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Addressing Labor Needs by Understanding Grower Perceptions about Adoption of Automated Nursery Technologies: A Resource for US Extension Professionals[1]

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Introduction

Nurseries produce plants that are essential to environmental, social, and economic well-being (Hall & Knuth, 2019), and as part of the US Green Industry, they are recognized as a vital component of US agriculture. Recent estimates show there were 16,420 nursery operations in the United States with total sales of about $5.9 billion in 2017 (USDA, 2019). However, this industry is currently facing significant challenges. Known for its high reliance on labor, the majority of the Green Industry is currently facing major challenges related to finding, attracting, and retaining employees (HindSite Software, 2019; Hyatt Presley, 2019). These challenges threaten the long-term future of this industry (Rihn et al., 2022; Warner et al., "Relating Grower Perceptions," 2022), but one promising solution is automated and mechanized nursery technologies (ANTs), which can complete some tasks more quickly and uniformly than manual labor and improve working conditions for employees (Grift et al., 2008).

ANTs include potting and mixing machines, irrigation timers, equipment designed to transport plant materials, and pruning innovations (Warner et al., "A Theory of Planned Behavior Evaluation," 2022). Automation allows the same task to be performed more efficiently, using fewer person-hours and often requiring less physical effort by workers (Adegbola et al., 2019; Posadas, 2018; Rihn et al., 2022; Manandhar et al., 2020). For example, automated pruning machines and automated fertilizer applicators allow workers to remain upright rather than stooped over in order to perform the task. ANTs can improve crop quality by completing repetitive tasks more uniformly and consistently. For example, potting and mixing machines can fill containers with a uniform and consistent blend of growing media and fertilizer, ensuring more uniform crop growth. Irrigation timers or sensors can schedule irrigation more consistently and regularly than human operators, resulting in more even container moisture levels that support crop growth (van Iersel et al., 2009). Irrigation control technology has also been shown to reduce water use compared

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to human operators (Cypher et al., 2022; Incrocci et al., 2014; van Iersel et al., 2009), thus improving environmental sustainability. Additionally, some nursery tasks, such as unnesting containers prior to feeding them into a potting machine, are repetitive and tedious and are particularly difficult to staff (Tim Wood, personal communication). Automation can help complete a task that is otherwise a high-turnover position and instead allow workers to do more engaging, stimulating tasks.

Despite its promise to help solve Green Industry labor issues, adoption of ANTs is rather low industry-wide, presenting an opportunity for Extension professionals to assist nursery clientele by helping them identify solutions. Extension professionals are known to be effective change agents who facilitate the adoption of best practices and technologies among specific target audiences (Rogers, 2003). Extension's success can be attributed to the use of sound formative audience research and needs assessment techniques. However, the absence of good information about the target audience's needs, perceptions, and behaviors can act as a barrier to successful Extension programs that lead to change. Therefore, the research presented here was undertaken to assess how nursery growers perceive ANTs and determine how these perceptions relate to adoption. This information could guide the development of Extension programs that help nursery operations make informed decisions about ANT adoption. Furthermore, this information is useful in identifying ANT characteristics that are positively correlated with ANT adoption. This document was designed for Extension professionals and other practitioners who serve nursery grower clientele across the United States, including companies developing and marketing ANTs to nursery operations.

Research Approach

The overall purpose of the study described here was to investigate growers' perceptions and how they relate to intent to adopt ANTs. The Diffusion of Innovations (DOI) framework (Rogers, 2003) was employed to address the research objectives. DOI provides insights into how information about innovations is communicated through a social system and how individuals make decisions about adopting different technologies. (For more information about DOI, visit *Planned Behavior Change: An Overview of the Diffusion of Innovations*.)

When people (e.g., nursery growers) consider the merits of a new technology during the innovation-decision process, five perceived attributes can negatively or positively influence their overall opinion:

1. Relative advantage—the extent to which an innovation is better than that which it replaces;

2. Compatibility—alignment with existing infrastructure, values, and needs;

3. Complexity—how difficult or simple the innovation is to understand or use;

4. Trialability—whether an innovation can be tested on a trial basis; and

5. Observability—visibility in the results of adopting an innovation.

People can be very inclined to adopt certain types of innovation while being not at all likely to adopt others (Rogers, 2003), so it is important to assess perceptions specific to a target audience and technology (Warner et al., "Relating Grower Perceptions," 2022). When a potential adopter perceives a strong relative advantage, believes a technology is compatible, does not find it overly complex, is able to try it out before committing to adopting, and can see the results of adopting, they are more likely to adopt (Rogers, 2003). (For information about how DOI has previously been used to understand growers' behaviors, visit *Meeting US Nursery and Greenhouse Growers' Needs with Water Conservation Extension Programs*.)

Specific goals of our survey were to:

- Illustrate growers' perceptions (relative advantage, compatibility, complexity, observability, trialability) as they related to ANTs, and to
- Examine the relationship between the five characteristics of innovations and the likelihood of adoption of ANTs.

We measured the five characteristics of ANTs by surveying US growers using a mixed-mode survey consisting of mail and web versions. We accessed the sample of growers 18 years and older through nursery certificates, nursery and industry associations, and electronic media. The sample included 1,225 growers. We used screening questions and visual prompts to ensure we had the appropriate decision makers in our sample, and therefore respondents were higher-level leadership, owners, presidents, CEOs, and other managers. Altogether we received 189 complete responses, which represents an 11.8% response rate and 89.0% cooperation rate according to the American Association of Public Opinion Research (AAPOR) response rate 1 formula (2020). In terms of representativeness of the sample, respondents reported slightly lower sales than the industry mean; there were fewer container-only producers and an overrepresentation of firms from the Southeast (see Rihn et al., 2022, for further discussion of the sample's representativeness).

We used a series of five-point Likert scales to measure the five characteristics of ANTs. The statements we used within each scale were informed by a series of qualitative listening sessions and refined using an expert panel (see Warner et al., "Relating Grower Perceptions," 2022, for details and the full instrument). Examples of the items were as follows:

1. Relative advantage: *Automated nursery technologies will improve the quality of the products we produce.*
2. Compatibility: *Automated nursery technologies are compatible with my operation.*
3. Complexity: *Automated nursery technologies are straightforward.*
4. Observability: *The results of using automated nursery technologies are apparent to me.*
5. Trialability: *I am able to experiment with automated nursery technologies as needed.*

The responses to the individual items could range from -2 (*strongly disagree*) to +2 (*strongly agree*). We created a mean from the set of responses corresponding to each of the characteristics, and therefore, each characteristic had a value that could theoretically range from -2, meaning a negative perception of the characteristic, (e.g., low compatibility), to +2, meaning a positive perception of the characteristic (e.g., high compatibility).

To assess likelihood of adoption, we asked growers to indicate their likelihood of adopting specific automated nursery technologies on a scale from *very unlikely* (-2) to *very likely* (2). If they were already using the technology they could indicate this. There were 27 total technologies listed in the survey, but the number that applied to the respondent varied by whether they were predominantly field growers, container growers, or a mix of the two. We created a mean from the likelihood responses and this value could theoretically range from -2 (low likelihood of adoption) to +2 (high likelihood of adoption).

Findings

Overall perceptions of relative advantage, compatibility, complexity, trialability, observability, and likelihood of adoption are presented in Figure 1. Key results are:

- Perceptions of relative advantage and observability were both positive, meaning that the advantage of ANTs over current production practices and the ability to observe the results associated with adopting ANTs could be motivations for adopting these technologies.
- Perceptions of compatibility were neutral but slightly positive, meaning the compatibility of ANTs with current nursery infrastructure and operator values and goals could be an incentive for adopting ANTs.
- Perceptions of complexity were neutral, meaning that respondents did not view ANTs as being overly simple or difficult.
- Perceptions of trialability were neutral and slightly negative, meaning the lack of perceived ability to test ANTs could be considered a barrier to adoption.
- Likelihood of adoption on average was close to neutral, which means that respondents are overall neither likely nor unlikely to adopt ANTs.

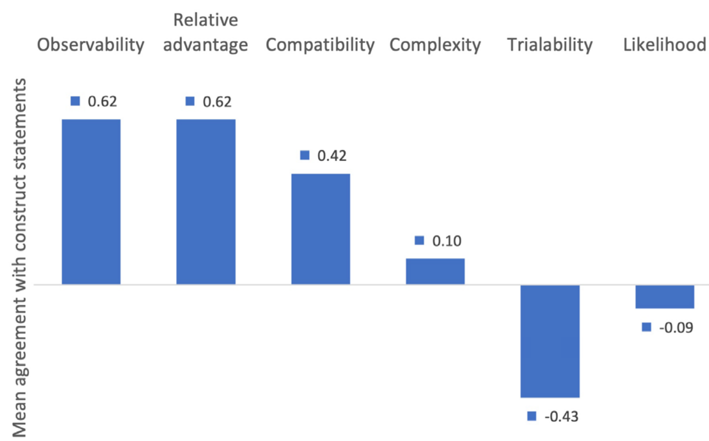

Figure 1. Perceptions of automated nursery technologies and likelihood of adoption from 189 nursery growers identified as being in higher level leadership positions. *Note.* All variables could range from -2 to +2. For relative advantage, compatibility, complexity, trialability, and observability, values of -2 would indicate strong disagreement or negative perceptions of that trait while values approaching +2 would indicate strong agreement or positive perceptions of that trait. For likelihood, values close to -2 would indicate low likelihood of adoption and values close to +2 would indicate high likelihood of adoption.

After perceptions were quantified, we used a multiple linear regression analysis to assess which of the perceived characteristics were correlated with the likelihood of future ANT adoption. When considered together, an increase in compatibility, increase in relative advantage, or decrease in complexity would be expected to correspond to an increase in likelihood of adoption. Observability and trialability did not appear to be correlated with the likelihood of adoption. Following DOI (Rogers, 2003), these findings imply that when growers perceive strong compatibility with their existing operations, infrastructure, and values; see ANTs as being better than the technologies or practices they will replace; and believe ANTs are straightforward and easy to use, the chances of adoption will be greater.

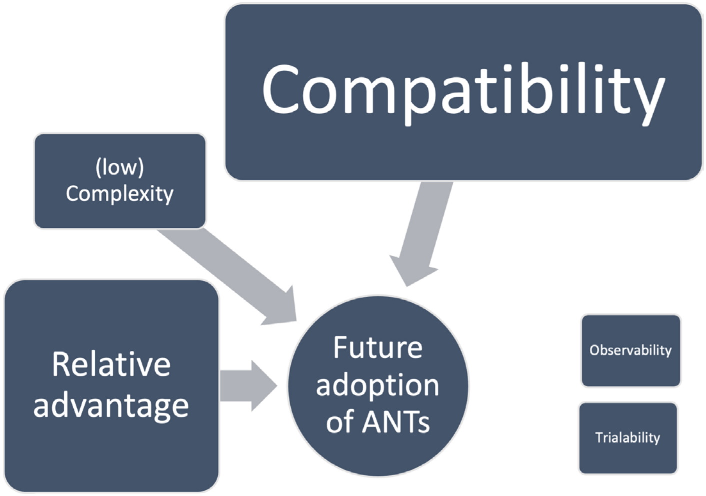

Figure 2. Perceptions of automated nursery technologies for predicting future adoption based on a survey of 189 nursery growers identified as being in higher level leadership positions. Relative size of text in the figure indicates strength of relationship.

How Extension and Other Practitioners Can Apply This Information

Extension professionals, researchers, and others who support the nursery industry can use these findings to help growers make more informed decisions about the adoption of ANTs. Specifically, there is an opportunity to provide information growers can use to match perceptions to the realities of using ANTs, especially for those that related to future adoption (compatibility, relative advantage, complexity) and addressing those that did not relate to future adoption (observability, trialability) can also improve overall perceptions associated with adopting ANTs. Some approaches to assisting growers as they consider ANT include:

- Helping growers consider **compatibility** with nursery operations' existing infrastructure, values, and goals.
- Helping growers to assess how ANTs can improve upon the technologies or production practices they supersede (**relative advantage**) through return on investment calculations, providing information and practical examples of results associated with ANT adoption. Information from actual operations currently using ANTs delivered through case studies could help growers make more informed decisions about the adoption of ANTs (may also affect perceptions of **observability**).
- Providing clear and easy-to-understand information about the implementation of ANTs in a nursery operation. This information could reduce perceptions about the **complexity** of these technologies.
- Providing opportunities for potential adopters to try out and observe the implementation of ANTs (**trialability**) through Extension activities, such as field days, or through trade shows would allow growers to hear firsthand from other growers about the benefits and challenges associated with the adoption of ANTs (may also affect perceptions of **observability**).

Conclusion

DOI provided insights that can be used by Extension professionals and other practitioners who serve nursery growers and other Green Industry clientele to promote adoption of ANTs to address labor challenges. Some characteristics of ANTs were seen positively, while others were seen as being more neutral. There are opportunities to bolster perceptions to facilitate diffusion as ANTs are developed and disseminated. This study considered a suite of ANTs to provide a starting point in developing and diffusing these types of innovations. Future research should examine the characteristics of specific technologies to pinpoint precise strategies aimed at behavioral adoption.

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