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Sorting Out the Details: A Q method Study Investigating Wheat Industry Professionals' Soil Health Management Practices, Information Needs, and Communication Preferences

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Sorting Out the Details: A Q method Study Investigating Wheat Industry Professionals' Soil Health Management Practices, Information Needs, and Communication Preferences

Abstract

There is a need to rethink the traditional approach to conservation outreach, especially among wheat producers in Texas, where adoption of soil health management practices remain low. The study is the first to use Q methodology to identify common viewpoints of wheat industry professionals regarding their beliefs and behaviors related to soil health management practices. After developing the concourse and Q set using interview data and previous research, we collected data from *N* = 36 wheat industry professionals who attended various grower events. During analysis, we extracted seven factors that each had between one and four defining variables and a composite reliability between .80 and .94. Together, the seven factors, each of which represented a common viewpoint, accounted for 59% of the variance. We used distinguishing statements and factor arrays to describe the group of professionals representing each viewpoint—Conservation-Resistant Practitioners, Management-Selective Practitioners, Conservation-Oriented Practitioners, Technology-Motivated Practitioners, Soil Health-Conscious Practitioners, Extension Adverse Practitioners, and Information-Seeking Practitioners. Participants generally disliked aspects of the traditional outreach approach, including print media (i.e., radio, fact sheets), one-on-one conservation planning (i.e., seasonal calls and visits from Extension agents), and demonstrations (i.e., did not need visual evidence from on-farm demonstrations that soil health management practices work). We also identified distinct soil health management behaviors, information needs, and communication preferences of each group that can be used to inform targeted outreach that may increase adoption of soil health management practices.

Keywords

conservation outreach, extension, Q method, soil health management, wheat producers

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Introduction

The traditional approach to outreach about soil health management practices (SHMPs) needs changing because, even though the adoption of SHMPs (e.g., cover crops) has increased over time, the rate of increase has decreased in recent years (Espenshade et al., 2022). The traditional approach to outreach "includes ongoing communications through print and digital media, one-on-one conservation planning, field days and demonstrations, networking events, and conferences" (Espenshade et al., 2022, 56A; Pape & Prokopy, 2017). Information distributed through these communication channels is largely based on research from public institutions (e.g., land-grant universities, cooperative extension, agricultural agencies) and focuses on new technologies and practices that farmers can use to improve soil health management (Espenshade et al., 2022).

Recent reports point to the lack of adoption of SHMPs in the U.S., providing further evidence that suggests the traditional approach to outreach may need changing. On a national scale, the most recent Census of Agriculture indicates two key soil conservation practices, cover cropping and reduced tillage, are used on 10% and more than 50% of cultivated lands, respectively (United States Department of Agriculture [USDA], 2019). From a regional perspective, Das et al. (2021) highlighted "the wide gap between scientific understanding and field-level adoption" by stating only 2.3% of cultivated lands in the Midwest use cover crops.

Although SHMP adoption rates vary considerably based on region and commodity (Wade et al., 2015), these national and regional averages correlate with those reported on wheat. For example, Gelardi (2023) reported that among more than 450,000 dryland wheat acres in Washington, 72% are cultivated using reduced or no till, 13% receive organic matter amendments, 5% are grazed by livestock, and 3% are cover cropped. These figures are consistent with national and statewide estimates, suggesting wheat producers in the U.S. use cover cropping very minimally but use no till as a primary practice (Gelardi, 2023). In Texas, however, SHMP adoption is low among wheat producers. According to the Texas Wheat Producers Board and Association (2020), the USDA Economic Research Service reported in 2017 that no till had a mere 15% adoption rate among wheat producers in Texas, compared to a 50% adoption rate among wheat producers across the country. It seems wheat producers there face distinct barriers to adoption that those elsewhere may not experience.

Some studies indicate higher adoption rates of SHMPs among wheat producers, but these studies are prone to self-selection bias. For example, in their survey of 470 producers in Nebraska and Oklahoma, most of whom grew wheat, Kelemen (2022) found 35.11% used cover cropping, 50.85% used no till, 57.02% used reduced till, 64.68% used diversified crop rotation, 29.57% used livestock grazing cover crops, and 25.32% used managed grazing. As another example, Lo (2020) surveyed 302 wheat producers in middle and west Tennessee and found 29.1% used cover cropping and 86.8% used no till. Participants' high adoption rates likely stemmed from the survey's focus on SHMPs, introducing a self-selection bias toward farmers who implemented them, as these figures are higher than statewide estimates (Kelemen, 2022; Lo, 2020; USDA, 2017).

To meet the needs of 21st century agriculture, Espenshade et al. (2022) proposed a new approach to conservation outreach that leverages the social sciences. By targeting farmers'

motivations and mental models, the impact of conservation outreach could be improved (Espenshade et al., 2022). There are six social science principles guiding the new approach: (1) understanding the factors influencing behavior change, (2) leveraging social networks and cultural influences, (3) developing strategic outreach messaging based on the first two principles, (4) framing outreach messaging using evidence-based framing strategies, (5) designing, promoting, and implementing outreach events to reach existing and new audiences, and (6) planning, managing, and evaluating outreach strategies. To implement this approach effectively, outreach professionals need training to develop their social science skills and knowledge (Espenshade et al., 2022).

Supporting Espenshade et al.'s (2022) call for a new social science approach to conservation outreach, Palm-Forster et al. (2019) conducted a comprehensive review of experimental research investigating how behavioral nudges influence producer decision making about agri-environmental challenges. As a result, they developed a framework to help inform such an approach. According to the framework, producers are heavily influenced by information source (Palm-Forster et al., 2019; Rogers, 2003; Varble et al., 2016). Producers often use friends or neighbors as their primary information source due to shared values and trusted relationships (Varble et al., 2016). Information delivered to producers about agri-environmental challenges, like SHMPs, should include salience points that are clear, concise, and nontechnical to influence decision making positively (Palm-Forster et al., 2019). Information should also include priming, or "subconscious cues, like words, sights, and sounds" to promote behavior change (Dolan et al., 2012; Palm-Forster et al., 2019, p. 21). Additionally, messages to producers should be developed with affect in mind, referring to the emotional responses the information may produce (Palm-Forster et al., 2019).

A body of literature exists that provides insight into producers' mental models regarding conservation practices. Many scholars have investigated factors influencing producers' adoption of SHMPs and "population-level characteristics to understand conservation decisions" (Espenshade et al., 2022, p. 57A). Producers' decisions to adopt SHMPs are influenced by personal characteristics, including education and technical knowledge (Palm-Forster et al., 2019; Prokopy et al., 2019; Reimer & Prokopy, 2014), and experience and confidence in a given practice (Kelemen, 2022). They are also influenced by economic-related factors (e.g., potential crop yields, reduced input costs [Bowman et al., 2016]), and logistical factors (e.g., short window between main crop harvest and cover crop planting [Das et al., 2021]). Research suggests farmers will adopt a new management practice if it maximizes their profits (Daberkow & McBride, 2003; Dewald et al., 2019; Lequin et al., 2019; Varble et al., 2016). Social and cultural factors, like environmental attitudes, relationships with conservation professionals, social network position, social norms, social identity, and ego (i.e., positive self-image) most influence producers' decisions to adopt SHMPs (Espenshade et al., 2022; Lequin et al., 2019; Palm-Forster et al., 2019; Prokopy et al., 2019; Ranjan et al., 2019).

Moreover, the way information is framed can influence SHMP adoption decisions. Stakeholders (e.g., advisers, farm representatives, policy makers) in Ingram et al.'s (2016) study identified a need for information about SHMPs to convey "economically viable ideas" that align with producers' priorities, rather than framing such information around carbon or climate change mitigation (p. 125). Singh et al. (2020) framed information about cover crops in contexts of climate change and extreme weather events and found neither frame was significantly more effective at increasing Midwestern crop advisors' likelihood to recommend cover crops. However, crop advisors who were skeptical of climate change were less likely to recommend the

practice. In addition to information framing, participation in educational programs may also influence producers' decision-making related to cover crops. Specifically, participating in environmental stewardship programs may motivate producers to adopt SHMPs (Bowman et al., 2016) because participation in federal conservation programs can provide both technical and financial incentives (Palm-Forster et al., 2019; Reimer & Prokopy, 2014).

Still, there is a lack of understanding about producers' decisions to adopt SHMPs (Thompson et al., 2014) because producers are a complex population who vary by many characteristics, including access to resources, exposures to risks, operational goals, motives, social networks, production needs, and type and size of operations (Thompson et al., 2014). Our study is the first to identify common viewpoints (e.g., beliefs, behaviors) regarding the SHMPs of wheat producers, and other wheat industry professionals, using Q methodology. We chose to focus on wheat industry professionals, primarily producers, due to the low adoption of SHMPs in wheat production, particularly in Texas (Gelardi, 2023; Texas Wheat Producers Board and Association, 2020; USDA, 2019). Results from the study will build on the new and improved SHMPs outreach approach that leverages the social sciences (Espenshade et al., 2022; Palm-Forster et al., 2019) by helping scholars and practitioners understand which elements of the traditional outreach approach wheat industry professionals like and dislike and providing insights into audience-specific outreach approaches that may be effective in delivering SHMP-related information.

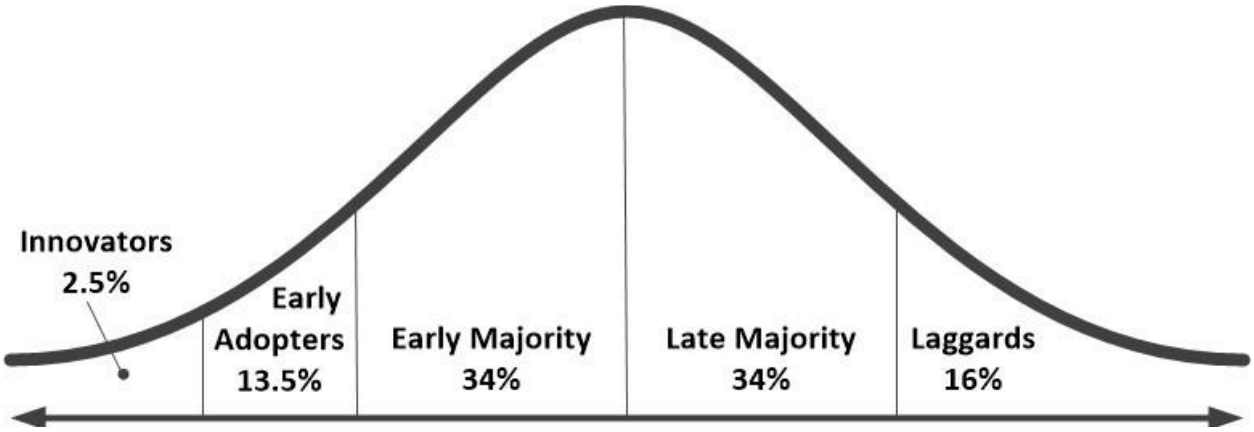
Theoretical Framework

We conducted our study through the lens of Rogers (2003) diffusion of innovations theory. Diffusion refers to how information about an innovation is communicated, or spread, through a social system (Rogers, 2003). There are two ways the theory can be used to evaluate agricultural producers' innovation adoption process. The first is to describe the categories of producers who adopt an innovation by characterizing them on a spectrum from innovators to laggards (Rogers, 2003). The second is to describe the innovation and how its characteristics affect producers' likelihood of adoption (Lavoie et al., 2021). In our study, we considered SHMPs as the innovation and wheat industry professionals as the adopters. We also investigated the communication channels and information sources wheat industry professionals (adopters) preferred when receiving information about SHMPs (innovation).

We chose to use this theory because "outreach must be carefully targeted to address the distinct needs and interests of these groups," referring to the categories of adopters (Carlisle, 2016, p. 29). The theory characterizes members of a social system into five adopter categories: innovators, early adopters, early majority, late majority, and laggards (see Figure 1; Rogers, 2003). Adopters are categorized based on their degree of innovativeness—a relative, continuous variable dependent on the group of adopters (Rogers, 2003). Importantly, producers who represent the different adopter categories experience different motivations and barriers to adopting SHMPs (Carlisle, 2016). Adopter categories are associated with specific characteristics that can further describe the adopters.

Figure 1

Distribution of the Five Adopter Categories According to Rogers's (2003) Diffusion of Innovations Theory



Note. Image obtained from Reiling (2022).

Innovators tend to be venturesome, or particularly interested in new ideas (Rogers, 2003). They are more willing to take risks and are open to new experiences (Adrian et al., 2005; Dessart et al., 2018; Rogers, 2003). Setbacks or challenges that may arise from adopting an innovation do not phase innovators, and they can proceed with a high degree of uncertainty (Rogers, 2003). Innovative producers focus on short-term payoffs and are less likely to focus on long-term payoffs (Palm-Forster et al., 2019). They seek to understand and apply complex knowledge including climate and environmental information (Dessart et al., 2018; Rogers, 2003). The most important role of innovators is launching an innovation into the social system (Rogers, 2003).

Early adopters are highly respected within their social system and sought for advice about an innovation (Rogers, 2003). Peers see early adopters as successful, and they hold a great deal of influence (Rogers, 2003). Early adopters decrease uncertainty about an innovation by providing their evaluation of the innovation to others (Rogers, 2003). In the context of cover crops, early adopters continuously plant them because they are willing "to self-learn and experiment through trial and error" (Dunn et al., 2016, p. 29).

The early majority adopters possess the same willingness to adopt an innovation as innovators and early adopters but lack the innovativeness and motivation to lead (Ong et al., 2022; Rogers, 2003). Therefore, interventions are needed to influence their adoption decisions (Ong et al., 2022). The late majority adopters are skeptical and tend to adopt an innovation just after the average member of a social system does so. The decision to adopt an innovation, for the late majority, results from a combination of economic necessity and peer pressure (Dessart et al., 2018; Rogers, 2003). Together, early majority and late majority adopters make up two-thirds of all members in a social system (Rogers, 2003).

Laggards, the last to adopt within a social system, are traditional in their perspectives and are resistant to change (Rogers, 2003). Laggards must be certain that an innovation will succeed prior to adoption (Rogers, 2003) and are usually only motivated by economic benefits (Dessart et al., 2018). Laggards continue to use practices they have used previously no matter the social system cost, and their social system tends to consist of others with similar, traditional values (Rogers, 2003).

Purpose of Study and Objectives

The purpose of our study was to identify common viewpoints of wheat industry professionals regarding beliefs and behaviors related to SHMPs. These beliefs and behaviors included wheat industry professionals' use of SHMPs, their perceived information needs, and their information source and communication channel preferences. Our study was guided by the following research questions:

1. What are the viewpoints of wheat industry professionals regarding beliefs and behaviors related to SHMPs?
2. What are the beliefs and behaviors related to SHMPs that wheat industry professionals generally agree are important and not important?

Materials and Methods

We used Q methodology to identify common viewpoints of wheat industry professionals regarding their beliefs and behaviors related to SHMPs. Q methodology is a person-centered research approach that produces holistic data (Rost, 2020; Watts & Stenner, 2012). It allows researchers to measure robustly the subjectivity behind people's perceptions, behaviors, feelings, and values (Cross, 2005; Leggette & Redwine, 2016). Results of Q method studies reveal groups of people who feel or behave the same way (Coogan & Herrington, 2011). Therefore, using Q methodology was appropriate to achieve the study's purpose because we wanted to identify groups of wheat industry professionals who thought similarly about SHMPs and the preferred communication channels and information sources of these groups when receiving information about SHMPs.

Concourse

After identifying the topic to investigate, the first step to conducting a Q method study is building the concourse (Previte et al., 2007). The concourse is a collection of knowledge, ideas, beliefs, opinions, and perceptions regarding the topic under study (Brown et al., 1999; Parrella et al., 2021; Stephen, 1985). It contains all relevant information about the topic and can be established through interviews, observations, literature, or media (van Exel & de Graaf, 2005). To build the concourse, we used a combination of interviews and literature. The interviews were conducted as part of a different study (Victoria et al., 2025). As a result of conducting 32 interviews, Victoria et al. (2025) determined the SHMPs of wheat producers in Texas, Oklahoma, and Louisiana based on their classification as an innovator, early adopter, early majority, late majority, or laggard. Findings associated with the study's five emergent themes—soil health management practices and techniques; current and potential programs for producers; programs that lead to adoption; current and desired information sources; and motivations for or barriers to adoptions—were used to build the concourse. We added to the concourse by searching the literature for more empirical research results pertaining to the research themes. Using the interview data and literature, we developed 75 statements, which served as the concourse.

Q Set

Once the concourse is built, the next step is to develop the Q set (Previte et al., 2007). The Q set, which is generated from the concourse, includes the statements presented to participants (Brown, 1993; Coogan & Herrington, 2011; Parrella et al., 2021). It must be clearly defined so that participants can respond based on their experience (Previte et al., 2007). To develop the Q set, several members of the research team (i.e., experts in soil and crop sciences, experts in agricultural communications) engaged in an in-depth discussion about the concourse to determine the relevance of each statement. As a result, we removed three statements from the concourse that were deemed nonessential, leaving us with a 72-statement Q set. Q sets usually include between 30 and 60 statements (Thomas & Watson, 2002). However, due to the depth of information revealed from the interview study and literature review, we chose to make the current study more exploratory by including statements pertaining to all themes rather than only one or two. Due to limited space, the Q set is presented in the results section with the factor arrays.

P Set

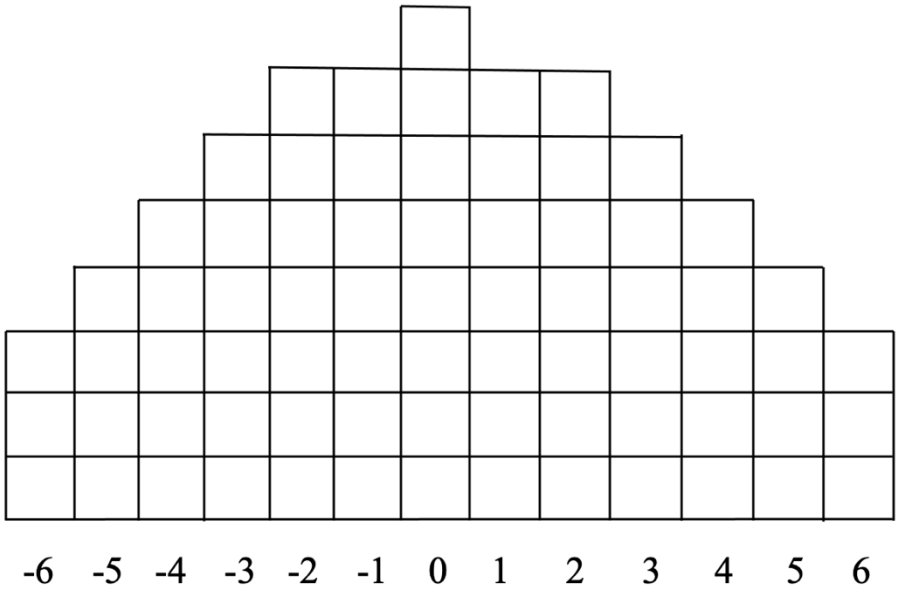
The P set refers to the group of participants who have been purposively selected to match the context of the study (Parrella et al., 2021; van Exel & de Graaf, 2005). Our P set included wheat industry professionals who attended the National Association of Wheat Growers Annual Conference in Kansas City, Missouri, in November 2021, the National Association of Wheat Growers Annual Conference and Commodity Classic in New Orleans, Louisiana, in March 2022, and the Texas A&M AgriLife Extension Service Millersview Field Day in Millersview, Texas, in May 2022 (N = 36). The wheat industry professionals were wheat producers, Extension employees, national and state wheat organization board members and employees, and wheat industry company employees. Some professionals chose not to participate; therefore, not every event attendee was part of the sample. Watts and Stenner (2012) recommended recruiting a P set that is at least half the size of the number of Q set statements. Therefore, because we had 72 Q set statements, our P set of 36 was sufficient.

Administering the Q Sort

The Institutional Review Board at Texas A&M University approved all participant consent procedures and data collection methods under the approval number: IRB2019-1163M. After developing the Q set and recruiting the P set, the next step is to administer the Q sort, which involves participants organizing the Q set statements onto a distribution board to reflect their beliefs (Coogan & Herrington, 2011; Leggette & Redwine, 2016; Previte et al., 2007). At each event, we set up two distribution boards so two attendees could participate in the study at one time and ask researchers for clarification if needed. We asked participants to organize the statements onto a 13-column distribution board (see Figure 2). The leftmost column (-6) contained the statement participants disagreed with most, or the statement least like them, and the rightmost column (6) contained the statement participants agreed with most, or the statement most like them (Brown, 1993). The middle column contained statements participants felt neutral about (Brown, 1993). The forced distribution requires participants to decide which statements most and least reflect their beliefs, behaviors, or values (Thomas & Watson, 2002).

Figure 2

Q Sort Distribution Board



Data Analysis

Once the Q sort is administered, the next step is to analyze the data (Previte et al., 2007). We analyzed the data using PQMethod software, a statistical program used to compute intercorrelations among Q sorts through factor analysis (Schmolck, 2014). We entered participants' 36 Q sorts into the software and conducted the factor analysis in three phases: factor extraction, factor rotation, and final factor analysis (Watts & Stenner, 2012).

We conducted a principal components analysis to identify closely related factors (Parrella et al., 2021). Each factor represents a group of participants who have a similar viewpoint (Forouzani et al., 2013). The principal components analysis produced Eigenvalues (EVs), or numbers indicating the statistical strength of factors (Watts & Stenner, 2012). Often, only factors with an Eigenvalue greater than one are extracted (Forouzani et al., 2013). In this case, 11 factors had an Eigenvalue greater than one, but only eight factors could be extracted using PQMethod software due to its default extraction limit (Parrella et al. 2021). We decided to extract seven factors because we found a natural break of 1.5 between the Eigenvalue of factor seven and the Eigenvalue of factor eight (Parrella et al., 2021). The seven-factor solution explained 59% of the variance, which is considered meaningful because 59% accounts for most the of the total variance (Watts & Stenner, 2012).

We conducted a varimax rotation to position the Q sort relative to how closely they related to the seven extracted factors (Watts & Stenner, 2012; Parrella et al., 2021). Factor rotations generate factor loading scores, which indicate the proximity of each Q sort to each factor (Watts & Stenner, 2012). Only Q sorts with factor loading scores greater than .60 on one factor and less than .40 on all other factors were included (Jordan et al., 2005; Watts & Stenner,

2012; Parrella et al., 2021). Implementing the 60:40 criteria ensures very close proximity between a Q sort and the factors it represents (Parrella et al., 2021).

We conducted a final factor analysis to explain the viewpoints of wheat industry professionals. To interpret the results, we relied on *z* scores, Q sort values, distinguishing statements, and factor arrays (Watts & Stenner, 2012; Parrella et al., 2021). A *z* score "is a weighted average of the values that the Q-sorts most closely related to the factor give to a statement" (Zabala & Pascual, 2016, p. 5). A Q sort value is the location in which participants placed a statement onto the distribution board (Parrella et al., 2021). A distinguishing statement is a statement that participants representing a particular factor placed in a significantly different location on the distribution board compared to participants representing the other factors (Parrella et al., 2021). A factor array is an estimate "of a factor's placement of statements representing their viewpoint" (Parrella et al., 2021, p. 12; Watts & Stenner, 2012). We created a label to describe the viewpoint that represented each factor (Parrella et al., 2021).

Last, we categorized each factor according to Rogers (2003) adopter categories (Carlisle, 2016). The process of labeling and categorizing each factor involved the research team interpreting collectively the aforementioned criteria, which inherently introduces a degree of subjectivity. Though subjective, the data were categorized consistently. For example, the statement 'I currently participate in the USDA's conservation-based programs' was sorted very positively by Conservation-Oriented Practitioners and Management-Selective Practitioners (column 5), but very negatively by Soil Health-Conscious Practitioners (column -5). Therefore, we used this statement to describe the viewpoints of these three practitioner groups.

It is important to note that, rather than categorizing wheat industry professionals on the adoption curve based solely on their SHMPs, we categorized them based on their SHMPs and their information source and communication channel preferences. By considering a range of perspectives and behaviors relating to SHMPs, we created a more nuanced understanding of where practitioners fall on the adoption curve. In real-life circumstances, individual behaviors and preferences are not isolated; rather, they are deeply interconnected. Using Q methodology enabled us to capture some of this complexity. Thus, our study moves beyond a simplistic view of where practitioners fall on the adoption curve based solely on SHMPs and instead embraces the reality of how they engage with and make decisions about innovations. Given our space constraints, we recommend referring to the factor arrays in Table 2 for additional evidence supporting our categorization of factors on the adoption curve.

Limitations

Our study has two primary methodological limitations. First, we defined *wheat industry professional* as any individual working in the wheat industry. At first, we sought only to recruit producers as participants; therefore, we did not include a demographic survey. After failed attempts, we recruited other participants who had different occupations within the industry to reach the minimum of 36 Q sorts. Although we know the majority of participants were producers, we do not know how many people working in different occupations represent each factor. Because of this, our conclusions and recommendations are broad, and not specific to these different industry groups because we are unsure how different industry professionals sorted the statements. Second, although personal characteristics (e.g., education) influence SHMP adoption, we could control for characteristics during data analysis. Unlike traditional quantitative approaches where control variables can be included in statistical models, Q methodology is

designed to explore subjective perspectives and shared viewpoints of participants. Future research should seek to determine how wheat industry occupation and personal characteristics influence beliefs and behaviors related to SHMPs.

Results and Discussion

To achieve research question one, we extracted seven factors, each of which represents a common viewpoint of wheat industry professionals. Each factor has between one and four defining variables and a composite reliability of between 0.80 and 0.94 (see Table 1). Each statement has a factor Q sort value, displayed in the factor arrays, which provides an estimate of where participants representing each factor placed the statement on the distribution board. The placement indicates how they perceived the statement's value (see Table 2). We organized our discussion of the factors based on where we perceived they fell on the adoption curve, from innovator to laggard (Rogers, 2003). We categorized professionals representing Factors Three and Five as early adopters, and professionals representing Factors One, Two, Four, Six, and Seven as early majority adopters. Understanding where these groups fall on the adoption curve may help professionals determine how to develop and implement targeted outreach.

Table 1

Factor Characteristics

Characteristics	Factors						
	1	2	3	4	5	6	7
No. of Defining Variables	2	4	2	2	3	3	1
Average Reliability Coefficient	.80	.80	.80	.80	.80	.80	.80
Composite Reliability	.89	.94	.89	.89	.92	.92	.80
Standard Error of Factor Z Scores	.33	.24	.33	.33	.28	.28	.45

Table 2

Factor Arrays for Each Statement

Statement No.	Statement	Factor Arrays						
		1	2	3	4	5	6	7
1	Using equipment/implementing technology that promotes soil sustainability is important to me.	3	1	2	6	4	1	-2
2	Having a no-till drill would be valuable to my operation and is important to me.	-1	6	5	-5	-3	1	-1
3	Managing the tilth and makeup of my soil is important to me.	5	0	3	3	0	2	3
4	Planting cover crops is important to me.	-6	-3	6	-5	4	6	-2
5	Using reduced tillage is important to me.	0	4	3	5	5	1	2
6	Effects of soil health management techniques on wheat stand/yield is important to me.	5	0	0	1	3	5	2
7	Implementing double cropping is important to me.	0	-6	0	-6	-1	0	2

Statement No.	Statement	Factor Arrays						
8	Understanding financial return of implementing soil health management practices is important to me.	4	5	1	-4	1	5	-2
9	Rainfall capture and soil water infiltration in my field concerns me.	6	6	2	3	0	2	3
10	Managing soil organic matter is important to me.	6	2	4	4	6	3	2
11	Managing microbial activity and diversity in my soil is important to me.	4	-4	3	3	4	2	0
12	The effects of the carbon cycle in my soil interests me.	3	-2	-2	-2	2	3	-1
13	Crop residue management plays a role in the health of my soil.	4	6	0	3	6	2	1
14	Soil sampling to assess the fertility and nutrients in my soil is important to me.	5	5	2	1	6	-2	0
15	Crop rotation is important for the management of my soil and plant health.	4	-3	6	5	5	2	-2
16	I apply the information learned at county Extension field days to my operation.	-2	3	0	-1	0	-4	2
17	Grower meetings are valuable for gaining information on improving my soil health.	2	-2	0	-2	-1	0	6
18	I am open to Extension-based intervention plans that will help me manage my soil health.	-1	-3	1	-1	-2	-5	0
19	Virtual learning workshops and activities would help me gain information about soil health management.	0	1	-4	-2	-1	1	0
20	Extension hosted workshops would help me to manage the health of my soil.	-3	2	-2	0	3	-4	-1
21	I currently participate in an NRCS farming conservation program.	-4	4	4	2	-6	-2	-4
22	I currently participate in the USDA's conservation-based programs.	0	5	5	0	-5	2	-1
23	I would be interested in an educational program that caters to farms of a similar capacity to mine.	2	1	0	-3	2	-1	-5
24	I am aware of the benefits of conservation farming programs.	1	2	3	5	3	5	0
25	Educational programs about how climate change may affect my crops would interest me.	-5	-4	-6	-1	-5	1	-4
26	Programs that provide equipment/ technology leases for minimally tilled soil interest me.	-5	0	6	-5	-3	2	-4
27	Programs that discuss managing soil health based on rainfall in my area interest me.	3	3	1	4	5	0	5
28	I am interested in receiving a visit from my Extension agent to receive recommendations for my operation.	-3	0	-2	-2	-2	-2	-3

Statement No.	Statement	Factor Arrays						
29	I am interested in receiving seasonal calls from my Extension agent to receive recommendations for my operation.	-2	-4	-5	-4	-2	-2	-6
30	Conservation-based incentive programs interest me.	1	-1	5	6	-3	6	5
31	Educational programs about soil health and wheat production would help me implement management techniques on my operation.	2	1	0	-5	2	4	4
32	Programs that reduce farming costs through equipment and technology interest me.	5	3	4	6	-1	4	3
33	I would like to know more about financial programs related to my operation.	-1	0	1	-2	-5	4	4
34	Soil health management programs designed specifically for the age of my farm interest me.	2	-3	-1	1	-3	-3	0
35	Programs that would build my knowledge of the effects of environmental patterns and soil health interest me.	-1	-2	-3	3	2	5	6
36	Programs focused on on-farm profitability and soil health management interest me.	-1	3	2	2	3	4	4
37	Programs that frequently provide beneficial scientific information would benefit my operation.	2	2	-1	-1	2	0	-5
38	Programs focused on practicing soil health management on leased land interest me.	-1	-5	1	2	2	0	-3
39	Programs focused on practicing soil health management on highly erodible land interest me.	0	0	-1	-1	0	-2	-5
40	I read the newspaper to be updated with Extension news.	-4	-4	-4	-3	-2	-5	-4
41	I attend farm field days to be updated with Extension soil management suggestions.	2	3	-2	1	1	-2	3
42	I use the information I learn from radio (farm reports and updates) on my operation.	-2	-3	-4	-4	-4	1	-3
43	I use the information I learn from TV on my operation.	-5	-5	-6	-3	-5	1	-6
44	I use the information I learn from Extension-based email on my operation.	-3	-1	-5	0	0	-4	-1
45	I use the information I learn in Extension-based letters on my operation.	-3	3	-2	2	1	-6	-1
46	I use the information I learn on social media on my operation.	-2	-1	-6	2	-4	-1	-6
47	Discussions with producers in my area help me gain soil health information.	1	1	1	2	0	-1	4
48	Discussions with my crop consultant help me gain soil health information.	-1	2	-3	4	-6	-3	1

Statement No.	Statement	Factor Arrays						
49	Discussions with Extension agents help me gain soil health information.	-2	2	-3	2	-2	-5	-4
50	Research and scientific findings are communicated in a way that is beneficial to me.	1	4	-4	-1	-4	-1	-3
51	If there is an issue with my soil or yield, I have someone knowledgeable I can contact.	3	1	3	5	1	-2	-5
52	I need visual evidence from on-farm demonstrations that soil health management practices work.	-2	-2	-1	1	-2	-1	-2
53	Fact sheets that display the benefits of soil health management practices benefit me.	1	-1	-1	1	1	0	1
54	My own knowledge of soil health management practices is the most effective for my operation.	1	0	2	4	-3	6	-3
55	I prefer to receive information about soil health management monthly.	1	-4	-3	-2	0	-3	6
56	I prefer to receive information about soil health management bi-annually.	2	-2	-5	0	0	-3	3
57	I prefer to receive information about soil health management yearly.	0	-1	-3	0	-1	-6	5
58	I would like to plant cover crops but need help and information to do so.	-6	-3	4	-4	-3	-5	1
59	I would like to implement reduced tillage methods but need assistance and information to do so.	-2	4	2	-6	-4	-6	0
60	I would like to implement double cropping methods but need assistance and information to do so.	-4	-5	3	-6	-6	-3	2
61	Competition with neighboring farms motivates me to implement soil health management practices.	-5	-6	-2	-3	-1	-1	-3
62	The possible profits of cover crops interest me.	-6	-1	5	-3	4	3	-2
63	I am knowledgeable about ways to keep my soil healthy for generations to come.	5	0	4	-2	1	-1	1
64	My heirs' knowledge about keeping soil healthy is important to me.	3	1	-3	-3	4	-4	1
65	I am emotionally connected to the health of my soil.	4	-6	1	4	3	0	0
66	There is value in scientific data from university research regarding tillage methods, cover crops, and double cropping.	-3	4	-1	0	5	0	-2
67	I need more information about soil fertility management practices before implementation.	-1	-1	-1	0	-1	-4	5

Statement No.	Statement	Factor Arrays						
68	The prices of fuel cause for me to consider using reduced tillage practices.	-4	5	-4	1	-2	3	2
69	I consider economics and productivity when deciding to implement soil health management practices.	3	2	2	3	1	4	4
70	Climate change or weather extremes and yield concern me.	0	-5	-5	-4	-4	3	1
71	Sharing information with other producers about soil sustainability is important to me.	-5	-2	0	0	3	-3	3
72	Helping other farmers implement sustainable practices on their operation interests me.	-3	-2	-2	-1	2	3	-1

Factor Three: Conservation-Oriented Practitioners

Factor Three explained 7% of the variance with two defining variables, a composite reliability of 0.89, an Eigenvalue of 2.12, and one distinguishing statement. Participants who represented Factor Three strongly agreed programs that provide equipment/technology leases for minimally tilled soil interested them (see Table 3). Based on the distinguishing statement and the factor arrays, we identified participants who represented Factor Three as Conservation-Oriented Practitioners.

Table 3

Distinguishing Statements for Factor Three with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
26	Programs that provide equipment/ technology leases for minimally tilled soil interest me.	6	1.74*

Note: * indicates $p < .05$.

Conservation-Oriented Practitioners valued and practiced soil health management through minimal tillage, cover crops, and crop rotation. They were not interested in learning about how climate change affects their crops, but they were interested in learning more about programs that provide equipment/technology leases for minimally tilled soil, conservation-based incentive programs, and programs that reduce farming costs through equipment and technology. Some of their interests could be indicative of farm size and structure. They did not want to receive information about SHMPs through traditional media (e.g., newspaper, radio, TV), social media, virtual workshops, or seasonal calls from their Extension agent. In fact, the only information source they felt slightly positive about was other producers. In addition, Conservation-Oriented Practitioners participated in USDA or Natural Resource Conservation Service (NRCS) conservation-based programs. Based on these characteristics, we believe these practitioners may be early adopters (Ong et al., 2022; Rogers, 2003). This suggests traditional mass communication channels may be less effective for this group and peer (producer-to-producer) communication should be leveraged to deliver SHMP-related information.

Factor Five: Soil Health-Conscious Practitioners

Factor Five explained 9% of the variance with three defining variables, a composite reliability of 0.92, an Eigenvalue of 1.71, and three distinguishing statements. Participants who represented Factor Five disagreed that programs reducing farming costs through equipment and technology interest them (see Table 4). They strongly disagreed that 1) they currently participate in the USDA's conservation-based programs; and 2) they want to know more about financial programs related to their operation. Based on the distinguishing statements and factor arrays, we identified participants who represented Factor Five as Soil Health-Conscious Practitioners.

Table 4

Distinguishing Statements for Factor Five with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
32	Programs that reduce farming costs through equipment and technology interest me.	-1	-0.12*
22	I currently participate in the USDA's conservation-based programs.	-5	-1.48*
33	I would like to know more about financial programs related to my operation.	-5	-1.49*

Note: * indicates $p < .05$.

Soil Health-Conscious Practitioners greatly valued soil health and found some SHMPs somewhat important (e.g., cover crops, reduced tillage). Managing soil organic matter, managing crop residue, and sampling soil to assess fertility and nutrients were very important to them, but they did not value double cropping and they did not participate in the USDA's conservation-based programs. Soil Health-Conscious Practitioners were not financially motivated, which is interesting considering most producers are (Daberkow & McBride, 2003; Dewald et al., 2019; Lequin et al., 2019; Varble et al., 2016). They were not interested in programs that reduce farming costs through equipment and technology, and they did not want to learn more about financial programs related to their operation. However, Soil Health-Conscious Practitioners were interested in learning about programs that discuss managing soil health based on rainfall in their area. In addition, these practitioners were least likely to gain information about soil health from crop consultants and traditional media (e.g., television) and somewhat likely to gain information from Extension hosted workshops. Soil Health-Conscious Practitioners valued scientific data about SHMPs and somewhat valued sharing information with other producers to help them implement sustainable practices. Based on these characteristics, we believe these practitioners may be early adopters (Rogers, 2003). For this group, outreach efforts may be most effective when delivered in interactive settings such as Extension workshops rather than financially oriented programs.

Factor One: Cover Crop-Resistant Practitioners

Factor One explained 10% of the variance with two defining variables, a composite reliability of 0.89, an Eigenvalue of 9.61, and one distinguishing statement. Participants who represented Factor One strongly disagreed that potential profits of cover crops interested them

(see Table 5). Based on the distinguishing statement and the factor arrays, we identified participants who represented Factor One as Cover Crop-Resistant Practitioners.

Table 5

Distinguishing Statements for Factor One with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
62	The possible profits of cover crops interest me.	-6	-1.94*

Note: * indicates $p < .05$.

Cover Crop-Resistant Practitioners were resistant to cover crops but valued soil health. They did not plant cover crops, were not interested in the potential benefits of planting cover crops, and did not want information about the practice. Despite their opposition toward cover crops, Cover Crop-Resistant Practitioners cared about soil health because they were concerned about rainfall capture and soil water infiltration and found managing soil organic matter important. These practitioners were somewhat interested in learning how to manage soil health based on rainfall in their area and how to reduce farming costs through equipment and technology. They were not interested in learning about how climate change affects their crops or about equipment or technology leases for minimally tilled soil. Cover Crop-Resistant Practitioners were slightly receptive to attending grower meetings but very unwilling to gain such information from traditional media (e.g., newspaper, TV). In addition, they generally did not value sharing information with other producers about soil sustainability or obtaining scientific data about SHMPs. Based on these characteristics, we believe Cover Crop-Resistant Practitioners may be early majority adopters (Rogers, 2003). Information for this group should be delivered through in-person formats like grower meetings rather than traditional media or science-heavy messaging.

Factor Two: Management-Selective Practitioners

Factor Two explained 9% of the variance with four defining variables, a composite reliability of 0.94, an Eigenvalue of 2.49, and three distinguishing statements. Participants who represented Factor Two strongly agreed that research and scientific findings were communicated to them in a beneficial way (see Table 6). They strongly disagreed that managing microbial activity and diversity in their soil was important to them and that they were emotionally connected to the health of their soil. Based on the distinguishing statements and factor arrays, we identified participants who represented Factor Two as Management-Selective Practitioners.

Table 6

Distinguishing Statements for Factor Two with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
50	Research and scientific findings are communicated in a way that is beneficial to me.	4	1.05*
11	Managing microbial activity and diversity in my soil is important to me.	-4	-1.29*

Statement No.	Statement	Q Sort Value	*Z* Score
65	I am emotionally connected to the health of my soil.	-6	-1.79**

Note: * indicates $p < .05$; ** indicates $p < .01$.

Management-Selective Practitioners were selective in their SHMPs and did not feel an emotional connection to the health of their soil. Managing microbial activity and diversity in their soil and double cropping were not important to them. However, they valued no-till drill, crop residue management, and soil sampling, and they were concerned about rainfall capture and soil water infiltration. These practitioners were somewhat interested in learning about on-farm profitability and soil health management, managing soil health based on rainfall in their area, and reducing farming costs through equipment and technology. They were not interested in learning how climate change affects their crops or how to manage soil health on leased land. Management-Selective Practitioners were somewhat likely to use information learned from county Extension field days and Extension-based letters. They were least interested in receiving information via seasonal calls from Extension agents and traditional media (e.g., newspaper, TV). In addition, Management-Selective Practitioners participated in USDA or NRCS conservation-based programs and valued scientific data about SHMPs. Based on these characteristics, we believe management-selective practitioners may be early majority adopters (Rogers, 2003). This group would benefit from outreach focused on SHMPs they value, shared through Extension sources.

Factor Four: Technology-Motivated Practitioners

Factor Four explained 10% of the variance with two defining variables, a composite reliability of 0.89, an Eigenvalue of 1.98, and one distinguishing statement. Participants who represented Factor Four strongly disagreed that educational programs about soil health and wheat production would help them implement management techniques on their operation (see Table 7). Based on the distinguishing statement and the factor arrays, we identified participants who represented Factor Four as Technology-Motivated Practitioners.

Table 7

Distinguishing Statements for Factor Four with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	Z Score
31	Educational programs about soil health and wheat production would help me implement management techniques on my operation.	-5	-1.53**

Note: ** indicates $p < .01$.

Technology-Motivated Practitioners neither used SHMPs nor wanted information about them. In fact, they firmly believed educational programs about soil health would not help them implement management techniques, and they did not want information about double cropping or reduced tillage methods. However, Technology-Motivated Practitioners valued technology and sought to implement equipment and technology to promote soil sustainability and reduce farming costs. They indicated interest in conservation-based incentive programs, suggesting their

willingness to adopt SHMPs may increase through incentives. These practitioners were most receptive to receiving information about soil health from crop consultants but were uninterested in receiving seasonal calls from their Extension agent or using the radio. Based on these characteristics, we believe Technology-Motivated practitioners may be early majority adopters (Rogers, 2003). Outreach for this group should leverage trusted crop consultants, focus on technology-driven approaches, and connect incentive programs to SHMP applications.

Factor Six: Extension Averse Practitioners

Factor Six explained 8% of the variance with three defining variables, a composite reliability of 0.92, an Eigenvalue of 1.63, and four distinguishing statements. Participants who represented Factor Six somewhat agreed they use information they learn from the radio and TV on their operation (see Table 8). They strongly disagreed that 1) they prefer to receive information about soil health management yearly and 2) they use the information they learn in extension-based letters on their operation. Based on the distinguishing statements and factor arrays, we identified participants who represented Factor Six as Extension Averse Practitioners.

Table 8

Distinguishing Statements for Factor Six with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
42	I use the information I learn from radio (farm reports and updates) on my operation.	1	0.44**
43	I use the information I learn from TV on my operation.	1	0.37**
57	I prefer to receive information about soil health management yearly.	-6	-1.65*
45	I use the information I learn in extension-based letters on my operation.	-6	-1.96*

Note: * indicates $p < .05$; ** indicates $p < .01$.

Extension Averse Practitioners valued cover crops and soil health. However, they did not want assistance from Extension. Instead, they believed their own knowledge of SHMPs was the most effective for their operation. Extension Averse Practitioners did not attend Extension field days or Extension workshops, and they were not open to Extension-based intervention plans to help them manage soil health. They were least likely to receive information about soil health from Extension agents, Extension-based communication (i.e., letters, emails), and the newspaper. Rather, Extension Averse Practitioners were only slightly likely to use information about soil health from traditional media (e.g., radio, TV). These practitioners wanted to learn more about programs not directly tied to Extension, such as conservation-based incentive programs and programs about the effects of environmental patterns on soil health. In addition, Extension Averse Practitioners did find sharing information with other producers about soil sustainability important. Based on these characteristics, we believe these practitioners may be early majority adopters (Rogers, 2003). Outreach for this group should bypass traditional Extension channels and instead engage them traditional mass media and peer networks, placing an emphasis on non-Extension conservation programs.

Factor Seven: Information-Seeking Practitioners

Factor Seven explained 4% of the variance with one defining variable, a composite reliability of 0.80, an Eigenvalue of 1.57, and five distinguishing statements. Participants who represented Factor Seven strongly agreed that 1) grower meetings are valuable for gaining information on improving their soil health; 2) they prefer to receive information about soil health management monthly and yearly; and 3) they need more information about soil fertility management practices before implementation (see Table 9). They strongly disagreed that programs frequently providing beneficial scientific information would benefit their operation. Based on the distinguishing statements and factor arrays, we identified participants who represented Factor Seven as Information-Seeking Practitioners.

Table 9

Distinguishing Statements for Factor Seven with their Associated Q Sort Value and Z Score

Statement No.	Statement	Q Sort Value	*Z* Score
17	Grower meetings are valuable for gaining information on improving my soil health.	6	1.84*
55	I prefer to receive information about soil health management monthly.	6	1.84**
57	I prefer to receive information about soil health management yearly.	5	1.53**
67	I need more information about soil fertility management practices before implementation.	5	1.53**
37	Programs that frequently provide beneficial scientific information would benefit my operation.	-5	-1.53*

Note: * indicates $p < .05$; ** indicates $p < .01$.

Information-Seeking Practitioners valued soil health but did not find SHMPs very important. Their beliefs regarding information about soil health were contradictory in the sense that they were very interested in receiving information about the effects of environmental patterns on soil health and felt very strongly about needing more information about soil fertility management practices before implementation, but they did not believe scientific information would benefit their operation. Therefore, it seems they did not know or believe the information they sought was the result of scientific research. To receive such information, Information-Seeking Practitioners preferred to attend grower meetings. They did not want to receive information about soil health via seasonal calls from their Extension agent, TV, or social media. Information-Seeking Practitioners also felt strongly about wanting to receive information about soil health management frequently—monthly and yearly. As much as they wanted information about soil health, these practitioners did not have someone knowledgeable to contact if they had an issue with their soil, suggesting they did not have a trusted information source. Based on these characteristics, we believe Information-Seeking Practitioners may be early majority adopters (Rogers, 2003). This group would benefit from outreach that prioritizes frequent, in-person opportunities like grower meetings and focus on building trusted relationships.

To achieve research question two, we identified consensus statements among participants. Participants generally disagreed with four statements: 1) they were interested in receiving a visit from their Extension agent to receive recommendations for their operation; 2) they were interested in receiving seasonal calls from their Extension agent to receive recommendations for their operation; 3) they read the newspaper to be updated with Extension news; and 4) they need visual evidence from on-farm demonstrations that soil health management practices work. In addition, participants neither agreed nor disagreed that fact sheets displaying benefits of soil health management practices benefit them. There were no statements participants generally agreed with.

Conclusions

We identified seven common viewpoints of wheat industry professionals: Conservation-Oriented Practitioners, Soil Health-Conscious Practitioners, Cover Crop-Resistant Practitioners, Management-Selective Practitioners, Technology-Motivated Practitioners, Extension Averse Practitioners, and Information-Seeking Practitioners. Results from the study reveal important information about these wheat industry professionals' SHMPs, the information they do and do not want to receive about soil health, and how they want to receive such information (i.e., communication channels, information sources).

Perhaps the most important conclusion drawn from the current study is that there is a critical need to change the traditional approach to outreach about SHMPs, which supports arguments made by Espenshade et al. (2022) and Palm-Forster et al. (2019). We found consensus among participants that they generally disliked aspects of the traditional approach, including print media (i.e., radio, fact sheets), one-on-one conservation planning (i.e., seasonal calls and visits from Extension agents), and demonstrations (i.e., did not need visual evidence from on-farm demonstrations that soil health management practices work) (Espenshade et al., 2022; Pape & Prokopy, 2017). Because we did not collect demographic information, we recognize that these practitioner groups may represent more than just wheat producers and that they may incorporate viewpoints of other wheat industry professionals. However, we do believe that, because the majority of participants were producers, a disconnect exists between producers and Extension that should be explored further. This disconnect has practical implications for how programming is designed and delivered, which may require "unlearning" long-standing outreach approaches and adopting audience-specific engagement methods that use communication channels, information sources, and tailored content to better match producer preferences.

We found no consensus among professionals regarding their general liking toward field days and networking events (e.g., grower meetings)—other aspects of the traditional approach (Espenshade et al., 2022; Pape & Prokopy, 2017). Some felt positive about attending field days (i.e., Soil Health-Conscious Practitioners, Cover Crop-Resistant Practitioners, Management-Selective Practitioners, Technology-Motivated Practitioners, Information-Seeking Practitioners) and grower meetings (i.e., Cover Crop-Resistant Practitioners, Information-Seeking Practitioners). Others felt negative or neutral about attending field days (i.e., Conservation-Oriented Practitioners, Extension Averse Practitioners) and grower meetings (i.e., Conservation-Oriented Practitioners, Soil Health Conscious Practitioners, Management-Selective Practitioners, Technology-Motivated Practitioners, Extension Averse Practitioners). This suggests that a one-size-fits-all approach to outreach is unlikely to be effective and that audience segmentation strategies are needed to deliver important information about SHMPs.

More outreach about SHMPs should focus on three areas: 1) managing soil health based on rainfall in specific areas; 2) reducing farming costs through equipment and technology; and 3) effects of environmental patterns on soil health. As Espenshade et al. (2022) noted, such outreach could be strategically designed, promoted, and implemented to reach existing and new audiences. In addition, conservation-based programs should offer incentives to increase participation because many professionals indicated they were interested (Palm-Forster et al., 2019; Reimer & Prokopy, 2014). Importantly, outreach about SHMPs should not focus on how climate change affects crops. Instead, it should focus on economically viable ideas and how crops are affected by extreme weather events, so professionals are more likely to adopt SHMPs and recommend their use to others (Ingram et al., 2016; Singh et al., 2020).

More research is needed to determine the types of wheat industry professionals who represent each viewpoint identified so their characteristics can inform the development of tailored outreach strategies. In addition, Cover Crop-Resistant Practitioners, Technology-Motivated Practitioners, and Information-Seeking Practitioners should be studied more in-depth because they were resistant to certain SHMPs. Similar to Dunn et al. (2016), we recommend analyzing the beliefs and behaviors of these professionals to better understand their barriers to adoption. Finally, although we identified the communication channels and information sources wheat industry professionals were least likely or somewhat likely to use, we did not identify those they were most likely to use. Therefore, research is needed to determine the communication channels and information sources that would encourage wheat industry professionals to adopt SHMPs.

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