or association communication level (e.g., local community), there is a smaller audience, but the concept of public communication remains the same. Intragroup communication for ICCs comes into play with involvement in professional organizations, for example university Extension, professional societies, or within their crop consulting company. When communication is between two persons, this is referred to as interpersonal communication (e.g., crop consultants and farmers). An ICC must have strong interpersonal communication skills because they are communicating primarily at the interpersonal level to field scouts and farmers. The lowest level of communication is intrapersonal communication where an individual is communicating with oneself (e.g., processing information). If an individual understands how, they process information they can more effectively share that with others to aid in interpersonal communication (e.g., ICC to field scout).

To reach the intended audience multiple levels of communication can be used. For example, if the message is to scout for a certain pest (i.e., insect, weed, pathogen) during a specific timeframe, multiple channels can be used by ICCs or Extension. These channels could include social media, Extension publications, and in-person communication between agronomists and farmers. The message may be slightly different for each channel, but the goal of the message remains the same for the intended audience of farmers: to bring awareness of the current pest, emphasizing the importance of the damage potential, and encouraging farmers to scout their field(s). This example uses multiple levels of communication from society-wide networks (i.e., mass communication) to interpersonal communication (i.e., between two individuals).

## General Communication Models

There are linear, interactive, and transactional representation models to explain types of communication. The Shannon-Weaver model (Figure 1.4) described in 1949 lays out a linear process of communication (Bryant and Thompson 2002; Telg and Irani 2012). The model begins with a source that creates the message that will be sent (Telg and Irani 2012). The source then encodes the message, deciding what to communicate, how to put the message into terms the receiver will understand, and how to transmit (i.e., channel) the message. The receiver then decodes the message. But noise (i.e., barriers) can impact the integrity and clarity of the message in which the receiver receives, often resulting in the misinterpretation of the message.

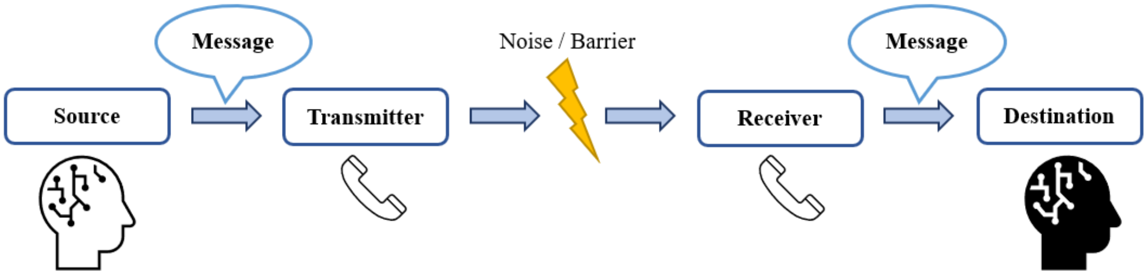



Figure 1.4. Shannon-Weaver model of communication.

There are four types of noise: mechanical, semantic, physiological, and psychological noise (Telg and Irani 2012; DeVito 2016). Mechanical noise (also called physical noise) is interference in the environment in which communication occurs (e.g., static on a phone call, loud voices in a restaurant while having a conversation). Semantic noise is the disruption of the message between the source and receiver. This disruption can be caused by the differences in terminology (i.e. jargon) used, primary language, educational level, personal experiences, cultural background, age, and gender (Telg and Irani 2012). Physiological noise is created within the source and receiver involving visual impairments, hearing loss, articulation problems, or memory loss. The final type of noise is psychological noise where there is a mental interference (i.e., wandering thoughts, preconceived ideas, closed-mindedness) in the source or receiver. Each of these types of noise can interfere at all levels of communication, especially interpersonal communication. For example, mechanical and semantic noise can occur simultaneously, especially if using a cell phone in rural areas where there can often be poor phone reception or communicating to a field scout who may not have a working knowledge of local geographic descriptions (i.e., local terminology).

Another linear communication model is the Westley-MacLean model. This model differs from the Shannon-Weaver model by adding a gatekeeper and mechanisms for feedback. The gatekeeper refers to a person who can control information and prevent it from reaching the receiver (Bryant and Thompson 2002). Feedback is the "return flow of information from the receiver to the original source" (Bryant and Thompson 2002). In oral or face-to-face communication, feedback can be immediate like nonverbal feedback cues, e.g., facial expression, body language, and voice inflection. In addition, the setting or place where you are communicating, time of day, and presence of other people contribute to the feedback you receive. Nonverbal feedback cues are critical in interpersonal communication because they can allow the source to make a real-time adjustment to the message. This feedback can aid in relationship building, especially between the ICC and field scout when working together daily to make effective routes to cover large acreages. When an ICC is instructing on travel routes to field locations or other concepts, confused facial expressions from the field scout can be valuable feedback, and the ICC can adjust the message immediately to provide clarity. However, in written communication, other cues such as the organization of the message, style, and tone can aid in understanding written feedback. Further models have been developed with greater complexity than the linear models described.

The Schramm interactive model (Figure 1.5) is a circular model, with the encoder and decoder sharing information. This model depicts the communicators interpreting and interacting nearly simultaneously while encoding and decoding messages to each other

(Bryant and Thompson 2002). The source and receiver alternate their role as encoder, interpreter, and decoder of the message. The Schramm interactive model can best be summed up as a conversation between two (i.e., interpersonal communication). Of these models the Schramm interactive model best represents interpersonal communication because this allows for nonverbal feedback. Most communication of an ICC is interpersonal. However, in a virtual presentation the Shannon-Weaver model would best represent this communication because there is no immediate feedback (i.e., nonverbal feedback) from the audience (if there is an audience present). An ICC can apply the Westley-MacLean model in interactions with multiple family members because one member could act as gatekeeper, preventing information from reaching the intended destination. Regardless of the communication model being used, defining the intended audience is critical for the success of a message.

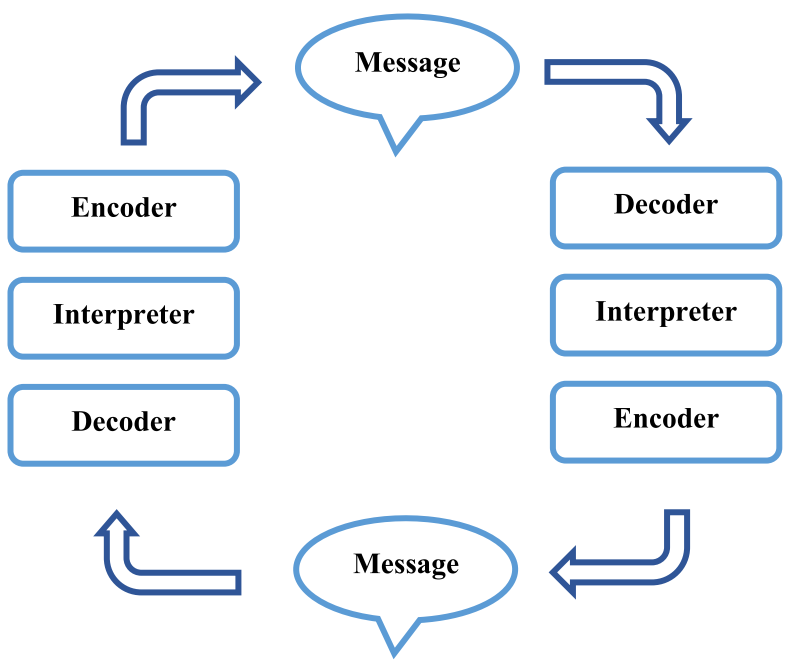



Figure 1.5. Schramm model of communication.

## Defining the Audience

To get to know your audience better an audience analysis can be conducted. An audience analysis is a description of an audience "on the basis of shared characteristics" (Telg and Irani 2012). This includes demographics, psychographics, sources or channels the audience uses, and prior knowledge and experiences. General demographics (i.e., gender, age, education level, ethnicity, and geographic location) are tangible characteristics of an audience. Psychographics focus on the intangible characteristics of an audience, for instance, the values and beliefs related to the topic being discussed. Different age groups acquire their information in different channels; therefore, if you intend to reach a range of ages with the same message, multiple channels should be used. Knowing these characteristics will aid in the creation of the message, identify the channels to transmit the message, and provide a potential frame of reference. A frame of reference is the overlapping of individual backgrounds, common experiences, or similar beliefs (Telg and Irani 2012). The frame of reference allows the source to create the message in a way the audience will understand.

## Message Creation

Once the audience has been established, the source must create the message with clarity in a way that is understandable to the receiver (i.e., audience). Therefore, the use of jargon (i.e. discipline-specific terminology), clichés, hype words, euphemisms, and discriminatory language should be avoided (Wilcox et al. 2015). Symbols, acronyms, and slogans can be used to enhance the clarity and simplicity of the message, although they can also create confusion if not well known (Wilcox et al. 2015). An example of a symbol in agriculture is the pesticide safety symbol of a skull-and-crossbones in an octagon shape that refers to danger. This is an easily recognized symbol that indicates the danger associated with a substance.

For a message to be understood and retained by the receiver, it also needs to be concise and limited to two or three key points. Provide the audience with relevant information to ensure they have context for the key points. For example, a researcher presenting at a scientific conference may go into great depth about their methodology. Although when the researcher is presenting the same research to farmers less detail should be included on the methods and focus mostly on the impact or "so what?" by addressing the following questions: 'Why should I care?' 'How can these research findings be applied to my farming situation?' (Sherman and Gent 2014). This conveys the message in a way so that the first time a person hears or reads it, they understand it. At a scientific conference, scientific jargon and acronyms may be more acceptable to use since the audience most likely includes peers in the same discipline and education level. However, the use of scientific jargon to a farmer audience would not be an effective communication strategy.

Researchers have their scientific jargon, but so do farmers, and this can be a communication barrier (i.e., semantic noise). Independent crop consultants work with farmers every day, and they need to listen and decode the message (i.e., the scenario a farmer is describing). Much of the farmer jargon can be regional with terms like hair pinning ("occurs during planting when seeds are surrounded by residue instead of soil"), gumbo ("typically wet, sticky, high clay soils"), and stools ("tillers of grass crops") (Briese 2019). This emphasizes the need for feedback in the communication process to ensure the message sent is being decoded correctly by the receiver. An important function of an ICC is to bridge the gap between the farmers with whom they communicate regularly and researchers or Extension personnel who may not often talk to farmers, this can include reporting new pests to Extension, asking for guidance, or Extension notifying ICCs about things to be aware of. In this process, ICCs should be creative with their message and use other strategies to communicate complex concepts more effectively.

A strategy in message creation when communicating a complex concept to various audiences is the use of metaphors or analogies. A metaphor is the use of a word or phrase that takes the meaning of something else. Analogies "are a comparison between different phenomena that bear some similarity at their functional or structure level" (García-Carmona 2020). For example, an analogy of "water flowing through a pipe" can be related to blood flowing in a blood vessel. This can be simplified to the metaphor "a blood vessel is a pipe" (Brown and Salter 2010). If this comparison is taken beyond this base, there is a limitation because the flow of blood through a blood vessel also depends on the elasticity and blood differs in mechanical properties (Brown and Salter 2010). The analogy and metaphor can be powerful tools to explain concepts, yet they have limitations if used incorrectly.

An example of an analogy in agricultural could involve a pest problem in a field. An ICC may take the farmer to the field to observe the problem. After observing the problem, it can be determined how to manage the situation. This process is similar to an individual going to a doctor for a medical problem and after evaluation a "solution" can be implemented. This analogy compares an ICC to a doctor and a field to a person. Analogies can be used to describe and compare the appearance of an object. A way to identify foxtail grass species is the comparison of facial hair of a young boy, teenager, and old man. Green foxtail (*Setaria viridis*) does not have pubescence on the leaf, and this can resemble a young boy who has yet to grow facial hair. A teenager may have some facial hair, and this represents yellow foxtail (*Setaria pumila*) with some pubescence on the leaf. Giant foxtail (*Setaria faberi*) represents an old man having dense facial hair (i.e., leaf pubescence).

For an analogy to be effective it must be simple, concise, clearly delivered, easy to remember, and relatable to personal experiences, and any limitations need to be explained (Brown and Salter 2010; Orgill and Bodner 2004; Niebert et al. 2012). If the audience does not have prior knowledge of the topic being used to create the analogy, the relationships of the analog and the key concepts from it need to be explained piece by piece. A criticism of using analogies is that the audience may lack prior knowledge which could result in misconceptions (Braasch and Goldman 2010). Braasch and Goldman (2010) demonstrated students who had prior knowledge performed better when reading the analogy and had fewer misconceptions. Furthermore, when creating or using analogies or metaphors the audience needs to make the connection to everyday life and be able to conceptualize it through physical and social experiences such as up and down, front and back, inside and outside. (Niebert et al. 2012). Agriculture provides many everyday experiences that can aid ICCs when communicating with farmers using analogies or metaphors.

Acronyms are another communication tool that can be beneficial but often carry pitfalls. An open dialogue and active listening between agricultural professionals are important because there are multiple disciplines (plant pathology, entomology, weed science) that use the same acronyms, yet these terms do not have the same definition across disciplines. Some examples of these acronyms are ET (economic threshold), EIL (economic injury level), DB (damage boundary), and DT (damage threshold). Independent crop consultants need to be fluent in terminology of multiple disciplines because she or he uses an interdisciplinary approach to solve agronomic problems. Defining these terms adds clarity to the discussion between ICCs and discipline-specific specialists to make management decisions.

Ideally, crop protection management decisions in agriculture are based on integrated pest management (IPM) strategies. IPM is defined as “a comprehensive pest technology that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment” (Pedigo and Rice 2009, p. 756). Integrated pest management developed out of environmental concerns raised by *Silent Spring* a book written by Rachel Carson in 1962 that identified environmental contaminations and raised social awareness to these issues. The discipline of entomology responded by developing better strategies to manage insect outbreaks. Weed science and plant pathology followed suit; however, terminology definitions were modified for application in each discipline. This created differing definitions and resulted in confusion with collaborating agricultural professionals (see Appendix A).

Entomology defines damage boundary as “the level of injury where damage can be measured” (Pedigo and Rice 2009, p.257). The damage boundary of entomology is equivalent to the damage threshold in weed science and plant pathology (Pedigo and Rice 2009; Coble and Mortensen 1992; Agrios 2005). Weed science defines damage threshold as “the weed population at which a negative crop yield response is detected” (Coble and Mortensen 1992). “The amount of crop damage that is greater than the cost of management measures" is how plant pathology defines damage threshold (Ownley and Trigiano 2017, p. 546). The economic threshold as entomology defines it is “the pest density at which management action should be taken to prevent an increasing pest population from reaching the economic injury level” (Pedigo and Rice 2009, p. 260). However, the use of economic threshold in weed science and plant pathology is equivalent to the economic injury level of entomology (Pedigo and Rice 2009). These differences emphasize that messages can be perceived differently when communicating to different audiences.

## Message Framing

Another important concept in creating a message is the use of frames. This involves establishing the context of the message being communicated, highlighting specific parts of the message over others to steer the conversation around certain aspects of the message (Krantz and Monroe 2016). The way messages are delivered impacts the receiver’s perceptions of the message. Through years of relationship building with his clientele, an ICC with Centrol Crop Consulting, Dr. Lee Briese, will adjust his wording to describe his observations of stand population (i.e., field population of crops). Some farmers are more particular about their crop stands than others, and because of this, he frames his message slightly differently for different farmers. For Farmer Smith, he will include the stand population as counted and write observational comments “stand looks good, thin in some places, nothing to worry about”, but to Farmer Johnson, he will say “low population but it will be okay”. These essentially mean the same thing about the plant population, but the perception of the message by the farmer is different. Farmer Smith is much more concerned about the stand count so saying, “stand looks good” first is important instead of starting with "thin in some places." Farmer Johnson usually has soybean stand problems in the beginning but by mid-summer, you would never know there was an issue with the stand. This observation was made while I was working with Dr. Briese, and he did not realize he used framing until I brought it to his attention. The working relationship and communication that an ICC has with their farmers is intriguing and can be strengthened by understanding details of how specialized model can be implemented.

## Specialized Communication Model

As the discipline of communication continued to evolve and diversify, there was a move away from general models to more specialized sub-fields of communication research and theory. A special type of communication involving new ideas is called diffusion which is "the process in which innovation is communicated through certain channels over time among the members of a social system" (Rogers 2003, p. 4). The diffusion of innovation theory developed by Everett Rogers serves as a framework to aid in the adoption of an innovation. In agriculture, the creation of new ideas or approaches to managing agronomic problems occur regularly (e.g., integrated pest management approaches) (Peshin et al. 2009). Agricultural Extension systems all over the world have used this theory for over 50 years to implement innovations (Rogers 1988; Beever 2016; Rogers 2003b).

### Diffusion of Innovation Theory

The diffusion of innovation theory can be applied to any innovation from the practice of boiling water for purification to adopting a new practice in agriculture. Since diffusion is a kind of social change, this requires an alteration "in the structure and function of a social system" (Rogers 2003, p. 6). Change contributes to uncertainty because there is a lack of information and predictability with innovation. An ICC or university Extension educator can provide unbiased information with the scientific background on an innovation to help ease concerns over uncertainty and enable farmers to make management transitions on their farm. This is a centralized diffusion system where experts are the head of a change agency and decide how to evaluate the innovation and channels for diffusing the innovation (Rogers 1983). Another diffusion system is a decentralized system where decisions are more widely shared by clients (e.g., farmers) who are the main mechanism of spread in a horizontal network (Rogers 1983).

Currently, in North Dakota, an innovation that farmers are experimenting with is wide-row corn (i.e., 60-inch corn row-spacing) and planting cover crops in between the rows. This initial farmer interest is decentralized diffusion. Due to farmer interest in wide-row corn, North Dakota State University (NDSU) Extension specialists are now conducting studies to provide information and data on this emerging innovation to support farmers in making informed decisions (Wick 2021). Since NDSU Extension has provided additional information to the farmers, this portion would be considered centralized diffusion.

A classic example of this theory is the diffusion of the use of hybrid corn in Iowa. In 1928, Iowa State University released hybrid corn to Iowa farmers, and by 1941 there was nearly 100% adoption (Rogers 2003a). The study of diffusion of hybrid corn involves the four main elements of diffusion: innovation, communication channels, time, and the social system (Rogers 2003a). Each of these elements contributes to the concept of diffusion.

Innovation

Perceived innovations include a relative advantage, compatibility, complexity, trialability, and observability (Rogers 2003a). Relative *advantages* with hybrid corn included a yield increase of about 20% per acre as compared to open-pollinated varieties, more stable yields due to increased drought-resistant, and better functioning of mechanical harvesting due to uniformity in plant structure (Rogers 2003a). Hybrid corn was *compatible* with farmers' current cropping system because it was "consistent with the existing [personal] values, past experiences, and need of potential adopters " (Rogers 2003, p. 15). If an innovation is not consistent with existing values and norms of a social system, it will not be adopted rapidly. Adopting hybrid corn did not require any equipment (i.e., planter) modification. However, other innovations may require equipment modification, and this can be a hurdle for adoption. Hybrid corn did require farmers to make changes to their existing behavior because with open-pollinated corn, the seed was saved year to year, but hybrid corn had reduced vigor after the first generation, requiring farmers to purchase seed every year.

When presenting an innovation to a familiar farm operation, an ICC must think about the logistics in making this transition. A farmer has many duties to fulfill during the growing season and may not have the time or labor to accomplish the adoption of an innovation. There was little *complexity* with hybrid corn with the key being purchasing seed every year. Finally, hybrid corn can be put into experiments (i.e., *trialability*) allowing farmers to *observe* the result of this innovation. Through centralized diffusion, Extension conducted field or plot trials which allowed farmers to see this innovation. Even with decentralized diffusion farmers had "experimental" fields to display the innovation. These results can be communicated through multiple channels to encourage further diffusion.

<u>Communication Channels</u>

The initial communication channel for hybrid corn diffusion was the Iowa Agricultural Extension Service and salesmen from seed companies. Nonetheless, the heart of the diffusion seemed to be interpersonal communication between farmers sharing personal experiences with the use of hybrid corn (Rogers 2003a). These conversations are essential, so potential adopters gain the knowledge necessary to reduce their uncertainty about the innovation leading to the innovation-decision process. In this example of hybrid corn, many advantages encouraged farmers to share their experiences. Other innovations such as intercropping flax with chickpeas, may not be easily shared or communicated unless the farmer is comfortable and has a good relationship with another farmer or an ICC. To effectively communicate an innovation, the primary audience and appropriate channels to reach the audience need to be identified.

<u>Time</u>

Time is arguably the most critical aspect in the diffusion process because it entails the innovation-decision process, and the speed of the process is driven by and varies with the categories of the adopters. The innovation-decision process "is the process through which an individual passes from first *knowledge* of an innovation to forming an attitude toward the innovation [*persuasion*] to a *decision* to adopt or reject, to *implementation* of the new idea, and *confirmation* of this decision" (Rogers 2003, p. 20). The first step of this process is *knowledge* and awareness of the innovation; therefore, information must be accurate for a favorable attitude to be formed. During this process, an individual seeks information to reduce the uncertainty of the innovation and will process this information and decide if this is the right decision for the individual. Farmers must be aware of the innovation and gain a degree of understanding of how it functions. Prior conditions exist before the knowledge stage of the information-decision process including the previous practice, identification that there is a problem that needs to be addressed, innovativeness of the innovation, and the norms of the social system (Rogers 2003c). If a farmer is not aware of the problem on their farm, how will the farmer ever know that something needs to be changed?

A farmer's field problems can be identified by the ICC or field scout, and then it can be brought up in conversation with the farmer. My North Dakota internship in 2019 with Centrol Crop Consulting turned out to be a wet summer, resulting in thousands of acres being covered by prevented planting insurance. Those acres were not planted but still scouted to identify weed pressures and decide how to manage those acres in the current year to prepare for the following growing season. Waterhemp (*Amaranthus tuberculatus*), was a prominent weed through several fields and had a late summer emergence. These observations were interpersonally communicated, and it was recommended that the farmer switch from Xtend to Enlist trait soybeans for the next growing season. This recommendation allowed the farmer to use the contact herbicide, Liberty in late summer to better manage the waterhemp in soybeans. The farmer then had the knowledge to make the decision on how to approach the problem.

After the individual has the knowledge of the innovation the next step in the information-decision process is *persuasion*. This is the process where the individual forms an unfavorable or favorable attitude towards the innovation. In the hybrid corn example, the interpersonal communication was mostly favorable resulting in a relatively short amount of time between introduction and the high adoption rate. The example of the waterhemp would be a similar scenario if the farmer wants to better manage weeds in his or her field. Therefore, a farmer will be more likely to form a favorable attitude because this only requires switching the seed that goes into the planter, making this a compatible innovation in his or her current operation. Furthermore, the farmer also knows how to properly use this innovation already (i.e., adding seed to the planter or change the herbicide in the tank) and an ICC (or others) can aid in the famers' knowledge of the underlying principles of how the innovation works.

Following, persuasion in the innovation-decision process the individual makes the *decision* whether to adopt the innovation or not. As previously described, the farmer has a lot to consider when determining if an innovation will be beneficial for them. The individual decides if they want to implement the innovation of growing hybrid corn or switch the trait of soybeans. Farmers may also adopt the innovation later. Moreover, there can be the discontinuance of the innovation where there is the decision to reject the innovation after it was previously adopted. Discontinuance can also occur in the confirmation stage. This could include active rejection with the farmer considering the innovation but deciding not to adopt it or passive rejection when the farmer never actually considers the use of the innovation (Rogers 2003c).

Through the *implementation* process, there could be re-invention or modification to the existing innovation for it to be a better fit for their lifestyle or farming operation. Even through this stage, there remains a certain degree of uncertainty about the potential consequences of the innovation for most individuals. Individuals actively seek information and want to know the answer to particular questions: "Where can I obtain the innovation? How do I use it? And What operational problems am I likely to encounter, and how can I solve them?" (Rogers 2003b, p. 179). The ICC can continue to support the farmer during implementation of the innovation and aid in answering these questions.

The final stage of the innovation-decision process is *confirmation*. In agriculture often this confirmation does not occur until later that season at harvest for the hybrid corn situation. If making the change from a tillage to no-tillage system, confirmation may not be apparent until several years later when seeing a change in soil structure. During this time if there is conflicting information about the innovation, the individual may reverse the decision of adopting the innovation (i.e., discontinuance). There is also the potential the individual may discontinue the innovation because a newer innovation may occur, this is called replacement discontinuance. Likewise disenchantment discontinuance may take place where there is a rejection of the innovation due to the result of dissatisfaction with its performance (Rogers 2003c).

In the adoption of corn hybrids, there was a spectrum of individuals who adopted this innovation over varying time intervals. This spectrum of individuals was described based on a normal distribution (i.e. bell curve) of the individual's time to adoption of the innovation (Figure 1.6) (Rogers 2003d). The average and standard deviation of this distribution were then used to divide adopters into five categories. The adopter categories influence communication channels used during the diffusion of the innovation. Mass media channels tend to be more important for the early adopters, whereas interpersonal communication is more important for the late adopters (Rogers 2003c). Mass communication brings about awareness (i.e., knowledge) of the innovation to innovators and early adopters which begins the innovation-decision process. However, late adopters do not rely on mass media because by the time they consider the innovation there are already others who are experienced with the innovation.

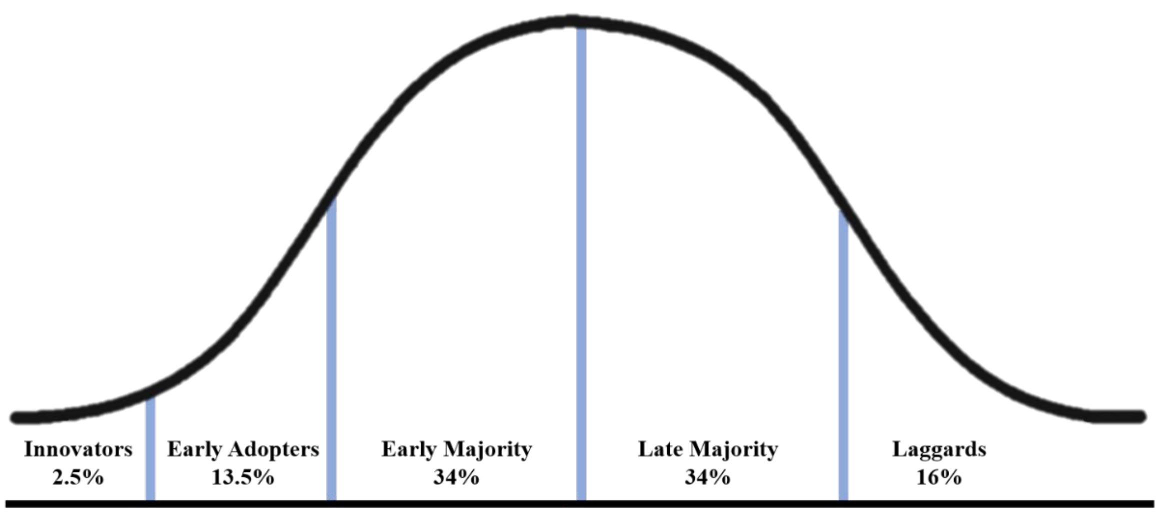



Figure 1.6. Spectrum of adopters within the Diffusion of Innovation Theory.

Innovators are individuals who are the first to adopt the innovation, and they include the first 2.5% of the bell curve. I worked with an innovative farmer while in North Dakota who was constantly coming up with new ideas and discussing those ideas with his ICC. The ideas evolved from just talking about it, to discussing the science behind the idea, and finally determining if the idea was worth giving it a try. The farmer observed that field peas were climbing up a weed, Canadian thistle (*Cirsium arvense*), and this sparked the idea of intercropping another plant with the peas to see if this would prevent the peas from lodging. After discussions with the ICC, this farmer decided to plant flax with his field peas, but he started small by planting only 15 acres. This innovation resulted in a two to four bushels per acre yield increase in field peas and 10 bushels per acre yield of flax that was sold for $11 per bushel. However, more “testing” needed to be done before the farmer would expand this practice on more acres and determine its feasibility. Innovators possess the ability to cope with a higher degree of uncertainty as compared to other adopter categories (Rogers 2003d). An innovator acts as a gatekeeper impacting the flow of new ideas into the social system (Rogers 2003d).

Understanding these categories of adopters is important to identify a farmer’s potential to fit into the different categories, especially the early innovators who account for the next 13.5% of the bell curve. The early adopters are respected leaders who tend to be a more integrated part of the social system (Rogers 2003d). Because these individuals are an integral part of the interpersonal networks, their adoption of an innovation will actively spread adoption of that innovation to new individuals. Potential adopters seek information and advice from the early adopters about the innovation, thus reducing the uncertainty of the idea and increasing the rate of adoption. When an ICC or other agricultural professional gets to know their farmers and identify those who are the early adopters, they can leverage the early adopters' influence to increase the diffusion of the innovation across their farmers. Early adopters can make a subjective evaluation and communicate their evaluation to peers in their social network (Rogers 2003d).

The last three categories of adopters are the early majority, late majority, and laggards. The early majority accounts for 34% of the bell curve, and they typically adopt the innovation just before the average member of the social system (Rogers 2003d). These individuals seldom hold leadership positions, but they are deliberate and willing when adopting the innovation. They hold a unique position in the social network between the early adopters and late majority, linking these individuals in the network.

Social norms play an important part for the late majority who account for 34% of the bell curve, and they adopt the innovation just after the average member in the social system. The late majority wait until most people in the social system have adopted the innovation and the weight of the system's norms favor the innovation. They approach the innovation with skepticism and caution as they may have limited resources, but they can be persuaded by the utility of the innovation (Rogers 1983). Individuals who are the last to adopt the innovation in the social system are laggards. Laggards are traditional, accounting for 16% of the curve, and often make decisions based on previous generation's norms, and they most often interact with others who have relatively traditional values. Often by the time laggards decide to adopt an innovation, another innovation supersedes it. Due to their traditional outlook, they tend to be behind in the awareness-knowledge aspect of the innovation-decision process. In addition, resistance by laggards may be due to limited resources making them proceed with extreme caution when adopting an innovation.

Gaining a perspective of each individual across this spectrum may help in identifying areas where they may have uncertainty. An ICC can bridge those uncertainties with knowledge and conversations over time to continue the progression of diffusion. It is important to highlight that assigning farmers to certain adopter categories is not static because the exact category for each farmer may differ for individual innovations. For example, a farmer who hires an ICC recognizes the knowledge benefit that she or he obtains from that relationship; however, the farmer may be more reluctant to adopt other innovations on his or her farm. Additionally, economic or environmental changes may result in a shift in the farmer's perception of an innovation. A North Dakotan farmer who I worked with said "Sunflowers were diseased, and the market went to hell. It was either change or die". This combination of economics and environmental conditions (i.e., increased moisture causing disease) resulted in the farmer being less reluctant to an innovation (i.e., to grow new crops).

Social System

The last element of diffusion is the social system which is "a set of interrelated units that are engaged in joint problem solving to accomplish a common goal" (Rogers 1983, p. 24). Everyone is part of a social system in some way. The early adopter plays an important role in the social system (i.e., interpersonal network) because of their leadership positions and frequent interactions with potential adopters who seek them out. This interactive process promotes decentralized diffusion. The ICC plays an important role in the diffusion of innovation by being a knowledge source that can provide the science behind an innovation and reduce the uncertainty behind the innovation.

Furthermore, an ICC serves as a person that connects farmers and researchers in the social system. Agricultural researchers' superior knowledge can create a communication barrier (e.g., jargon) between them and farmer clientele. An ICC is a change agent who influences farmers in the innovation-decision process in a way that is deemed favorable by a change agency (e.g., Agricultural Extension). A change agent is an individual who can speed up the rate of adoption, but they also may slow the diffusion process to prevent undesirable effects of the innovation (Rogers 2003b). According to Rogers (2003b) the seven roles of a change agent are to: 1) develop a need for change, 2) establish an information exchange relationship, 3) diagnose problems, 4) create an intent to change in the client, 5) translate an intent into action, 6) stabilize adoption and prevent discontinuance, and 7) achieve a terminal relationship.

An ICC fulfills these roles daily while interacting with their farmer clientele. As an ICC is scouting a field, he or she identifies problem areas in the field and communicates these observations, so the farmer becomes aware of the *need to change* or alter their management strategy. Over time the ICC develops a rapport (i.e., relationship) with their clientele allowing for *information exchange*. The ICC *diagnoses problems* and tailors solutions (i.e. recommendation) to address those problems in the field. The ICC formulates multiple solutions for the farmer to consider and these are tailored to account for the farmer's goals as well as their constraints from time, labor, equipment, etc. All of this can readily *create an intent to change* management strategies. The interpersonal communication between a farmer and an ICC is very much relational, and through conversations and time, the intended solution is *translated into action*.

If an ICC identified issues with a crop stand, then one solution is to make modifications or adjustments to the planter. If the farmer follows through with this, then next year an ICC may make additional comments on the stand, if it is good, to provide the farmer with confirmation of the success of the innovation. The purpose of these comments would be to reinforce and *stabilize the adoption to prevent discontinuance*. At times, a farmer comes up with his or her own ideas to solve problems on their farm. By this point, the ICC may serve as a person to bounce ideas off, apply their understanding of science to the scenario, and predict what may happen based on their previous experiences. This demonstrates the achievement of a *terminal relationship* where the farmer is now also a change agent. A farmer grows through this process, becoming a change agent to his or her interpersonal network, but there is the constant need to scout fields and identify problem areas, so the role of ICC remains important in a farming operation. Nevertheless, the ICC is a change agent within the social system to farmers who he or she works for.

An aspect of the social system which plays a significant role in the diffusion of an innovation is cultural norms. In the village of Los Molinos in Peru, the diffusion of boiling drinking water to prevent infectious diseases was unsuccessful partly because of the cultural beliefs of the villagers. The local tradition of the villagers linked hot food with illness and “boiling water makes it less ‘cold’ and hence, appropriate only to the sick” (Rogers 2003a, p. 4). If a person is not ill, then by village norms they are prohibited from drinking boiled water. The Los Molinos example emphasizes that regardless of the innovation it needs to be compatible with the “values, beliefs, and past experiences of the social system” (Rogers 2003a, p 4.).

Another example of an innovation that was not consistent with cultural values was the so-called “miracle” rice bred by the International Rice Research Institute (IRRI) in the Philippines (Rogers 2003e). IRRI bred rice was high-yielding and had resistance to pests, but the breeders did not pay attention to the taste of the rice. Villagers who adopted the new rice variety in south India found that the new rice did not taste “right”; therefore, the new IRRI rice varieties were grown and sold at the marketplace, but the villagers planted traditional rice for personal consumption. Breeders were informed that the taste of their rice was incompatible with the traditional rice and responded “We triple rice yields. People will soon learn to like the taste of our IRRI rice!” in the 1960s (Rogers 2003e, p.241). The breeders at IRRI have worked through the decades to improve rice varieties and have considered taste according to a comment from Ruariaih Sackville-Hamilton, an evolutionary biologist who manages the IRRI gene bank “Our work to conserve rice has a proven track record in bringing benefits to the world. With this collection safely conserved, we can continue to use it to develop improved rice varieties that farmers can use to respond to the challenges in rice production and to adapt to the changing tastes and preferences of consumers everywhere.” (International Rice Research Institute 2018). This highlights the need that even taste of the rice needs to be considered for a smoother diffusion of the new variety (i.e., innovation). The theory of planned behavior (TPB) can be applied to this situation by addressing human behavior.

## Theory of Planned Behavior

One of the most popular models in explaining, predicting, and changing human behavior is the Theory of Planned Behavior (TPB) (Ajzen 2012). There are three constructs to this theory: control beliefs, attitudes, and subjective norms (Ajzen 1991).

*Control beliefs* (i.e. perceived behavioral control) is the ease or difficultly that an individual perceives when performing the behavior (Senger et al. 2017). A person's *attitude* about a behavior is shaped by their perception of how unfavorable or favorable the behavior will be. One's perception of the behavior is based on information (or misinformation) or even an emotional reaction to the behavior which may be supported by personal values and beliefs (Senger et al. 2017). The perceived social pressure to perform or not to perform the behavior is influenced by *subjective norms* (Senger et al. 2017; Ajzen 1991). If an individual has more favorable control beliefs, attitudes, and subjective norms, then there is a greater likelihood that an individual will perform the behavior (Ajzen 2012).

Connections between the diffusion of innovation theory and TPB can be made by considering the adoption of an innovation as the behavior. Each of these TPB constructs can relate to specific areas within the diffusion of innovation theory. *Control beliefs* relate to the first element of diffusion referring to the innovation and how a potential adopter of an innovation perceives the relative advantage, compatibility, etc. of the innovation. The innovation needs to be compatible with the farmer's operation, and the individual needs to have a positive view of ease of adoption (e.g., hybrid corn). An ICC can aid potential farmer adopters by observing the farmer's operation and serving as an external perspective to help identify where the innovation can be tailored, so it is more compatible with the farmer's operation.

The third element of diffusion (i.e., time) relates to *attitudes* of the TPB because this involves the information-decision process, where the potential adopter receives the knowledge or information about the innovation forming a favorable or unfavorable opinion about the innovation. Through conversations with farmers, an ICC can provide knowledge about the innovation and identify misinformation that the farmer has heard about the innovation. Due to the relationship with the farmer, an ICC may be more effective in communicating the innovation, so the farmer forms a favorable opinion. Through this process, adopters seek information about the innovation and an ICC can be a resource during this time.

Lastly, *subjective norms* relate to the social system element of diffusion. When performing a behavior (i.e., adoption of an innovation), there are social pressures that farmers face related to what farmers in their neighborhood may deem “normal”. For example, the innovative farmer I worked with in North Dakota said, “Most of the time I'm the one to do…the weird things.” This farmer was self-aware that he managed his land differently than his neighbors. This farmer was not concerned about what others thought about him, and he only wanted to do what he believed was right for his farming operation. Additionally, the social norms include the cultural norms which need to be consistent with an individual’s values (e.g., IRRI – diffusion of new rice varieties). According to the TPB, an individual needs to favor all three constructs to perform the behavior (i.e., adopting an innovation). Therefore, there are three critical areas to focus on in the adoption of an innovation: ensuring the perceived innovation is compatible with the farmer’s operation, disseminating information and knowledge that will aid in farmers having a favorable attitude about the innovation, and making sure the innovation is aligned with existing cultural norms. Independent crop consultants make effective change agents by communicating innovations to their farmer clientele, building trusting relationships, and understanding where the innovation fits into an operation and into existing cultural norms.

## Conclusion

Communication is a process that cannot be avoided because it impacts nearly every aspect of a person's life. The Shannon-Weaver model of communication helped in establishing components of communication. All communication is based on the components of the source, message, receiver, and feedback and within these components noise occurs disrupting the process. The intended audience and level of communication must be kept in mind when creating a message that is well received and understood by the receiver. Understanding the level at which the message to being communicated is important because with mass media you are more likely to reach innovators and early innovators, whereas later adopters will be reached through interpersonal communication.

While ICCs have an interdisciplinary knowledge of production agriculture, they must also have extensive communication skills to be successful. Most of the communication for an ICC occurs at the interpersonal level which is represented by the Schramm interactive model. ICCs are creative in their message creation by using analogies, metaphors, and framing to communicate complex concepts. They play a critical role in social networks through communication to field scout(s), farmers, industry colleagues, and government. Through these processes they serve as change agents in the diffusion of innovations in production agriculture. When ICCs serve as change agents they act as gatekeepers, either speeding up or slowing down diffusion, which is similar to the Westley-MacLean communication model. Due to this role of the ICC and how they build strong relationships over time, they are active in each element of diffusion (i.e., innovation, communication channels, time, social system) helping in adoption as explained by the TPB. Understanding these communication concepts will refine and strengthen the ICC's communication skills. The next chapters will explore communication aspects between the ICC and field scout(s), farmers, and their social networks.

**Literature Cited**

Agrios, George. 2005. "Plant Disease Epidemiology." In *Plant Pathology*, 5th ed., p. 272–274. Elsevier Science & Technology. Burlington, MA:

Ajzen, Icek. 1991. "The Theory of Planned Behavior." *Organizational Behavior and Human Decision Processes*, Theories of Cognitive Self-Regulation, 50 (2): 179–211. doi:10.1016/0749-5978(91)90020-T.

Ajzen, Icek. 2012. "The Theory of Planned Behavior." In *Encyclopedia of Epidemiology*, p 1033–1035. Thousand Oaks: SAGE Publications, Inc.

Beever, Gavin. 2016. "Diffusion of Innovations Theory - Adoption and Diffusion." *Extension Practice*. https://extensionaus.com.au/extension-practice/diffusion-of-innovations-theory-adoption-and-diffusion/.

Braasch, Jason L. G., and Susan R. Goldman. 2010. "The Role of Prior Knowledge in Learning From Analogies in Science Texts." *Discourse Processes* 47 (6). Routledge: 447–479. doi:10.1080/01638530903420960.

Briese, Lee. 2019. "Science Communication in Agriculture: The Role of the Trusted Adviser." Dissertation. Univ. Neb.- Linc. 1–87

Brown, Simon, and Susan Salter. 2010. "Analogies in Science and Science Teaching." *Advances in Physiology Education* 34 (4). American Physiological Society: p. 167–169. doi:10.1152/advan.00022.2010.

Bryant, Jennings, and Susan Thompson. 2002. "Understanding Media Effects." In *Fundamental of Media Effects*, p. 3–20. McGraw-Hill Higher Education.

Coble, Harold D., and David A. Mortensen. 1992. "The Threshold Concept and Its Application to Weed Science." *Weed Technology* 6 (1): 191–195.

DeVito, Joseph A. 2016. *The Interpersonal Communication Book*. 14th ed. Pearson Education, Inc. Willard, OH.

García-Carmona, Antonio. 2020. “The Use of Analogies in Science Communication: Effectiveness of an Activity in Initial Primary Science Teacher Education.” *International Journal of Science and Mathematics Education*, doi:10.1007/s10763-020-10125-2.

International Rice Research Institute. 2018. “The World’s Rice Bowl: Protected in Perpetuity.” *International Rice Research Institute*. [Accessed May 2, 2021]. https://www.irri.org/news-and-events/news/world%E2%80%99s-rice-bowl-protected-perpetuity.

Krantz, Shelby A., and Martha C. Monroe. 2016. “Message Framing Matters: Communicating Climate Change with Forest Landowners.” *Journal of Forestry* 114 (2): 108–115. doi:10.5849/jof.14-057.

McQuail, Denis. 1987. “The Rise of Media of Mass Communication.” In *Mass Communication Theory*, 2nd ed., p. 3–26. SAGE Publications Ltd. London.

Niebert, Kai, Sabine Marsch, and David F. Treagust. 2012. “Understanding Needs Embodiment: A Theory-Guided Reanalysis of the Role of Metaphors and Analogies in Understanding Science.” *Science Education* 96 (5): 849–877. doi:10.1002/sce.21026.

Orgill, MaryKay, and George Bodner. 2004. “What research tells us about using analogies to teach chemistry.” *Chemistry Education Research and Practice* 5 (1).: 15–32. doi:10.1039/B3RP90028B.

Ownley, Bonnie H., and Robert T. Trigiano, eds. 2017. *Plant Pathology*. 3rd ed. CRC Press. Boca Raton, FL, USA:

Pedigo, Larry P., and Marlin E. Rice. 2009. "Economic Decision Levels for Pest Populations." In *Entomology and Pest Management*, 6th ed., p. 255–281. Pearson Education. Upper Saddle River, NJ:

Peshin, Rajinder, J. Vasanthakumar, and Rajinder Kalra. 2009. "Diffusion of Innovation Theory and Integrated Pest Management." In *Integrated Pest Management: Dissemination and Impact: Volume 2*, edited by Rajinder Peshin and Ashok K. Dhawan, 1–29. Dordrecht: Springer Netherlands. doi:10.1007/978-1-4020-8990-9_1.

Post, G. R. 1988. "The Private Consultant: Benefit or Burden?" *HortScience (USA)*. https://agris.fao.org/agris-search/search.do?recordID=US8853515.

Rogers, Everett M. 1983. *Diffusion of Innovations*. 3rd ed. Free Press; Collier Macmillan. New York: London:

Rogers, Everett M. 1988. "The Intellectual Foundation and History of the Agricultural Extension Model." 9 (4):492–510. doi:10.1177/0164025988009004003.

Rogers, Everett M. 2003a. "Elements of Diffusion." In *Diffusion of Innovations*, 5th ed., p. 1–38. Free Press. New York, NY

Rogers, Everett M. 2003b. "The Change Agent." In *Diffusion of Innovation*, 5th ed., p. 365–401. Free Press. New York, NY

Rogers, Everett M. 2003c. "The Innovation-Decision Process." In *Diffusion of Innovation*, 5th ed., p. 168–218. Free Press. New York, NY

Rogers, Everett M. 2003d. “Innovativeness and Adopter Categories.” In *Diffusion of Innovation*, 5th ed., p. 267–299. Free Press. New York, NY

Rogers, Everett M. 2003e. “Attributes of Innovations and Their Rate of Adoption.” In *Diffusion of Innovation*, 5th ed., p. 219–266. Free Press. New York, NY

Senger, Igor, João Augusto Rossi Borges, and João Armando Dessimon Machado. 2017. “Using the Theory of Planned Behavior to Understand the Intention of Small Farmers in Diversifying Their Agricultural Production.” *Journal of Rural Studies* 49: 32–40. doi:10.1016/j.jrurstud.2016.10.006.

Sherman, Jennifer, and David H. Gent. 2014. “Concepts of Sustainability, Motivations for Pest Management Approaches, and Implications for Communicating Change.” *Plant Disease* 98 (8): 1024–1035. doi:10.1094/PDIS-03-14-0313-FE.

Telg, Ricky, and Tracy A. Irani. 2012. “Effective Communication and Message Development.” In *Agricultural Communications in Action A Hands-On Approach*, 19–28. Delmar Cengage Learning.

Wick, Abbey. 2021. “DIRT Workshop.” *NDSU Soil Health*. North Dakota State University Extension. Fargo, ND. [Accessed May 2, 2021]. https://www.ndsu.edu/soilhealth/dirt-workshop/.

Wilcox, Dennis, Glen Cameron, and Bryan Reber. 2015. “Communication.” In *Public Relations Strategies and Tactics*, 11th ed., p. 171–196. Pearson Education. Upper Saddle River, NJ

.

# CHAPTER 2

# INDEPENDENT CROP CONSULTANTS TRAINING THE FIELD SCOUT USING EXPERIENTIAL LEARNING AND SCAFFOLDING

## Introduction

Independent crop consultants are a great source of knowledge, and the next generation can learn so much from them. However, training from the ICC to the field scout can be lacking. Proper training is required for the field scout to do his or her job effectively, which impacts the job of an ICC in the number of acres to scout and field observations that are used to develop management recommendations for the farmer. An ICC can apply educational methods, such as experiential learning and scaffolding, to leverage a field scout's knowledge and supply additional training to boost the field scout's confidence and abilities. Field training incorporates the components of the biology and ecology of the crop and associated pests (i.e., integrated pest management approach) to provide a wholistic view of the field situation. Enhancing the observational skills necessary for effective scouting and the agronomic knowledge in the field scout is critical. It is also important to develop the field scout's ability to readily navigate to farmer's fields; therefore, Metes and Bounds and the Public Land Survey System should be included in the field training process (Gay 2015). The goal of this chapter is to aid ICCs in training field scouts and emphasize the importance of effective teaching and interpersonal communication strategies that address for the needs of individual field scouts.

## Experiential Learning

ICCs are not teachers in a formal classroom setting, but they utilize crop fields as their classroom. They should leverage previous experiences both formal and informal to enhance the field scouts' learning through a hands-on experiential learning approach. Kolb (2015) defines the experiential learning cycle as a dynamic process that incorporates the taking in of information through an experience (i.e., grasping) and the individual's interpretation and action taken upon the information or experience (i.e., transforming) (Kolb 2015).

There are four components of the experiential learning cycle: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Figure. 2.1) (Kolb 2015). Learners can begin this cycle at any given point within the cycle. For example, learners may also learn about multiple insect sampling techniques in class (i.e., abstract conceptualization) and then act upon that knowledge when in the field to catch certain insects (i.e., active experimentation). The grasping experience includes the concrete experience and the abstract conceptualization, and the transforming experience involves active experimentation and reflective observation. The concrete experience provides the learner (i.e., field scout) an opportunity to observe/experience a new situation or the reinterpretation of existing experiences. Reflective observation involves reflection upon the experience and identifying any inconsistencies between the experience and prior understanding. The abstract conceptualization process occurs after reflecting on the experience, a new idea, or an understanding of an existing abstract concept. Active experimentation is the last stage where the learner applies or tests out the new understanding.

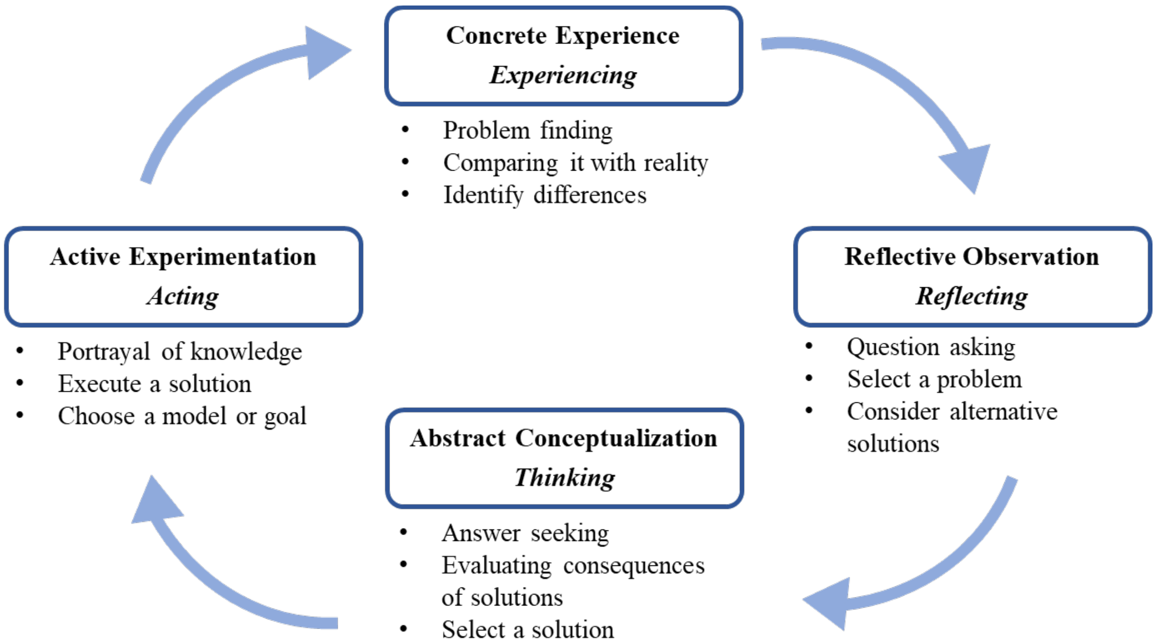



Figure 2.1. Kolb Experiential Learning Cycle (adapted from Kolb 2015).

Experiential learning should incorporate formal and informal learning experiences together for a better understanding of concepts. For example, in Invasive Plants (AGRO 426/826) at the University of Nebraska-Lincoln, the life cycle of invasive plants (i.e., weeds) is covered. Students struggled to see the benefit of learning the life cycle of plants covered in the lab portion of the class. However, students readily realize the importance of the plant life cycles when combined with a hands-on experience, such as scouting a field.

In my first couple weeks scouting at Centrol Crop Consultant, I realized the importance of plant life cycles in knowing what weeds to scout for depending on the season. In North Dakota, spring wheat was the first crop that we scouted in early spring, and the two primary weeds seen were downy brome (*Bromus tectorum*) and foxtail barley (*Hordeum jubatum*). Both weeds are winter annuals making them the first weeds observed in the spring and emphasizing the need to manage these weeds before they produce seed.

This experience demonstrates the four components of the Kolb experiential learning cycle beginning with concrete experience, where I had the opportunity to gain a new experience scouting crops in North Dakota. The reflective observation took place when I observed the seasonality of the weeds. At that time, a new understanding emerged of the importance of plant life cycles (i.e., abstract conceptualization). The last component of the learning cycle, active experimentation, occurred when I applied my new understanding in the context of scouting spring wheat. The ICC can aid the scout in experiential learning by providing structure, such as pointing out that both (downy brome and foxtail barley) weeds are winter annuals. Providing structure while learning describes the educational method of scaffolding.

## Scaffolding

ICCs may use scaffolding without knowing that it even exists. This process enables the field scout to solve a complex problem or accomplish a task unassisted that would otherwise be beyond their current abilities (Chittooran 2018; Hmelo-Silver et al. 2007). Scaffolding involves the ICC facilitating the learning process by providing support to the field scout to aid in the mastery of scouting. This educational method is most useful when learning a new task that has multiple steps. Scouting can be broken down into multiple steps from monitoring crop health (e.g., emergence, population stand, nutritional requirements), identifying pests (i.e., weeds, arthropods, pathogens), quantifying the density and distribution of pests, and evaluating when problems need to be addressed. Instructional scaffolding is much like the scaffolding used in the construction of a building. The scaffolding is in place to support the building, and it is removed as the building becomes more stable and can stand on its own.

There are three essential characteristics of scaffolding including ICC and field scout interaction (i.e., teacher-student), proximal development zone, and scaffold component of the scaffolding (Chittooran 2018). An open dialogue between the ICC and field scout is needed so there is a collaborative environment reflecting a shared responsibility in learning. The open dialogue allows each person to receive feedback with the ICC being able to clarify direction and the field scout to ask questions. To ensure maximum learning for the field scout, the learning needs to occur within the proximal development zone. This is the gap between the point the field scout needs support and where the scout can scout independently. The knowledgeable ICC needs to be able to evaluate the student's function including the strengths, weaknesses, and the need for additional guidance. The goal of scaffolding is for the student to master the task and be independent in performing the task, requiring the ICC to gradually remove the scaffolding.

Through instructional scaffolding from the ICC, field scouts develop confidence and independence. Scaffolding is teaching in the proximal development zone, and this requires interpersonal communication/social interaction between the ICC and field scout, so the ICC can develop an understanding of what the field scout knows. An ICC can gather a general idea of terminology to use when communicating to the scout by asking about their educational background (i.e., classes they have taken), their prior relevant experiences, and proceed by asking additional questions in the field. For example, a field scout who has taken a weed or plant identification course should recognize terms like ligule, leaf pubescence, leaf collar, etc. But if the scout does not know this terminology, this needs to be the starting point. If the field scout has taken a plant identification course, then a potential starting point is to discuss characteristics of plant families of common weed species in the local area. It is critical for the ICC to continually assess the field scout's abilities, so the scaffolds can be adjusted based on the progress.

To accomplish effective scaffolding, there are two additional aspects: modeling and practicing (Chittooran 2018). Modeling is the ICC demonstrating the scouting process so the field scout can observe the process and all the steps it includes. At times modeling may be difficult for the ICC because they know the process so well that it is difficult for them to display all or certain aspects of the process that are just innate to them. This proves to be difficult for the field scout to understand the field scouting process which can be specific to individual ICCs. This also requires ICCs to acknowledge that he or she may not have included needed information for the scout. Along with modeling comes practicing, where the ICC takes a step back and observes the field scout in a field. The ICC can evaluate areas where improvement is needed and areas where clarification in the instructions is needed. Scaffolding can be a beneficial process for the field scout if an open dialogue exists and it is executed effectively by ICCs.

## Field Training Using Experiential Learning and Scaffolding

Effectively training a field scout can result in increased confidence, independence, and self-improvement, and it can reduce the number of acres an ICC must cover themselves. Scouting is the process in which observational data is collected to identify pests and monitor crop health to diagnose agronomic problems which contribute to creating a field report that includes management recommendations. It is the process of training the eyes to observe what is out of place (i.e., abnormalities). An analogy to describe this concept is if you are going into a grocery store, searching for a specific item (e.g., Campbell soup) you know the shape and color of the packaged item (i.e., red and white can). You go to the section where it should be, and your eyes eliminate items that do not have the ideal packaging and seeks out potential items of what the packing should look like. This is an example of visual scanning, a psychology term, referring to ocular strategies used to actively process visual stimuli (e.g. faces, scenery, objects) and acquire relevant visual information (Hutman 2013). Your eyes adjust to the appearance of a healthy plant and can identify abnormalities whether it is the crop itself or a patch of weeds, defoliation of the crop, etc.

The biology and ecology of a crop and associated pests are foundational in the field training process. The field training process will use experiential learning and scaffolding. Educational methods are applied, but also this process focuses on an integrated pest management (IPM) approach. An IPM program is "a comprehensive pest technology that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment" (Pedigo and Rice 2009, p. 756). This section focuses on the training aspects that contribute to developing field recommendations.

Ideally this approach begins with the ICC and the field scout in a field together discussing the crop and pests, quantifying the observations, and then proceeding to other fields. Foundational aspects of field training include monitoring crop health, identifying pests in the field, scouting strategies, quantifying pests, and navigation to fields. If the biology and ecology of the crop are considered, the list of potential target organisms can be narrowed (e.g., scouting of winter annual weeds occurring in early spring). However, focused scouting does not mean other organisms should be ignored because there can always be abnormal occurrence of them. If the field scout already knows the foundational concepts of identification, then the ICC can use that foundation as the base of the scaffolding and aid the scout in the application of concepts to field situations. Experienced ICCs may streamline these foundations because they are very familiar with the geographic area and know what to expect throughout the season.

In addition, an ICC should provide the equipment needed for the field scout to use during the summer to be successful in scouting. Essential items for scouting include a tape measure, hand trowel, shovel, hand lens, pocketknife, mechanical hand counter, plastic bags, plastic vials (to collect samples), soil thermometer (for early in the season), a way to record observations (e.g., digital recorder, scouting sheets), a compass, and access to reference material for identification (Doll et al. 1998). Other equipment may be needed depending on the crop and sampling technique, for example, a sweep net, long-reach pruner (i.e., sampling hops leaves), pheromones traps, etc. Having the proper equipment for scouting is necessary for monitoring crop health, and the identification, and quantification of pests.

**Monitoring Crop Health**

Monitoring crop health includes knowing the appearance of a healthy plant, performing population stand counts, and recording the growth stage of the crop. Knowing the appearance of a healthy crop plant is key in identifying and diagnosing agronomic problems. A healthy plant “can carry out its physiological functions to the best of its genetic potential” (Agrios 2005a, p. 5).

My first experience scouting hops in Yakima, Washington is a great example of why an understanding of a healthy plant is needed when scouting. Most crops are supposed to be a 'normal' green color in appearance; however, the hop variety Eukanot ®, formerly called equinox, does not have this 'normal' appearance (BarthHaas 2021). Before the summer equinox, Eukanot ® has a bright light green appearance as compared to the hop variety, Cascade ® which has a 'normal' dark green appearance. After the summer equinox, Eukanot ® is a different shade of green. Prior to knowing this about Eukanot ®, I assumed that there was a nutrient deficiency rather than different varietal characteristic.

Nutrient deficiencies or toxicities are abiotic factors that can also impact the plant health. There are 14 essential mineral elements (Macronutrients: nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg). Micronutrients: iron (Fe), sulfur (S), manganese (Mn), zinc (Zn), copper (Cu), boron (B), molybdenum (Mo), chloride (Cl), nickel (Ni) ), excluding carbon, hydrogen, and oxygen, required for plant growth and reproduction (Daroub and Snyder 2007; Marschner 2012; MarMcCauley et al. 2009). Based on the nutrient quantities the plant takes up, nutrients are divided into macronutrients (greater quantity) and micronutrients (lesser quantity) (Daroub and Snyder 2007). In deciphering plant nutrient deficiencies or toxicities, it is important to know if the nutrient is mobile (N, P, K, Mg, Cl, Ni), immobile (Ca, B, Cu, Fe, Mn, Zn), or partially mobile in the plant (S, Mo). This will aid in understanding what nutrient is deficient or toxic in the plant by observing plant symptoms. Generally, macronutrient deficiency symptoms are exhibited on the older growth because they are mobile in the plant, whereas micronutrients deficiencies are exhibited in the new growth, due to them being immobile in the plant. McCauley et al. (2009) provides an identification key covering common nutrient deficiency symptoms. If the symptoms on the plant are not consistent with a nutritional issue, then other abiotic factors may be contributing to the observed symptoms. These factors could include too low or high temperature, lack or excess moisture, lack or excess of light, lack of oxygen, air pollution, mineral toxicities, soil acidity or alkalinity, the toxicity of pesticides, improper cultural practices, etc. (Agrios 2005a). If the plant symptoms are not conclusive, plants can be sent to a diagnostic lab.

Performing stand counts is another important component of monitoring crop health. This is more relevant to annual crop stands because stand counts provide data to determine if replanting an entire field or sections of the field is necessary. In the Midwest seeding rates for corn and soybeans vary. Corn is planted at 28,000 to 42,000 seeds per acre, and soybeans are generally planted around 100,000 plants per acre (Sisson et al. 2021). Stands counts for corn are measured by counting the number of plants in a specified length of row depending on row racing as shown in Table 2.1 (Sisson et al. 2021). For soybeans, there are two methods for determining the plant population. The first is to count the stand in 1/10,000 of an acre as described in Table 2.2. The second method involves counting the number of plants within a hoop and using a multiplication factor as described in Table 2.3 (Sisson et al. 2021). Monitoring crop health also involves documenting growth stages every time the field is scouted. There are multiple systems for describing the crop growth stage, thus clear communication and understanding is needed of what system is used is being used.

<table>
<tr><td colspan="2">Measurements for determining plant populations in 1/1,000 of an acre</td></tr>
<tr><th>Row Spacing</th><th>Row Length to Measure</th></tr>
<tr><td>7 inches</td><td>74 feet, 9 inches</td></tr>
<tr><td>10 inches</td><td>52 feet, 3 inches</td></tr>
<tr><td>15 inches</td><td>34 feet, 10 inches</td></tr>
<tr><td>20 inches</td><td>26 feet, 2 inches</td></tr>
<tr><td>30 inches</td><td>17 feet, 5 inches</td></tr>
<tr><td>36 inches</td><td>14 feet, 6 inches</td></tr>
<tr><td>38 inches</td><td>13 feet, 9 inches</td></tr>
<tr><td colspan="2"><u>How to use:</u><br>1. Measure row length for appropriate row spacing in the field.<br>2. Count the number of plants in the row length.<br>3. Repeat steps 1 & 2 in 6-10 representative areas in the field to calculate average number of plants.<br>4. Multiply the average number of plants by 1,000 for final plant population per acre.</td></tr>
</table>

Table 2.1. Row spacing and row length to measure for determining plant populations in 1/1,000 of an acre (adapted from Sisson et. 2021).

| Measurements for determining soybean populations in 1/10,000 of an acre | | |
|---|---|---|
| **Row Spacing** | **Number of Rows to Count** | **Row Length to Measure** |
| 7.5 inches | 4 | 21 inches |
| 15 inches | 2 | 21 inches |
| 30 inches | 1 | 21 inches |
| How to use:<br>1. Measure 21 inches of row length.<br>2. Count the number of plants in the row length.<br>3. Repeat steps 1 & 2 in 6-10 representative areas in the field.<br>4. Multiply the average number of plants by 10,000 for final plant population per acre. | | |

Table 2.2. Row spacing and row length to measure for determining soybean populations in 1/10,000 of an acre (adapted from Sisson et. 2021).

<table>
<tr><td colspan="2">Measurements for determining soybean populations using hula hoop method</td></tr>
<tr><th>Diameter of Hoop</th><th>Multiplication Factor</th></tr>
<tr><td>18 inches</td><td>24,662</td></tr>
<tr><td>21 inches</td><td>18,119</td></tr>
<tr><td>24 inches</td><td>13,872</td></tr>
<tr><td>27 inches</td><td>10,961</td></tr>
<tr><td>30 inches</td><td>8,878</td></tr>
<tr><td>33 inches</td><td>6,165</td></tr>
<tr><td colspan="2"><u>How to use:</u><br>1. Randomly throw hula hoop in field.<br>2. Count the number of plants within hoop.<br>3. Repeat steps 1 & 2 in 6-10 representative areas in the field.<br>4. Multiply the average number of plants by multiplication factor that corresponds to the hoop diameter for final plant population per acre.</td></tr>
</table>

Table 2.3. Determining soybean populations using the hula hoop method (adapted from Sisson et. 2021).

The Biologische Bundesanstalt, Bundessortenamt, and CHemische Industrie (BBCH), is “a system for a uniform coding of phenologically-similar growth stages of all mono- and dicot- yledonous plant species” (Meier et al. 2009). There are ten principle growth stages for the BBCH including: 0 - germination / sprouting / bud development, 1 - leaf development (main shoot), 2 - formation of side shoots / tillering, 3 - stem elongation or rosette growth / shoot development (main shoot), 4 - development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot), 5 - inflorescence emergence (main shoot) / heading, 6 - flowering (main shoot), 7 -

development of fruit, 8 - ripening or maturity of fruit and seed, and 9 - senescence, beginning of dormancy (Meier et al. 2009). To precisely define all phenological growth stages there is a two-digit code which is the principle stage number (as listed above) along with a secondary growth stage number (Meier et al. 2009). The BBCH system can be used for any plant, and there is published literature that provides the specific scale and illustrations for individual crops such as soybeans, peanut, cotton, safflower, asparagus, etc. (Munger et al. 1997; Munger et al. 1998a; Munger et al. 1998b; Flemmer 2015; Feller et al. 2012).

For cereal grains, a version of the BBCH is used that is referred to as the Zadoks scale (Zadoks et al. 1974). The Feekes scale is another scale used for cereal grains, and it consists of a scale from one through 11 (Broeske et al. 2018). On the Feekes scale a '1' refers to seedling growth, 2-5 is tillering, 6-10 is stem extension, 10.1-10.5 is heading, 10.5.1-10.5.4 is flowering, and 11.1-11.4 is ripening (Broeske et al. 2018). Broeske et al. (2018) provide a chart that compares the Feekes and Zadoks scale to help clarify similarities between the two scales which are commonly used.

In the United States, BBCH staging is not widely used for corn (*Zea mays*) or soybean (*Glycine max*) crops. The leaf collar method is widely used by the industry for corn. For this method, plant growth stages are broken down into two main phases, vegetative and reproductive (Abendroth et al. 2011). During vegetative growth, the leaf collar method of staging corn involves counting leaves showing visible collars. A leaf collar is located at the base of the leaf blade where it wraps around the stem, and it can be identified as a visually distinct band. Stages during vegetative growth will include a V for the vegetative phase and the number of leaf collars visible on the plant. Once the ear and its silks are visible, the plant has reached the reproductive growth phase, and staging of the plant focuses on ear and kernel development on the primary ear. The reproductive phase will include an R then a number one through six to describe what stage it is at. Similarly, soybean staging is also broken down into vegetative and reproductive phases (Pedersen and Licht 2014). The description of each stage for corn and soybeans is different, but the numbering system is similar. For a complete description of corn growth stages see the publications *Corn Growth and Development* (Abendroth et al. 2011) and *Soybean Growth and Development* (Pedersen and Licht 2014).

Plants require a specific amount of heat to develop from one growth stage to the next (Miller et al. 2018). Calculating growing degree days (GDD) assigns a heat value for every day, and these are called heat units. For each crop, there is a threshold temperature above which growth and development begins. Some crops also have an upper threshold above which growth and development ceases. For example, the lower threshold for corn growth is 50°F and the upper threshold is 86°F (Abendroth et al. 2011; Dwyer et al. 1999; Stewart et al. 2012). To calculate GDDs for each day, use the following formula using Fahrenheit temperatures:

$$GDD_F=[(T_{min}+T_{max})/2] - T_{base},$$

where $T_{min}$ is the minimum daily air temperature, $T_{max}$ is the maximum daily air temperature, and $T_{base}$ is the specific developmental threshold temperature for the crop. For $T_{min}$, if the temperature is less than the base (e.g., for corn 50°F), use that base temperature. Similarly, for $T_{max}$, if the temperature is greater than the upper threshold (e.g., for corn 86°F), use that upper threshold (Abendroth et al. 2011). The *Crop Scouting Basic for Corn and Soybeans* by Sisson et al. (2021) provides an example of how to calculate GDD. However, GDDs are not applicable for soybeans because they are photoperiod sensitive (i.e., growth responds to relative length of light and dark periods). Soybean genotypes have different photoperiod requirements and are affected by temperature (Pedersen and Licht 2014). An increased average temperature speeds up flowering and reduced average temperature delays flowering (Pedersen and Licht 2014). The appearance of a healthy crop, population stand counts, and growth stages provide a general overview of the crop health.

**Pest Identification in the Field**

Pest identification refers to sight identification in the field, but at times pests cannot be properly identified and further examination is required. Plants face biotic (i.e., infectious pathogens, arthropods) attacks but also abiotic (i.e., nutrient deficiency, soil acidity, lack of light, etc.) where a diagnostic clinic may need to be involved. University Extension professionals and diagnostic clinics can aid in the correct identification of specimens. Clinics are located at most land grant universities, and these clinics can provide a lab diagnosis. To find a plant diagnostic clinic near you visit the National Plant Diagnostic Network website which provides locations across the United States, Puerto Rico, Virgin Islands, and American Samoa. When a specimen needs to be sent to the lab, contacting the lab before sending it will be beneficial so they can provide direction on how to prepare the sample for shipping and are aware that the sample is coming. A lab diagnosis involves observation of the specimen under a compound microscope (e.g., fungi spores, arthropods), pure cultured (e.g., bacteria), a DNA analysis (e.g., viruses), bioassay, or potentially Koch's Postulate is performed (Agrios 2005a). Yet much can still be determined in a diagnosis by looking at the appearance of the plants in the field to gather additional information to make a complete diagnosis.

Correct identification of potential pests and beneficial organisms in the field is the foundation of scouting. Both experiential learning and scaffolding can be used in training the field scout in identifying pests. The ICC can ask the field scout about the educational background of their relevant course and previous experience in scouting field crops. This knowledge allows the ICC to determine appropriate scaffolding while training the scout. Every crop and local geographic area will have specific pest and beneficial organisms that an ICC will need to teach the scout. For example, while scouting row crops (e.g., corn, soybeans, wheat, dry beans, flax, field peas, rye) in North Dakota the primary focus was identifying weeds to make herbicide recommendations. Whereas the focus of specialty crops (e.g., hops, potatoes, mint, asparagus, peppers, cucurbits) in Washington was on the pest and beneficial arthropods.

Weed identification

Teaching weed identification may be slightly easier than arthropods because weeds are stationary. Utilizing a field as a classroom the ICC can show the field scout the typical weeds that they will observe. The field perimeter is an excellent place to begin aiding the scout in weed identification because the border typically has most all weed species that will be found within the field. A scaffolding approach to teaching plant identification would include asking the scout general questions about plant structure, leaf arrangements, or differences between a monocot or dicot to identify a starting point. A general understanding of plant structure will aid in identification, especially the collar region for grasses. These structures include the ligule, sheath, collar, auricles, midvein, and leaf blade. Structures in a dicot differ with a stem having nodes, stipules, internodes, axillary buds, and leaves attached to petioles. Plants have different life cycles and root systems will vary. Annual plants have a taproot or fibrous root, whereas perennial plants have rhizomes, tubers, stolons, or bulbs.

Furthermore, plants can be differentiated by leaf arrangements (i.e., alternate, opposite, basal rosette, whorled), leaf margins (e.g., entire, crenate, serrate), leaf shape (i.e., elliptic, lanceolate, linear, oblong, obovate, orbicular, ovate, reinform, spatulate), and other characteristics. To practice using this terminology the field scout can use dichotomous keys and key out the plant to be identified. If the field scout can identify a weed, they can work backwards in the key to get more familiar with this terminology to aid them in identify other weed species. *Practical Weed Science for the Field Scout* by Bradley et al. (2009) provides dichotomous keys for common broadleaf and grass weed species found in corn and soybeans. Several other good weed resources include: *Weeds of the Midwestern United States and Central Canada*, *Weeds of the South*, *Weeds of the West*, and *Weeds of the Northeast*. (Whitson et al. 2012; Bryson and DeFelice 2010; Bryson and DeFelice 2009; Uva et al.1997). Understanding this botanical terminology will enable field scouts to have an “easier” time searching reference material when identifying unknown plants.

Most weed identification occurs early as seedlings or in the vegetative stage because these are the ideal stages to manage weeds with herbicides. Herbicide rates often depend on the height and density of weeds in the field, such as Pursuit ® (BASF Corporation 2017). While an ICC is showing these weeds to a field scout it is important to point out identifying characteristics of each weed or at least weeds that look similar.

Even though waterhemp (*Amaranthus palmeri*) and redroot pigweed (*Amaranthus retroflexus*) are in the Amaranthaceae family it is important to distinguish one from another. These weeds can be differentiated by the length of the petiole and the pubescence on the stem (Ikley and Jenks 2019). Waterhemp has a petiole that is longer than the length of the leaf and lacks pubescence on the stem. Redroot pigweed has pubescence on the stem. Even though these weeds are in the same plant family, proper identification is important because the different herbicide chemistries must be used for each species due to herbicide resistance common in North Dakota (North Dakota State University Extension 2021).

Arthropod identification

A starting point for arthropod identification is showing images or collections of arthropod pests. An ICC can clearly show identifying characteristics of these arthropods because they are stationary, and if collections are available, actual size differences can be shown. Unlike plant identification, arthropod identification is more complex because the terminology can vary across orders making dichotomous keys difficult to use. Crop specific field guides often provide a listing of common insects found in the crop. *Field Guide to Insects and Spiders of North America*, *Kaufman Field Guide to Insects of North America*, and Bugguide.net are good identification resources (Eaton and Kaufman 2007; Evans 2008; “Overview of Orders of Insects” 2021). An experienced ICC may be able to observe and identify an arthropod without being able to explicitly state identifying characteristics. Therefore, a conversation about what led the ICC to that identification would guide the field scout in their ability to critically inspect the arthropod and seek resources to determine characteristics.

A beginning step of arthropod identification is counting the number of legs on an adult specimen. For this document, discussion will be limited to two classes: Arachnida and Insecta. If the specimen has four pairs of legs it fits into the class of Arachnida. They have two main body parts called the abdomen and cephalothorax. If the specimen has three pairs of legs, it is an insect. They have three main body parts, the head, thorax, and abdomen. The twospotted spider mite (TSSM) (Acari: Tetranychidae) is an arachnid and causes significant yield losses worldwide in agricultural crops (Attia et al. 2013). This mite has approximately 3,877 host species of outdoor and greenhouse crops which makes it a prominent pest (Attia et al. 2013).

Narrowing the possibilities of an unknown insect down to an order is helpful to determine identification. Common insect orders that cause agricultural damage are Coleoptera (beetles), Hemiptera (true bugs, aphids, leafhoppers), Thysanoptera (thrips), Diptera (flies, midges), Hymenoptera (sawflies), Orthoptera (grasshoppers, crickets), and Lepidoptera (butterflies, moths) (Table 2.4) (Metcalf and Metcalf 1993). Characteristics to separate orders include number of wings, wing characteristics (e.g., functionality, scales, etc.), and mouthparts as described in Table 2.4).

| Insect Orders of Agricultural Damaging Pests | | | | |
|---|---|---|---|---|
| **Insect Order** | **Common Name** | **Type of Metamorphosis** | **Characteristics of Order** | **Type of Mouthpart** |
| Coleoptera | Beetle | Complete | Four wings; first pair thickened or hardened and usually as long as abdomen. | Chewing |
| Diptera | Flies, midges | Complete | Only one pair membranous wings | Modified for sponging, cutting-sponging, and piercing sucking |
| Hemiptera | True bugs, aphids, leafhoppers | Gradual | Scutellum: large triangle on the back. Wings held rooflike over abdomen | Piercing-sucking |
| Hymenoptera | Sawflies, bees, wasps | Complete | Hind wings smaller than front wings with cross veins. | Chewing or chewing-lapping |
| Lepidoptera | Butterflies, moths | Complete | Four large wings, covered by scales | Siphoning, larvae - chewing |
| Orthoptera | Grasshoppers, crickets, katydids | Gradual | Four wings, front wings somewhat thickened. Jumping hind legs. | Chewing |
| Thysanoptera | Thrips | Gradual | Wings with setae or fringes | Rasping-sucking |

Table 2.4. Common insect orders of agricultural damaging pest (adapted from Pedigo and Rice, 2009).

Understanding life cycles of different insects can clarify field observations to know the timing of when immature or adults will be present. Four general life cycles exist for insects, including no metamorphosis, incomplete metamorphosis, gradual metamorphosis, and complete metamorphosis (Pedigo and Rice 2009b). Gradual metamorphosis includes three life stages: egg, nymph, and adult. The nymphs do not have fully developed wings or external genitalia and generally feed on similar material through all life stages. Wing pads on the nymphs will develop into the wings in the adults. Complete metamorphosis has four life stages: egg, larvae, pupa, and adults. The larval stages typically consume more food than adults. The development of insects impacts the time in which scouting occurs.

Plants and insects are similar with both being influenced by temperature; therefore, insect development is also driven by degree days (DD). Degree day calculations for insects use the same equation as mentioned earlier for plants. Accumulated DDs above a base temperature can predict the development of insects through their life cycle (Sisson et al. 2021). Degree days are useful in many areas of effective pest management (Herms 2004; Pruess 1983). Table 2.5 displays examples of insects, their base temperature, and how DDs are used for scouting or management purposes.

| Insect and Corresponding Use of Degree Days | | | |
|---|---|---|---|
| **Insect Order** | **Insect** | **Base Temperature** | **Use of Degree Days** |
| Diptera | Seedcorn maggot (*Delia platura*) | 39°F | Adults emerge at about 200, 600, and 1,000 DD. |
| Lepidoptera | Stalk borer (*Papaipema nebris*) | 41°F | Start scouting whorls to determine if larvae are present when 1,300-1,400 DD have accumulated. |
| Lepidoptera | Western bean cutworm (*Striacosta albicosta*) | 50°F | Scouting should occur at twenty-five percent of cutworm flight (2,577 DD). |
| Lepidoptera | Black cutworm (*Agrotis ipsilon*) | 51°F | Larvae start cutting at 300 DD after eggs are laid. |
| Coleoptera | Corn rootworm (*Diabrotica* spp.) | 52°F | About half of eggs hatch between 684-767 DD (soil). |

Table 2.5. Insect and Corresponding Use of Degree Day (adapted from Sisson et al. 2021 and Cluever et al. 2021).

Correctly identifying pests and beneficial organisms while scouting can impact the ICC's recommendation. Beneficial organisms refer to natural enemies that feed on or attack pests (Mahr et al. 2008). This diverse group of beneficial organisms include predators (e.g., insects, birds, bats, rodents, frogs, arachnids), parasitic insects (e.g., parasites, parasitoids), nematodes, and pathogens (Mahr et al. 2008). The diversity of beneficial organisms present in a field will depend on multiple factors (e.g., cropping system, pest populations, pesticides, environmental conditions, etc.). Typical beneficial arthropods observed in hops are the western predatory mite (Acari: Phytoseiidae), minute pirate bug (Hemiptera: Anthocoridae), lady beetle (Coleoptera: Coccinellidae), green lacewing (Neuroptera: Chrysopidae), bigeyed bug (Hemiptera: Geocoridae), damsel bug (Hemiptera: Nabidae), ground beetles (Coleoptera: Carabidae), and syrphid fly larvae (Diptera: Syrphidae) (Walsh et al. 2015). Beneficial arthropods are generally similar across many different crops, but beneficial species may vary depending on geographic locations.

Beneficial organisms are important because they feed on the common arthropods in hop yards. Two common arthropod pests found on hop leaves are aphids and TSSMs. The shape and size of their bodies can distinguish them from one another the larger aphids having more of a football shaped body and TSSM having a rounded oval body. Identifying these arthropods correctly is important because the damage they cause can differ. Aphids excrete honeydew and a complex of common fungi feed on it to produce sooty mold. This mold impacts the cone quality of hops (Walsh et al. 2015). Preliminary research indicates TSSMs feeding after mid-July can impact yields and the levels of desired alpha and beta acids (Walsh et al. 2015). Several beneficial arthropods feed on aphids and TSSMs and impact their population dynamics.

Parasitic wasps may be difficult to observe while scouting; however, aphid mummies are evidence that these beneficial organisms are present. Aphid mummies are a result of a wasp parasitizing an aphid, killing the aphid, and pupating within the remnants of the aphid exoskeleton (Mahr et al. 2008). Understanding the importance of aphid mummies is a good application in learning for the scout to make connections to what is present in the field. Another observation where a scout can make a connection is that if lady beetles are present, then aphids are most likely present as well.

Plant pathogen identification

Plant pathogens can be even more difficult to identify because most are microscopic and often, they are only present within the plant tissues. The primary broad categories of plant pathogens include bacteria, fungi, nematodes, and viruses; although, several other categories exist including oomycetes, mollicutes, parasitic higher plants, and protozoa (Agrios 2005a). Correct identification of pathogens is crucial for applying the correct management strategy, especially if pesticides are used (e.g., fungicide, nematicide, bactericide). With plant pathogens, most of the time only the symptoms are observed. Symptoms are the "visible or otherwise measurable adverse changes in a plant, produced in reaction to infection by an organism or to an unfavorable environmental factor" (e.g., root rots, wilts, leaf spots, blights, rusts, smuts) (Agrios 2005a, p. 5). Signs are also important in diagnosis of plant pathogens, and signs are the physical evidence of the pathogen (e.g., fungal fruiting body, powdery mildew on a leaf). Disease occurs when there is an interaction of three components: susceptible host, pathogen, and environment (Agrios 2005b). These components are called the disease triangle (see Figure 2.2). For example, fusarium head blight (*Fusarium graminearum*) also called head scab (pathogen) of wheat (host) needs warm (59 to 86°F), humid, and wet environmental conditions for infection to occur (Schmale III and Bergstrom 2003). All three of these components must be present for the disease cycle to proceed.

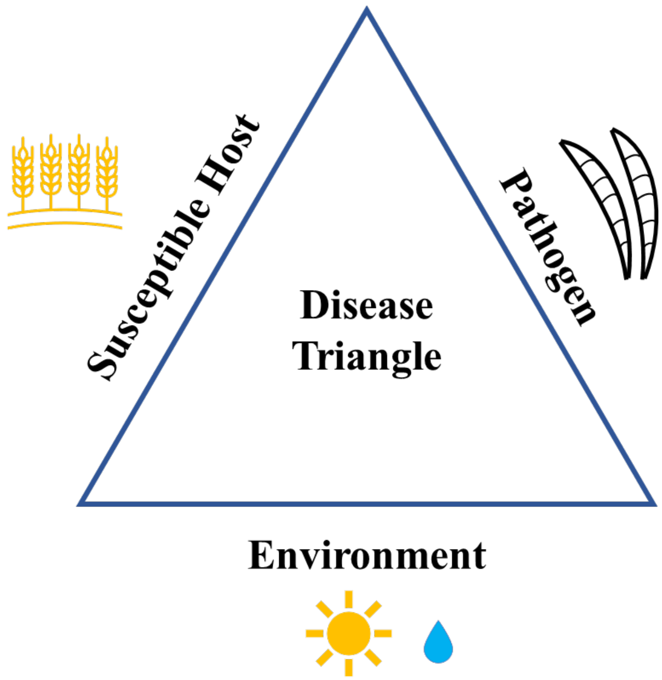



Figure 2.2. Disease triangle is composed of a susceptible host, pathogen, and the environment. Fusarium head blight (*Fusarium graminearum*) also called head scab of wheat needs warm (59 to 86°F), humid, and wet environmental conditions for infection.

The disease cycle includes a series of events that lead to the development and continuation of disease. The primary events of a disease cycle consist of "inoculation, penetration, the establishment of infection, colonization (invasion), growth and reproduction of the pathogen, dissemination of the pathogen, and survival of the pathogen in the absence of the host, i.e., overwintering or oversummering of the pathogen" (Agrios 2005b, p. 80). A monocyclic disease cycle involves only one infection cycle per year (e.g., *Phytophthora sojae* of soybean) (Figure 2.3). A polycyclic disease cycle involves multiple infection cycles per crop per year (e.g., late blight of potato - *Phytophthora infestans*) (Figure 2.3) (American Phytopathological Society 2021; Schumann and D'Arcy 2010a). Depending on the disease, arthropods can contribute to the disease cycle if they are a disease vector and transmit the pathogen to plants, thus these arthropods could be considered inoculum to initiate the disease cycle. Understanding the disease cycle of typical pathogens associated with crops in a geographic region aids in creating a scouting plan and ultimately developing management recommendations to break the cycle.

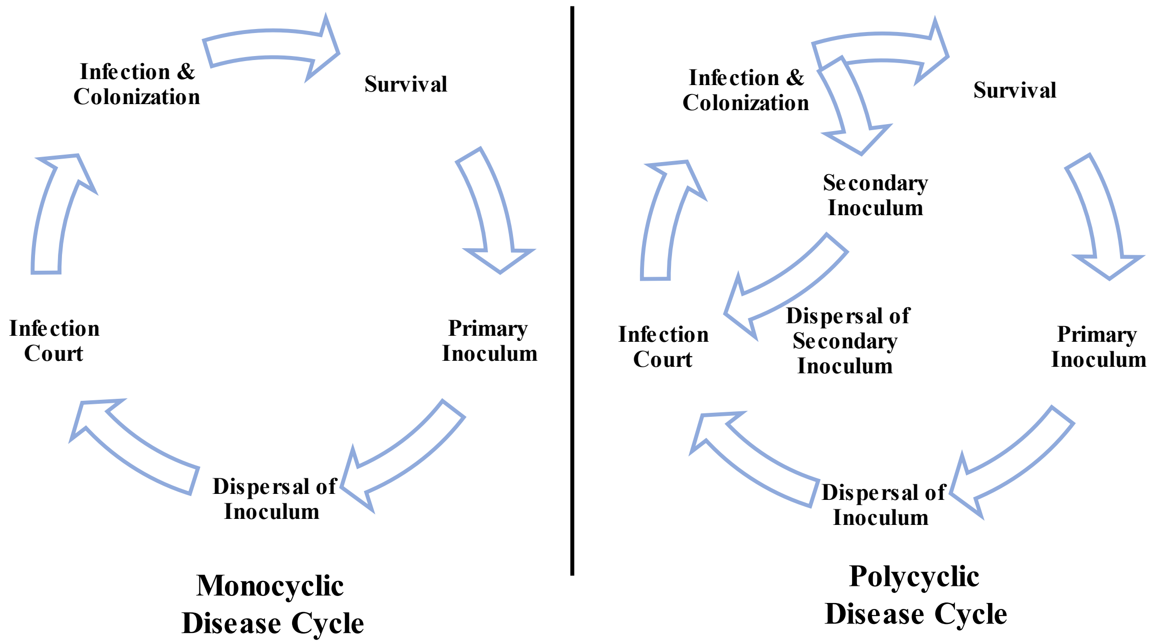



Figure 2.3. Diagrams of a monocyclic and polycyclic disease cycle.

Identifying and distinguishing plant pathogens groups in the field can be difficult, even with a trained eye for signs and symptoms. Field observations, field distribution, symptom distribution on plant, and bioassays (generally conducted by a diagnostic clinic) contribute to a complete diagnosis. Field symptoms of bacterial diseases often include water-soaking, a yellow hallow (due to dying cells surrounding the leaf spot), angular leaf spots, wilting (loss of turgidity), and soft rots (plant tissue liquefy and collapse) (Schumann and D'Arcy 2010b). An accumulation of bacteria in plant tissue results in a visible shiny appearance. This can be seen as a bacteria ooze (also known as exudate) (e.g., Goss's bacteria wilt and blight of corn *Clavibacter nebraskensis*) when cutting the plant. For a complete diagnosis, a diagnostic lab will observe the symptoms, determine if bacteria streaming is observed from a lesion under a microscope, and then perform an assay to confirm the diagnoses.

Fungal infection in plants result in a number of symptoms such as wilting, discoloration of the active xylem, root rots, cankers, leaf curl, stunting, galls, witches' broom (Carris et al. 2012; Schumann and D'Arcy 2010c). Symptoms of fungal infection may also be accompanied by signs, depending on the pathogen. There are a wide range of fungal signs from spores and fruiting bodies. For example, orange powdery spores which are a characteristic of rust, black powdery spores which are a characteristic of smut diseases, and white powdery mycelium is a characteristic of mildew (Schumann and D'Arcy 2010a). To confirm the field identification of fungus, a diagnostic lab will observe spores under a microscope, and an assay may also be performed.

Viruses are very small and cause distinctive symptoms to their hosts such as "mosaic patterns, chlorotic or necrotic lesions, yellowing stripes or streaks, vein clearing, vein banding, leaf rolling and curling" (Gergerich and Dolja 2006; Agrios 2005a). *Maize dwarf mosaic virus* of corn displays the characteristic virus mosaic pattern. Although viruses have distinctive symptoms, a lab assay is needed to confirm the virus symptomology.

The last main plant pathogen group are nematodes. Nematodes, non-segmented roundworms, are ubiquitous but not all cause disease to plants (Schumann and D'Arcy 2010c). Their life cycle consists of a egg, four juvenile stages until they become a reproductive adult (Schumann and D'Arcy 2010c). Plant symptoms of nematodes often result in general symptoms of plants wilting, stunting, and yellowing due their feeding.(Schumann and D'Arcy 2010c). Nematodes can be located both above or below ground. Examples of below ground nematodes are root-knot, cyst, root lesion, burrowing, dagger, sting, and stubby-root (Schumann and D'Arcy 2010c). Above ground nematodes include foliar, seed gall stem, and bulb (Schumann and D'Arcy 2010c). Due to nematodes living above and below ground, often the entire plant and soil samples are needed to diagnosis nematodes present and confirm the cause of the observed symptoms.

Lastly when identifying pathogens, is it imperative to realize that there can be secondary invaders, called saprophytes. These are organisms that colonize dead organic matter (i.e. tissue) to obtain their nutrients (Schumann and D'Arcy 2010a). The American Phytopathological Society (APS) publishes disease and pest compendia for specific crops that are good resources for identifying pathogens. The combination of signs, symptoms, host crop, and environmental conditions contributes to making a field diagnosis. But if further identification is necessary, the specimen should be sent to a diagnostic clinic.

The ICC can evaluate the field scout's pest identification skills by comparing pests identified in the field after both have scouted the same field. Additional guidance can be provided by the ICC to narrow the scout's search when he or she is looking up the specimen in a reference book or the internet. Another way the ICC can aid in this process is by encouraging the scout to take and share quality pictures of the specimen. The ICC can provide the correct identification or provide identifying characteristics to the scout to enhance the learning process. This allows the field scout to learn how to look up specimens by using identifying characteristics. Most land grant institutions create field guides for specific crops which contain growth stages and typical pests, and these can be good resources (Abendroth et al. 2009; Kandel and Endres 2019). These foundational aspects of a healthy plant and the basics of weeds, arthropods, and plant pathogens are an important base of the scaffolding during field training.

**Scouting Strategies**

After the foundational aspects of field identification have been covered and the ICC observes growth and confidence in the field scout, the ICC can teach scouting strategies, the next scaffolding piece of field training. These strategies are based on the biology and ecology of the crop and associated pests. The frequency of scouting needs to be determined and can be adjusted later in the season depending on the pest pressures or farmer management practices. From my experience with row and perennial crops, a seven-to-10-day field visit frequency is a standard practice for independent crop consulting companies. Scouting strategies incorporate different scouting patterns and detailed sampling methods for specific pests. While scouting, a quantitative assessment of the pests must be recorded in a field report. A field report contains the observational data collected and management recommendations, if needed to prevent an economic loss.

The scouting pattern should be representative of the field and decided on before entering the field. A pattern that is representative of field will help the scout detect if there is a uniform, random, or aggregated distribution of the pest or health of the crop (Figure 2.4) (Davis 2000). Topography, soil type, etc. can contribute to the distribution of pests in the field. For example, Canada thistle (*Cirsium arvense*) has an aggregated distribution because of the perennial nature and extensive root system (Bryson and DeFelice 2010). An M, S, V, or W shaped pattern is recommended for scouting as shown in Figure 2.5 (Doll et al. 1998). The pattern should be perpendicular to how the crop is planted. If the field is planted north-south, then the field should be scouted west-east. This perpendicular pattern will allow the scout to see in between the rows better than if looking with the rows.

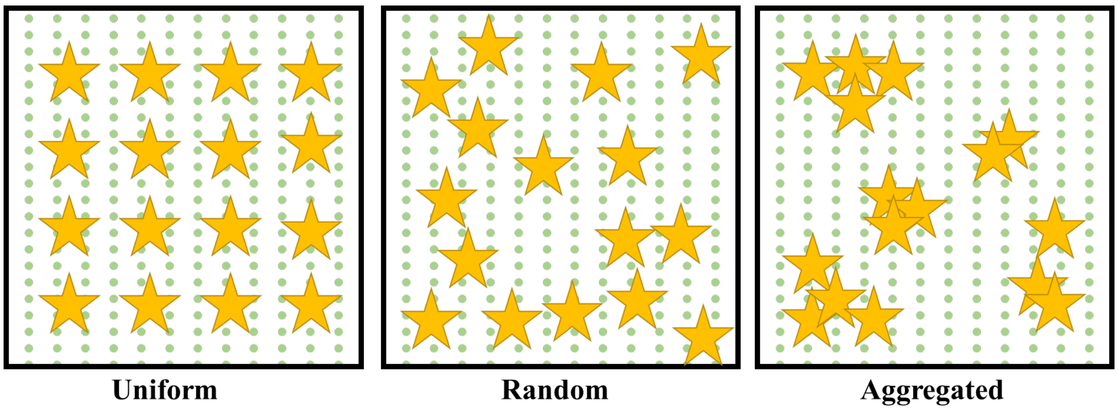



Figure 2.4. Distribution patterns in a field. The green dotted lines represent crop rows, and the yellow stars represent pests' distribution.

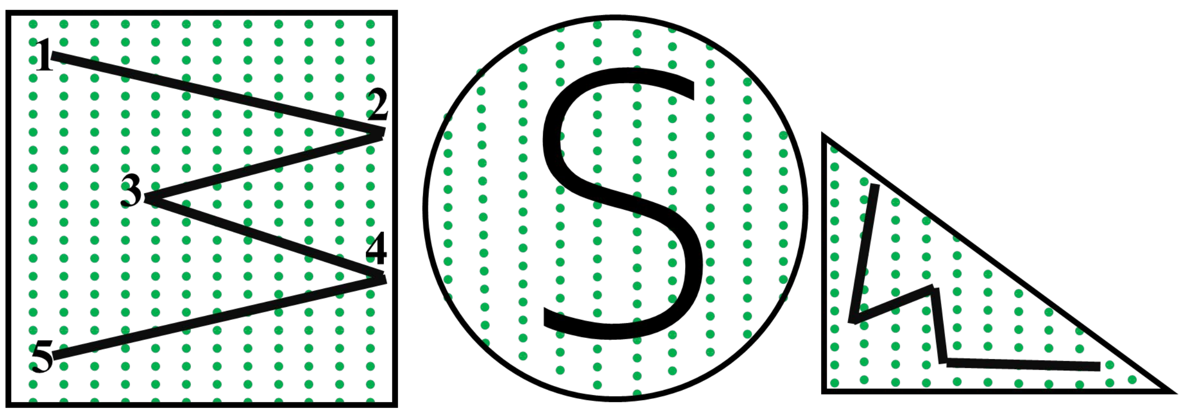



Figure 2.5. Example scouting patterns for various shaped fields. An example of numbered sites is shown in the square field.

Scouting patterns may vary with the crop and if it is being scouted on foot or using an ATV. Scouting on foot often occurs for specialty crops. Walking reduces the amount of dust that is kicked up which can contribute to TSSM infestations (e.g., hops). While scouting a field on foot, sites are selected to obtain a representative sample of the field. The number of sites used per field is adjusted according to the size of the field; the larger the field, the more sites used in a field. The sites are located along the chosen sampling pattern for the field. Protocols for site location may vary depending on the company, crop, and pest. An example of site locations is shown in the square field in Figure 2.5. When walking between sites it is important to note any abnormalities compared to the rest of the field.

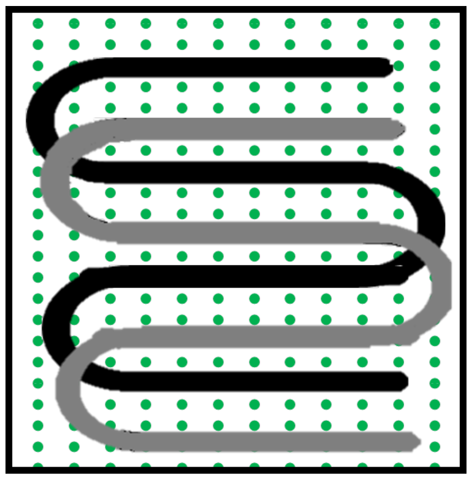


Figure 2.6. Example scouting pattern for an ATV.

An ATV is usually used when covering large row crop fields. Scouting with an ATV occurs early in the season when crops are in their vegetative growth. Utilizing an ATV will cease after certain crop growth stages or when the crop has exceeded roughly 18 inches (approximate clearance of an ATV) to prevent plant injury or damage. An ATV is not used after the joint stage of small grains, the vegetative stage six (V6) of corn (because the growing point is above ground), and after canopy closure of soybeans. Further scouting of row crops will occur on foot after these growth stages. While scouting on an ATV, a serpentine pattern is followed as shown in Figure 2.6. Every time a field is scouted, the pattern should be offset from the pattern that was scouted last.

Offsetting the scouting pattern will help the scout see slightly different areas of the field with the potential of identifying abnormalities in the field.

In contrast to scouting on foot, scouting using ATV allows for nearly the entire field to be observed, but practice is needed for training the eye for efficient observation. For example, the width of the serpentine pattern should be adjusted to how far a person can see. If the field scout does not have confidence in identifying a weed from a distance, then the serpentine pattern should be closer to ensure the entire field is being observed to catch anything abnormal. The ICC needs to encourage the scout to use the ATV as a tool because there is still a need to get off the ATV and look at the crop or pest up close. Another challenge while scouting on an ATV occurs when wind distorts the expected shape or outline of a weed, and a closer look may be needed for correct identification.

Throughout the season the pace of scouting row crops will change. The speed of the ATV while scouting should be adjusted to ensure that the scout is not missing pests. A decent speed to start scouting is about 8-10 mph. The ICC can aid the scout in adjusting his or her pace on the ATV by comparing notes on a field. If the field scout is missing essential weeds that need to be controlled, then the scout should reduce his or her speed on the ATV. As previously mentioned, the field visit frequency is seven to 10 days, and that means after roughly a month, the fields have been thoroughly scouted with all weeds being documented and quantified.

The ICC can determine if the scouting pace should change and tell the scout to do quick passes. These passes generally occur right before scouting on an ATV ceases due to crop growth stage or an ATV clearance. The typical serpentine pattern should be limited to potentially only a V-shape or less to limit damage or injury to the crop. Quick passes mean scouting is altered where the fields are scouted a bit faster to observe and document major weed problems or patches. This altered scouting provides the needed information for the ICC to determine the best timing on when the farmer should apply herbicides. Earlier passes have helped identify weeds and problems areas in the field, while quick passes help fine tune the herbicide application for the growth stage/height of the weeds and appropriate crop growth stage. For example, if there is volunteer corn in a soybean field and the whorl of the corn plants are roughly 10 inches, the herbicide recommendation may need to be changed to another herbicide to ensure control. An ICC can direct the field scout the exact pattern he or she may want the field scout to follow. Once mid to late growing season has been reached the scouting pace changes, but the pests present in the field will also change. Local field guides for specific crops may have monthly scouting calendars that display the dates when you are more likely to observe pests.

**Quantification of Pests**

The teaching of the scouting pattern should be accompanied with sampling methods to quantify pests that are observed in the field. Due to the biology and ecology of the pests, sampling methods to measure or quantify pests vary. For example, quantification of a sample could include the actual pest number, pest density, a scale of damage, or percentage of infestation, ground cover, diseased plants, etc. The purpose of quantifying what is observed in the field is for the ICC to make a management recommendation based on an economic threshold (ET) if one exists for the pest. Economic thresholds are developed from relationships between pest density and yield loss derived from field research studies. Each pest discipline has a slightly different definition for an ET:

- Weed Science - "weed population at which the cost of control is equal to the crop value increase from control of the weeds present" (Coble and Mortensen 1992)
- Entomology - “the pest density at which management action should be taken to prevent an increasing pest population from reaching the economic injury level” (Pedigo and Rice 2009, p. 260)
- Plant Pathology - "the level of disease, i.e., the amount of plant damage, at which control costs just equal incremental crop returns" (Agrios 2005, p. 274).

Regardless of the specific ET definition, the goal of the ICC’s management recommendation is to prevent economic yield loss which is “the difference between the attainable yield and the actual yield” (Agrios 2005, p. 273). Additionally, ICC’s generally take a proactive approach in management by forewarning farmers of potential pests (e.g., weeds and arthropods) that could move into their geographical area and keep track of conducive environmental factors that favor plant pathogens. A proactive approach combines a variety of management strategies besides pesticides that include: biological control, when possible, cultural practices (e.g., narrow row spacing), mechanical control (e.g., tillage), prevention for pathogens, and many other management practices that can be altered to fit the farmer’s need.

Another component the ICC takes into consideration while tailoring the recommendation to a specific farmer’s field is the field history of the pest, pesticide usage, typical management practices, weather conditions, weed seedbank, etc. Without quantifying the pests, recommendations cannot be made. Even though the field scout is not creating recommendations it can be beneficial for the scout to understand the concepts that contribute to creating the recommendation. This will help the field scout realize the purpose behind what they are doing and the importance of the data collection.

Weed science

In weed science, there are limited ETs for a specific weed in a cropping system and the value of a threshold density for weed management has been questioned (Zimdahl 2018a). The ET of velvetleaf (*Abutilon theophrasti*) in corn was calculated by Cousens (1985), and estimates from the resulting model ranged from 0.3 to 2.4 plants/$m^2$ (Zimdahl 2018a). Even when only four to five velvetleaf plants/$m^2$ competed with corn, velvetleaf produced 8,000 – 10,000 seeds/$m^2$that went into the seedbank (Zimdahl 2018a). There is a diversity of weeds in any given field; therefore, a single ET for a specific weed would be impractical for the ICC to use. Furthermore, this emphasizes the need to manage weeds over time because of the weed seedbank and the variability year to year. Yield loss from all competing weeds must be considered when and ICC makes management recommendations.

Plant competition for nutrients, water, and light is the most harmful aspect of weeds contributing to yield loss (Zimdahl 2018b). Thus the threshold concept for weeds is based on the response of yield and measured by population variables such as “density, biomass, or percent ground cover” (Coble and Mortensen 1992, p. 199). Individual crop consulting companies may create their own scales that they use to quantify the potential impact from weeds, or they many use the actual weed density in the field. An example of a density scale that can be used is shown below:

- "*Scattered-Weeds present but very few plants within the field. Enough plants to produce seed but not likely to cause economic loss in the current year.*
- *Slight-Weeds scattered throughout the field, an average of no more than 1 plant per 3 feet of row, or scattered spots of moderate infestations. Economic loss unlikely but possible in certain areas.*
- *Moderate-Fairly uniform concentration of weeds across the field. Average concentrations of no more than 1 plant per foot of row or scattered spots of severe infestations. Economic loss likely unless control measures taken.*
- *Severe-More than 1 plant per foot of row for broadleaf weeds and 3 plants per foot of row for grasses, or large areas of heavy infestations. Economic loss certain unless weeds controlled.*" (Doll et al. 1998, p. 2)

The scale above is missing an important component needed for the management recommendation, weed growth. Due to plant competition being a concern for yield loss it is necessary to know the average weed height and/or growth stage of the weeds (could use BBCH system) for the ICC to make the correct herbicide recommendation. As mentioned before herbicide rates may change due to weed density or height. Thus, the scale should be used for each weed species identified in the field along with the plant growth stage or height. For example, waterhemp is moderate at an average height of six inches and common ragweed is slight at a height of four inches.

Entomology

Due to the diversity of arthropods, there are a variety of direct and indirect sampling techniques to estimate arthropod populations. The sampling unit is "a proportion of habitable space from which insects count are taken" (Pedigo and Rice

2009b, p. 216). Common direct sampling techniques for insect / arthropod pest management are *in situ* counts (i.e., counting the arthropods directly on the plant, if necessary using magnification), knockdown (i.e., insects removed from their habitat), netting (e.g., sweep net, aerial net), trapping (e.g., the use of baits, Malaise trap, pitfall traps), and extraction from soil (e.g., the use of a Berlese funnels for soil cores) (Pedigo and Rice 2009c). Indirect sampling techniques consists of measuring the effects of insects such as a percent of plants showing "deadheart" caused by a boring insect, or percent defoliation (Pedigo and Rice 2009c). From these techniques, two kinds of arthropod population estimates emerge: an absolute and relative estimate. An absolute estimate measures the actual number of arthropods in the population (e.g., number per plant, number per tiller, or number per acre) (Pedigo and Rice 2009c). Whereas relative estimates provide a relative measures arthropod activity or presence (e.g., number per trap, number per sweep) (Pedigo and Rice 2009c).

A sampling program is the procedure that is implemented to guide how sampling units should be taken. This includes the: 1) arthropod stage to sample, 2) number of sampling-units per sampling site and per field, 3) spatial pattern to obtain sampling units (e.g., S, V, M or W shaped pattern), and 4) the seasonal timing and frequency of sampling (Pedigo and Rice 2009c). Knowing the arthropod stage that causes damage is essential in determining the sampling procedure and ultimately making management decisions. For example, lepidopteran larvae consume a lot of leaf material just before they pupate. If these pests are approaching maturity, they will soon stop feeding and pupate. Thus, treatment would not be necessary because they have already done their injury to the plant.

Insect pests can cause injury but not necessarily damage. Entomology makes a distinction between injury and damage. Injury is "the effect of pest activities on host physiology that is usually deleterious" (Pedigo and Rice 2009b, p. 256). Insects defoliating a plant is an example of injury. Damage is "a measurable loss of host utility, most often including yield quantity, quality, or aesthetics" (Pedigo and Rice 2009b, p. 256). An insect damaging the sweet corn ear, such as the corn earworm (*Helicoverpa zea*) is an example of direct damage (Bessin 2019). The bean leaf beetle (*Cerotoma trifurcata*) is an insect that causes both injury (i.e., defoliation) and damage (i.e., to soybean pods) (Hodgson 2017). In Nebraska, there are two generations, and the first generation causes injury feeding on the leaves. Depending on the severity of the defoliation injury and the growth stage of the soybeans, this injury can result in damage (i.e., yield loss). The second generation of beetles also feeds on the pods, causing damage to the beans (Ohnesorg and Hunt 2015; Hodgson 2017).

The growth stage of a plant will impact the damage resulting from defoliation. For example, soybeans in the vegetative stage can withstand defoliation up to 30% without significant yield loss because new leaf growth will continue allowing for greater light interception (i.e. photosynthetic activity) and compensate for the lost leaf area (Ohnesorg and Hunt 2015). Although, during the reproductive stages soybean treatment should be considered if defoliation exceeds 20% because plants at these stages are more sensitive to leaf loss (Ohnesorg and Hunt 2015). Therefore, training the scout to estimate defoliation is necessary to determine management recommendations especially when there are multiple insects feeding. LeafByte, a free application (for Apple products) is a great tool to the train the eyes in estimating defoliation. It calculates the percent defoliation by measuring the total leaf area and consumed leaf area. Figure 2.7 displays a range of defoliated soybean leaves from 4 - 39 % as calculated by LeafByte.

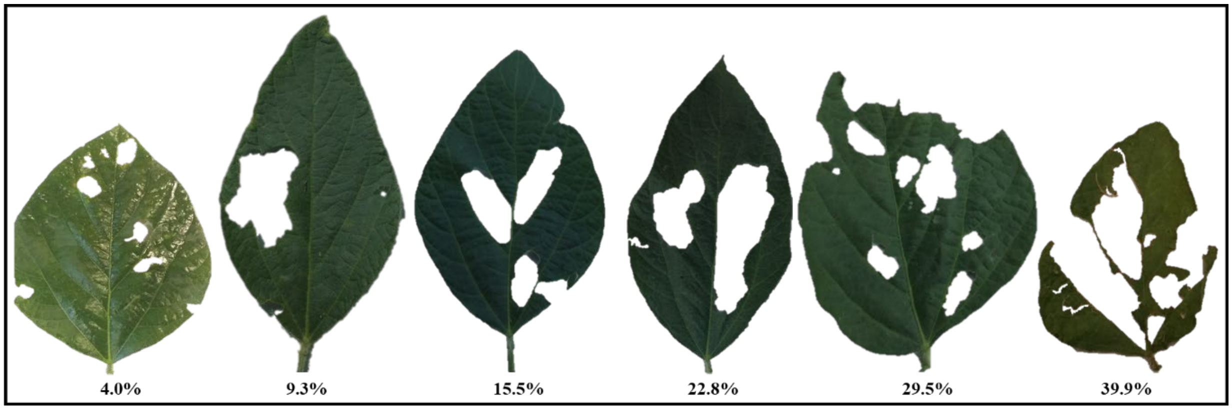



Figure 2.7. Increasing percentage of defoliated soybean leaves. Leaf defoliation estimated by LeafByte app (https://zoegp.science/leafbyte).

The experience of an ICC can enhance the entomology training of a field scout by familiarizing them with arthropods that are commonly present in that geographic location. In addition, with the ICC's experience and local knowledge, they may be able to alter an insect specific sampling plan to include areas where they are more likely to first observe a pest. For example, the soybean aphid (*Aphis glycines*) overwinters on buckthorn trees *(Rhamnus cathartica)* (Koch 2016)). Therefore, "hot spots" of soybean aphids are often found in fields which have tree lines nearby (Koch and Potter 2018). An experienced ICC knows that certain fields fit these criteria, and they will scout these areas thoroughly to determine how much time is needed to scout for soybean aphids in other areas. The ICC can share this local knowledge with the field scout, to aid them in scouting efficiency.

Plant pathology

The discipline of plant pathology has unique metrics for disease assessment (Nutter et al. 1991). These quantitative measurements include disease intensity, incidence, severity of disease, and disease prevalence (Nutter et al. 1991; Bock et al. 2010; Agrios 2005c). The “general term for amount of disease present in a population” is disease intensity (Nutter et al. 1991, p. 1187). Disease intensity is “commonly expressed as either disease incidence … or disease severity.”(Teng 1983). Disease incidence is the “number of plant units sampled that are diseased expressed as a percentage of the total number of [plants] units assessed, e.g., proportion (percentage) of plants diseased in a population” (Nutter et al. 1991, p. 1187). The severity of a disease is the “area of sampling unit (plant surface) affected by the disease, expressed as a percentage or proportion of the total area” (Nutter et al. 1991, p. 1187). Disease prevalence is the “incidence of fields with diseased plants in a defined geographic area (county, state, etc.), i.e., number of fields where a disease is present divided by the total number of fields sampled” (Nutter et al. 1991, p. 1187). A farmer may ask the ICC if this disease is seen in other areas scouted. Essentially the farmer is asking the ICC about disease prevalence but is not using this terminology.

The above terminology is not commonly used between an ICC and farmer, but it is still important to teach the field scout, so he or she is aware and understands this terminology when speaking with others. University Extension provides updates to the agricultural community (often using this terminology), to forewarn to scout for diseases. Disease intensity, prevalence, incidence, and severity provide the broad scope of disease assessment, but signs or symptoms of the disease need to be established through visual estimation or digital imagery (e.g., image analysis in the visible spectrum) (Bock et al.

2010). Independent crop consulting companies often use visual estimation with a rating scale (i.e., description in words or numbers, ranging from no disease to fully diseased) that are created as standard scales for the specific pathogen (Nutter et al. 1991).

Four types of rating scales are typically used to visually measure plant disease: nominal or descriptive scales, ordinal rating scale, ratio scale, and interval scales (Bock et al. 2010). Descriptive scales divide the disease intensity into classes often using terms such as, “slight”, “moderate”, or “severe” (Bock et al. 2010). However, descriptive scales can be highly variable depending on the individuals rating them and on the lack a quantitative definition.

Arbitrary classes are created for ordinal scales, where each class represents an increase in the severity of disease symptoms. An example of this scale used for the severity of *zucchini yellow mosaic virus* and *watermelon mosaic virus* on watermelon is “0=no symptoms; 1=slightly mosaic on leaves; 2=mosaic patches and/or necrotic spots on leaves; 3=leaves near apical meristem deformed slightly, yellow, and reduced in size; 4=apical meristem with mosaic and deformation; and 5=extensive mosaic and serious deformation of leaves, (or plant dead)” (Bock et al. 2010, p. 75). This scale has similar faults as the descriptive scale because it is highly variable depending on the rater. However, they are still widely used for specific diseases, especially when symptoms are hard to quantitatively measure (Bock et al. 2010).

The ratio scale estimates the disease severity using a continuous percentage scale (Bock et al. 2010). Advantages of this scale are that the upper and lower limits are consistently defined (0 and 100%) and that this scale is universally familiar which is beneficial in communicating field observations. The final rating scale is the interval scale consisting of a number category that has a known numeric value (Bock et al. 2010). The Cobb scale used to access the severity of rusts on wheat was the first interval scale developed. Cobb's scale includes a standard area diagram (SAD) that is displayed on a wheat leaf or head with five levels (1-5) of rust that represent 1, 5, 10, 20, and 50% disease (Bock et al. 2010). The rater then selects the correct category that best matches the leaf. Standard area diagrams have been shown to improve the accuracy of the raters (e.g., field scout and ICC) (Bock et al. 2010). Examples of SADs can be found in Bock et al. (2010). This is a similar concept to estimating the percentage of leaf defoliation in entomology. Calibrating the field scout in their ability to rate or estimate intensity is important for consistency in the measurements between the ICC and scout.

Regardless of the visual scale being used by the ICC and field scout, it is critical to include the growth stage, affected plant part (e.g., foliage, stem, flower, fruit, root, bulb, etc.), and distribution (e.g., lower leaves vs. higher leaves) of the disease on the plant and on the plant part observed. These differences can be important in determining management strategies, specifically if a fungicide is needed to protect specific growth stages. Corn and wheat are good examples because the ear leaf (corn) and the flag leaf (wheat) contribute significantly to grain fill, and protecting this plant material ensures maximum photosynthetic capacity of these leaves (De Wolf 2018). An example of a disease where growth stage and disease distribution on the plant is critical with stripe rust of wheat.

Inoculum of stripe rust (*Puccinia striiformis*) of wheat can overwinter as mycelium and/ or urediniospores on volunteer wheat or urediniospores can be blown into an area via southernly winds (De Wolf 2018). This disease occurs with cooler temperatures (50-59°F) and eight hours of free moisture on leaves (Wegulo and Byamukama 2012). Symptoms begin on lower leaves and proceed to the top of the plant. A fungicide application for stripe rust will depend on the growth stage when its presence is first observed, but must also account for the pre-harvest interval (PHI) stated on the fungicide label. (Wegulo and Byamukama 2012).

Throughout the season different diseases will be present due to environmental conditions and because certain growth stages of the crop are more susceptible than others. An understanding of disease cycles and their interactions with cropping systems (i.e., annual and perennial crops) will greatly aid in scouting. As previously mentioned, arthropods can be vectors of diseases; therefore, in these cases it is necessary to consider the insect lifecycle in establishing the scouting process. In corn and soybeans, seedling blights (e.g., *Fusarium* spp., *Rhizoctonia* spp., *Phytophthora* spp., *Pythium* spp.) will appear near the beginning of the growing season (Munkvold and White 2016; Hartman et al. 2015). Whereas foliar diseases (e.g., *Cercospora* spp., *Puccinia* spp., *Peronosclerospora* spp., *Erysiphe* spp., etc.) occur mid to late season when there is more vegetive growth (Munkvold and White 2016; Hartman et al. 2015). Late season diseases in annual crops could include various types of rots (i.e., stalk, stem, ear, root, etc.), white mold (*Sclerotinia* spp.), and others. The occurrence of disease does not stop at harvest because pathogens can impact the end product (e.g., grain, fruit, vegetables, etc.) in storage.

A good understanding of disease cycles (including the environmental conditions) and susceptible growth stages of crops will increase the likelihood of timely disease management; however, a disease outbreak can still be missed. In these instances, valuable information can be collected and added to the field history to benefit future decision making. An experienced ICC, who has scouted a field for many years will know areas of the field that are more prone to various diseases (i.e., “hot spots”). With this knowledge, an ICC will be able to guide the field scout to these areas and show them what to look for in other fields. Local knowledge, plus input from disease forecasts made by universities or other organizations/companies (e.g., iPiPE- Integrated Pest Information Platform for Extension and Education, Spornado, Sporecaster, etc.) can greatly aid in scouting for disease. All observed pests in the field must be quantified and documented for the ICC to create field reports for the farmer.

**Entering pest quantification/data entry**

Independent crop consulting companies will have different platforms to collect data (i.e., quantified identified pests, crop health, etc.) and get it to the hands of the farmer. In the field, there are several ways to document data including manually recording on a crop-specific field sheet or using a digital voice recorder. Both ways require that the data be later inputted into the computer software that the company uses to produce the field reports. However, if a tablet or iPad is used to enter data in the field, this bypasses the step of entering the data from the written crop sheets or digital recorder.

To make data input simpler when using either method, it is important to have a standard method to record the data, so the person entering the data into the computer program can easily read and understand observations. For example, when an ICC or field scout enters the field, the first thing is to record the farmer’s name, field name, crop, and crop stage. The next observations would be the pest, pest stage (e.g., weed height, insect life stage), pest rating, and plant population. It is important to document all observations in the computer program. Later the ICC can decide to include or exclude those notes on the field report. These notes are valuable for field history in case something occurs later in the season. An example of this might be a wet area in the field that could later be a "hot spot" for a disease. An ICC may not want the farmer to be concerned with this as the farmer is unable to do anything about it anyway; therefore, these notes are not relevant for the farmer at this time.

Regardless of the scale that is being used for monitoring crop health and pests, it is critical for effective communication that there is a common understanding of the scale and terminology between the ICC, field scout(s), and farmer. The ICC needs to know the farmer's expectations on how to document the pests. For example, in hops the number of aphids, TSSMs, predatory mites, etc. will be recorded by site location, but the average aphids per leaf per field is also included in the field report. If this exceeds the ET, then the ICC will provide a recommendation for a pesticide application. This allows the farmer to make an actionable decision on what he or she wants to do for management. Additionally, there needs to be clear communication and calibration between the ICC and field scout concerning the interpretation of the scale being used. For example, a field having 'moderate waterhemp at six inches in height' needs to mean the same for both the ICC and scout.

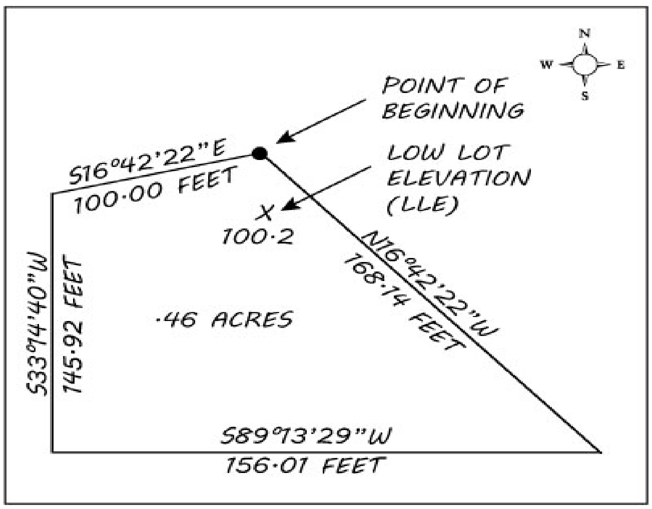
Throughout the field training process, there needs to be an open dialogue between the field scout and ICC, so they can ask questions of one another. This helps the field scout understand scouting expectations, and the ICC can gauge the field scout's understanding of concepts. The initial training of the field scout should occur in multiple fields so the ICC can show different management practices and potential pests. Depending on the comfort level of the field scout, an ICC can determine how to continue the training process either jointly or independently. Either way, the field scout will need to know how to navigate from field to field after the ICC has shown the scout the agronomic foundations of scouting.

**Navigating to the field**

ICCs and medical doctors are similar because they both identify and diagnose problems; however, ICCs have to travel to their ‘patients’ (i.e., fields). Understanding how to read a map is an indispensable skill that field scouts must learn so they can locate fields. Navigating to fields using GPS coordinates or specific areas within the field can be quite effective. Although the luxury of using digital devices if not always available due to lack of reception. An understanding of dividing land as per the legal descriptions greatly enhances the field scout’s ability to navigate to the field. Then field scouts can aid the ICC in developing efficient scouting routes.

Legal descriptions of the fields are described in property deeds. These legal descriptions are developed from the Metes and Bounds system or the Public Land Survey System (PLSS). While the farmer may not use the legal description for the field name, ICCs may prefer to use the legal descriptions. This allows the ICC to see where multiple farmers’ fields are in context on a map, instead of using names like ‘Allen’s half by Johnny's’. The farmer’s field name has no bearing on its location if you do not know where Johnny’s place is. Therefore, for clear communication, both the legal name and what the farmer calls the field should be on the field report.

Metes and Bounds tracks a path around the property from a logical starting point and is primarily used in the eastern United States. These descriptions consist of a boundary line, a bearing, and then a distance for both lines (Gay 2015). Metes refer to measurements which are the bearings and distances. Monuments (e.g., abutter, stone wall, stone monument) that fix the location of the line are bounds (Gay 2015). An example of a Metes and Bounds illustration and legal description is shown in Figure 2.8.




"The area is shown as .46 acres

The Low Lot Elevation (LLE) is show with an X and labeled 100.2

A compass with N at the top is located in the right side of the image.

The lines and markings around an irregular shaped lot represent: BEGINNING at the northeast lot corner; thence S16°42'22"E, 100.00 feet; thence S33°14'40"W, 145.92 feet; thence S89°13'29"W, 156.01 feet; thence N16°42'22"W, 168.14 feet to the POINT OF BEGINNING."

Figure 2.8. Illustration and legal description of land using Metes and Bounds. Illustration and description credit to https://emilms.fema.gov/IS1120/groups/77.html.

For most states across the United States, the PLSS has been used to divide the land into square parcels. The PLSS began in 1785 in Ohio and was established by the General Land Office which later merged with the Bureau of Land Management (Gay 2015). This method of dividing the land does not apply to Georgia, Connecticut, Delaware, Kentucky, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, North Carolina, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Virginia, and Texas (Gay 2015). In Texas, a variation of the PLSS system is used (Gay 2015). To comprehend this system, it is helpful to be familiar with its terminology.

There are several terms that the PLSS is based on including initial points, principal meridians, and base lines. The principal meridians and base lines originate from initial points, which are fixed on the ground in various locations across the United States (Gay 2015). Meridian lines run north-south and converge at the earth's poles. Unlike meridian lines, base lines are true west and east and are parallel to the equator. The convergence of the meridians results from fitting a two-dimensional plane to a spherical earth. Township lines are north to south and range lines are west to east every six miles forming a grid. The 6x6 mile grid formed by the township and range lines (36 square miles) forms a township.

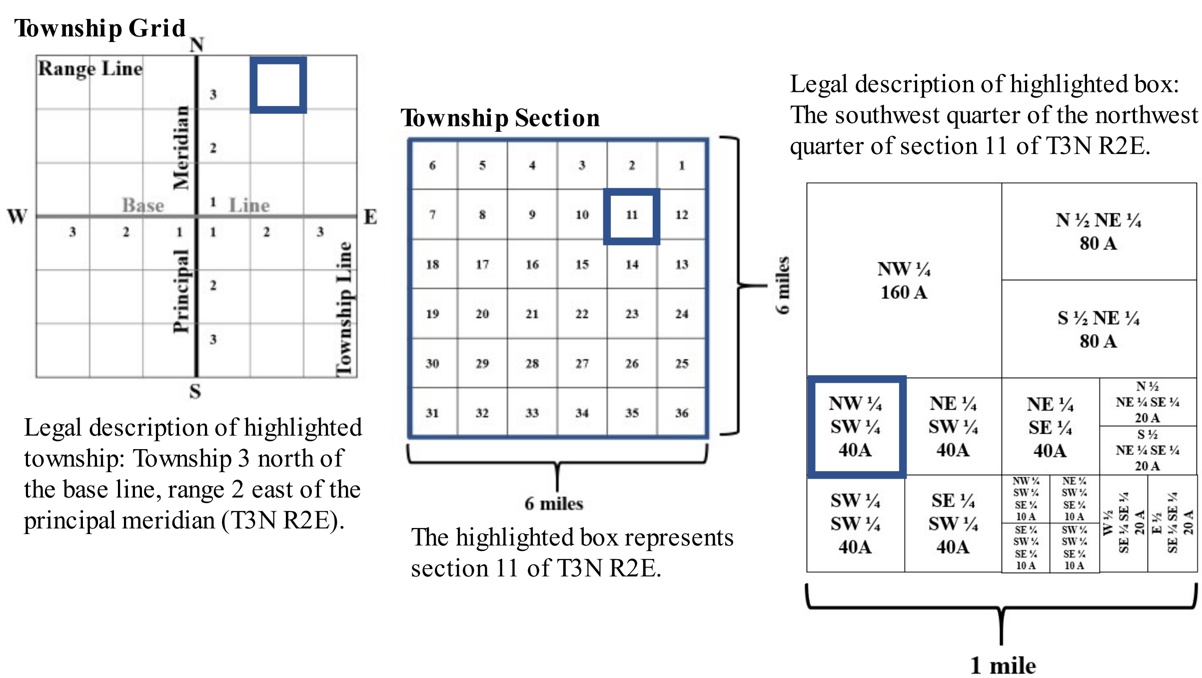



Figure 2.9. Illustration and legal description of land using the Public Land Survey System (PLSS). From left to right an illustration of the township grid (T3N R2E), township section (11), and 40 acres of land in section 11.

A legal description of a township (e.g., T3N R2E) describes township three north (of the base line) and range two east (of the principal meridian). This is a general description of a township, and naming of the specific principal meridian (e.g., sixth principal meridian) is needed to clearly distinguish this township from others. Townships are further divided into 36 square mile sections. Section one of a township is located in the northeast corner, and the sections are numbered sequentially to the east and continue in a serpentine pattern with section 36 in the southeast corner of the township (see Figure 2.9). Each one square mile section is further divided into halves, quarters, and smaller units until the piece of land is identified (see Figure 2.10. Not all sections are exactly one mile in length. Due to the convergence of the principal meridians, sections on the north and west sides of the township are subject to dimensional changes (Gay 2015).

Legal names begin with a specific description and then proceed to a more general location. For example, in Figure 2.9 the name of the 40 acres highlighted in the blue box in the far-right diagram is the northwest quarter of the southwest quarter of section 11 of township 3 north, range 2 east. Awareness of these two systems of dividing the land will aid the scout in understanding how the legal name of the field was developed and provide perspective on the location where fields are in proximity to others. After the field scout has an understanding of the locations of fields, they must navigate to them by using directions.

Teaching how to navigate can be a very challenging task as it comes easily to some individuals but challenging to others. A cell phone, tablet, or iPad, etc. can make navigation much easier by using digital maps (i.e., satellite view). Using a compass application on a device can also aid you to know what direction you are facing.

Additionally, the shape of the field can be very helpful to know if you are in the 'right' field or orientate yourself within the field. This can be beneficial when scouting a new field and site locations need to be established for the season. After a few visits to a field, the field scout may not even need to use their device to locate sites. Borders of the field with trees, railroad tracks, river, ridge, etc. can also aid you in knowing that you are in the correct field. When there is not enough reception for the device's application, it is important to figure out other options of how to navigate.

From my experience and speaking with others on this topic there are three main approaches to teach directions: using cardinal directions, utilizing landmarks, and sequential navigation. Cardinal directions are north, south, west, and east. Some people innately know what direction they are facing no matter the circumstance. Although, others may use landmarks to orientate themselves to the cardinal directions by using roads, mountains, rivers, buildings, etc. Sequential navigation requires you to orient yourself to a location on a map and then navigate to the next field based on your current locations. At times sequential navigation can be valuable when a GPS device does not have a signal and there are no distinctive landmarks. Figure 2.10 displays multiple irrigated pivots, and you must navigate to potato field 208. Directions like the following may be helpful. After entering the farm entrance turn north (right), then proceed until you see the first blueberry field and turn west (left) and continue past the third blueberry field and the next mint field to the first potato field.

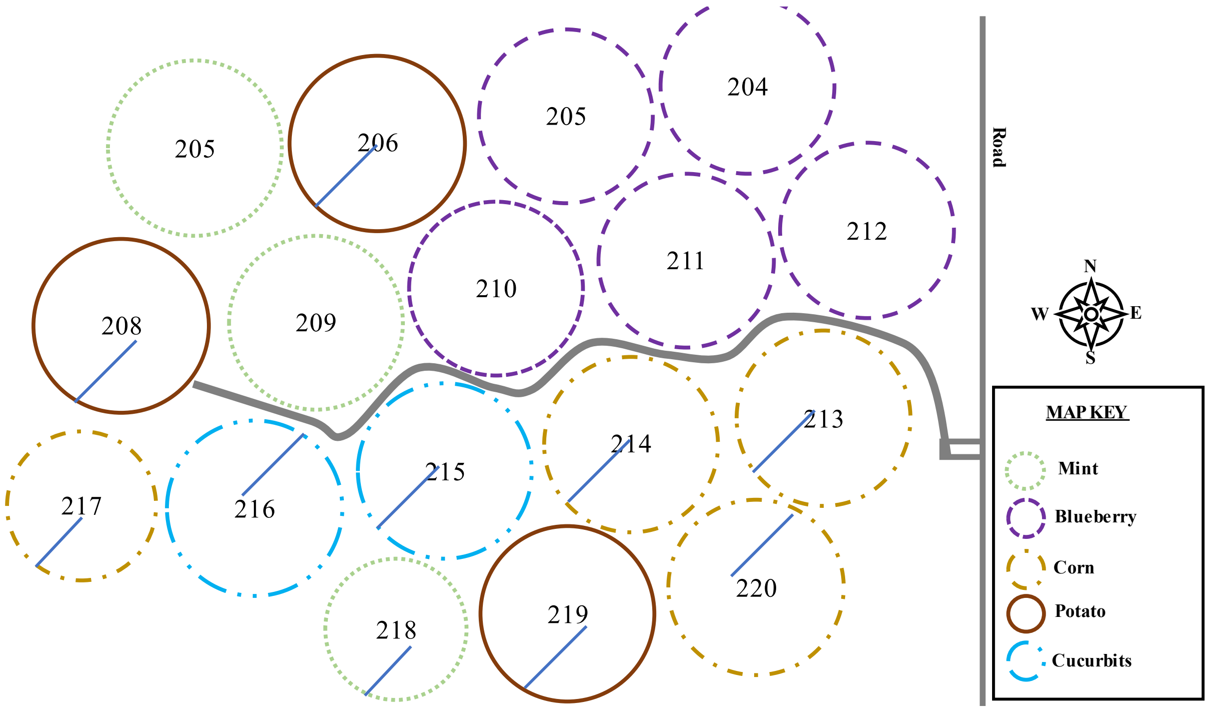



Figure 2.10. Illustration displaying sequential navigation through pivot irrigated fields.

Systematically planning the route for scouting fields or site locations within a field when multiple individuals are involved is key for efficiently scouting the many acres an ICC has to cover. When there are a large number of fields next to each other that need to be scouted, a good strategy is to work towards each other, where one person is working clockwise, and the other is working counterclockwise. Systematic route planning allows for all individuals to eventually meet each other. This strategy is shown in Figure 2.11, the field borders are represented by the black lines are all fields need to be scouted. The field scout can start on the west side of the road and work south as shown by the blue circles. Then the ICC starts on the east side of the road and progresses south until he or she meets the field scout. A similar method can be applied for scouting using field sites in a field where one individual covers the sites which are on the north side of multiple fields and the other covers the south site locations. It is good for the ICC to mention the field or site location where they will most likely meet the field scout. This helps the field scout keep a pace that is comfortable for themself. If the ICC is not in this location, then the field scout should communicate with the ICC to make sure the field or site is already done or if they are okay.

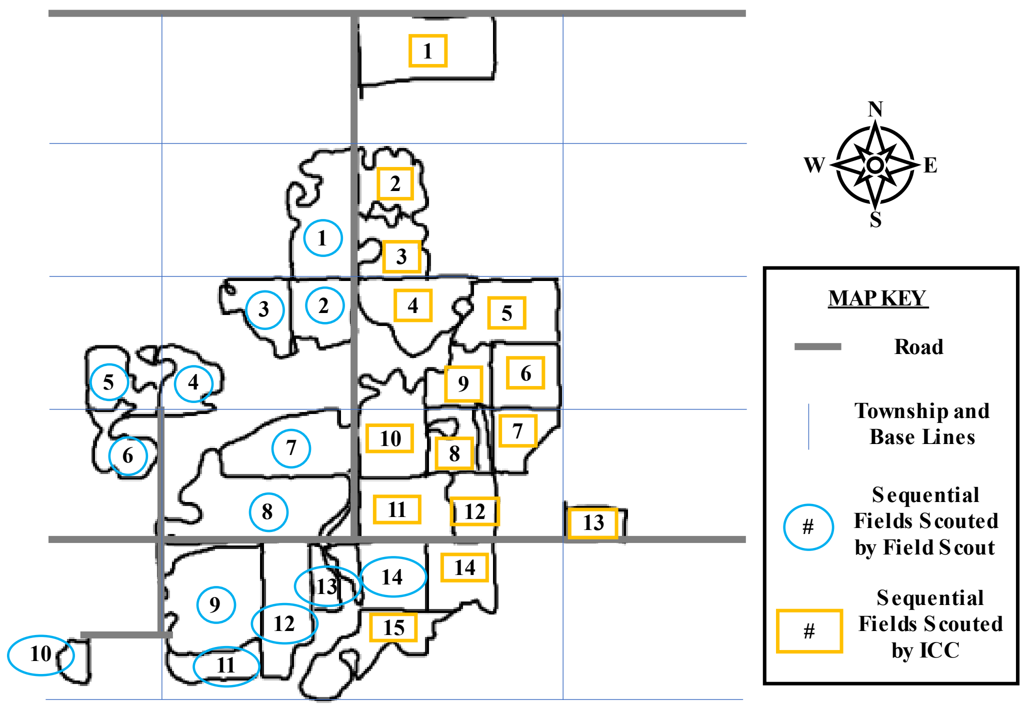



Figure 2.11. Systemic route planning for scouting. The black outlines represent fields. The field scout with scout all fields with the blue circle and the ICC will scout the fields with yellow squares.

In this route planning strategy, the individuals involved need to be able to distinguish field borders especially when fields are adjacent. When you are in large fields, and field borders, like trees or a road, are not easy to recognize an ICC needs to point out other characteristics so the field scout can recognize when they are in a different field. Field borders can be located by observing the direction in which the crop is planted, different crop residue compared to the rest of the field, observing distant tree lines which are often planted on section lines, or observing if a new field entrance is nearby. For most hop yards, the field is labeled by the farmer with a number, but if there are multiple varieties within a field and they are managed differently, then paying attention to the skip row(s) (i.e., rows not planted to separate hop varieties) is important to distinguish varieties within a yard. When you are scouting pivot irrigated fields, the field border is usually distinct because field lanes are usually surrounding them; however, that does not make navigation easy as the field lanes are not in a true direction because of their curve. Depending on the situation, route planning may not always work, and improvising is the best strategy. Developing the field scouts' navigation skills is critical in successfully locating fields by incorporating how the land is divided, how they use directions depending on the situation, and how they develop the field route for scouting.

## Applying Experiential Learning to Field Scenarios

As the summer progresses and the field scout develops confidence in their scouting abilities, the ICC can continue training by having them apply their skills and knowledge to put the puzzle pieces together. Experiential learning can occur at various levels as demonstrated in the following scenarios. The ICC can aid the field scout in the process by asking questions like: 'what do you think happened here?' from the symptomology of this weed, 'what herbicide was applied?', 'after scouting the field, do you think an insecticide is needed?', 'was this field recently sprayed with an insecticide?', 'what management practice will be beneficial next year to prevent this situation?'. These questions help the field scout reflect upon their field observations (i.e., reflective observation component of experiential learning). While a field scout may answer 'I do not know', it is important to aid the field scout in thinking through their field observations (i.e., abstract conceptualization component of experiential learning). Some of these observations could include crop health, the appearance of herbicide injury or a nutrient deficiency, observing what weeds are dying or not dying. These observations could contribute to a better understanding of the field scenario (i.e., active experimentation component of experiential learning). After discussing these scenarios with the ICC, the field scout can interpret the observations. This is completing the fourth component of experiential learning: concrete experience. The following scenarios occurred during my internship and included components of experiential learning.

While scouting a carrot seed field in Washington, I had the opportunity to put together the puzzle pieces and help my co-worker understand the situation. Because these carrot fields were scouted weekly, we knew that we had seen an increase in insect activity in the fields and knew that insect activity early in the morning was less than their activity by noon. We also observed that the beehives were removed from the field borders, as compared to last week.

We arrived at the first field that morning (~7 a.m.), as normal I went to the first field site and conducted my sweeps (i.e., using a sweep net), there was little activity in the net, and some insects were on the ground. I proceeded to the next site and noticed these same observations. Taking another look at those insects on the ground, I noticed that some were upside down and legs twitching. This was not a normal sight that we have seen in the carrot field before. From these observations and comparison to the normal observations, I was able to conclude that the carrot seed field was recently sprayed with an insecticide. My co-worker did not connect these observations as quickly, but I was able to go through these observations and discuss what led me to this conclusion. Since an insecticide had not been previously sprayed, I proceeded to call our boss to update her and to ask what insecticide was applied and what the re-entry interval (REI) was for that specific insecticide. We were past the REI of the insecticide, thus we continued to scout the field to ensure the insecticide application worked as expected.

Another example of putting together the pieces is a corn field scenario in North Dakota. The corn was roughly at vegetive stage five, this field had a moderate amount of weed seedlings that were roughly six inches in height; however, in the lower areas of the field, there were fewer weeds observed. The next week that the field was scouted there were very few weeds observed in the field. This was a tougher scenario to determine what occurred without knowing what the farmer had applied to the field. During the week in between the visits, it had rained in this area. The farmer had applied a residual soil-applied herbicide, thus resulting in the lower areas having fewer weeds because of the moisture as compared to the rest of the field. The rain during the week activated the herbicide and that is why the rating of the weeds decreased to very few in the field.

Piecing information together is important for scouting, but also for safety. These examples emphasize the need for communication between the ICC and farmer especially when it comes to pesticide application. But the ICC must communicate appropriate instructions and precautions to the field scout. The pesticide label is the law and should be followed for the safety of all involved. Another safety aspect is for the field scout and ICC to follow through with the established field route. Then if something happens, the other person will have a better idea of where to look for them. One occurrence of this is when the field appear to be ‘safe’ to drive through with an ATV, but the next thing you know, you are stuck in mud. When scouting on foot, the same rule applies because heat stress or other emergencies can occur, and assistance could be required.

## Conclusion

Teaching a field scout to scout can be a challenging task during the fast-paced planting season. Yet it can be rewarding for both the ICC and field scout and contribute to a successful summer. The ICC must teach the foundational aspects of scouting including how to monitor crop health, pest identification in the field, scouting strategies, quantification of pests, and finally navigating to the field. Field training uses the scout's previous experiences and education (i.e., experiential learning) and then builds upon their abilities (i.e., scaffolding) all while using an IPM approach. This approach starts with the ICC modeling how to scout fields from identifying to quantifying pests. For the ICC and field scout to learn from each other through the summer, it is necessary to have an open line of communication. This allows the ICC to determine the level of scaffolding needed to develop confidence and mastery in scouting and navigating to fields. While this approach may not cover every aspect of scouting, this serves as a base that can be modified for individual field scouts and the ICC's teaching style.

**Literature Cited**

Abendroth, Lori, Roger W. Elmore, Robert G. Hartzler, Clarke McGrath, Daren S. Mueller, Gary P. Munkvold, Richard Pope, et al. 2009. *Corn Field Guide*. Extension and Outreach Publications. Iowa State University Extension. Ames, IA. [Accessed June 18, 2021]. https://lib.dr.iastate.edu/cgi/viewcontent.cgi?article=1023&context=extension_pubs.

Abendroth, Lori J., Roger W. Elmore, Matthew J. Boyer, and Stephanie K. Marlay. 2011. *Corn Growth and Development*. 1009. Iowa State University Extension. Ames. IA.

Agrios, George. 2005a. "Introduction." In *Plant Pathology*, 5th ed. p. 4 - 74. Elsevier Science & Technology. San Diego, CA.

Agrios, George. 2005b "Parasitism and Disease Development." In *Plant Pathology*, 5th ed., p. 77–103. Elsevier Science & Technology. San Diego, CA.

Agrios, George. 2005c. "Plant Disease Epidemiology." In *Plant Pathology*, 5th ed., p. 272–274. Burlington, MA: Elsevier Science & Technology. San Diego, CA.

American Phytopathological Society. 2021. "Disease Progress." *Disease Progress*. The American Phytopathological Society. St. Paul, MN. [Accessed May 24. 2021]. https://www.apsnet.org/edcenter/disimpactmngmnt/topc/EpidemiologyTemporal/Pages/Disease Progress.aspx.

Attia, Sabrine, Kaouthar Lebdi Grissa, Georges Lognay, Ellyn Bitume, Thierry Hance, and Anne Catherine Mailleux. 2013. "A Review of the Major Biological Approaches to Control the Worldwide Pest *Tetranychus Urticae* (Acari:

Tetranychidae) with Special Reference to Natural Pesticides." *Journal of Pest Science* 86 (3): 361–386. doi:10.1007/s10340-013-0503-0.

BarthHaas. 2021. "Ekuanot® | BarthHaas." [Accessed April 14, 2021]. https://www.barthhaas.com/en/hop-varieties/ekuanot.

BASF Corporation. 2017. "Pursuit ® Herbicide." [Accessed June 15, 2021]. http://www.cdms.net/ldat/ld01S006.pdf.

Bessin, Ric. 2019. "Corn Earworm Management in Sweet Corn | Entomology." University of Kentucky Cooperative Extension Service. Lexington, KY. [Accessed June 14, 2021]. https://entomology.ca.uky.edu/ef318.

Bock, C. H., G. H. Poole, P. E. Parker, and T. R. Gottwald. 2010. "Plant Disease Severity Estimated Visually, by Digital Photography and Image Analysis, and by Hyperspectral Imaging." *Critical Reviews in Plant Sciences* 29 (2): 59–107. doi:10.1080/07352681003617285.

Bradley, Kevin W., William G. Johnson, R. J. Smeda, and Chris Boerboom. 2009. "Practical Weed Science for the Field Scout: Corn and Soybean (2009)." University of Missouri Extension. Columbia, Mo. [Accessed June 10, 2021]. https://mospace.umsystem.edu/xmlui/handle/10355/7582.

Broeske, Mimi, Shawn Conley, John Gaska, and Adam Roth. 2018. *Winter Wheat Development and Growth Staging*. University of Wisconsin-Madison Extension. Madison, WI.

Bryson, Charles T., and Michael DeFelice, eds. 2009. *Weeds of the South*. University of Georgia Press. Athens, GA.

Bryson, Charles T., and Michael DeFelice, eds. 2010. *Weeds of the Midwestern United States and Central Canada*. University of Georgia Press. Athens, GA.

Carris, L. M., C. R. Little, and C. M. Stiles. 2012. “Introduction to Fungi.” [Accessed June 20, 2021]. American Phytopathological Society. St. Paul, MN. https://www.apsnet.org/edcenter/disandpath/fungalasco/intro/Pages/IntroFungi.aspx.

Chittooran, Mary. 2018. “Scaffolding.” In *The SAGE Encyclopedia of Educational Research, Measurement, and Evaluation*, p. 1452–1454. SAGE Publications, Inc. Thousand Oaks, CA.

Cluever, J., Peterson, J., Wright, R., & Bradshaw, J. 2021. *Degree-days for Prediction of Western Bean Cutworm Flight*. CropWatch. University of Nebraska - Lincoln. Lincoln, NE. [Accessed July 26, 2021]. https://cropwatch.unl.edu/2021/degree-days-prediction-western-bean-cutworm-flight

Coble, Harold D., and David A. Mortensen. 1992. “The Threshold Concept and Its Application to Weed Science.” *Weed Technology* 6 (1): 191–195.

Cousens, Roger. 1985. “A Simple Model Relating Yield Loss to Weed Density.” *Annals of Applied Biology* 107 (2): 239–252. doi:10.1111/j.1744-7348.1985.tb01567.x.

Daroub, Samira H., and George H. Snyder. 2007. “The Chemistry of Plant Nutrients in Soil.” In *Mineral Nutrition and Plant Disease*, p. 1–8.: The American Phytopathological Society. St. Paul, MN.

Davis, Paula M. 2000. “Statistics for Describing Populations.” In *Handbook of Sampling Methods for Arthropods in Agriculture*, p. 33–54. CRC Press. Raton, FL.

De Wolf, Erick. 2018. "Wheat Stripe Rust." Kansas State University Agricultural Experiment Station and Cooperative Extension Service. Manhattan, KS. [Accessed June 5, 2021]. https://bookstore.ksre.ksu.edu/pubs/EP167.pdf.

Doll, J., C. Grau, B. Jensen, J. Wedberg, and J. Meyer. 1998. "Scouting Corn: A Guide to Efficient Pest Scouting." Integrated Pest Management Program - University of Wisconsin - Extension, Cooperative Extension Service. Madison, WI. [Accessed June 3, 2021]. http://corn.agronomy.wisc.edu/management/pdfs/a3547.pdf.

Dwyer, Lianne M., Douglas W. Stewart, L. Carrigan, B. L. Ma, P. Neave, and D. Balchin. 1999. "A General Thermal Index for Maize." *Agronomy Journal* 91 (6): 940–946. doi:10.2134/agronj1999.916940x.

Eaton, Eric, and Kenn Kaufman. 2007. *Kaufman Field Guide to Insects of North America*. Hillstar Editions L.C. New York, NY.

Evans, Arthur V. 2008. *Field Guide to Insects and Spiders*. Sterling Publishing. Ontario, Canada

Feller, C., E. Richter, T. Smolders, and A. Wichura. 2012. "Phenological Growth Stages of Edible Asparagus (*Asparagus Officinalis*): Codification and Description According to the BBCH Scale." *Annals of Applied Biology* 160 (2): 174–180. doi:10.1111/j.1744-7348.2012.00530.x.

Flemmer, A. C., M. C. Franchini, and L. I. Lindström. 2015. "Description of Safflower (*Carthamus Tinctorius*) Phenological Growth Stages According to the Extended BBCH Scale." *Annals of Applied Biology* 166 (2): 331–339. doi:10.1111/aab.12186.

Gay, Paul. 2015. “The Public Land Survey System.” In *Practical Boundary Surveying: Legal and Technical Principles*, edited by Paul Gay, p. 99–110. Cham: Springer International Publishing. Switzerland. doi:10.1007/978-3-319-07158-9_7.

Gergerich, Rose C, and Valerian V. Dolja. 2006. “Introduction to Plant Viruses, the Invisible Foe.” The Plant Health Instructor. *Introduction to Plant Viruses, the Invisible Foe*. [Accessed June 5, 2021]. https://www.apsnet.org/edcenter/disandpath/viral/introduction/Pages/PlantViruses.aspx.

Hartman, G.L., J.C. Rupe, E.J. Sikora, L. L. Domier, J.A. Davis, and K.L. Steffey, eds. 2015. *Compendium of Soybean Diseases and Pests*. 5th ed. The American Phytopathological Society Press. St. Paul, MN.

Hutman, Ted. 2013. “Visual Scanning.” In *Encyclopedia of Autism Spectrum Disorders*, edited by Fred R. Volkmar, p. 3300–3305. Springer. New York, NY. doi:10.1007/978-1-4419-1698-3_654.

Herms, Daniel A. 2004. “Using Degree-Days and Plant Phenology to Predict Pest Activity.” In *IPM (Integrated Pest Management) of Midwest Landscapes*, 49–59. SB-07645. Minnesota Agricultural Experiment Station.

Hmelo-Silver, Cindy, Ravit Golan Duncan, and Clark A. Chinn. 2007. “Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller, And.” *Educational Psychologist* 42 (2): 99–107. doi:10.1080/00461520701263368.

Hodgson, Erin W. 2017. "Bean Leaf Beetle | Integrated Crop Management." *Iowa State University Extension and Outreach*. Iowa State University. Ames, IA. [Accessed June 15, 2021]. https://crops.extension.iastate.edu/bean-leaf-beetle.

Ikley, Joe, and Brian Jenks. 2019. "Palmer Amaranth and Waterhemp." *North Dakota State Extension W1916*. North Dakota State University. Fargo, ND. [Accessed May 20, 2021]. https://www.ag.ndsu.edu/publications/crops/identification-biology-and-control-of-palmer-amaranth-and-waterhemp-in-north-dakota/w1916.pdf.

Kandel, Hans, and Greg Endres. 2019. *Soybean Production Field Guide for North Dakota*. A1172 ed. North Dakota State University Extension. Fargo, ND. [Accessed June 10, 2021]. https://www.ag.ndsu.edu/extensionentomology/recent-publications-main/publications/A-1172-soybean-production-field-guide/view.

Koch, Robert. 2016. "Soybean Aphid." *University of Minnesota Extension*. University of Minnesota Extension. Minneapolis, MN. [Accessed June 18, 2021]. https://extension.umn.edu/soybean-pest-management/soybean-aphid.

Koch, Robert, and Bruce D. Potter. 2018. "Scouting for Soybean Aphid." *University of Minnesota Extension*. University of Minnesota Extension. Minneapolis, MN. [Accessed June 15, 2021]. https://extension.umn.edu/soybean-pest-management/scouting-soybean-aphid.

Kolb, David A. 2015. "The Process of Experiential Learning." In *Experiential Learning*, 2nd ed., 31–61. Pearson Education, Inc. Upper Saddle River, NJ.

Mahr, Daniel L., Paul Whitaker, and Nino M. Ridgway. 2008. *Biological Control of Insects and Mites: An Introduction to Beneficial Natural Enemies and Their Use in Pest Management*. University of Wisconsin-Extension. Madison, WI.

Marschner, Petra, ed. 2012. *Marschner's Mineral Nutrition of Higher Plants*. 3rd ed. Elsevier Ltd.

McCauley, Ann, Clain Jones, and Jeff Jacobsen. 2009. "Functions and Deficiency and Toxicity Symptoms." Montana State University Extension. Bozeman, MT. [Accessed June 22, 2021]. https://mtvernon.wsu.edu/path_team/Plant-Nutrient-Functions-and-Deficiency-and-Toxicity-Symptoms-MSU-2013.pdf.

Meier, Uwe, Hermann Bleiholder, Liselotte Buhr, Carmen Feller, Helmut Hack, Martin Hess, Peter D. Lancashire, et al. 2009. "The BBCH System to Coding the Phenological Growth Stages of Plants - History and Publications. - University of Nebraska - Lincoln" 61 (2): 41–52.

Metcalf, Robert L., and Robert A. Metcalf. 1993. *Destructive and Useful Insects Their Habits and Control*. 5th ed. R. R. Donnelley & Sons Company. New York, NY

Miller, Perry, Will Lanier, and Stu Brandt. 2018. "Using Growing Degree Days to Predict Plant Stages." Montana State University Extension. Bozeman, MT. [Accessed May 25, 2021]. https://www.researchgate.net/profile/J_Tarafdar/post/Is_there_a_database_containing_growth_stage_phenophase_by_accumulated_growing_degree_days_by_agricultural_crops_available_in_the_public_domain/attachment/5c57fa923843b0544e63ec8e/AS%3A722503433453568%401549269650262/download/mt200103ag.pdf.

Munger, P., H. Bleiholder, H. Hack, M. Hess, R. Stauss, T. van den Boom, and E. Weber. 1997. "Phenological Growth Stages of the Soybean Plant (*Glycine Max* L. MERR.): Codification and Description According to the BBCH Scale*." *Journal of Agronomy and Crop Science* 179 (4): 209–217. doi:10.1111/j.1439-037X.1997.tb00519.x.

Munger, P., H. Bleiholder, H. Hack, M. Heß, R. Stauss, T. van den Boom, and E. Weber. 1998. "Phenological Growth Stages of the Peanut Plant (*Arachis Hypogaea* L.): Codification and Description According to the BBCH Scale1." *Journal of Agronomy and Crop Science* 180 (2): 101–107. doi:0.1111/j.1439-037X.1998.tb00377.x.

Munger, P., H. Bleiholder, H. Hack, M. Hess, R. Stauß, T. van den Boom, and E. Weber. 1998. "Phenological Growth Stages of the Cotton Plant (*Gossypium Hirsutum* L.): Codification and Description According to the BBCH Scale1." *Journal of Agronomy and Crop Science* 180 (3): 143–149. doi10.1111/j.1439-037X.1998.tb00384.x.

Munkvold, Gary P., and Donald G. White, eds. 2016. *Compendium of Corn Diseases*. 4th ed. The American Phytopathological Society Press. St. Paul, MN.

North Dakota State University Extension. 2021. "2021 ND Weed Control Guide — NDSU Weed Science." North Dakota State University Extension. Fargo, ND. [Accessed June 5, 2021]. https://www.ag.ndsu.edu/weeds/weed-control-guides/2021%20nd-weed-control-guide-1/2021-nd-weed-control-guide/view.

Nutter, Jr, Forrest, Paul Teng, and F.M. Shokes. 1991. "Disease Assessment Terms and Concepts." *Plant Disease* 75: 1187–1188.

Ohnesorg, Wayne J., and Thomas E. Hunt. 2015. "Managing Soybean Defoliators." NebGuide: G2259 Nebraska Extension. University Nebraska-Lincoln Extension. Lincoln, NE. [Accessed June 13, 2021]. https://extensionpublications.unl.edu/assets/pdf/g2259.pdf.

"Overview of Orders of Insects." 2021. Bug Guide. [Accessed June 30, 2021] https://bugguide.net/node/view/222292.

Pedersen, Palle, and Mark Licht. 2014. *Soybean Growth and Development*. Vol. PM 1945. Iowa State University Extension. Ames. IA.

Pedigo, Larry P., and Marlin E. Rice. 2009a. "Economic Decision Levels for Pest Populations." In *Entomology and Pest Management*, 6th ed., p. 255–281. Pearson Education. Upper Saddle River, NJ.

Pedigo, Larry P., and Marlin E. Rice. 2009b. "The Insect Life Cycle." In *Entomology and Pest Management*, 6th ed., p. 147–176. Pearson Education. Upper Saddle River, NJ.

Pedigo, Larry P., and Marlin E. Rice. 2009c. "Surveillance and Sampling." In *Entomology and Pest Management*, 6th ed., p. 213–254. Pearson Education. Upper Saddle River, NJ.

Pruess, Kenneth P. 1983. "Day-Degree Methods for Pest Management1." *Environmental Entomology* 12 (3): 613–619. doi:10.1093/ee/12.3.613.

Schmale III, D.G., and G. C. Bergstrom. 2003. "Fusarium Head Blight in Wheat." *Fusarium Head Blight*. The American Phytopathological Society. [Accessed June 16, 2021] https://www.apsnet.org/edcenter/disandpath/fungalasco/pdlessons/Pages/Fusarium.aspx.

Schumann, Gail L., and Cleora J. D'Arcy. 2010a. "What Is Wrong with My Plant?" In *Essential Plant Pathology*, 2nd ed., p. 1–12. The American Phytopathological Society. St. Paul, MN.:

Schumann, Gail L., and Cleora J. D'Arcy. 2010b. "What Are the Causes of Plant Diseases? Bacteria." In *Essential Plant Pathology*, 2nd ed., p. 51–68. The American Phytopathological Society. St. Paul, MN.

Schumann, Gail L., and Cleora J. D'Arcy. 2010c. "What Are the Causes of Plant Disease? Nematodes." In *Essential Plant Pathology*, 2nd ed., p. 69–86. The American Phytopathological Society. St. Paul, MN.

Sisson, Adam J., Daren S. Mueller, Shawn Conley, Corey K. Gerber, Scott H. Graham, Erin Hodgson, Travis Legleiter, 2021. "Crop Scouting Basics for Corn and Soybean." *Crop Protection Network*. [Accessed June 5, 2021]. doi:10.31274/cpn-20201214-0. https://cropprotectionnetwork.org/series/field-crop-scouting/publications/preface.

Stewart, Lucy R., Md Ashraful Haque, Mark W. Jones, and Margaret G. Redinbaugh. 2012. "Response of Maize (*Zea mays* L.) Lines Carrying Wsm1, Wsm2, and Wsm3 to the Potyviruses Johnsongrass Mosaic Virus and Sorghum Mosaic Virus." *Molecular Breeding* 31 (2): 289–297. doi:10.1007/s11032-012-9789-5.

Teng, P. S. 1983. "Estimating and Interpreting Disease Intensity and Loss in Commercial Fields." *Phytopathology* 73 (11): 1587–1590.

Uva, Richard H., Joseph C. Neal, and Joseph M. Ditomaso. 1997. *Weeds of the Northeast*. Cornell University Press. Cornell, NY.

Walsh, Douglas B, David H Gent, James D Barbour, Rick A. Boydston, Ann E George, David G James, and J Robert Sirrine, eds. 2015. *Field Guide for Integrated Pest Management in Hops*. 3rd ed. Washington State University Extension. Pullman, WA.

Wegulo, Stephen N., and Emmanuel Byamukama. 2012. "Rust Diseases of Wheat." University of Nebraska-Lincoln Extension. Lincoln, NE. [Accessed June 18, 2021]. https://extensionpublications.unl.edu/assets/pdf/g2180.pdf.

Whitson, Tom D., Larry C. Burrill, Steven A. Dewey, David W. Cudney, B.E. Nelson, Richard D. Lee, and Robert Parker, eds. 2012. *Weeds of the West*. 11th ed. Color World Printers. Jackson, WY.

Zadoks, J. C., T. T. Chang, and C. F. Konzak. 1974. "A Decimal Code for the Growth Stages of Cereals." *Weed Research* 14 (6): 415–421. doi:10.1111/j.1365-3180.1974.tb01084.x.

Zimdahl, Robert L. 2018a. "Weed-Management Systems." In *Fundamentals of Weed Science*, 5th ed., p. 609–649. Elsevier Inc.

Zimdahl, Robert L. 2018b. "Weeds: The Beginning." In *Fundamentals of Weed Science*, 5th ed., p. 17–46. Elsevier Inc.

# CHAPTER 3

# USING FARMERS' MOTIVATIONS AND VALUES TO COMMUNICATE MANAGEMENT PRACTICES

## Introduction

Independent crop consultants (ICCs) communicate with farmers daily during the growing season. Over time ICCs get to know their audience (i.e., farmers) well and this contributes to their effective communication strategies with farmers and the subsequent adoption of improved management practices. Through two internships, I observed this communication, and this led me in developing this study to investigate the communication between the farmer and ICCs. In the spring of 2019, I was introduced to Morgan MathisonSlee, a Ph.D. candidate in the Community Sustainability Department at Michigan State University, and I have collaborated with her in this study. Morgan's research focuses on the well-being of producers who are using adaptive multi-paddock grazing with cattle. Through her research, she has conducted in-depth interviews that include the identity and motivations of beef producers. This study combines her experience and background in the social sciences with my agronomic field experience and interest in communication. In conducting this study, my goal was to obtain a better understanding of communicating with farmers. As a future agronomist, this information will assist me in gaining insight into their farming operation and tailoring agronomic recommendations to meet their specific needs and goals.

Independent crop consultants are professionals who are independent of product sales and who provide a comprehensive approach covering the production of agricultural crops with topics including plant pathology, entomology, weed science, plant science, economics, water management, and soil science (Post 1988). Sherman and Gent (2014) conducted farmer interviews on hop and mint farmers in Oregon and Washington. For most of the farmers they interviewed, farmers stated that the consultant of their choice would be an individual with whom they had an established long-term relationship, "trustworthy, knowledgeable, and effective at addressing his or her needs versus an outside agenda." Consultants service farmers by providing regular and complete observations of their client's fields. Management recommendations are developed from these observations for their farmer clientele. These recommendations are communicated directly to farmers orally and/or through written communication. As an interpersonal communicator, the ICC needs to understand their farmer clientele to ensure effective information transmission and implementation of recommendations.

Models have been developed to illustrate the process of communication. The Schramm interactive model depicts interpersonal communication with the source (i.e. ICC) and receiver (i.e. farmer) sharing information (Bryant and Thompson 2002). They alternate roles as an encoder (creating message), interpreter, and decoder (decoding the message). This communication occurs simultaneously and nonverbal feedback cues such as facial expressions, body language, and voice inflections can allow real-time adjustment of the message. Nonverbal cues can aid ICCs in adjusting the message while communicating management recommendations.

Parminter and Perkins (1997) highlight the relevance of values in the communication between ICCs and farmers to improve management practices. Similarly, Sherman and Gent (2014) emphasize the importance of values in farmer management decisions, but also the necessity of experts to recognize those values and adapt conversations to farmers to avoid “alienation”. These studies are supported by the literature in the field of science communication (Dietz 2013). “Science communication usually focuses on facts, not values… However, decisions always involve values,” (Dietz 2013). This quote emphasizes the need of communicators to tailor their message for receivers, based on their specific values. There is limited literature that directly describes the role of farmer values and motivations in communication between ICCs and farmers (Parminter and Perkins 1997; Sherman and Gent 2014). This study seeks to apply the literature of science communication to identify ways to improve communication between farmers and agricultural experts (e.g., ICCs).

## Theoretical Framework

Aspects of the diffusion of innovation theory developed by Everett Rogers and the Theory of Planned Behavior developed by Icek Ajzen can be applied to communication between ICCs and farmers (Rogers 2003; Ajzen 1991). There are four main elements of diffusion including: innovation, communication channels, time, and the social system (Rogers 2003). According to the Theory of Planned Behavior, an individual who has a more favorable opinion of all three constructs (i.e., control beliefs, attitudes, and subjective norms) has a greater likelihood of performing a particular behavior (Ajzen 1991). Both theories incorporate values. For example, the behavior of reducing tillage can be explored by using both theories because the farmer must have a favorable perception of the innovation and it needs to be compatible with their existing values for the farmer to adopt the management practice.

Communication can influence values just as values can influence communication. Values are deeply held beliefs that act as principles to be used when making decisions or interacting with the world around you (Schwartz 2012). Schwartz's Short Value Survey (SSVS) is commonly used in value research and is based on the Schwartz theory of basic human values. This survey contains 57 value statements that can be categorized into 10 basic held values: power, achievement, hedonism, stimulation, self-direction, universalism, benevolence, tradition, conformity, and security. The SSVS has been administered across more than 82 countries worldwide, and these 10 motivationally distinct values have been shown to transcend people in all cultures (Schwartz 2012). Factor analyses completed from thousands of completed surveys show that in an average population, power and achievement cluster into a value category known as 'self-enhancement'. Also, benevolence and universalism make up the 'self-transcendence' value category; conformity, tradition, and security are part of the 'conservation' category; and hedonism, self-direction, and stimulation cluster into the 'openness to change' value category (Figure 3.1) (Schwartz 2012). Additionally, the value hedonism is situated between the self-enhancement and openness to change value categories because it contains characteristics of both value categories. Being willing to improve yourself and try new things are potentially closely related depending on the situation the individual is in (Schwartz 2012). While it is important to know that there is a set of universal values, it is knowing how an individual prioritizes those values that is key to effective communication, motivation, and change (Rogers 2003; Ajzen 1991; Sherman and Gent 2014; Manfredo et al. 2017; Fischer and Boer 2016; Maybery et al. 2005; Dessart et al. 2019).

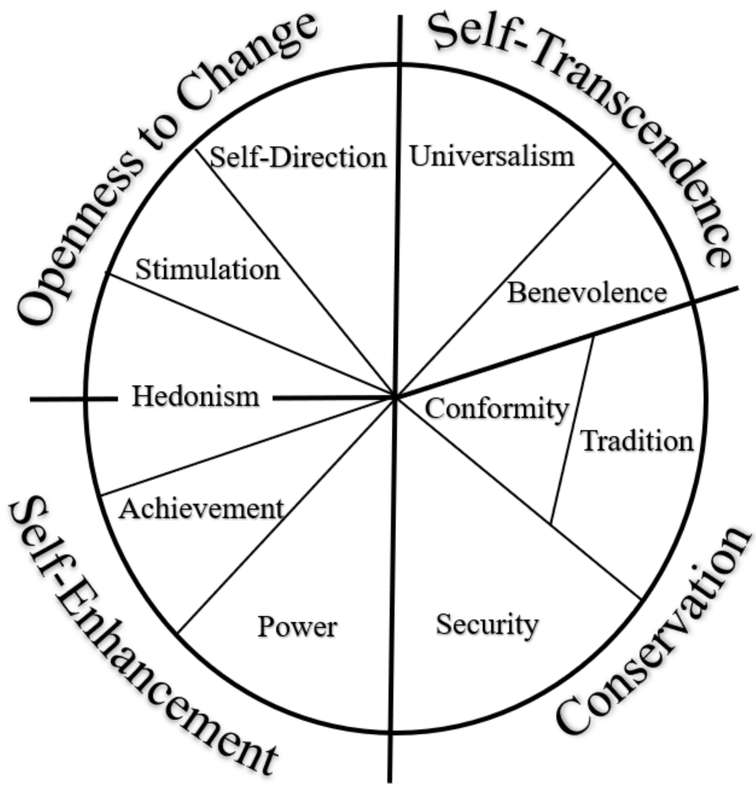



Figure 3.1. Theoretical model of relationship among 10 motivational types of values. Adapted from Schwartz 2012. The values (slices of pie) make up each of the four value categories (self-enhancement, openness to change, self-transcendence, and conservation).

## Purpose and Objectives

The purpose of this research is to explore communication strategies using farmers' motivation and values. To accomplish this, the study is comprised of three objectives: 1) Explore how ICCs communicate to farmers, 2) Explore the motivation and values farmers use when making management decisions, 3) Determine farmers' highest held values according to the Schwartz theory of basic human values.

## Methodology

Participants included two ICCs from Centrol Crop Consulting, Inc. (Twin Valley, MN) and 11 of their farmer clientele in Barnes and Stutsman counties in North Dakota.

The ICCs had a combined 26 years of consulting experience on 102,000 acres including corn, soybeans, wheat, barley, oats, dry beans, alfalfa, with one also consulting on rye and flax. Each ICC held Certified Crop Advisor credentials. The farmers ranged in age between 31-65 years and farmed between 1,300-7,500 acres. Corn and soybeans were grown by all farmers and 45% grew wheat.

**Interview Instrumentation**

The ICC interviews addressed how they communicate science-based recommendations, how they encourage a farmer to change management practices, and what motivates them to encourage a farmer to change management practices. Several questions about weed management were asked because this is a commonality between all farmers. Farmer interviews focused on their identity, farming motivations, and goals. Individual interviews of all participants contained general demographics and were conducted by the principal investigator in August 2019.

The ICCs from Centrol Crop Consulting participated in interviews lasting from 20-60 minutes in length. ICCs interviews took place at a location chosen by the ICC. Interviews consisted of the following questions:

1. Why do you communicate problems differently to different farmers?
2. How do you communicate problems differently to different farmers?
3. How do you encourage a farmer to change management practices?
4. How do you communicate your recommendations to the farmer?
5. What motivates you to encourage a farmer to change management practices?
6. Do you communicate the science behind what is observed in the field?

   a. If so, how do you communicate a complex science-based topic to explain why problem X is being observed in the field? If not, why?
   b. Why do you communicate the science-based explanation behind what is being observed or could potentially be observed if a new idea to manage X?
7. When you know the farmer has X, Y, and Z weeds in the field. How do you explain to the farmer that they should use a different seed variety and do it successfully?
8. How do you encourage a farmer that weed X is worth controlling?

Farmer clientele participated in interviews lasting 20-75 minutes each. Interviews took place in a location chosen by the farmer, and farmers were asked the following questions:

1. Do you identify as a farmer? If no, how would you describe yourself? Why don't you consider yourself to be a farmer?
2. What does it mean to you to be a farmer?
3. When did you start farming and what motivated you to start farming?
   a. What was the main goal when you started farming? Did you have specific goals for your farm?
   b. Did you achieve your goals?
   c. What is the main goal for the farm now?
   d. What are you doing to achieve your current goals?
4. Over time people's thoughts and attitudes change. Has the way you farm / manage the land changed since you started farming? If so, how?
5. What motivates you to continue to farm?

6. Do you enjoy working with your Centrol Crop Consultant?

**Survey Instrumentation**

In addition to the interview, farmers were asked to rank the level of importance of each of the Schwartz values (Appendix B). Participants were instructed to rate the importance of the following values as a life-guiding principle for you. Participants responded to each of the 10 values on a Likert scale from zero to eight with the labels being: 0 – opposed to my principles, 1 – not important, 5 – important, 8 – of supreme importance(Schwartz 1992).

1. Power (social power, authority, wealth)
2. Achievement (success, capability, ambition, influence on people and events)
3. Hedonism (gratification of desires, enjoyment in life, self-indulgence)
4. Stimulation (daring, a varied and challenging life, an exciting life)
5. Self-Direction (creativity freedom, curiosity, independence, choosing one's own goals)
6. Universalism (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection)
7. Benevolence (helpfulness, honesty, forgiveness, loyalty, responsibility)
8. Tradition (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty)
9. Conformity (obedience, honoring parents and elders, self-discipline, politeness)
10. Security (national security, family security, social order, cleanliness, reciprocation of favors)

**Thematic Analysis**

The interview transcripts were analyzed using qualitative content analysis as described by Piso et al.(2019) to identify emergent themes in the data (transcripts). The data were coded inductively by highlighting sections of the transcripts that were deemed important to the objectives by the researchers, and themes were developed by categorizing the codes into related concepts (e.g., economics, family, etc.). This was an iterative, collaborative process. The researchers (LO and MM) independently coded two farmer transcripts to develop the codebook. The two researchers discussed the codes they had developed and then co-coded one more farmer interview using the list developed. They met afterward to determine the application of the codes and inter-coder reliability. New codes that emerged were discussed to determine if they should be included in the codebook. Finally, the remaining interviews were divided between the two researchers (i.e., four interviews each) and were coded deductively from the established codebook and no new codes were created. When settling on the phrase to use in the code book, it was important that each code be a reflection of the language used by the farmers (Glaser 1965). After all farmer transcripts had been coded, the researchers met to discuss any questions or concerns each researcher had about their respective transcripts. The researchers found inter-coder agreement on all farmer transcripts.

This process was repeated with the ICC interviews with each researcher coding one interview. Because the focus of those interviews was different, a new codebook was required. All analyses (i.e., coding and thematic creation) were conducted in the qualitative data analysis software MaxQDA 2020 Analytics Pro (Verbi Software, Berlin, Germany). This research project was approved by the Institutional Review Board at the University of Nebraska-Lincoln (IRB#20190819643EX).

### Schwartz Short Value Survey Analysis

In the original work, Schwartz (1992) outlines multiple ways that the survey can be analyzed, and the researchers used a confirmatory factor analysis to determine if the structuring of the values that Schwartz observed were also present in the farmer sample (Schwartz and Boehnke 2004). The factor analysis option in Statistical Package for Social Sciences (SPSS) (IBM Corp. Released 2020. IBM SPSS Statistics for Mac OS. Version 27.0. Armonk, NY: IBM Corp.) was used for the confirmatory factor analysis.

## Findings

The thematic results are divided into the source (i.e., ICC) and receiver (i.e., farmer) as per the Schramm interactive model (Bryant and Thompson 2002) illustrating interpersonal communication between the ICC and farmer. The ICC plays an important role to farmers by educating them, tailoring recommendations, providing motivation for the recommendations, determining effective communication channels for the recommendation, and adapting communication styles for them. From the farmers' interviews, four main themes of identity, motivations, limitations, and how ICCs support them were identified.

### Role of an ICC as a Communicator to Farmers

<u>Theme: Educating the farmer</u>

An ICC provides the farmer with management recommendations and additional information about the science behind management practices (e.g., how pesticide products work in organisms) that helps farmers make informed management decisions. One ICC stated, "Yes [I communicate science], but it's different levels for different farmers. Give them what they need to know so that they can defend themselves against misinformation." Another ICC emphasized that we can use the products (e.g., pesticides) in agriculture because of the science and research behind them. As one ICC further described, there is scientific research that supports specific label rates for product safety, and it is not "two glugs per acre." While communicating the science, both ICCs mentioned it is important to present it in a way that makes sense to the farmer, but in a way that is not condescending or off-putting.

Theme: Tailoring recommendation

ICCs make specific recommendations on each individual field because they are aware of farmer constraints (e.g., labor, time, equipment) and how the constraints influence efficiency, productivity, and the farmer's management decisions. When having a conversation about the recommendations with the farmer, an ICC may pick up on concerns or how much risk a farmer is willing to take. Potential risks need to be accounted for as one ICC indicated, "New ideas are always risky. They're always dangerous. And you have to… outweigh the…risks with benefits." To address the main problems in the field, multiple management options are provided to the farmers by an ICC. An ICC needs to account for farmer's limitations to make an effective recommendation the farmer will consider. If a farmer perceives the recommendation as progressive, then an ICC has the opportunity to explain why they are making the recommendation. For example, one ICC said, "you have to … explain why…you're choosing to move forward and be progressive." Explaining the science behind a product can help a farmer understand how it works and understand the appropriate time and situation to use a pesticide. The quote below sums up the process behind how an ICC tailors the recommendation:

> *"Make sure that [farmers] recognize that there is a challenge or a problem or something that's not working right. ... and that there are other solutions. ...But those options have to be custom fit or tailored to...that farm in that field. ... Farmers have different goals and they're simply not going to accept certain management practices. ...Other farmers are a little more open to different things. But then there's also limitations on equipment and expense, time, labor. ...That's the puzzle to put together as they find what solutions fit for that farmer in that situation to solve that problem."*

<u>Theme: Motivations for recommendations</u>

When ICCs were asked what motivates them to encourage a farmer to change management practices, both emphasized proactive approaches. This can be seen in the comments for one ICC, "I would rather prevent disasters…put out the fire now…before it becomes a big old blaze where it's out of control and I can't do anything about it. …What I'm trying to do is be more…proactive rather than reactive." They recognize a current or future problem and work to find an economic solution for the farmer. In addition to the solution being economical and profitable for the farmer, an ICC said that it needs to make sense.

<u>Theme: Communication channels of the recommendation</u>

The medium of how the recommendation is communicated are channels. Printed sheets are the most common channel for a Centrol Crop Consultant to communicate their recommendation. Recommendation sheets are divided into specific recommendations for each field, providing observations of pests, crop health, etc., along with the quantification of each pest found in the field. If a pesticide application is needed, the sheet will include the timing of the application, application rate, re-entry interval posting requirements, EPA number, tank mixing order, and all information needed for (North Dakota) state records. Though printed sheets are the standard procedure, farmers may just want a text message, email, or log into the cloud to receive the recommendation.

ICCs need to be creative in the channel to communicate the recommendation to the farmer. Even though printed sheets are the main way recommendations are communicated to farmers, one ICC stated, "how people get them and how people use them are very different." This emphasizes the communication channels may differ between farmers. Another ICC interviewee expressed this need: "For some guys, I have to jump up and down and almost dress like the weed…to get [farmers] to pay attention to me about it." This highlights that communication channels may vary for different farmers.

Theme: Communication style

Communication approaches that ICCs utilize are adapted for individual farmers. The ICC needs to know their farmers and be able to adjust their strategies to meet the farmer's expectations. One way to do this is to use analogies and other examples which a farmer relates to, so the farmer can understand what is being communicated. The more relatable the examples or analogies are to a farmer's daily life, the more likely they are to understand the concept. This can be seen in the comment from an ICC interviewee, "If you can relate it to something that they're more familiar with… they understand." Communication style may differ depending on the season. During the busy season, the communication style should be adapted to fit the schedule of the farmer. This may be a quick text message for fields that require a pesticide application as soon as possible or a longer discussion about management decisions when there is more time. The style of communication used also depends on the kind of relationship the ICC has with the farmer and whether it is more of a business relationship or friendship, as described:

> *"One of the main reasons is their expectations and then the individual relationship I have with the guys [farmers]. ...[For] some it's a very personal friendship relationship where we talk about all kinds of things, family and fun and that kind of stuff. The other guys [farmers], it's more of a business relationship where it's more directly related to what we're doing in the crops or the fields."*

**Farmers as the receiver of the ICCs' communication**

To be an effective communicator, the ICC must know their farmers by understanding their identity, motivations, limitations, and how they support the farmer. This understanding aids the ICC in creating recommendations that a farmer may adopt.

<u>Theme: Identity of farmers</u>

Identity refers to what an individual ascribes to. When asked what it means to be a farmer, farmers had a range of answers, but most emphasized the individuality of farmers. All farmers ascribe to being a farmer, yet several farmers who had livestock considered themselves as a farmer with cattle or a farmer / rancher. One farmer said he ascribes to a farmer most of the time and the rest of the time considers himself a "traveling partier." Being raised on a farm impacted how farmers respond to their identity compared to non-generational farmers. Some of the most common responses when discussing why they farm were: "you are born into it," "it is in my blood," and "it's a way of life." One farmer stated, "if I didn't have family that did [farm], no I wouldn't… pick it up." One farmer had a different perspective because although he was not raised on a farm, he did have relatives that farmed and therefore was familiar with farming. This perspective is described in this comment, “Growing up in Minneapolis, I had family that…farmed, so I knew what a farm was like, but I never grew up on a farm or was involved with it.” Another farmer stated that he did not have a choice, “I graduated from college in 1980 when you couldn't get a job no matter how great a degree you had.” Because this farmer could not get a job, he said he was “forced into farming.” Each farmer had a unique perspective and experiences that shaped their identity.

Furthermore, farmers have a great deal of pride in what they do, for example, a farmer expressed: “we're producing food for the world.” Another farmer emphasized that “everyone in this world needs my occupation three times a day and nobody else’s occupation could say that.” One farmer stated, “you work your butt off and you have a challenge to get something done by a certain timeframe and it's gratifying when you get done and look at the teamwork that everyone put into it to make that happen.” Farmers are proud of producing food and accomplishing tasks on their farm.

Theme: Farmer motivations

During the interviews, when farmers mentioned what motivated them to farm, their responses included sub-themes of knowledge collection, soil health, family, and economics. Knowledge collection refers to when farmers discussed the need for continued learning about farming methods. Ten farmers said they attend field days or agricultural meetings and four of those farmers specifically discussed learning more agricultural practices (i.e., knowledge collection). Some farmers are not satisfied by doing the same management strategies and seek to learn new principles about farming practices. These farmers see value in continual learning because they can try something new on their farm and learn from it. Then they can make modifications if needed to fit the farm operation, as described in the following quote:

> *"The same goal is what it was when I started, just to improve and keep improving and changing, learning. Learning is probably the biggest one. Trying something and seeing what the results are. I just like working with soil and crops and equipment. I don't consider this work. …What do you call it? If you enjoy what you do, you never have to work a day in your life, and I don't consider this work."*

The sub-theme soil health was coded with five farmers when farmers discussed the importance of soil health or when they referenced soil management. Farmers were motivated to incorporate management methods that improved their soil to ensure that they would be leaving their soil in the same, or better condition (e.g., prevent erosion of topsoil) as when they started farming. For example, one farmer described soil health as "Keep the soil in good health...It's like noxious weeds…don't let those get crazy and run away from you. Not let your farming practices affect others." Another farmer mentioned that soil health is important for future generations "making sure we're not giving them weed-infested clay and making sure that the topsoil is still there and in good condition." The farmers were eager to learn from others during meetings about methods to improve the health of their soil and were concerned about the impacts of their farm on the surrounding environment:

> *"As soil health evolves. I think we're trying to pick the practices that we learn about that work best for the farm. …One of the reasons why I like to go to*

*meetings and hear what other people think is important as far as soil health and then seeing if something that they think is important if you can incorporate that practice…on your farm."*

All farmers were motivated by their families by either providing for them or thinking of the future generation (i.e., generational farm). Even though farmers work very long hours, they realized why they are doing it. One farmer said, "definitely at the point now that…you're doing it for the family." Farmers feel the pressure of a generational farm where they do not want to lose the farm. For example, a farmer stated, **"**Fourth generation on it. Don't wanna screw it up". During the farm transition, the new generation faces pressure to make sure the farm is stable because the farmer may feel the weight of retirement from the previous generation. The new generation does not want to put the previous generation's lifestyle at risk. Not only do current farmers feel pressure from previous generations, but they also feel pressure about sustaining the farm for future generations. Farmers also realized that their children must have a desire to farm and that it is not a career that should be forced upon them. The following quote describes the pressure one farmer faces:

*"You feel more of the pressure of the generations before you and the generation coming. … You don't want to let your dad down, your grandpa down. And if the kids want a farm, you want it to be there for him. And yet it used to be more about me wanting to build a farm to do all that for me."*

Succession planning was at the forefront for six farmers (both generations) working on transitioning the farm into the next generation. Preparing for the next generation includes succession planning so there is smoother transition between generations. This is shown by the following quote, “Nowa- days [my] main goal is succession and everything that entails. I mean, that would be making sure we have a big enough base for the next generation as far as acres are concerned.” One farmer noted that time would be well spent by “having some sort of monthly meetings like that where you can address anything or things like succession planning.” In certain cases, all family members did not see the value in planning, and there was a struggle within the family to sit down and have a conversation about the transition.

In some operations, the focus was on the younger generation deciding if they wanted to farm, thus impacting the older generation's plan for retirement or stepping down from the manager position on the farm. This concept is described in the following quote: “Talking about it [succession plan] and waiting for him [nephew] to make a decision… with what his goals are, determine my goals once he makes that decision and then we've got to start making a plan.” One farmer was considering the current economic situation and did not necessarily want to pass down the farm yet. This perspective is illustrated in the statement, "Well, my main goal *was* [emphasis original] to pass it down to my family. You know, to be able to have one of my sons or both of them farm, right now, with how the economy and all that, it's not high on my list.” Farmers see the value of succession planning to ease the transition between generations.

Economics motivated six farmers because a farm is unlikely to survive without making money. This can be seen in the comment from one farmer, “Just not mess up at first and make a profit so I could keep doing it.” If specific crop markets are not profitable, farmers will raise different crops to make ends meet: “Sunflowers were diseased, and the market went to hell. It was either change or die,” and “Wheat still doesn't pay the bills. Never has really.” Money was a driver for retirement and one farmer explained that he either needed $1 million cash in the bank or 10 quarters of land (1,600 acres) paid for and that he had neither. It is important to note that four farmers talked about the importance of economics as a determinate of being able to retire.

Theme: Limitations Identified by Farmers

The limitation code was coded 62 times when farmers brought up economic or environmental resources that restricted the potential of the farm. Specific limitations included labor, capital investment, and environmental changes. For management tasks to be done efficiently during peak times of the year, having enough labor is critical. One farmer interviewee described this as, “Making sure we have people around. … I think that's one thing we need to work on right now is having time and manpower.” Even with government programs or cost-sharing, testing new practices, such as allowing a beef producer’s cattle to graze on the land, still requires a significant investment (water, fencing, time, etc.). Additionally, the price of equipment has increased over time and this is often a hurdle for farmers who need new equipment. One example was how the cost of a combine had changed over time: “that's one piece of equipment from $125,000 to $400,000 in 15 years.” The unpredictability of commodity markets will always be a concern of farmers. One farmer stated, “we don’t have control over the all the markets.” Through time, these limitations impact farmer operations in different ways.

Environmental challenges have shaped the management practices of farmers whether that is weed management decisions, growing new crops, or implementing cover crops because of the increase of available moisture that allows cover crops to be planted. A farmer described how the environment has changed:

> *"Back in the 1970s when I started, there was no way you could…put cover crops out. … We were just starved for moisture. … I can't even describe how much this is weird, but now we have enough moisture, we can raise a crop and raise some cover crops too, now it makes sense."*

Theme: ICCs supporting the farmer

The farmer interviews provided insight into how they view the ICC support. An ICC supports the farmer in various ways from being independent of product sales, providing knowledge, and providing emotional support. As several farmers commented in their interview, they value an ICC because they are independent and do not have a conflict of interest, such as not selling a product. Additionally, the ICCs were commended on the information they provide. In one example a farmer explained they do a "very good job of letting us know what's out there [in the field]." Their in-depth knowledge about the farmer's field history aids them in recommending specific product active ingredients and supply subsequent information (e.g., application timing, adjuvants, etc.) for farmers.

Having an ICC means a farmer is not in this alone, and the ICCs have the farmers' back. This concept was described by one farmer interviewee: "…looking out to save us money, but doing a good job of making sure we're doing …what we need to do.…He's [independent crop consultant] going over and checking this stuff over that we don't know." One farmer expressed the support that an ICC provides: "have him [independent crop consultant] watching your back is, is important to me." Additionally, a trusting relationship between the ICC and the farmer is important for the farmer to have confidence in the ICC's recommendations. For example, one farmer discussed trust in this statement: "it's tough to find hardworking, trustworthy people. That's what [independent crop consultant and field scouts] are. So, we can trust; trust your calls."

The farmer has an ICC to scout their fields, make pesticide recommendations, reduce workload, and can reduce stress. Determining whether a pesticide is needed can be an expensive decision and farmers find support in this decision from the ICC. One farmer described this support in this statement: "[the independent crop consultant] just gives me…A lot of support on those decisions…it's made spraying and applying insecticide…much less stressful because… [independent crop consultant is] so knowledgeable on it and telling me what right products to use are."

A farmer finds value in an ICC who is knowledgeable and stays current on emerging pests in the region. This relieves a burden from farmers because, as one farmer stated, "I don't need to know everything and that's why we got [an independent crop consultant]." By staying up to date on current pests, an ICC can have a progressive outlook and forewarn farmers to adopt different management strategies, preventing a dramatic shift in management strategies in a single growing season. The following quote displays how important it is the ICC remains up-to-date: "I appreciate [independent crop consultant] knowledge. I mean, forewarned us of resistance weeds five years before they were coming...I trust him [my independent crop consultant] very much."

One farmer specifically mentioned how he appreciates the knowledge of an ICC and how the ICC communicates the information in a way the farmer understands. This can be seen in the one farmer's comment: "very personable…very approachable…

[independent crop consultant] doesn't try to intimidate you with his knowledge or anything. I mean, [independent crop consultant] brings it down to my level." The ICC is a science-based professional and farmers value this knowledge to brainstorm new management practices with their ICC as illustrated in this quote: "even bouncing ideas off of [independent crop consultant] is helpful.

Not only does an ICC support the farmer in agronomic ways, but also through providing emotional support and a listening ear. One farmer said, "I remember [independent crop consultant] told me this … where sometimes people call him not really looking for information, but somebody [to] just hold your hand a little bit because… we're having…troubles." Farmers have multiple obligations in their work and personal life.; an ICC understands what it takes to be a farmer and can help reduce some of their farm stress.

**Schwartz Short Value Survey Findings**

There was consistency among all farmers in Stutsman and Barnes counties, in their ranking of the Schwartz's values. After conducting a confirmatory factor analysis, we found that the 11 farmers tended to categorize the 10 basic human values differently than the general population, as described by Schwartz (1992). The Schwartz's model has four broad value categories: openness to change, self-transcendence, conservation, and self-enhancement (Figure 3.1). The factor analysis showed that these values fell into three value categories for the 11 farmers: category 1 was power, tradition, security, and conformity; category 2 was hedonism, universalism, and benevolence; and category 3 was achievement, stimulation, and self-direction (Table 3.1). In this farmer population, the values of power, hedonism, and achievement are the three values that do not fall into the expected broad value categories, but the other values are separated into their expected groups (Figure 3.1)

| Confirmatory Factor Analysis of Values<br>Rotated Component Analysis | | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| **Power** | -0.603 | 0.558 | 0.255 |
| **Achievement** | 0.257 | -0.125 | 0.854 |
| **Hedonism** | 0.052 | 0.884 | 0.035 |
| **Stimulation** | -0.198 | -0.046 | 0.863 |
| **Self-Direction** | -0.259 | 0.298 | 0.639 |
| **Universalism** | -0.336 | 0.770 | -0.052 |
| **Benevolence** | 0.163 | 0.945 | -0.004 |
| **Tradition** | 0.922 | -0.017 | -0.071 |
| **Conformity** | 0.972 | -0.091 | 0.011 |
| **Security** | 0.970 | 0.067 | -0.076 |
| Rotation Method: Varimax with Kaiser Normalization. a. rotation converged in 4 iterations | | | |

Table 3.1. Factor analysis of the farmers' SSVS revealed three value categories: category 1; power, tradition, security, and conformity, category 2: hedonism, universalism, and benevolence, category 3: achievement, stimulation, and self-direction.

Based on the 10 basic human values, certain values were considered more important than others. However, central tendency statistics illustrate that there is not a single value that was considered ‘less than important’ (Table 3.2). Self-direction and benevolence received the highest mean scores (Table 3.2), while hedonism, tradition, conformity, and security averaged the second highest. Universalism, achievement, stimulation, and power had the lowest mean scores. Power was the lowest ranked value with a mean and median of four, indicating just under half of the farmers ranked it as important.

| Schwartz Short Value Survey Statistics | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **Power** | **Achievement** | **Hedonism** | **Stimulation** | **Self-Direction** | **Universalism** | **Benevolence** | **Tradition** | **Conformity** | **Security** |
| N Valid | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| N Missing | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mean | 4.00 | 5.73 | 6.09 | 4.82 | 6.91 | 5.55 | 7.09 | 6.27 | 6.09 | 6.36 |
| Median | 4.00 | 6.00 | 7.00 | 5.00 | 7.00 | 6.00 | 7.00 | 7.00 | 7.00 | 7.00 |
| Mode | 5 | 6 | 7a | 5 | 6a | 4 | 7a | 7 | 7 | 7 |
| a. Multiple modes exist. The smallest value is shown. | | | | | | | | | | |

Table 3.2. Summary of rankings farmers applied to each value. Self-direction and benevolence received had the highest means.

## Discussion

Communication is an evolving process where there is a need for continued adaptation for the specific audience. The interaction between an ICC and farmer is complex, and there will never be a formula on how an ICC can effectively communicate to a farmer. However, this study does provide insight into identity, motivations, limitations, and the farmer’s perspective of how ICCs support them. The themes that emerged from the ICC and farmer interviews support aspects of both the diffusion of innovation theory and theory of planned behavior. ICC themes of tailoring recommendations, communication channels for recommendations, and communication style relate to the communication channel element in the diffusion of innovation. The

ICC themes of educating farmers and motivations for recommendations and the farmer theme on how ICCs support them fall into the element of time in this theory. Farmer themes of motivations, limitations, and identity relate to the constructs of attitudes and control beliefs in theory of planned behavior. If ICCs think critically about how a person answers a question or interacts with them, then the ICC can adapt their communication style and their recommendations to be most effective with each individual farmer.

These interviews speak volumes to who the farmer is, how they perceive farming, and their motivations, along with what constraints they are currently facing. But these interviews are only a snapshot of the entire picture. If the interview had been my first interaction with these farmers, therefore their first impression of me, in some cases, I would have effectively communicated with the farmer, but not always. One farmer was excited and passionate about farming, and it was evident when he said, “Oh man, I love planting in the rain.” Additionally, this farmer stated, “I like to go to meetings and hear what other people think is important, as far as soil health and then seeing if something that they think is important, if you can incorporate that practice…on your farm.” During this interview, I could tell that he is a progressive farmer and was eager about trying new practices. Due to his eagerness, if I were his ICC, I would support this farmer by providing the scientific knowledge about what practices he wants to try. One ICC said, “[this farmer] is always in a happy-go-lucky mood,” and from this interaction I would be concerned if I could not hear the farmer’s eagerness in his voice. This would be worrisome indicating something is potentially wrong and providing emotional support would be a better way to communicate with him at that time.

In another example the farmer said, "you feel more of the pressure of the generations before you," and he was serious the entire interview. Therefore, I would take a serious approach when communicating with this farmer. However, when asking an ICC how he communicates with this farmer, it was different than what I had anticipated. The ICC said, "[this famer] would be insulted if you didn't joke with him." From this ICC's statement it becomes apparent that, I would not have communicated with this farmer effectively because I would have been too serious while he is more comfortable with jovial conversations. This emphasizes the need for building a trusting relationship between an ICC and their farmer clientele to be most helpful to these farmers.

Open dialogue and active listening between the ICC and farmer are needed to build a trusting relationship. Listening is a process that entails five stages: receiving (i.e., hearing) the message, understanding the meaning of the message, remembering what you heard, evaluating the message, and lastly responding by answering or providing feedback (DeVito 2016a). Through this process, both the farmer and ICC can learn and understand each other's motivations.

The farmers in this study validate the results of Sherman and Gent (2014) because they valued the ICC as a person they can trust who has agronomic knowledge to support their farm but also who is supportive emotionally. To establish a trusting relationship, interpersonal competence must be developed (DeVito 2016b). Adapting communication includes selecting the channel(s) by which the recommendation is communicated, using analogies or examples, and the ability to communicate the science behind management practices or biological processes in a way the farmer clearly understands.

To develop a trusting relationship, it is important for farmers to understand the motivations of the ICC. The ICCs were motivated to make the farmer profitable and seek proactive tailored solutions for each farmers' operation. To develop effective communication, an ICC can learn about what motivates a farmer by critically listening to them. Some farmers were motivated by continually learning about management practices, newly available technology, or improving their operation in some capacity. Multiple farmers were interested in soil health where they wanted to leave the soil in a better condition than when they started farming. An ICC can aid these farmers by sharing knowledge and developing tailored recommendations while considering potential farmer constraints. If a farmer is motivated by conserving the farm for future generations, they may consider using management strategies where results are not seen immediately. This could include management strategies such as transitioning from tillage to reduced tillage or no-tillage, where benefits are not readily apparent. If a farmer values generational farming, then an ICC could utilize this value in communicating management practices, where there is not an immediate economic benefit because the farmer is looking beyond a single person's lifetime and wants to make adjustments that benefit the next generation.

To be an effective communicator and make applicable recommendations, an ICC needs to be aware of farmer limitations and motivations. Limitations can include labor, capital investment, and environmental conditions. These limitations are often intertwined with economic motivation. For example, if a field requires a pesticide application, the ICC will take into account the farmer's equipment, available labor, and provide a prioritized list of fields needing application. In addition, capital-investment can be a hurdle when farmers are considering a new management practice that requires new equipment.

Equally important to understanding a farmer's motivations and limitations is knowing how they prioritize values. The results from the SSVS indicate that these farmers interpret some values differently than Schwartz's analysis of the broader population because the values of power, achievement, and hedonism did not align with Schwartz (1992). Farmers ranked power lower and tended to rank conformity, tradition, and security higher (i.e., conservation value category). This study aligns with Dobricki (2011), Graskemper (2020), and Baur et al. (2016), where they saw farmer's value categories differed from the general population. Baur et al. (2016) used the Portrait Value Questionnaire (PVQ), an alternative to the SSVS, to survey ~72,000 participants of which 1146 (1.6%) were farmers. They found that farmers scored significantly lower on openness to change and significantly higher on conservation when compared to the general public. When they looked at the second value-pair, self-transcendence and self-enhancement, farmers scored significantly higher in self-transcendence and significantly lower in self-enhancement compared to the general population. Our sample size was not as large as Baur et al. (2016), but it does support their findings. The SSVS findings add to the broader literature that applies Schwartz's (1992) held values to farmers, which is currently very limited (Dobricki 2011; Graskemper et al. 2020; Parminter and Perkins 1997; Baur et al. 2016). Knowing that farmers often rank values differently than the general population can be an asset to an ICC when communicating with farmers.

The findings in this exploratory study provide insight into the communication between the ICC and farmer. To determine if these findings are representative for farmers across the United States a larger sample size of ICCs and their farmer clientele would be advised for future research. This would allow for a broader understanding and application of communication research between these individuals. Because this study focused on how ICCs support farmers, future studies could explore how ICCs view their role in supporting the farmer. This can then be compared to the perspective of the farmer, and communication improvements can be made if differences are seen between the farmers and ICC perspectives. From these exploratory interviews, we can conclude that farmers have individual goals, motivations, and communication styles. An ICC's ability to adapt to farmers can result in a symbiotic relationship.

**Literature Cited**

Ajzen, Icek. 1991. “The Theory of Planned Behavior.” *Organizational Behavior and Human Decision Processes*, Theories of Cognitive Self-Regulation, 50 (2): 179–211. doi:10.1016/0749-5978(91)90020-T.

Baur, Ivo, Martin Dobricki, and Markus Lips. 2016. “The Basic Motivational Drivers of Northern and Central European Farmers.” *Journal of Rural Studies* 46: 93–101. doi:10.1016/j.jrurstud.2016.06.001.

Bryant, Jennings, and Susan Thompson. 2002. “Understanding Media Effects.” In *Fundamental of Media Effects*, p. 3–20. McGraw-Hill Higher Education.

Dessart, François J, Jesús Barreiro-Hurlé, and René van Bavel. 2019. “Behavioural Factors Affecting the Adoption of Sustainable Farming Practices: A Policy-Oriented Review.” *European Review of Agricultural Economics* 46 (3): 417–471. doi:10.1093/erae/jbz019.

DeVito, Joseph A. 2016a. “Listening in Interpersonal Communication.” In *The Interpersonal Communication Book*, 14th ed., p. 147–157. Pearson Education. Willard, OH.

DeVito, Joseph A. 2016b. “Foundations of Interpersonal Communication.” In *The Interpersonal Communication Book*, 14th ed., p. 1–15. Pearson Education. Willard, OH.

Dietz, Thomas. 2013. “Bringing Values and Deliberation to Science Communication.” *Proceedings of the National Academy of Sciences* 110 (3). : 14081–14087. doi:10.1073/pnas.1212740110.

Dobricki, Martin. 2011. “Basic Human Values in the Swiss Population and in a Sample of Farmers.” *Swiss Journal of Psychology* 70 (3). Hogrefe AG: 119–127. doi:10.1024/1421-0185/a000047.

Fischer, Ronald, and Diana Boer. 2016. “Values: The Dynamic Nexus between Biology, Ecology and Culture.” *Current Opinion in Psychology* 8.: 155–160. doi:10.1016/j.copsyc.2015.12.009.

Glaser, Barney G. 1965. “The Constant Comparative Method of Qualitative Analysis.” *Social Problems* 12 (4).: 436–445. doi:10.2307/798843.

Graskemper, Viktoria, Karolin Meine, and Jan-Henning Feil. 2020. “Values of Farmers in the Context of Entrepreneurship–Evidence from Germany.”

Manfredo, Michael J., Jeremy T. Bruskotter, Tara L. Teel, David Fulton, Shalom H. Schwartz, Robert Arlinghaus, Shigehiro Oishi, et al. 2017. “Why social values cannot be changed for the sake of conservation.” *Conservation Biology* 31 (4): 772–780. doi:https://doi.org/10.1111/cobi.12855.

Maybery, Darryl, Lin Crase, and Chris Gullifer. 2005. “Categorising Farming Values as Economic, Conservation and Lifestyle.” *Journal of Economic Psychology* 26 (1): 59–72. doi:10.1016/j.joep.2003.10.001.

Parminter, T. G., and A. M. L. Perkins. 1997. “Applying an Understanding of Farmers’ Values and Goals to Their Farming Styles.” *Proceedings of the New Zealand Grassland Association*, 107–111. doi:10.33584/jnzg.1997.59.2273.

Piso, Zachary, Lissy Goralnik, Julie C. Libarkin, and Maria Claudia Lopez. 2019. “Types of Urban Agricultural Stakeholders and Their Understandings of Governance.” *Ecology and Society* 24 (2). Resilience Alliance Inc.

Post, G. R. 1988. “The Private Consultant: Benefit or Burden?” *HortScience (USA)*. 23:490-492.

Rogers, Everett M. 2003. “Elements of Diffusion.” In *Diffusion of Innovations*, 5th ed., p. 1–38. Free Press. New York, NY.

Schwartz, Shalom H. 1992. “Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries.” In *Advances in Experimental Social Psychology*, 25:1–65. Elsevier.

Schwartz, Shalom H. 2012. “An Overview of the Schwartz Theory of Basic Values.” *Online Readings in Psychology and Culture* 2 (1). doi:10.9707/2307-0919.1116.

Schwartz, Shalom H, and Klaus Boehnke. 2004. “Evaluating the Structure of Human Values with Confirmatory Factor Analysis.” *Journal of Research in Personality* 38 (3): 230–255. doi:10.1016/S0092-6566(03)00069-2.

Sherman, Jennifer, and David H. Gent. 2014. “Concepts of Sustainability, Motivations for Pest Management Approaches, and Implications for Communicating Change.” *Plant Disease* 98 (8): 1024–1035. doi:10.1094/PDIS-03-14-0313-FE.

# CHAPTER 4

# THE INDEPENDENT CROP CONSULTANT'S ROLE IN BRIDGING COMMUNICATION ACROSS THE SOCIAL SYSTEM

## Introduction

In the social system, the Independent Crop Consultant (ICC) bridges communication between field scout(s), farmers, colleagues, industry professionals, and government agencies. An ICC has their 'boots on the ground' daily during the growing season collecting field observations (i.e., identifying, and quantifying plant health and pests). Independent crop consultants serve as an advocate for the farmer in various ways, sharing their knowledge, helping in management decisions, connecting them to local University Extension or other professionals, and providing a voice for them in government affairs (policy/regulation). Finally, the ICC can provide information about new technology and management strategies as well as a listening ear and emotional support for the farmer when there are many stressors.

## Bridge with Field Scouts

Field scouts supports the ICC in collecting field observations and increases the acres that an ICC can cover. Throughout the summer, the field scout will be able to observe IPM strategies, expand communication skills with farmers, gain hands-on scouting experience of pest identification and quantification, improve navigation skills, and learn more about their own interests. An ICC can assess a field scout's strengths and weaknesses and connect them to industry professionals or point them on a career path on which they will be successful.

## Bridge with Farmer

Independent crop consultants provide services of scouting and management recommendations of individual fields for farmers. Over the years, an ICC forms a trusting relationship with their farmer clientele. Independent crop consultants learn about the farmer's motivations and values as well as their communication style. Since many farms are family-run, ICC's also get a glimpse into the family dynamics. Farm families are not unique in that there can be a lack of communication. This lack of communication can be a stressor for all members of the family and the ICC. An ICC can assist in getting everyone to have a similar understanding about a situation and subsequent management decisions to address it.

Farmers have many stressors in their life, and this can lead to difficulties in their mental health. Regular interactions between the ICC and farmer may enable them to see behavioral changes and recognize warning signs to identify someone who may be at risk. Warning signs of stress include a change in routine (e.g., social activities, local coffee shop talk), a decline in the care of livestock or pets, increase in illness or other chronic conditions, increase in farm accidents due to fatigue or ability to concentrate, no longer taking pride in farm buildings and grounds, and decreased interest to commit to future activities(Cornell University 2021; American Farm Bureau Federation 2021). An ICC can provide a listening ear for farmers who are dealing with stress and direct them to local professionals trained in (rural) mental health.

## Bridge with Network of Industry Professionals

The field observations the ICC collects are valuable in multiple ways at a micro-level for tailoring management recommendations for farmers and at a macro-level for the larger agricultural community. At the micro-level, colleagues and other ag professionals are a valuable resource during the growing season because this provides a local perspective of what others are observing. An ICC must stay current on evolving management practices, new technology, emerging pests, etc. to provide management options for farmers. Consultants need to stay up to date by networking with colleagues and others in the industry, such as local ag professionals, university Extension professionals, professional societies, government agencies (e.g., USDA, EPA, NRCS), and others.

Connecting with an Extension specialist helps the ICC to know what is occurring statewide and regionally. This information is beneficial as it can provide advanced notice of potential risks that may need to be addressed. Extension specialists and educators are shifting programming to a network-based approach for knowledge transfer and farmer adoption of science-based concepts, as opposed to the traditional top-down, linear model which may result in a disconnect between research and the on-farm application of the research (Wick et al. 2019; Mueller 2021). An ICC, as a change agent with 'boots on the ground' is a valuable bridge in enhancing this network-based approach by connecting the farmers to researchers and tailoring on-farm research applications. In addition, ICCs can support Extension specialists by providing 'boots on the ground' observations and feedback. The specialists are often in charge of an entire state, and it is difficult to gain this 'boots on the ground' perspective across the state. These field observations can be crucial in determining management strategies, if new diseases or pests emerge (e.g., bacteria leaf streak of corn or soybean gall midge) (Jackson-Ziems et al. 2016; McMechan et. 2019).

Independent crop consultants can increase their social networks by being a member of a professional society. There are many professional societies in agriculture with some having an overarching agricultural focus, while others are discipline-specific (see Table 4.1). Through these organizations, an ICC can learn from others about agricultural practices and pests throughout the U.S. and beyond. Management practices that fit one area can be modified to different scenarios addressing specific farmer needs. Professional societies can also serve as agricultural advocates (Hattermann 2020).

| **Agricultural Related Professional Societies** | **Focus Area** |
|---|---|
| National Alliance of Independent Crop Consultants (NAICC) | Overarching |
| Global Alliance of Independent Agricultural Consultants (GAIAC) | Overarching |
| American Society of Agricultural Consultants (ASAC) | Overarching |
| American Society of Agronomy (ASA) | Agronomy |
| Crop Science Society of America (CSSA) | Crop Science |
| Soil Science of America (SSSA) | Soil Science |
| American Phytopathological Society (APS) | Plant Disease |
| Entomological Society of America (ESA) | Entomology |
| Society of Nematologists (SON) | Nematodes |
| Weed Science Society of America (WSSA) | Weed Science |
| National Association of Plant Breeders (NAPB) | Plant Breeders |
| American Society of Agricultural and Biological Engineers (ASABE) | Engineers |

Table 4.1. Agricultural related professional societies that Independent Crop Consultants (ICCs) may be a part of.

### Serving as ‘Boots on the Ground’ Advocate

All professional societies listed except for GAIAC, have public policy/regulation/government affairs committees that advocate for agriculture or discipline-specific issues. The annual Crawfish Boil on the Hill hosted by the NAICC in Washington, DC is a unique event that provides this networking between ICCs and congressmen, senators, and their staff. The event includes NAICC participants “visiting government officials and representatives and their staff" to discuss important issues relevant to farmer clientele of NAICC and companies that support their farmers (Hattermann 2020, p. 126). The experience and knowledge that the ICCs bring to the discussion are important because it directly reflects the challenges farmers are facing. This event consists of relationship building and expressing appreciation to government representatives over an authentic Louisiana crawfish meal. The Crawfish Boil on the Hill began over 20 years ago and is an eagerly anticipated event by the NAICC and government officials (Hattermann 2020). Other societies also have congressional visit days where members meet with representatives to discuss important issues. Providing the 'boots on the ground' perspective to government officials is an important part of the development of policy. Additionally, ICCs serve as intermediaries between policy and farmers to increase farmer adoption of management practices (Eanes et al. 2019).

## Conclusion

While the ICC has a broad background of agricultural production, they must also have the communication skills to deliver the message to their audience. Through building a trusting relationship, they adapt their communication style (i.e., communication competence) to their audience. An open dialogue and active listening aids them in their ability to train the field scout and understand motivations and values of farmers to enable more effective interaction on management decisions. The ICCs 'boots on the ground' perspective is valuable for the farmer and the agricultural community as whole. Independent crop consultants are instrumental in the social system because they connect many individuals together that otherwise may not be connected in a network.

## Literature Cited

American Farm Bureau Federation. 2021. “Farm State of Mind - Stronger Together.” *America Farm Bureau Federation*. [Accessed June 22, 2021]. https://www.fb.org/land/fsom.

Cornell University. 2021. “Farm Stress Management.” *NY FarmNet*. [Accessed June 22, 2021]. https://www.nyfarmnet.org/farm-stress.

Eanes, F. R., Singh, A. S., Bulla, B. R., Ranjan, P., Fales, M., Wickerham, B., Doran, P. J., & Prokopy, L. S. (2019). Crop advisers as conservation intermediaries: Perceptions and policy implications for relying on nontraditional partners to increase U.S. farmers’ adoption of soil and water conservation practices. *Land Use Policy*, *81*, 360–370. doi:10.1016/j.landusepol.2018.10.054.

Hattermann, Dennis R. 2020. “NAICC Advocating for Research and Crop Consultants.” Andrew Coates, Rodney Bennett, and Jeanette M. Van Emon, editors. Navigating Legal Challenges in the Agrochemical Industry, *ACS Symposium Series* 1362:121–134. doi:10.1021/bk-2020-1362.ch009.

Jackson-Ziems, Tamra, Kevin Korus, Tony Adesemoye, and Jan Van Meter. 2016. “Bacterial Leaf Streak of Corn Confirmed in Nebraska, Other Corn Belt States.” *CropWatch*. University of Nebraska - Lincoln Extension. Lincoln, NE. [Accessed June 16, 2021]. https://cropwatch.unl.edu/2016/bacterial-leaf-streak-corn-confirmed-nebraska.

McMechan, Justin, Thomas Hunt, and Robert J. Wright. 2019. “Soybean Gall Midge: An Emerging Pest of Soybeans.” *CropWatch*. University of Nebraska - Lincoln

Extension. Lincoln, NE. [Accessed June 16, 2021]. https://cropwatch.unl.edu/2019/soybean-gall-midge-emerging-pest-soybeans.

Mueller, Nathan. 2021. "Local Programs." *CropTech Cafe*. University of Nebraska - Lincoln Extension. Lincoln, NE. [Accessed June 16, 2021]. https://croptechcafe.org/localprograms/.

Wick, Abbey F., Jean Haley, Caley Gasch, Terry Wehlander, Lee Briese, and Susan Samson-Liebig. 2019. "Network-Based Approaches for Soil Health Research and Extension Programming in North Dakota, USA." *Soil Use and Management* 35 (1): 177–184. doi:10.1111/sum.12444.

# Appendix

## Appendix A – Pest Quantification Terminology

| Pest Quantification Terminology Across Disciplines | | | |
|---|---|---|---|
| **Terms** | **Entomology** | **Plant Pathology** | **Weed Science** |
| **Damage Boundary** | "the level of injury where damage can be measured" (Pedigo and Rice 2009, p. 257) | _____ | _____ |
| **Damage** | "a measurable loss of host utility, most often including yield quantity, quality, or aesthetics" (Pedigo and Rice 2009, p. 256) | "any reduction in the quantity and / or quality of yield that results from injury" (Nutter et al. 1991, p. 1187) | _____ |
| **Economic Damage** | "the amount of injury at which will justify the cost of artificial control measures" (Pedigo and Rice 2009, p. 256) | _____ | "the weed population that caused a yield reduction" (Zimdahl, 2018, p. 641) |
| **Damage Threshold** | _____ | "the disease level at which yield and/or quality begins to be adversely affected." (Zadoks and Schein 1979, p. 350) | "the weed population at which a negative crop yield response is detected" (Coble and Mortensen 1992) |
| **Economic Threshold** | "the pest density at which management action should be taken to prevent an increasing pest population from reaching the economic injury level" (Pedigo and Rice 2009, p. 260) | "the level of disease, i.e., the amount of plant damage, at which control costs just equal incremental crop returns" (Agrios 2005, p. 274). | "weed population at which the cost of control is equal to the crop value increase from control of the weeds present" (Coble and Mortensen 1992) |
| **Gain threshold** | "beginning point of economic damage" Gain Threshold= (management costs ($/acre)/ market value ($/bushel))= bushels/acre (Pedigo and Rice 2009, p. 256) | _____ | _____ |
| **Period Threshold** | _____ | _____ | "implies that there are times during the crop cycle in which weeds are more or less damaging than at others" (Coble and Mortensen 1992) |
| **Action Threshold** | The economic threshold is sometimes called the action threshold. (Pedigo and Rice 2009, p. 260) | "the pest level at which control measures should be deployed to avoid economic losses" (Ownley and Trigiano 2017, p. 541) | "the point at which some control action is initiated, and usually includes economic considerations along with other less tangible factors such as aesthetics, risk aversion, or sociological pressures" (Coble and Mortensen 1992) |
| **Economic-Injury Level** | "the lowest number of insects that will cause economic damage, or the minimum of insects that would reduce yield equal to gain threshold" (Pedigo and Rice 2009, p. 257) | "the lowest intensity of disease that will cause economic damage" (Zadoks and Schein 1979, p. 350) | _____ |
| **Economic Loss** | _____ | "the difference in financial return between maximum economic yield and actual yield." (Nutter et al. 1993, p. 214) | _____ |
| **Injury** | "effect of pest activities on host physiology that is usually deleterious" Direct Injury - "yield forming organs" Indirect Injury - "non yield-forming organs" (Pedigo and Rice 2009, p. 256) | "visible or measureable symptoms and / or signs caused by a pahogen or pest" (Nutter et al. 1991, p. 1187) | _____ |
| **Sign** | _____ | "an indication of disease from direct observation of a pathogen or its parts" APS | _____ |
| **Symptom** | _____ | "an indication of disease by reaction of the host, e.g., canker, leaf spot, wilt" APS | _____ |
| **Disease Intensity** | _____ | "general term for amount of disease present in a population" (Nutter et al. 1991, p. 1187) | _____ |
| **Disease Incidence** | _____ | "Proportion or percent of plant units that are diseased." (Nutter et al. 1991, p. 1187) | _____ |
| **Disease Severity** | _____ | "area of sampling unit (plant surface) affected by disease, expressed as a percentage or proportion of the total leaf area" (Nutter et al. 1991, p. 1187) | _____ |
| **Disease Prevalence** | _____ | "incidence of fields with diseased plants in a defined geographic area (county, state, etc.), i.e., number of fields where a disease is present divided by the total number of fields sampled" (Nutter et al. 1991, p. 1187) | _____ |
| ***Note '______' term is not applicable to the discpline.** | | | |

# Appendix A - References


American Phytopathological Society. 2021. “S-V.” *Illustrated Glossary of Plant Pathology*. The American Phytopathological Society. St. Paul, MN. [Accessed June 8, 2021]. https://www.apsnet.org/edcenter/resources/illglossary/Pages/S-V.aspx.

Agrios, George. 2005. “Plant Disease Epidemiology.” In *Plant Pathology*, 5th ed., p. 272–274. Burlington, MA: Elsevier Science & Technology.

Coble, Harold D., and David A. Mortensen. 1992. “The Threshold Concept and Its Application to Weed Science.” *Weed Technology* 6 (1): 191–195.

Nutter, Jr, Forrest, Paul Teng, and F.M. Shokes. 1991. “Disease Assessment Terms and Concepts.” *Plant Disease* 75: 1187–1188.

Nutter, F., Teng, P., & Royer, M. (1993). Terms and Concepts for Yield, Crop Loss, and Disease Thresholds. *Plant Disease*, *77*, 211–215. https://doi.org/10.1094/PD-77-211

Ownley, Bonnie H., and Robert T. Trigiano, eds. 2017. *Plant Pathology*. 3rd ed. Boca CRC Press. Raton, FL.

Pedigo, Larry P., and Marlin E. Rice. 2009. “Economic Decision Levels for Pest Populations.” In *Entomology and Pest Management*, 6th ed., p. 255–281. Pearson Education. Upper Saddle River, NJ.

Zadoks, J. C., & Schein, R. D. (1979). Epidemiology and plant disease management. *Epidemiology and Plant Disease Management.* Oxford University Press Inc. New York, NY.

Zimdahl, Robert L. 2018. “Weed-Management Systems.” In *Fundamentals of Weed Science*, 5th ed., p. 609–649. Elsevier Inc.

## Appendix B – Schwartz Short Value Survey

THE SHORT SCHWARTZ'S VALUE SURVEY

Instructions:

Please, rate the importance of following values as a life-guiding principle for you. Use the 8-point scale in which 0 indicates that the values is opposed to your principles, 1 indicates that the values is not important for you, 4 indicates that the values are important, and 8 indicates that the values is of supreme importance for you.

The scale:

| | Opposed to my principles | Not important | | | Important | | | | Of supreme Importance |
|---|---|---|---|---|---|---|---|---|---|
| 1. POWER (social power, authority, wealth) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 2. ACHIEVEMENT (success, capability, ambition, influence on people and events) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 3. HEDONISM (gratification of desires, enjoyment in life, self indulgence) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 4. STIMULATION (daring, a varied and challenging life, an exciting life) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 5. SELF-DIRECTION (creativity, freedom, curiosity, independence, choosing one's own goals) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 6. UNIVERSALISM (broad-mindedness, beauty of nature and arts, social justice, a world at peace, equality, wisdom, unity with nature, environmental protection) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 7. BENEVOLENCE (helpfulness, honesty, forgiveness, loyalty, responsibility) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 8. TRADITION (respect for tradition, humbleness, accepting one's portion in life, devotion, modesty) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9. CONFORMITY (obedience, honoring parents and elders, self-discipline, politeness) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 10. SECURITY (national security, family security, social order, cleanliness, reciprocation of favors) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

**REFERENCE**: Lindeman, M & Verkasalo, M. (2005). Measuring values with the Short Schwartz's Value Survey. Journal of Personality Assessment, 85(2), 170-178