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Exploring the Influence of Innovation Characteristics on the Adoption of a Water and Input Saving Technology in the Jordan Valley: Implications for Community Extension Workers

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Abstract

As the world's population is set to increase to an estimated 9.6 billion people, the greater the strain becomes on the food system to meet people's food and nutrition needs (United Nations, 2013). The MENA region is expected to increase in population by double by 2050 further straining their water and food resources (IFPRI, 2010). Improved innovations to increase production have been encouraged to address those issues. Fertigation, and in particular the more effective hydraulic injector, was introduced in the Jordan Valley to help manage the amount of fertilizer application, reduce run-off in irrigated agriculture, and improve water use efficiency. However, despite its advantages, the hydraulic injector fertigation technology has not been widely adopted. This study sought to better understand this phenomena through the use of mixed methods research on the impact of innovation characteristics, as defined by Rogers (2003), on adoption of the technology. Results found complexity to have a statistically significant impact on adoption and to be a significant predictor of adoption. While not specifically a component of Roger's innovation characteristics, affordability was a key factor in non-adoption.

Keywords: Jordan, adoption, fertigation, Diffusion of Innovations

Introduction

As the world's population is set to increase to an estimated 9.6 billion people, the greater the strain becomes on the food system to meet people's food and nutrition needs (United Nations, 2013). Middle East North Africa (MENA) is expected to follow this trend and is expecting to double in population by 2050 (IFPRI, 2010). Additionally, changes in climate, reduction of water resources, increasing unemployment, and conflicts exacerbate food insecurity for countries in MENA (IFPRI, 2010).

Growing populations and increased water use has further created a water scarcity issue in Arab countries (WB, FAO, & IFAD, 2009). According to the World Bank (2007), about 73% of renewable water resources are constantly withdrawn from the natural system in the MENA region, as compared to the 1 to 30% in other regions. MENA countries are faced with very limited internal renewable water resources, are among the lowest in the world, and are to be reduced by an expected 50% by 2050 (FAO, 2014). This rapid reduction in water resources directly impacts the agricultural production of the region.

Jordan is one of the driest countries in the world with an annual precipitation below 100 mm (FAO, 2009). The changes in crop yield and water consumption levels by agriculture and other sectors has been linked with adverse climate change and water and food insecurity (Al-Bakri et al., 2013). Jordan has been working on increasing its production through improved agricultural practices including the use of improved irrigation techniques.

Along with improvements in irrigation, came the increased use of fertigation. Fertigation improved water usage, however fertilizers were applied without accounting for the actual needs of the crops, leading to over application and waste (Zuraiqi, Rusan, & Qawasmi, 2004). In response, fertigation technologies were developed to increase the direct application of fertilizers in conjunction with irrigation practices. Through fertigation technologies, fertilizers are injected through drip emitters to achieve the optimum level of water content and nutrient concentration applied directly to the root zone (Bar-Yosef, 1999; Gardner & Roth, 1984; Miller, Rolston, Rauschkolb, & Wolfe, 1981; Papadopoulos, 1993).

The hydraulic injector technology is an advanced fertigation technology that controls the nutrient concentration in irrigation water based on crop requirements, allowing farmers to achieve optimum fertilizer and water applied directly to the root zone (Zuraiqi et al., 2004). While the injectors have been seen to have a high advantage over the other types of fertigation, the high costs and the need for training of highly skilled operators may pose significant limitations in farmers' adoption of this hydraulic fertigation technology.

Despite the obvious success of an innovation in pilot tests, encouraging farmers to adopt a new practice can be very difficult due to factors such as conflicting information, risk, implementation costs, or other factors (Vanclay & Lawrence, 1994). Adoption of innovations must occur in order to meet the challenges presented from changes in climate, water resource availability, and strains on food systems. Fertigation, and in particular the more effective hydraulic injector, was introduced in the Jordan Valley to help manage the amount of fertilizer application, reduce run-off in irrigated agriculture, and improve water use efficiency. However, despite its advantages, the hydraulic injector fertigation technology has not been widely adopted.

Theoretical Framework

Rogers (2003) developed a theoretical framework by which an innovation moves through the process of diffusion to adoption. Rogers (2003) defined diffusion as the process by which an innovation passes through communication channels over time among people within a social structure. The adoption process is based on a series of decisions that individuals make to decide to adopt or reject (Feder, Just, & Zilberman, 1985; Gatignon & Robertson, 1991; Rogers, 2003). Rogers' (2003) has been previously applied to look at the adoption of water saving technologies in greenhouses (Lamm et al., 2017), which has many parallels to the current study.

Characteristics of the innovation itself have been seen to influence adoption (Feder, 1982; Feder et al., 1985; Fliegel & Kilvin, 1973; Lamm et al., 2017; Rogers, 2003). Through extensive research, Rogers (2003) found five characteristics that can help to explain the rate of adoption of individual innovations: relative advantage, compatibility, complexity, trialability, and observability. Each innovation characteristic can affect the adoption decision in different ways.

Relative advantage is when new innovations are seen as relatively better than the preceding practices (Rogers, 2003). The relative advantage needs to be great enough for the targeted people to want to make the decision to adopt. It can be measured in terms of economic gain, social prestige, convenience, and/or satisfaction (Rogers, 2003). Relative advantage is the perceived total benefits if one adopts the innovation and has been seen as a decisive factor in determining adoption of an innovation (Lamm et al., 2017; Pannell et al., 2006).

Another important characteristic is how compatible the innovation is with existing norms and values, past experiences, and present needs (Rogers, 2003). Not only does an innovation need to be compatible personally with the farmer, it must also be compatible with existing technologies, practices, and resources being used by the farmer (Kaine & Lees, 1994; Lamm et al., 2017). Additionally, the innovation must be at an acceptable level of complexity, which is the degree that an innovation is perceived as relatively difficult to understand and use (Rogers, 2003). The easier it is for a household to try an innovation, the better it will be for the adoption process. It is important to note even if the innovation itself is not complex, implementing the innovation might add to the complexity of the farm's activities (Pannell et al., 2006). Tornatzky and Klein (1982) found a negative relationship between complexity and adoption.

Trialability refers to how easily a potential adopter can learn about an innovation's performance and optimal management (Pannell et al., 2006). The ability to try the innovation can give the adopter information that may reduce uncertainty about the relative advantage and complexity of an innovation (Lamm et al., 2017; Pannell, et al, 2006; Rogers, 2003).

Lastly, the degree to which the innovation's advantages and impacts can be observed will be a determining factor for the individual (Rogers, 2003). When impacts are easily seen, the person will want to adopt to show others what he or she is doing and the resulting successes. Likewise, high observability can lead to observational learning by neighboring farmers and can aid in diffusion of an innovation (Geroski, 2000; Lamm et al., 2017; Shampine, 1998).

Purpose & Objectives

The purpose of this study was to explore how innovation characteristics impacted the adoption of hydraulic injector fertigation by farmers in the Jordan Valley. The specific research objectives were:

1. Describe current fertigation practices in the Jordan Valley.
2. Describe how innovation characteristics influence adoption of the hydraulic injector.

Methodology

This study was conducted as a mixed method case study of farmers in the Jordan Valley. Merriam (1998) defined a case study as a descriptive and heuristic design meant to give an in-depth understanding of a situation and the associated meanings for those involved. This approach is focused in particular to the population being studied, provides a thick rich description, and allows for an illuminated understanding of the phenomenon (Merriam, 1998). As a process, adoption is extremely complex and can benefit from the case study approach.

The complexity of this study calls for an appropriate use of a convergent parallel mixed methods design (Creswell & Plano Clark, 2007). This type of design allows for different, but complementary data to be collected concurrently. In this approach, quantitative and qualitative were collected separately and independently. Quantitative data, collected via questionnaire, were analyzed first, and then qualitative data, collected via focus groups, were used to help explain the quantitative results.

Context

Jordan is in the arid MENA region: northwest of Saudi Arabia, Israel, and the West Bank to the west, Syria to the north, and Iraq to the northeast. Jordan is mostly an arid desert with a short rainy season in the western part of the country. Only 1.97% of Jordan is considered arable land. To further complicate the situation, Jordan struggles with issues of deforestation, desertification, soil erosion, and depletion of freshwater resources (CIA, 2011). According to the World Bank (2013), Jordan is the world's fourth poorest country in terms of water resources. Most of the water use in the country is for agricultural production, which is the major source of food for Jordanians as well as providing export crops. The Jordan Valley is situated along the western part of the country and is the nation's most fertile region. With its geographical diversity and availability of water resources, the Jordan Valley is the ideal and most prominent place for agricultural production. Water use in the Jordan Valley and its production of agricultural crops make this area the most ideal from which to understand adoption of water saving technologies by farmers.

Subjectivity Statement

As a Hispanic-American woman, I am privileged to have unique values, characteristics, and worldviews as products of my life experiences. I have traveled and worked in several developing contexts. I have dedicated my work to the study of behavior change and base my work in the theory of Diffusion of Innovations. As a researcher, I recognize that as the instrument for the qualitative portion of this study, my biases may impact data interpretation.

Data Collection

Quantitative methods. According to Rogers (2003), adoption is "a decision to make full use of an innovation as the best course of action available" (p. 21). For the purpose of this study, adoption will be defined as use of the injector pump for fertigation or no use. It is important to note that this definition does not leave room for modification or partial use of an innovation presenting a limitation of this study. Stratified random sampling was used allowing for subsets of the population to be studied according to their different characteristics (Ary, Jacobs, & Sorensen, 2010). Researchers in Jordan had a list of potential participants in each strata. The sample resulted in a total of 61 adopters and 39 as non-adopters. Adopters were comprised of farmers who learned about the technology through a loan program as well as farmers who did not take the loan but still adopted the technology.

The instrument collected both demographics and perceptions of characteristics of the hydraulic fertigation technology. Questions pertaining to innovation characteristics were adapted from Moore and Benbasat's (1991) previously developed instrument which measured perceptions of adoption of an innovation. The questionnaire presented Rogers' (2003) innovation characteristics detailed by in a 38-item instrument.

The innovation characteristics as a part of Moore and Benbasat's (1991) questionnaire were: voluntariness, relative advantage, compatibility, image, ease of use, result demonstrability, visibility, and trialability. To keep true to Roger's (2003) theory, relative advantage, compatibility, complexity (ease of use), observability (visibility), and trialability were used in the questionnaire. It is important to note that when complexity is measured, it is in fact measuring the perceived ease of use by the farmer. The instrument was modified to include 22 items, which were tailored to reflect fertigation as the innovation and the Jordanian research context.

The questionnaire was designed for oral administration, differing from other questionnaire formats, as deemed appropriate for the Jordanian context. The questionnaire was mostly closed-ended questions with some open-ended questions. A panel of experts was asked to review the questionnaire to determine the content and construct validity before administration. Face validity was ensured through a cognitive evaluation with a group of advisors (Ary et al., 2010). Construct validity was further assessed through Cronbach's alpha and a factor analysis to determine internal consistency (Cronbach, 1971). To address error, the researcher used the tailored design method (Dillman, Smyth, & Christian, 2009). Non-response error was reduced through the face-to-face administration.

Reliabilities for the innovation characteristic index were calculated *ex post facto* as a pilot test was not possible. A Cronbach's alpha of a 0.70 or higher is seen to be a reliable index (Nunnaly, 1978). The relative advantage index consisted of five items ($\alpha = 0.86$). The compatibility index consisted of four items ($\alpha = 0.90$). The complexity index originally consisted of five items. After a factor analysis of the items, one was removed leaving four items ($\alpha = 0.73$). The trialability index consisted of four items ($\alpha = 0.61$). Lastly, the observability index consisted of four items ($\alpha = 0.78$).

Qualitative methods. Qualitative methods were essential to gaining an in depth understanding of the adoption process. Quantitative data gives a general understanding, while the qualitative data allows for more in depth exploration of the phenomenon (Creswell & Plano Clark, 2011; Flick, 2007). Purposive sampling reflects the diversity within the population under study, is most often used in qualitative research, and was thus used in this study (Barbour, 2007; Merriam, 1998). Three semi-structured three focus groups were conducted, two with adopters, and one with non-adopters. Each focus group had four to five participants. The semi-structured format allows for the researcher to explore interesting paths opened by the participant's responses (Kvale, 2007; Merriam, 1998). The researcher's in-country collaborator facilitated the focus groups while two trained research assistants took notes. The researcher was also present and took observational notes.

Limitations

Limitations of this study are important to note. The research was conducted in Arabic. To address this, the Brislin model for cross-cultural translation (Jones, Lee, Phillips, Zhang, & Jaceldo, 2001) was used to ensure correct wording for the questionnaire and the focus group questions. Focus groups were facilitated in Arabic by a Jordanian researcher using a moderator's guide, which was translated from English to Arabic and back again to ensure meaning transfer.

Data Analysis

Correlations were first run to see if any relationships existed (Ary et al., 2010). A logistic regression was deemed appropriate to look at a binomial dependent variable and several independent variables impacting the dependent variable (Ary et al., 2010). Ultimately, a backward step-wise regression was conducted to further explore the effect of the variables. The dependent variable for this study was: adoption or non-adoption. The independent variables were characteristics of the innovation.

Qualitative data analysis was conducted using context-driven coding to explore the adoption of fertigation. This was driven by Rogers' (2003) theory creating previously established codes (Merriam, 1998). The codes were the innovation characteristics according to their descriptions per Rogers' theory. Emergent codes were also allowed as the data dictated.

Qualitative and quantitative data are inherently different giving diverse insight to the study. As such, it is important to maintain the integrity of the data and merge the data after separate analysis and interpretation (Creswell & Plano Clark, 2007). Once all data was analyzed, the researcher combined the data from the quantitative questionnaire and the qualitative focus groups under each objective to present overall results. The integration of the data gives a complete picture of the data set, which answers the overall research question.

Results

A total of 100 farmers were surveyed. One hundred percent of questionnaire respondents were male, ages ranging from 21 to 70 with a mean age of 45.87 (*SD* = 10.88). The largest portion of respondents had at least a secondary school education (37%). About half (57%) reported fully owning their farms. Farms in Jordan are measured in dunam or 0.24 acres. The farms varied in size from 7 dunam (1.73 acres) to 70 dunam (17.30 acres). The mean farm size was 34.79 dunam (8.60 acres) (*SD* = 9.06). Respondents represented 19 villages and 2 regions. All respondents were from the Middle and South areas of the Jordan Valley. Ninety-nine percent of respondents reported having begun using fertigation more than two years ago.

Objective 1: Fertigation in the Jordan Valley

The following results describe the current situation for fertigation in the Jordan Valley. Ninety-nine percent of respondents stated they were familiar with fertigation. Table 1 shows the varying degrees to which respondents stated their familiarity with the different fertigation technologies, both in having knowledge of the technology and having seen it in use, as well as use of the technologies on their farms. All (100%) of respondents had heard about the water pump technology, 99% had seen it in use, and the majority of farmers (68%) reported using this technology on their farm. Additionally, respondents stated they heard about fertigation technologies from various sources, primarily from other farmers (92%).

Table 1
Familiarity with Fertigation Technologies and Use

Fertigation Technology	Distribution (percentage) Knowledge of Yes	No	Seen in use Yes	No	Use on farm Yes	No
By-pass tank	53	47	47	53	1	99
Water pump suction	100	0	99	1	68	32
Hydraulic injector	78	22	80	20	58	42
Electric pump	44	56	41	59	22	78
Venture injector	51	49	53	47	15	85

However, responses indicated the National Centre for Agricultural Research and Extension (NCARE) (79%) and the private sector (76%) also played a significant role in providing information about fertigation.

Seventeen different crops were reported as using fertigation in production in open planting as well as greenhouses. Over half (61%) of respondents reported growing tomatoes with a mean productivity in the greenhouses of 14.32 tons/dunum. Data showed certain crops are more appropriately grown in greenhouses rather than open planting, and vice versa. Total area under fertigation ranged from 1 dunum (0.25 acres) to 70 dunum (17.30 acres) with a mean of 32.42 dunum (8.01 acres) (*SD* = 11.27). When asked if the area under fertigation was the entire farm, 85% stated it was. Most frequently stated reasons for using fertigation on the entire farm were: work is completed faster (61.6%), increased productivity (19.8%), and the land needs fertilizer (22.4%). Likewise, the biggest reason for not applying it to the entire farm was the high costs associated with purchasing and maintaining the system (80%).

Objective 2: Innovation Characteristics and Adoption

The second objective was to measure how these innovation characteristics influenced adoption of the hydraulic fertigation technology. Indices for each innovation characteristic were calculated by using a grand mean for all questions within that index (see Table 2). Index means could range from 0 to 1.0; strongly disagree (0.0) to strongly agree (1.0). Relative advantage had an overall index mean of 0.66 (*SD* = 0.17). Compatibility had an overall mean of 0.67 (*SD* = 0.15). Complexity had an overall index mean of 0.68 (*SD* = 0.13). Trialability had an overall index mean of 0.57 (*SD* = 0.12). Lastly, observability had an overall index mean of 0.61 (*SD* = 0.14).

Table 2
Index Means of all Innovation Characteristics by Adopter/Non-adopter

Innovation Characteristics	Adopter Mean	SD	Non-Adopter Mean	SD	Overall Mean	SD
Relative Advantage	0.66	0.17	0.65	0.17	0.66	0.17
Compatibility	0.67	0.12	0.67	0.18	0.67	0.15
Complexity	0.70	0.12	0.65	0.15	0.68	0.13
Trialability	0.58	0.10	0.56	0.16	0.57	0.12
Observability	0.63	0.10	0.58	0.18	0.61	0.14

A binary logistic regression analysis was conducted using the five innovation characteristics as independent variables to predict their influence on adoption (or non-adoption) of the hydraulic injector fertigation technology. A test of the full model (including all independent variables) against the constant model was not found to be statistically significant, χ^2 (5, N = 100) = 8.059, p = 0.15. Table 3 shows the analysis of the regression.

Table 3
Logistic Regression Results for Innovation Characteristics

						95% CI Exp (B)	
	B	SE	Wald	p	Exp (B)	Lower	Upper
Intercept (constant)	-2.78	1.62	2.94	0.09	0.06		
Relative Advantage	-0.14	2.12	0.01	0.95	0.87	0.04	54.98
Compatibility	-1.92	2.75	0.49	0.48	0.15	0.00	31.71
Complexity	3.91	2.13	3.35	0.07	49.70	0.76	3256.73
Trialability	0.28	2.06	0.02	0.89	1.33	0.02	74.60
Observability	2.61	1.77	2.17	0.14	13.57	0.42	435.38

Note: Model Summary (Omnibus Tests): Chi-square = 8.06; 2-Log Likelihood=125.69; df=5; p=0.15; Nagelkerke's R^2=0.15, Cox and Snell R^2=0.08

A backward stepwise binary logistic regression (Wald) was then conducted (Table 4). Step 1, including all predictor variables, was not significant χ^2 (5, N = 100) = 8.06, p = 0.15. None of the predictors were found to be statistically significant. The following step (2), removing relative advantage, remains to not be statically significant, χ^2 (4, N = 100) = 8.05, p = 0.09. Again, none of the individual predictors are statistically significant. Step 3, removal of trialability, presented a statistically significant model, χ^2 (3, N = 100) = 8.04, p = 0.05. No predictors were significant. Step 4, removing compatibility, maintained a statically significant model, χ^2 (2, N = 100) = 6.90, p = 0.03. No predictors were significant. Finally, step 5, with removal of observability, yielded a statistically significant model, χ^2 (1, N = 100) = 4.58, p = 0.03. Complexity alone was significant (p = 0.04).

Table 4
Backwards Logistic Regression Results for Innovation Characteristics

						95% CI Exp (B)	
	B	SE	Wald	p	Exp (B)	Lower	Upper
Intercept (constant)	-2.12	1.26	2.83	0.09	0.12		
Complexity	3.49	1.70	4.23	0.04	32.75	1.17	911.96

Note: Summary (Omnibus Tests): Chi-square=4.58; 2-Log Likelihood=129.17; df=1; p=0.03; Nagelkerke's R^2=0.05, Cox and Snell R^2=0.06

Focus groups. The focus groups (FG) also gave insight into the adoption of the hydraulic injector fertigation technology based on innovation characteristics (compatibility, relative advantage, and observability). Additionally, another theme beyond Rogers' five characteristics emerged from non-adopters, affordability.

Relative advantage. Participants stated their opinions of the innovation pertaining to the perceived relative advantages. "[Fertigation] reduces expenses and increases production" (FG 1). They spoke about increased production. "…We see there is a profit from its use, good production, and see that there is equal distribution of fertilizer down every irrigation line" (FG 3). "In the long run, there will be more production and less cost" (FG 1). Another participant mentioned long-term gains: "Saving fertilizer will be reflected in the cost and there will be improvement in [my] household livelihood" (FG 1).

Participants mentioned savings as a relative advantage. "We search for something that will save water, save time for production and saves costs. Anything that will give us money saving" (FG 2). Another stated, "I concentrate on the profits of the technology to know if I will adopt the technology" (FG 3). One participant stated why he did not use the technology on his entire farm. "The project came to me, but I have a big farm and it needs more time to use the technology…" (FG 2).

Compatibility. In the first focus group with non-adopters, one farmer stated why he would not use fertigation. "We farm like our fathers and grandfathers" (FG 1). The fertigation technology the non-adopters were using was taught to them by their ancestors. "We hear about the hydraulic injector but did not want to use it because the traditional way suits my needs" (FG 1). The new technology was not compatible with their experiences or desired operating methods. Another participant spoke about land ownership and adoption. "If we own the land, we will adopt… If we do not own, we will not adopt the technology. We do not want to invest in land that we do not own" (FG 3). The hydraulic injector requires significant infrastructure and as such is not likely to be adopted by a farmer that does not own the land and would not benefit from the investment should the land owner change their renting policies. Similarly, a different participant stated, "I have heard about fertigation but I do not use it. I farm on shared land" (FGW 4). Sharing the land is not conducive to investing in a technology for land that is not their own.

Complexity. Participants mentioned some difficulties in using fertigation. "When I irrigate in winter, it takes too much time working with the fertigation technology. This creates too much humidity in the greenhouse" (FG 2). The farmers believed the hydraulic injector to work too slowly causing excess humidity and potential fungal conditions in the greenhouses. Similarly, another participant stated "if there is no sun, the production is low. The climate must be suitable for the moisture needed" (FG 2). They stated production through the use of fertigation using the hydraulic injector depended on an ideal climactic situation.

Observability. Participants stated that seeing the technology influences their adoption. "Before we adopt any new technology, we need to examine this technology and see the benefits before we adopt it ourselves" (FG 3). Farmers felt that hands-on experiences with the technology and visual results help them to make the decision to adopt or not adopt.

Affordability. During the non-adopter focus group, participants mentioned the affordability of the technology several times as a factor in adoption. "Fertigation saves 100% of fertilizers but it is very expensive" (FG 1). Despite potential benefits, cost is mentioned again. "We have heard it is excellent, but it is very costly" (FG 1). According to NCARE, the hydraulic injector technology costs about $1000 dinars which is a significant cost for small farmers. One participant mentioned funding. "If there is no [financial] support to help us use these options, how can we use it?" (FG 1). Another participant spoke about the loans for the technology. "There were criteria to take loan to buy the hydraulic injector. We cannot pay installments. We have other needs to pay" (FG 1).

Conclusions, Implications & Recommendations

Fertigation is not new to Jordanian farmers. Yet, there has not been much research conducted to investigate what they know about it. Farmers in the Jordan Valley seem to be very familiar with fertigation. However, their familiarity and use of the different types of fertigation technologies varied. Data indicated the majority of farmers had some knowledge of each of the different types of fertigation. It is interesting to note that at least two-thirds of the respondents had at least heard of the hydraulic injector and yet the majority stated they only used the water pump suction technology.

Seventeen crops are being produced using fertigation. Farmers in the Jordan Valley grow these crops both under greenhouses and in open fields. For many of the crops (11 of 17 reported), mean productivity in the greenhouses is more than in the open field. Due to the climactic conditions in Jordan, it is fitting that production would be reported to be greater in the greenhouses. Based on both the quantitative and qualitative data, farmers are aware of the benefits of the hydraulic injector fertigation technology stating faster work time, increased productivity, and overall fertilizer and water savings. Despite this, they are also aware of the cost of this technology as a barrier to adoption (to be discussed further below).

Exploring the impacts of innovation characteristics on adoption is not new. However, it has not been explored for this population until this study. The questionnaire provided a glimpse into how farmers in the Jordan Valley view the hydraulic injector fertigation technology. The focus groups provided additional insights for each characteristic.

Innovation Characteristics

Relative advantage. Respondents moderately agreed the hydraulic injector provides a relative advantage. According to Rogers (2003), relative advantage is expressed in economic profitability or social prestige. This was well demonstrated in the qualitative data. Participants stated they saw profitability through increased productivity as well as savings in fertilizer and water costs. Profitability was also mentioned as a prerequisite for adoption. The potential for increased profitability from an innovation has been noted by other researchers (Lamm et al., 2017). During the focus groups, the moderator and the farmers discussed their challenges with agriculture as a source for their livelihoods. This explains their need to see the profitability before making a decision to adopt. They are willing to make changes to technologies in their farming but want to be somewhat sure they will have a true possibility to make a profit.

Compatibility. Respondents moderately agreed they found the hydraulic injector technology to be compatible with existing practices. Similar to relative advantage, the majority of respondents agree that the hydraulic injector is compatible with their existing values, past experiences, and needs (Rogers, 2003). The focus groups provided different information for the compatibility of the technology. Compatibility is important as it begins to touch on a farmer's personal frame of reference. Incompatibility has been previously shown as a barrier to adoption (Lamm et al., 2017). The participants of the focus groups were proud to be farmers. Some stated they farm the way they were taught to farm. Therefore, the hydraulic injector was not compatible with their preferred agricultural practices.

Likewise, the hydraulic injector takes investment in infrastructure. This investment is not only costly, but difficult to do when the land is not owned. Farmers spoke about their resistance to use the technology because they rented the land. During the focus groups, participants explained the difficulty with land ownership. Many smaller farmers rent the land, which introduces a level of uncertainty of subsequent land use and/or access. A compatible technology fits more closely with an adopter's situation. The infrastructure needed for this technology makes it incompatible for certain farmers.

Complexity. Respondents moderately agreed that the hydraulic injector technology was relatively easy to use. Rogers (2003) said that complexity relates to how easy a technology is to use and understand. During the focus groups, complexity was not directly mentioned. However, some farmers spoke about difficulties that arose from fertigation use in the greenhouses. Complexity in greenhouse technologies has been previously noted as important for adoption (Lamm et al., 2017). A number of participants stated the technology needed the appropriate temperature to work. They also said it was a slower technology and that this caused there to be too much humidity in the greenhouses that created an environment for mold to grow and harm production. While the technology itself was not seen to be difficult to use, there were difficulties that arose from its use. These difficulties can further reduce the innovation's perceived relative advantage.

Trialability. Farmers neither disagreed nor agreed that the hydraulic injector was available for trial. Some innovations can be difficult to try. The degree to which a technology can be experimented with is important to dispel uncertainty and allow a farmer to see how it works for them (Rogers, 2003). As mentioned before, the hydraulic injector technology needs infrastructure that not all farmers have due to lack of land ownership and financial support. This greatly reduces the trialability of the hydraulic injector. Other opportunities to try the hydraulic injector may not be available.

Observability. Respondents somewhat agreed the technology was visible. During the focus groups, one participant mentioned the need to see the results of the technology. Rogers (2003) stated that the results of some technologies are easier to see than for others. The questionnaire directed the inquiry more towards the visibility of the innovation itself rather than its results. In the focus groups, farmers said they know the results of using the technology, however they had not seen the results in person.

Affordability. The majority of the participants noted the technology was not an affordable technology. Rogers (2003) mentioned the initial cost of an innovation, as part of relative advantage, which can potentially affect rate of adoption. The costs of new technologies has been previously noted by researchers (Lamm et al., 2017). The sample included respondents who had received loans to help them cover the expenses of the hydraulic injector technology. Those farmers discussed how the loan enabled them to adopt the technology. Affordability, as a part of relative advantage, goes beyond the initial cost. Farmers acknowledged the maintenance and upkeep of the innovation to be an inhibitor of adoption. Despite knowing the benefits, affordability was reiterated as the main factor for non-adoption.

Overall characteristic indices. Overall, the indices did not differ greatly between adopters and non-adopters. Complexity and observability both differed by 0.05 (greater for adopters) between the two groups. However, the complexity mean for adopters was greater than the overall index mean, recognizing that a higher mean for complexity means the respondents found the technology to be less complex. Perceived complexity is negatively related to an innovation's rate of adoption (Rogers, 2003). Adopters are currently using the technology and thus have had the opportunity to use it and could have potentially rated the technology to be less complex. Likewise, observability was also higher for adopters than for non-adopters. Since the adopters were already using the technology, they could better see it in use and its.

Influence of Innovation Characteristics on Adoption

The binary logistic regression model with all independent variables (relative advantage, compatibility, complexity, trialability, and observability) proved to not be a significant predictor of adoption. Non-significant results here suggest that the odds for adoption are similar regardless of the innovation characteristics. However, to explore innovation characteristics further, a backward stepwise binary logistic regression (Wald) was conducted which did result in complexity as a statistically significant predictor of adoption.

To understand the results, it important to remember: the higher the complexity score, the more that person perceives the technology to be easy to use. The logistic regression coefficient (B = 3.49) demonstrated a positive relationship. As the complexity score increases (ease of use), so does the likelihood of adoption. The more a person perceives the innovation to be easy to use, the more likely they are to adopt (Rogers, 2003; Tomatzky & Klien, 1982). The odds ratio (Exp (B) = 32.75) showed that for every one unit increase in complexity (ease of use), the odds for adoption increase by nearly 33. Finally, the Chi Square has a p-value of 0.03, which indicates that the model, including only complexity, is a good predictor of adoption.

Recommendations & Implications

Extensionists seeking to increase the adoption of new technologies must take into consideration the innovation and their perceived characteristics. However, they are not the only consideration. Adoption of innovations should be viewed as a holistic process. Accordingly, extensionists with NCARE should focus their primary efforts on the complexity and affordability of the hydraulic injector technology, while also acknowledging the relative advantage, compatibility, trialability, and observability.

The innovation can be a sound, worthwhile technology but if it is not perceived to meet the needs, desires, and context of the potential adopters, it is unlikely to be used to the capacity intended. Innovation characteristics as well as adopter categories and diffusion networks should be examined to better understand the dynamics of an innovation's adoption/diffusion process.

This research provides a foundation for further research to be conducted. A potential study to identify adopter categories for farmers in the Jordan Valley could be useful for further dissemination and adoption of fertigation technologies such as the hydraulic injector. Not all individuals adopt an innovation at the same rate (Rogers, 2003). Adopter categories will help extension agents know what particular groups of people value. In understanding their values and characteristics, targeted interventions to encourage adoption can be planned and executed. The development of different messages administered through different communication channels can help increase the adoption and diffusion of an innovation. With new forms of communication and continued technology development, further research needs to be conducted.

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