

**Using Rogers' Diffusion of Innovations to Interpret Crop Producers' Adoption of Precision Agriculture (PA) Technology Practices to Improve Nitrogen Use Efficiency**

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## Using Rogers' *Diffusion of Innovations* to Interpret Crop Producers' Adoption of Precision Agriculture (PA) Technology Practices to Improve Nitrogen Use Efficiency

### Introduction/Need for Research

Nitrogen (N)-Rich Strips and the Sensor Based Nitrogen Rate Calculator (SBNRC) are examples of PA tools available to producers for about 20 years (Birehane, 2017). These tools help producers optimize their application of nitrogen, i.e., the most limiting nutrient for plant growth. If adopted together, the tools represent a *technology cluster* (Rogers, 2003). Widespread use of such, however, remains limited, uneven, or non-existent among many who could benefit from adopting the technology. An interdisciplinary team of researchers at Oklahoma State University (OSU), including agribusiness, agricultural education, and plant and soil sciences, sought to study producers' adoption behaviors regarding this technology. Understanding why producers choose to adopt or reject an innovation can guide the development of new PA tools and techniques, reveal needed modifications of existing technologies, and inform researchers and extension educators about how to better serve their stakeholders. This implied the need to gather data from producers who had experience with using the technology. 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. Equally daunting is the problem of verbalizing the theoretical framework for the purposes of publication in the research literature" (para. 2). Another failing significant as Camp's (2001) assertions 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 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. He posited that "[d]iffusion is the process by which (1) an *innovation* (2) is *communicated* through certain *channels* (3) over *time* (4) among the members of a *social system*" (Rogers, 2003, 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 of adoption. Personal connections and relationships among members of a social system are also important catalysts influencing an innovation's adoption rate as well as perceptions of its attributes or key characteristics (Rogers, 2003). Moreover, these manifest and are perceived differently depending on adopter category, i.e., 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) five key attributes of an innovation – relative advantage, compatibility, observability, trialability, and complexity – were assessed by nine response items. Five-point, Likert-type response scales were developed to measure producers'

views on relative advantage and complexity. Similar items assessed their views about the SBNRC. Other items were developed to determine the adopter categories to which the producers likely belonged, e.g., year of adoption; from whom they learned about the innovations, e.g., a scientist versus a peer farmer; number of related trainings attended; and 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; and two follow up, reminder messages were transmitted 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).

### **Selected Results/Conclusions/Implications/Recommendations**

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; two-thirds farmed  $\leq 1000$  acres. Wheat was the crop for which most used the technologies. Recall problem (Rogers, 2003) notwithstanding, 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. Of note, 55% ( $f = 33$ ) of the producers reported discontinuance of their adoption of the PA tools. Regarding their opportunities to observe the use of N-Rich Strips 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. As for using the PA tools on a trial or limited basis before making their initial adoption decisions, 60% ( $f = 36$ ) had tried the N-Rich Strips and nearly two-thirds ( $f = 15$ ) of the SBNRC users had done that. Both attributes – observability and trialability – support the likelihood of adoption occurring (Rogers, 2003). Producers' perceptions of the relative advantage (Rogers, 2003) associated with using the N-Rich Strips was measured with a Likert-type scale:  $1 = No\ value$  to  $5 = High\ value$ . If considering the scale's real limits, the producers perceived the N-Rich Strips had *Average value* ( $M = 3.17$ ;  $SD = 1.14$ ). Rogers' (2003) attribute of complexity was assessed with a perceived level of difficulty response scale: *Not difficult* =  $1$  to *Very Difficult* =  $5$ . Applying the same real limit intervals, both tools were viewed as *Slightly difficulty* to use: N-Rich Strips,  $M = 1.75$  ( $SD = 1.01$ ), and SBNRC,  $M = 1.83$  ( $SD = 0.92$ ). However, several narrative statements referenced various issues of difficulty. Although the attribute of compatibility was not explicitly measured, 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. So, the technology was not as compatible with their farming systems as they may have initially thought. Rogers' (2003) model was a useful lens for interpreting the producers' adoption decisions for the PA tools 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 for emergent themes in the producers' narrative comments and in-depth interviews may be assistive in this regard. In addition, more effective ways are needed to increase questionnaire response rates with the targeted group.

**References**

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