

Introduction/Need for Research

Nitrogen Rich Strips (NRS) and the Sensor Based Nitrogen Rate Calculator (SBNRC) are examples of PA technologies available to producers for about 20 years (Birehane, 2017). These tools help producers optimize their application of nitrogen, the most limiting nutrient for plant growth. If adopted together, the tools are a "technology cluster" (Rogers, 2003). However, widespread adoption of such remains limited, uneven, or non-existent among many who could benefit. Understanding why producers choose to adopt or reject these innovations could

- guide the development of new PA tools and techniques;
- reveal needed modifications of existing technologies;
- inform researchers and extension educators about how to better serve their stakeholders.

However, Camp (2001) asserted that "a major stumbling block for many researchers in conceptualizing research is the development of an adequate theoretical framework for a study" (para. 2). Another failing significant as Camp's (2001) assertion are researchers using data collection instruments thought to be appropriate for the phenomena or situational contexts without embedding relevant constructs and items, i.e., observables or variables of interest, resonating with their studies' theoretical and/or conceptual frames. We, therefore, sought to do that regarding the targeted respondents' adoption behaviors by using Rogers' (2003) diffusion of innovations model to guide instrument development as well as data analysis and interpretation.

Theoretical/Conceptual Framework

According to Rogers (2003), change is a *process*, including the diffusion of innovations: "diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system" (p. 11). Rogers' (2003) model guided our development of response items, especially regarding perceived attributes of innovations among other variables associated with an innovation's rate and constancy of adoption. Personal connections and relationships among members of a social system are also important catalysts influencing an innovation's adoption as well as favorable perceptions of its attributes (Rogers, 2003). Moreover, these manifest and are perceived differently depending on adopter category, e.g., earlier versus later adopters (Rogers, 2003). Interactions involving change agents, opinion leaders, and potential adopters, which often involve creating awareness, using persuasion, and offering opportunities for the attributes of observability and trialability to be perceived, can positively affect an innovation's rate of adoption (Rogers, 2003).

Methodology

This was a descriptive-exploratory study. Other than anecdotal data, very little information existed about adopters' perceptions of the PA technologies studied. Our online survey Qualtrics questionnaire included forced-choice (Yes/No), Likert-type scale, and open-ended items. Producers' perceptions of Rogers' (2003) key attributes of an innovation were assessed, such as:

- Relative advantage
- Compatibility
- Observability
- Trialability
- Complexity

Five-point, Likert-type response scales were developed to measure their views on relative advantage and complexity. Producers' perceptions of the relative advantage (Rogers, 2003) associated with using the PA technology was measured with a Likert-type scale: 1 = *No value* to 5 = *High value*. Rogers' (2003) attribute of complexity was assessed with a perceived level of difficulty response scale: *Not difficult* = 1 to *Very difficult* = 5. Other items were developed to determine the adopter categories to which the producers likely belonged:

- year of adoption;
- from whom they learned about the innovations, a scientist versus a peer farmer;
- number of related trainings attended;
- highest level of education.

A panel of experts reviewed the instrument to verify its face and content validity. It was distributed through an electronic mail listserv of subscribers who had attended trainings on plant nutrient management provided by Extension professionals at OSU. Dillman et al. (2009) recommendations for data collection were followed:

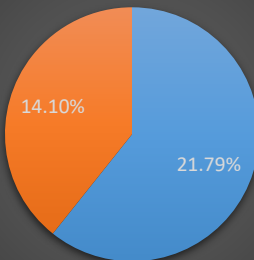
- a prenotice email message was sent to the intended respondents;
- an invitation message with a link to the questionnaire was sent next;
- two follow up, reminder messages were sent to increase response rate.

Sixty or about 10% of producers responded to the questionnaire limiting generalizability of the study's findings. Data were analyzed with descriptive statistics. Rogers' (2003) theoretical framework aided in analyzing, interpreting, and reporting the findings (Camp, 2001).

Results/Conclusions

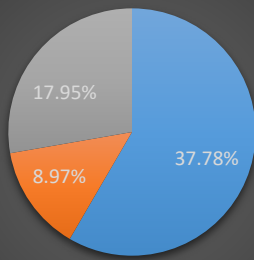
All but one producer was male; most were white. More than 90% had earned a bachelor's degree or higher levels of education. The group's mean age was 57 years; they had farmed for about 30 years on average; and two-thirds farmed ≤ 1000 acres. Wheat was the crop for which most used the technologies. The producers' self-reported earliness to lateness of adoption by year ranged from 1995 to 2019. As a group, they reported attending an average of 2.06 Extension trainings each year. The most often cited communication channel for knowing about the tools was OSU Extension. If considering the scale's real limits, the producers perceived the NRS had *Average value* ($M = 3.17$; $SD = 1.14$). Applying the same real limit intervals, both tools were viewed as *Slightly difficulty* to use: NRS, $M = 1.75$ ($SD = 1.01$), and SBNRC, $M = 1.83$ ($SD = 0.92$). However, several narrative statements referenced various issues of difficulty. See Figures 1 and 2 for the percentages of producers' statements regarding their perceptions of the innovations' attributes. Both observability and trialability support the likelihood of adoption occurring (Rogers, 2003). Regarding the producers' opportunities to observe the use of NRS prior to adoption, 70% ($f = 42$) said *Yes* and nearly two-thirds ($f = 15$) of the SBNRC users had first observed it in practice before adopting (see Figure 3). As for using the technology on a trial or limited basis before making their initial adoption decisions, 60% ($f = 36$) had tried the NRS and nearly two-thirds ($f = 15$) of the SBNRC users had. Of note, 55% ($f = 33$) of the producers reported discontinuance of their adoption of the PA technologies.

Figure 1. Producers' Perceptions of Attributes Supporting Adoption



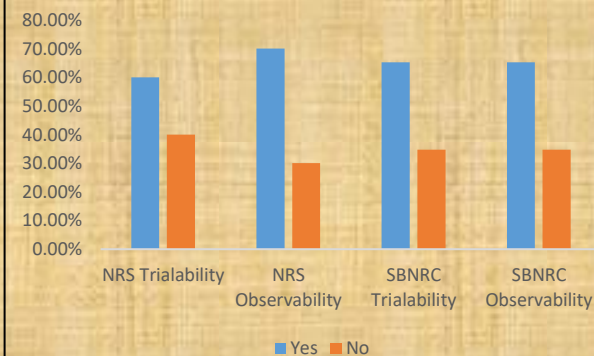
■ Relative Advantage/Low Complexity ■ Compatibility

Figure 2. Barriers to Adoption and/or Disenchantment Leading to Rejection



■ Lack of Compatibility ■ Lack of Relative Advantage ■ High Complexity

Figure 3. Opportunities for Trialability and Observability of NRS and SBNRC



Implications/Recommendations

Regarding the attribute of compatibility, some producers noted the need for rainfall soon after applying N, but it did not always rain, nor did they irrigate. Issues also arose if their wheat was grazed by cattle for a time, which is a common practice in Oklahoma (see Figure 2). So, the technology was not as compatible with their farming systems as some adopters may have initially thought. Rogers' (2003) diffusion of innovations model was a useful lens for interpreting the producers' adoption decisions for the PA technologies investigated. Change agents for these technologies should stress the related attributes in their trainings, e.g., by using demonstrations and other promotion efforts to increase the likelihood of adoption. However, more work is needed to avert producers' disenchantment (Rogers, 2003) with the tools after having adopted but later rejecting. A content analysis of emergent themes in the producers' narrative comments and follow up, in-depth interviews may be assistive in this regard. In addition, more effective ways are needed to increase questionnaire response rates with the targeted survey group. (Note the visual evidence of a N-rich strip in the first photo below indicating a response to additional N and a handheld Green Seeker sensor in the second photo.)



References

Birehane, D., Arnall, B., & Raun, B. (2017, April). *The evolution of reference strips in Oklahoma - Oklahoma State University*. <https://extension.okstate.edu/fact-sheets/the-evolution-of-reference-strips-in-oklahoma.html> | Camp, W. G. (2001). Formulating and evaluating theoretical frameworks for career and technical education research. *Journal of Vocational Education Research*, 26(1). <http://scholar.lib.vt.edu/ejournals/1VER/v26n1/camp.html> | Dillman D. A., Smyth, J. D., & Christian, L. M. (2009). *Internet, mail, and mixed-mode surveys: The tailored design method*. John Wiley & Sons. | Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). The Free Press.