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Are Labor Shortages Pushing the U.S. Nursery Industry toward Automation and Mechanization?

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Agricultural industries are adopting emerging technologies to increase sustainability, profitability, and efficiency. The benefits of technology adoption need to outweigh the adoption costs and—in a period of increasing input costs, slim labor supply, and high uncertainty in energy markets—technological promises seem more and more appealing. However, not all producers are ready to commit to the change, particularly in industries where profit margins are thin and adoption takes time, like the nursery industry.

The U.S. nursery industry has steadily increased in size and economic impact over the past few decades. Ornamental horticulture industry revenues were reported at $13.8 billion in 2019 (USDA-NASS, 2020). Main products include ornamental plants, fruit-bearing trees, and shrubs propagated or started in what is known as plant nurseries. Most often, these plants will be transplanted into landscapes, gardens, or—in the case of fruit crops—orchards. The industry has adopted several automation and mechanization practices (e.g., conveyors, potting machines, irrigation controllers) and is now exploring digital technologies (e.g., drones). Labor demand is increasing (Fulcher et al., 2023) and so are labor costs (Hall, 2023), so we can expect an increased interest in the automation and mechanization of production tasks.

As nursery operators and industry experts explore adopting technological advancements, they need to understand available technologies to better evaluate benefits and costs and potential risks associated with such investment. Moreover, if the predominant reason for such investment is to address labor shortages and manage increasing labor costs, the effects of that investment may depend on availability of capital, labor-saving approaches (e.g., training, higher wages; Fulcher et al., 2023) and, of course, the type of production and scale of operations (Rihn et al., 2023). Here we need to note that the industry may be facing the ripple effects of an artificial intelligence (AI) revolution affecting labor needs, tasks, and compensation for higher-paid positions.

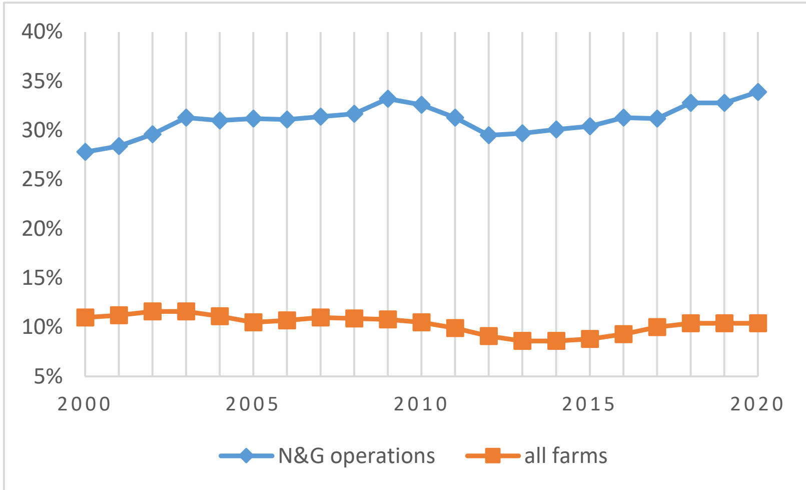
Labor Challenges and Management Strategies in the Nursery Industry

As in every agricultural industry, labor needs are dictated by the production cycle. For the nursery industry, this translates to labor-intensive tasks including (i) blending, mixing, and testing growing media and applying fertilizers; (ii) transplanting, weeding, thinning, or pruning crops; (iii) applying pesticides; (iv) organizing spacing and moving containers; (v) cleaning, grading, sorting, packing, and (vi) loading harvested products.

Nurseries tend to employ skilled labor, with most operations' workforce rotating into different jobs through the growing season. For instance, workers could be planting new plants one day, fertilizing and pruning the next day, and then shift to loading trucks and shipping the following day. Sometimes employees are quite specialized, but those highly specialized positions are limited. Growers will manage plants and logistics with a single or defined set of "blocks," possibly greenhouses, and propagators may only focus on propagation. There are specialized office jobs as well (e.g., sales force, marketing). This article focuses on the production side of nurseries.

In most instances, labor shortages are hard to tackle, and labor is generally one of the costliest inputs that growers experience; it is an input that is not easily ignored. Figure 1 shows trends in labor costs as a share of total gross cash farm income for all farms and for nursery and greenhouse from 1999 to 2020 (USDA-NASS, 2020b). During the period, all farms experienced labor costs at about 10% of total gross cash farm income. The nursery and greenhouse industry portrays a constant, slightly increasing trend, with labor costs reported at 29% in 1999 and 34% of total gross cash farm income in 2020.

Figure 1. Labor Costs as a Share of Total Gross Cash Farm Income for Nursery and Greenhouse Operations, 2000–2020



Note: Values for each year are 3-year moving averages.
Data Source: USDA, Economic Research Service and USDA, National Agricultural Statistics Service, Agricultural Resource Management Surveys

Industry reports document the persistent challenges of securing labor for the nursery industry. Nursery Management (2022, 2024) reported insufficient availability of qualified labor (32% in 2024, 42% in 2023) as a cause of limiting new hires. Higher wages are another reason listed as a deterring factor for new hires (26% of respondents in 2023) along with financial limitations. According to the same source, though staff hiring and training is among the top of the list for improvement efforts, a considerable group of respondents have no recruiting efforts (40% in 2023 and 59% in 2024) for the next generation of workers and managers.

Considering most of the production work needed is physically demanding and often in unfavorable conditions, it is not surprising that the workforce supply can be lacking. This means operations will have to increase pay to entice workers to join or explore more tech-savvy options, such as automation and mechanization, both documented practices.

Automation and Mechanization Technologies

Nurseries present unique challenges for automation that are not observed or felt in many other agricultural sectors. The primary challenge is the diversity of crops. Unlike an apple orchard, broccoli farm, or soy plantation, nurseries rarely grow a single crop. Some nurseries are more specialized than others, but even fruit tree nurseries typically produce at least ten taxa. A standard ornamental nursery must produce at least 40 different crops to stay economically viable (This is not a hard-and-fast rule, just often the case.) Many larger nurseries grow hundreds of taxa, each vastly different in size and production requirements. Nurseries will have small 1-gallon bedding plants that require high maintenance in one plot and perhaps trees in 20-gallon containers in the very next plot. The trees likely need less supervised growing than the bedding plants, and shrubs in 3-gallon containers fall somewhere in between. This diversity, which strengthens the green industry and provides greater opportunities, also generates challenges for mechanization.

Taking this a step further, all these plants have different production requirements. So, if a task, say fertilization, were to be automated, the source code or upfront planning would be relatively difficult. Plants of widely different species, all at different stages of their lifecycle and size, with entirely different production requirements, are growing together in the same operation. The skill level for someone or a team to pursue automation would be much higher than that of the automated harvesting of a single-sized monoculture crop (e.g., cotton, carrots, or apples).

Many studies have examined the use of automation and mechanization as a labor-saving technology (Posadas et al. 2008; Posadas, 2012; Adegbola, Fisher, and Hodges, 2019; Josefsson, 2019; Rihn et al., 2023). Some of the main operations where automation can be adopted include preparing substrates, filling containers, moving containers, placing plant liners, planting seeds, pruning, applying fertilizers and pesticides, and irrigating. Below, we present some examples.

Figure 2. Automated Pot Fillers

Pot Filling

Currently, the most common form of automation in the nursery industry is pot filling. The most rudimentary and likely cost-effective option consists of a conveyer belt system that moves empty containers down the conveyer line. A hopper is placed midway through the line that spills substrate into the containers as they pass through (Figure 2).

However, as technology has advanced quickly, these systems have become more sophisticated in recent years, with added detail and performances. A multihopper system can now fill half of the container, while an employee places a transplant within the container, which then moves down the line, and the remaining void space is filled with the second hopper, not only filling but filling and transplanting. This improvement is still low-tech but vastly increases the efficiency of the operation. Further technological advances have allowed for more precision filling of small containers, often in the form of plug cell trays, a plastic system with anywhere from 18 to 270 individual containers. These small-volume cells require significant precision to fill, as minor differences in filling uniformity can result in a major proportion of the void being filled improperly (Figure 3).

Figure 3. Pot Filling Advances

Advances in container-filling technologies have now begun to result in extremely cost-effective applications. Small-scale container fillers that require a single person to operate them are becoming relatively affordable and available for smaller-footprint operations.

Transplanting

As technology advances, so does sensing and computer-assisted automation. Many high-tech greenhouse operations now have transplanting machines that can extract a small, rooted plug (a plant grown in a tiny cell tray) from its tray and insert the rooted plug into a larger container. This is the major step for floriculture crops between propagation (i.e., creating new plant material) and final sizing (transplanting into the salable container sizes). These systems are further capable of discarding culls—plants that do not meet predefined quality standards. This requires real-time scanning and fast processing. Add-ons exist that will automatically hydrate or "water-in" the freshly transplanted containers, as they move through an irrigation station within the conveyor-belt system.

Irrigation Control

There have been significant advances in irrigation control and automation in recent decades. However, many nurseries still manually turn valves on and off, every day. In the 2010s, much research across the country focused on using sensor-based irrigation, to ensure that plants were watered adequately but limit overwatering. Those sensors come in the form of TDR volumetric water content sensors, lysimeter-based sensors, and capacitance sensors, among others. Automation technologies and platforms were developed to control solenoid valves based on measurements from these devices. A growing number of production nurseries across the country employ major moisture-sensing technologies to control irrigation.

However, water is critical in nursery production, more so than in most agricultural production practices. Since the vast majority of nurseries grow plants in containers, plants have limited rooting volumes, significantly reduced from in-ground production. Moreover, the crops have no access to water from the soil, so the only water that goes in must be physically or mechanically applied. There is a very small window for mistakes, especially in the hot or dry conditions that are often best for plant production. Just a single day of no water can cause irreversible damage in some instances. Trust in automatic irrigation control has been a critical issue in this regard, particularly due to the precision required for successful production. Because of this, low adoption rates have stumped sensor-based irrigation automation research.

In greenhouse and controlled environments, there are some more well-adopted irrigation automation systems. Automated boom irrigation systems are becoming mainstays, with booms that sweep across large benches applying irrigation directly to containers. However, like most irrigation systems, these are, more often than not, scheduled by time as opposed to moisture sensing.

Intelligent Spray Applications

One of the more popular automation innovations that has come about recently is intelligent sprayers. The nursery industry deals with a lot of pests, from insects and weeds to diseases and pathogens. Growers managing these pests require persistence and continued effort to combat and prevent issues. Nursery and ornamental producers have an even greater issue as the visual and aesthetic properties are the most important aspect for purchasing. Just minor damage can deem a plant or crop unsalable.

Drones

In recent years, researchers across the country have made significant progress in developing turnkey technologies for nurseries with regards to spraying agrichemicals. Advances in smart spray technologies, involving precision target-application sprayers pulled behind tractors, yield very precise application of chemicals. Another technology that employs smart spray application is drones. Drones can apply chemicals precisely to the needed area, similar to pull-behind sprayers; however, through drones, specific plants can be targeted with very limited access. So, growers can utilize more of their space for growing as opposed to leaving space open for tractors and spray systems.

Drones also provide growers with another valuable opportunity. They can be effectively utilized to scout for pests, stress, disease, and a wide range of other crop deficiencies and ailments. Drones equipped with remote sensing technologies can identify water-stressed plants throughout the nursery. Pest damage can be detected rapidly through unmanned aerial assessments on a regular basis, thus slowing the spread and allowing for rapid response. The use of drones in nursery operations is quickly rising across the country, and it seems new advances in technologies are coming fast.

Robotics

Over the past decade, robotics have been implemented in some large nurseries across the country, predominately to move containers—a low-skill but time-consuming task. The robots can be controlled via remote control or with a set number of parameters that may dictate a group of containers moved from one production pad to another, allowing a single person to conduct a task that might have taken a whole team. Highly-skilled maintenance personnel and highly-skilled operators are reportedly a challenge for operations to invest in and continue to use robotics.

Artificial Intelligence Applications

Artificial intelligence (AI) technology is expected to revolutionize agricultural industries, including the nursery industry. In production operations, AI applications may be tied to monitoring of agricultural procedures and tasks and data collection for the operation. Real-time data analysis leading to automated and instantaneous decision making may translate to more efficient production. For example, AI can monitor inventory and help identify trends in purchases. However, these applications require capital investments with high up-front costs, potential restructuring of the business model, and strategic planning over a long-term horizon, rendering them too costly for many operations.

Yet there is another aspect of the business where AI applications are less costly and reportedly implemented successfully and in a short period. AI can create content for businesses—such as reports, training manuals and product content, and social media posts—minimizing time spent on these tasks. With an abundance of content that large language models (LLMs) (deep-learning algorithms like ChatGPT) can pull from, it is highly plausible that nursery industries can benefit from them. Examples of this technology include MasterGarden.ai from Scapify, an AI-powered chatbox sourcing from an extensive database from The University of Georgia Agriculture Extension. This tool offers personalized assistance for plant care, landscaping, and horticulture-related questions. Another example is GrowBot, a feature of From Seed to Spoon app, a gardening resource offering personalized gardening advice.

One criticism of LLMs is that the content generated is not flawless; it still requires proofreading and making sure that the sources used for this content generation are correct. Hence, sophisticated industry knowledge is needed for these tasks, especially to create unique content for an operation. Another risk is the replication of faulty recommendations. Again, industry expertise will be valuable here. From a labor perspective, AI will affect the labor needs and tasks associated with potentially higher paying jobs as it frees up time from previously time-consuming content generation tasks.

Closing

Adoption of emerging technologies, though promising, is a case-by-case evaluation of the needs, constraints, and opportunities of the operation. In this short article, we highlighted automated and mechanized nursery technologies, which may be considered simplistic to a digitalized push many industries are experiencing, yet they are not widely adopted. More research in this area, as well as extension efforts to better understand the needs and constraints faced by the industry, is advised.

We would also like to caution about the effects of automation and mechanization and AI applications in the industry when they are considered particularly as a labor-cost-saving mechanism. Considering the dependency on farm workers for production-oriented tasks, a more qualitative assessment is needed to understand the benefits and costs of transitioning to automated and mechanized processes and AI technologies. However, it would be myopic not to consider how these technologies may affect higher-paying positions and how they may shape workforce development for the industry.

For More Information

Adegbola, Y.U., P.R. Fisher, and A.W. Hodges. 2019. "Economic Evaluation of Transplant Robots for Plant Cuttings." *Scientia Horticulturae* 246(27):237–243.

Fulcher, A., A.L. Rihn, L.A. Warner, A.V. LeBude, S. Schexnayder, J.E. Altland, N. Bumgarner, S.C. Marble, L. Nackley, and M. Palma. 2023. "Overcoming the Nursery Industry Labor Shortage: A Survey of Strategies to Adapt to a Reduced Workforce and Automation and Mechanization Technology Adoption Levels." *HortScience* 58(12):1513–1525.

Hall, C. 2023. *An Index of Prices Paid by Growers in the Green Industry*. 2023 update. Available online: https://mnla.org/sites/default/files/inline-files/Grower_Index_of_Prices_Paid_2023.pdf

Josefsson, S. 2019. *Adoption of Automation in the Horticulture Industry: A Case Study at a Robotics Company in the U.S. and Canada*. KTH Royal Institute of Technology Degree Project in Industrial Engineering. Available online: http://www.diva-portal.org/smash/get/diva2:1327754/FULLTEXT02

Nursery Management Staff. 2022. "State of the Industry: Looking Ahead." *Nursery Management.* Available online: https://www.nurserymag.com/article/state-of-the-industry-2023-economic-outlook/
———. 2024. "State of the Industry: Labor." *Nursery Management.* Available online: https://www.nurserymag.com/article/2024-nursery-management-state-industry-report-wholesale-growers-labor/

Posadas, B.C. 2012. "Economic Impacts of Mechanization or Automation on Horticulture Production Firms Sales, Employment, And Workers' Earnings, Safety, and Retention." *HortTechnology* 22(3):388–401.
Posadas, B.C., P.R. Knight, R.Y. Coker, C.H. Coker, S.A. Langlois, and G. Fain. 2008. "Socioeconomic Impact of Automation on Horticulture Production Firms in the Northern Gulf of Mexico Region." *HortTechnology* 18(4):697–704.

Rihn, A.L., M. Velandia, L.A. Warner, A. Fulcher, A., S. Schexnayder, and A. LeBude. 2023. "Factors Correlated with the Propensity to Use Automation and Mechanization by the US Nursery Industry." *Agribusiness* 39(1):110–130.

U.S. Department of Agriculture, Economic Research Service (USDA-ERS), and U.S. Department of Agriculture, National Agricultural Statistics Service (USDA-NASS), Agricultural Resource Management Surveys, selected years. https://www.ers.usda.gov/topics/farm-economy/farm-labor#size

U.S. Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) 2020. "Horticulture: Results from the 2019 Census of Horticultural Specialties." *2017 Census of Agriculture, Highlights* ACH17-25. Available online: https://www.nass.usda.gov/Publications/Highlights/2020/census-horticulture.pdf

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