

Strengthening Understanding and Access to Technology in Eco-Friendly Agriculture for Youth to Achieve Sustainable Development Goals

Indra Purnama^{*1,2}, Mulono Apriyanto^{1,2}, Fawzia Novianti^{1,2,3}, Anisa Mutamima⁴, Dita Fitriani^{2,5}, Ditdit Nugeraha Utama⁶, Dilla Anggrayni¹, Muhammad Dian Hanafi⁷, Vania Bratandari Febri⁷, Vicky Daniel Liklikwatil⁷, Rahman Saleh⁷, Mayor Pintaro Lowiz Debataraja⁷, Anggraini Jelita⁵, Nihal Raj Singh Sidhu⁷, Daud Maruli Siburian⁷, Harbangan Toesfer Manulang⁷, Fajar Ammaf Fahreza⁷, Kristian Natallofa Gowasa⁷, Badru Ramdani⁷, Atika Suri⁷, Danang Hadi¹

¹Graduate School of Agricultural Sciences, Universitas Lancang Kuning, Pekanbaru, 28266, Indonesia

²Center for Sustainable Tropical Agricultural Research, Universitas Lancang Kuning, Pekanbaru 28266, Riau, Indonesia

³Graduate School of Agriculture, Tokyo University of Agriculture and Technology, Fuchu 183-8509, Japan

⁴Department of Chemical Engineering, Faculty of Engineering, Universitas Riau, Jalan HR. Soebrantas KM. 12.5, Pekanbaru 28293, Indonesia

⁵Department of Agricultural Product Technology, Faculty of Agriculture, Universitas Lancang Kuning, Pekanbaru 28266, Indonesia

⁶Department of Computer Science, BINUS Graduate Program, Bina Nusantara University, Jakarta 11480, Indonesia

⁷Department of Agrotechnology, Faculty of Agriculture, Universitas Lancang Kuning, Pekanbaru 28266, Indonesia

*Corresponding author(s): indra.purnama@unilak.ac.id

ARTICLE HISTORY

Received : 2024-08-19

Revised : 2024-08-30

Accepted : 2024-09-13

Keywords:

Sustainable Farming Practices

Precision Agriculture

Youth Empowerment

Environmental Sustainability

Digital Tools

ABSTRACT

Agriculture remains a vital sector for rural livelihoods, yet it faces multiple challenges, including environmental degradation, unstable production, and limited adoption of modern technology by farmers. This community service program aimed to strengthen the understanding and accessibility of eco-friendly and digital farming technologies for young farmers in Kecamatan Bungaraya, particularly in Desa Buntan Lestari, a key agricultural hub in Riau Province, Indonesia. The program aligns with the broader effort to achieve the Sustainable Development Goals (SDGs), particularly those related to responsible production, climate action, and sustainable land use. The program was conducted in two stages: (1) training workshops, where participants were introduced to eco-friendly practices and digital tools through lectures, discussions, and hands-on demonstrations, and (2) field mentoring, where experts guided farmers in applying these technologies in their fields. To assess the program's effectiveness, pre-tests and post-tests were conducted to measure improvements in participants' knowledge, while continuous field monitoring evaluated the practical impact of the techniques on productivity and environmental sustainability. The results showed a significant improvement in participants' understanding, with post-test scores reflecting a 100% increase in knowledge compared to pre-test scores. Furthermore, farmers reported increased confidence in utilizing digital tools to optimize resource use and reduce environmental impact. This program demonstrates a successful model for promoting eco-friendly and technology-driven agricultural practices among young farmers, contributing to the achievement of sustainable development goals in rural areas.



1. INTRODUCTION

Agriculture plays a crucial role in supporting the livelihoods of rural communities, especially in regions like Kecamatan Bungaraya, where the majority of the population relies on farming as their primary source of income. However, modern agriculture faces several significant challenges, including environmental degradation, fluctuating productivity, and the slow adoption of technology among farmers. These challenges threaten not only the sustainability of agricultural practices but also the socio-economic well-being of farming communities. One of the key issues in traditional farming practices is the overuse of chemical inputs, such as synthetic fertilizers and pesticides, which can lead to soil degradation, water pollution, and loss of biodiversity. This environmental



degradation negatively impacts long-term agricultural productivity and poses risks to human health and ecosystems (Purnama et al., 2024a; Purnama & Mutamima, 2023; Partheepan et al., 2024). As a response, sustainable agriculture practices that focus on minimizing environmental harm while maintaining high productivity have gained global attention. These practices include the use of organic fertilizers, integrated pest management (IPM), and agroforestry systems, which are more environmentally friendly and resource-efficient (Purnama et al., 2024b).

Despite the growing awareness of sustainable farming practices, many farmers in rural areas remain hesitant to adopt these methods due to limited knowledge, technical skills, and access to resources (Purnama et al., 2023a; Purnama et al., 2024c; Worku et al., 2019). This is particularly true in the context of digital farming technologies, which have the potential to revolutionize agriculture by enabling more precise and efficient management of resources. Digital tools, such as precision farming applications, drones, and sensors, provide real-time data on soil conditions, crop health, and weather patterns, allowing farmers to make informed decisions (Purnama et al., 2024b). However, the adoption of these technologies remains low among smallholder farmers, primarily due to lack of access, affordability, and technical know-how.

To address these challenges, innovative solutions that combine eco-friendly farming practices and digitalization are needed to promote sustainable agriculture. The introduction of these technologies can help farmers increase productivity while minimizing environmental impact. In Indonesia, initiatives to promote sustainable agriculture have been implemented in various regions, but many rural farming communities, such as those in Kecamatan Bungaraya, are still in the early stages of adopting these innovations. The purpose of this community service program was to introduce and train farmers in Kecamatan Bungaraya, particularly in Desa Buntan Lestari, on the use of eco-friendly and digital farming technologies. This area is a key agricultural hub in Riau Province, and the implementation of sustainable farming practices is essential for its long-term agricultural development. The program included intensive training on the use of organic fertilizers, natural pest control methods, and digital farming applications to monitor soil, weather, and crop health. By providing practical training and continuous field assistance, this program aimed to ensure that farmers could successfully implement the technologies and achieve sustainable increases in productivity.

By combining eco-friendly farming methods with digital tools, this program also aimed to address key barriers to adoption, such as limited technical knowledge and access to resources. Regular monitoring and evaluation were conducted to assess the impact of the technologies on productivity and environmental sustainability. Through this comprehensive approach, the program sought to create a replicable model that could be applied in other regions facing similar challenges, ultimately contributing to the broader goal of promoting sustainable agricultural practices in Indonesia

2. LITERATURE REVIEW

Sustainable agriculture is defined as farming practices that meet current food production needs while preserving environmental health, economic profitability, and social equity for future generations. This concept emphasizes that agricultural activities should not only focus on short-term productivity but also on long-term sustainability. This can be achieved by minimizing environmental degradation, conserving natural resources, and improving the economic viability of farming communities. According to Trigo et al (2021), the key principles of sustainable agriculture include the efficient use of natural resources, ecosystem preservation, and social sustainability. Practices such as water conservation, soil management, and reducing the use of synthetic inputs like chemical fertilizers and pesticides are fundamental to sustainable agriculture. Agroecological approaches, such as agroforestry, crop rotation, and integrated pest management (IPM), help maintain biodiversity while protecting the environment and ensuring long-term soil fertility (Purnama et al., 2024b; Baker et al., 2020; Green et al., 2020). These methods also focus on creating farming systems that are economically viable for farmers while supporting rural communities' livelihoods and improving food security.

Eco-friendly farming practices, often referred to as organic farming or agroecology, aim to reduce the environmental impacts of conventional agriculture. Organic farming emphasizes the use of natural fertilizers, such as compost and manure, which improve soil fertility and structure without the negative effects commonly associated with chemical fertilizers. These organic inputs are beneficial for enhancing soil biodiversity and water retention, leading to healthier and more productive soils (Purnama et al., 2023b; Dhaliwal et al., 2023). Furthermore, organic farming promotes biodiversity and soil health by avoiding harmful chemical inputs. Natural



pest control methods, such as IPM, focus on utilizing biological control agents and minimizing the use of synthetic pesticides, thus reducing soil and water contamination and protecting beneficial organisms. Additionally, crop diversification, through practices like crop rotation and polyculture, enhances biodiversity and reduces the risk of pest infestations, soil depletion, and disease outbreaks (Ijaz et al., 2019). Research shows that adopting eco-friendly farming practices leads to more resilient agricultural systems by improving the ecosystem's ability to recover from environmental stresses, such as extreme weather or pest outbreaks (Saxena et al., 2021; Sarma et al., 2024).

Digitalization in agriculture, often referred to as precision farming, has emerged as a key strategy for improving productivity, efficiency, and sustainability. Digital farming integrates modern technologies like sensors, drones, and farm management software to collect and analyze data in real-time. This data-driven approach allows farmers to make precise decisions about their crops, soil, and water management. Sensors deployed in the field provide real-time data on soil moisture, nutrient levels, and plant health, enabling farmers to optimize the use of inputs like water and fertilizers, reducing waste and improving yields (Purnama et al., 2024b). Similarly, drones equipped with cameras and sensors offer a cost-effective way to monitor large areas, detecting issues such as disease outbreaks, pest infestations, or crop stress (Anghelache et al., 2021). These technologies provide farmers with detailed insights that were previously unavailable and help improve decision-making processes. Additionally, farm management applications allow farmers to integrate real-time data with weather forecasts and predictive analytics, making farming less labor-intensive and more efficient. These innovations have the potential to significantly reduce input costs, increase yields, and improve environmental outcomes by reducing the overuse of resources (Charania & Li, 2020).

The combination of eco-friendly farming practices and digital technologies offers a powerful approach to achieving sustainable agriculture. While eco-friendly practices help reduce environmental harm, digital technologies enhance efficiency and decision-making in resource management. For instance, precision irrigation systems can be paired with organic fertilizers to optimize water use while improving soil fertility. Similarly, integrated pest management becomes more effective when supported by real-time data from sensors or drones, allowing farmers to monitor pest populations and crop health more accurately (Chen et al., 2021). Digital farm management systems also assist farmers in implementing crop rotation or polyculture systematically, optimizing planting schedules and improving biodiversity. This integrated approach addresses the need to increase productivity while minimizing the ecological footprint of agriculture, which is especially important for smallholder farmers who often face challenges in maintaining productivity while adopting sustainable practices (Hernández-Ochoa et al., 2022).

The integration of eco-friendly practices with digital agriculture not only promotes sustainable farming but also helps address key barriers such as limited access to knowledge, resources, and technology. By leveraging real-time data and precision tools, farmers can make more informed decisions, reduce costs, and mitigate environmental risks. The adoption of these technologies has been shown to significantly improve farm efficiency and resilience to climate change, making it a crucial component of future agricultural development (Liang & Shah, 2023).

3. METHOD

Location and Participants

The community service program was conducted in Kecamatan Bungaraya, specifically in Desa Buntan Lestari, a key agricultural hub in Riau Province. The selection of this location was based on the village's reliance on agriculture as its primary economic activity and the need to address challenges related to environmental degradation, low productivity, and the slow adoption of digital farming technologies. The participants consisted of 19 youth local farmers, primarily smallholder farmers, with varying levels of education and experience in sustainable agriculture and digital farming technologies.

Program Design and Implementation

The program was designed to address two main objectives: improving farmers' understanding of sustainable agriculture practices and introducing digital technologies to enhance farming efficiency and environmental sustainability. The program was divided into two major components: training workshops and field

mentoring. Program Design and Implementation can be seen in Figure 1.

a. Training Workshops

The workshops provided intensive training on eco-friendly farming techniques and the use of digital tools in agriculture. These workshops were delivered through lectures, group discussions, and demonstrations.

- Eco-friendly farming techniques: This module covered the use of organic fertilizers, natural pest control methods, and crop diversification (such as crop rotation). Participants were trained on how these practices can improve soil health, reduce chemical inputs, and promote biodiversity.
- Digital farming technologies: Participants were introduced to precision agriculture tools, such as soil sensors, drones, and smart farming applications. The training focused on the application of these technologies in monitoring soil moisture, detecting plant diseases, and optimizing the use of water and fertilizers based on real-time data.
- Each training session was followed by practical demonstrations, where participants could observe how digital technologies and eco-friendly practices are applied in real-world farming situations. This hands-on approach was essential in ensuring that participants could confidently adopt the techniques after the training.

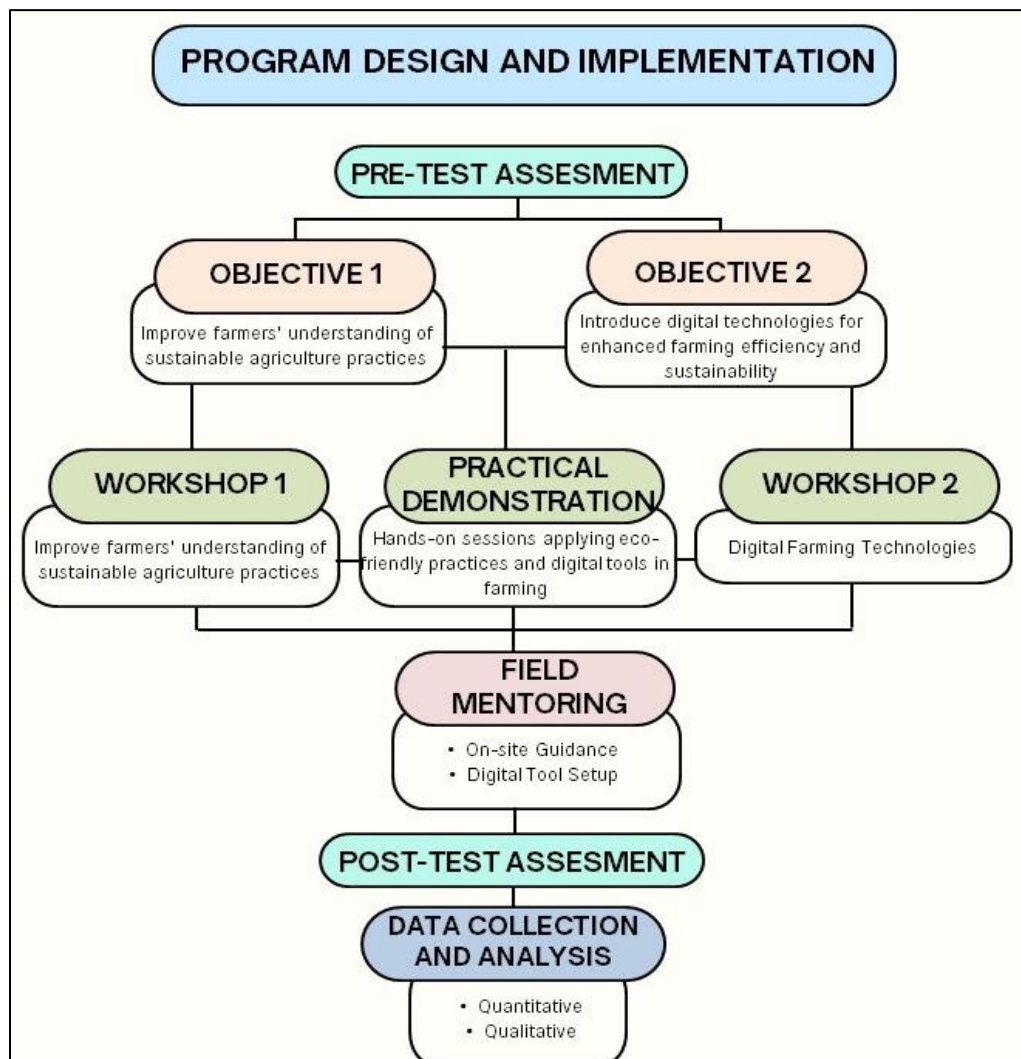


Figure 1. Program Design and Implementation Flowchart

b. Field Mentoring

In addition to the workshops, the program included a field mentoring component, where agricultural experts provided on-site assistance to farmers. The mentoring was carried out in two phases:

- Phase 1: After the workshops, agricultural experts visited participants' farms to provide guidance on implementing eco-friendly practices, such as preparing compost from organic waste, applying natural pest control methods, and practicing crop rotation.



- Phase 2: The second phase involved introducing and setting up digital farming technologies. Farmers were assisted in installing and operating soil moisture sensors, using drones for crop monitoring, and setting up smart farming apps on their mobile phones. This phase ensured that farmers could effectively integrate digital tools into their farming practices.

The mentoring sessions aimed to reinforce the knowledge gained during the workshops and provide real-time problem-solving support to farmers as they implemented the new practices.

Data Analysis

The data collected from the pre-test and post-test assessments were analyzed using descriptive statistics to measure the participants' knowledge improvement. The average pre-test scores were compared with the post-test scores to assess the effectiveness of the training workshops. Additionally, field data on crop yields, input use, and soil quality were analyzed to determine the practical impact of the eco-friendly practices and digital technologies.

- Quantitative analysis: The pre-test and post-test results were analyzed to calculate the percentage of knowledge improvement. This analysis provided a clear indication of the workshop's effectiveness in increasing participants' understanding of sustainable agriculture and digital farming technologies.
- Qualitative analysis: Data from the interviews and field observations were analyzed qualitatively to identify common challenges and benefits experienced by farmers in adopting the new practices. This analysis helped refine the mentoring approach and provided insights for scaling up the program in other regions.

4. RESULT AND DISCUSSION

Program Activities

The workshop aimed to improve the understanding of young farmers regarding sustainable agriculture, eco-friendly practices, and digitalization in farming. The activities involved lectures, discussions, and hands-on demonstrations, as illustrated in Figure 2, which shows the process of conducting the workshop. This comprehensive approach ensured that participants gained both theoretical and practical knowledge. To evaluate the success of the workshop, a pre-test was conducted before the sessions, and a post-test was administered afterward. Both tests were designed to assess two main categories: participants' knowledge and their experiences or challenges in implementing digital farming technologies.



Figure 2. The workshop process for enhancing understanding of sustainable agriculture and digital farming

Improvement In Participants' Understanding (Knowledge Category)

The pre-test results showed that participants had limited understanding of sustainable agriculture and digitalization concepts. Figure 3 shows the distribution of pre-test and post-test scores. Before the workshop, participants could only answer an average of 1 out of 8 questions correctly, indicating that most participants were unfamiliar with key concepts such as agroforestry, the benefits of natural pesticides, and the function of drones in modern agriculture. After the workshop, post-test results showed a significant improvement, with all participants answering every question correctly (8 out of 8). This improvement indicates that the workshop was effective in enhancing participants' understanding of the fundamental principles and applications of sustainable farming and digitalization in agriculture.

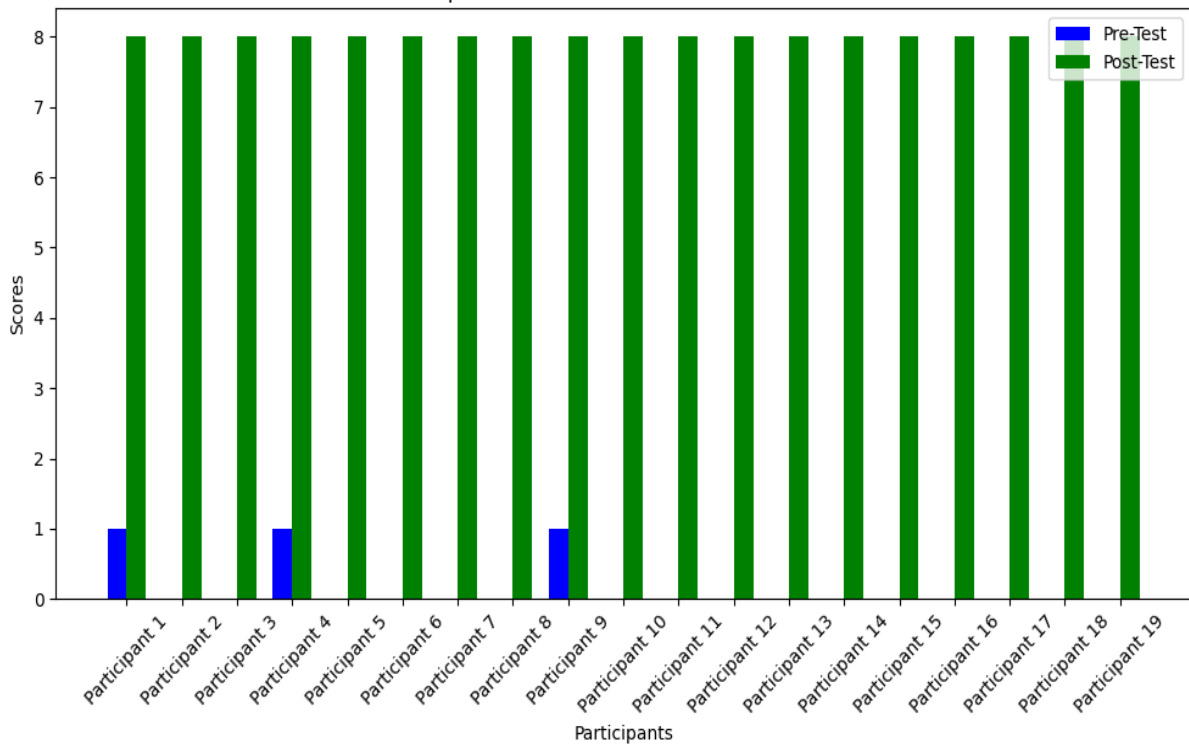


Figure 3. Comparison of pre-test and post-test scores for participants in sustainable agriculture workshop

The 100% improvement in post-test results suggests that the combination of lectures, discussions, and simulations of digital farming technologies (such as soil sensors and drones) greatly helped strengthen the participants' understanding. This aligns with findings from (Nurmansyah et al., 2024), which stated that practical approaches in agricultural education can significantly boost the adoption of technology among young farmers.

Experience and Challenges in Implementing Technology (Opinion Category)

In addition to knowledge-based questions, participants were asked to provide their opinions on their experiences and challenges in adopting digital farming technologies and eco-friendly practices. Table 1 summarizes the distribution of answers regarding the participants' experiences and challenges.

Table 1. Distribution of Experience and Challenge Responses

Question	Most Common Answer
Have you ever applied digital farming technologies?	No
What are the challenges in implementing digital farming?	Lack of digital tools
What is the biggest challenge in implementing eco-friendly farming?	High cost of technology
If you face challenges, where do you seek solutions?	Search on the internet

In the pre-test, most participants reported that they had never used digital farming technologies, and the main challenges identified were lack of equipment and high costs. This suggests that while participants are aware of the potential of digital technologies, they face significant barriers to access and resources. In the post-test, while the main challenges participants faced remained high costs and limited access to technology, there was a notable improvement in how participants approached problem-solving. They increasingly sought solutions through the internet and consultations with academics after being provided with additional information about accessible resources that support digital farming practices. This reflects an increase in participants' confidence in addressing challenges, in line with findings by (Anwarudin et al., 2020), who emphasized the importance of increasing access to information for young farmers.

Implications for Enhancing Technology Access and Information

The increase in participants' understanding, combined with the shift in how they seek solutions, demonstrates that technology-based education in community service has a significant impact on the readiness of



young farmers to adopt sustainable farming practices and digitalization. However, despite the improvement in understanding, several major challenges still need further attention, such as:

- Limited access to technology: Participants identified the high costs of digital tools, such as drones and sensors, as the main barrier. This highlights the need for additional support programs, such as subsidies for agricultural technology or partnerships with technology providers.
- Expansion of educational programs: Given the positive results of this workshop, it is recommended to conduct follow-up educational activities and expand the reach to ensure that more young farmers can benefit from similar training.

Based on these findings, a more systematic approach is needed to provide broader access to technology and information related to digital farming. Partnerships between the government, private sector, and academics are crucial to providing the necessary tools for young farmers to adopt sustainable agricultural practices.

5. CONCLUSIONS

This activity successfully improved participants' understanding of sustainable agriculture and digitalization. The 100% improvement in post-test results shows that the right educational methods can significantly enhance young farmers' knowledge and readiness. However, challenges such as high technology costs and limited access should be addressed in future community service programs.

6. ACKNOWLEDGEMENT

We would like to express our deepest gratitude to all the parties who contributed to the success of this community service. The workshop activities for I.P., F.N., M.A., and D.F. were generously funded by a grant from the School of Graduate Studies, Universitas Lancang Kuning, while the activities for D.N.P. were supported by a grant from BINUS University. Furthermore, we would like to extend our appreciation to the students who carried out the mentoring activities with great dedication. These activities were made possible through the financial support of the Program Peningkatan Kapasitas Organisasi Mahasiswa (PPK Ormawa) Student Executive Board (SEB) of the Faculty of Agriculture Unilak, provided by Ministry of Education, Culture, and Technology, for M.D.H., V.B.F., V.D.L., R.S., M.P.L.D., A.J., N.R.S.S., D.M.S., H.T.M. This collaborative effort among institutions and students was instrumental in achieving the program's objectives, and we are sincerely grateful for the support and commitment from all parties involved.

REFERENCES

- Anghelache, D., Persu, C., Dumitru, D., & Bălțatu, C. (2021). Intelligent monitoring of diseased plants using drones. *Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series*, 51(2), 146-151.
- Anwarudin, O., Sumardjo, S., Satria, A., & Fatchiya, A. (2020). Proses dan pendekatan regenerasi petani melalui multistrategi di Indonesia. *Jurnal Penelitian dan Pengembangan Pertanian*, 39(2), 73-85.
- Baker, B. P., Green, T. A., & Loker, A. J. (2020). Biological control and integrated pest management in organic and conventional systems. *Biological Control*, 140, 104095.
- Charania, I., & Li, X. (2020). Smart farming: Agriculture's shift from a labor intensive to technology native industry. *Internet of Things*, 9, 100142.
- Chen, C. J., Huang, Y. Y., Li, Y. S., Chen, Y. C., Chang, C. Y., & Huang, Y. M. (2021). Identification of fruit tree pests with deep learning on embedded drone to achieve accurate pesticide spraying. *IEEE Access*, 9, 21986-21997.
- Dhaliwal, S. S., Sharma, V., Shukla, A. K., Verma, V., Kaur, M., Shivay, Y. S., Nisar, S., Gaber, A., Brestic, M., Barek, V., Skalicky, M., Ondrisik, P., & Hossain, A. (2022). Biofortification—A frontier novel approach to enrich micronutrients in field crops to encounter the nutritional security. *Molecules*, 27(4), 1340.
- Green, K. K., Stenberg, J. A., & Lankinen, Å. (2020). Making sense of Integrated Pest Management (IPM) in the light of evolution. *Evolutionary Applications*, 13(8), 1791–1805. <https://doi.org/10.1111/eva.13067>.
- Hernández-Ochoa, I. M., Gaiser, T., Kersebaum, K. C., Webber, H., Seidel, S. J., Grahmann, K., & Ewert, F. (2022). Model-based design of crop diversification through new field arrangements in spatially heterogeneous landscapes. A review. *Agronomy for Sustainable Development*, 42(4), 74.



- Ijaz, M., Nawaz, A., Ul-Allah, S., Rizwan, M. S., Ullah, A., Hussain, M., ... & Ahmad, S. (2019). Crop diversification and food security. *Agronomic Crops: Volume 1: Production Technologies*, 607-621.
- Liang, C., & Shah, T. (2023). IoT in agriculture: The future of precision monitoring and data-driven farming. *Eigenpub Review of Science and Technology*, 7(1), 85-104.
- Nurmansyah, J. F., Rozaki, Z., Wulandari, R., & Aminah, C. W. (2024, July). Kontribusi Generasi Muda Terhadap Masa Depan Pertanian Indonesia. In *Seminar Nasional Agribisnis (Vol. 1, No. 2, pp. 90-95)*.
- Partheepan, K., Musthafa, M. M., & Bhavan, T. (2024). Mitigating climate change and its impact on food security by integrating ecosystem services to agroecosystems in Sri Lanka. *YSF Thematic Publication 2024*, 377.
- Purnama, I., Mutamima, A., Nelvia, N., Arini, A., Ihsan, F., & Yolanda, A. M. (2024a). Pestisida dalam Sistem Pertanian Tropis Berkelanjutan. Soega Publishing: Bojonegoro.
- Purnama, I., Syafrani, S., Mutamima, A., Saputra, R., Nasution, N., Amalia, A. (2024b). Edible Oilseeds Research - Updates and Prospects. In N. A. Anjum, A. Masood, S. Umar, & N. A. Khan (Eds.), *Improving Edible Oilseed (Oil Palm) Health and Productivity: Integration of Sustainable Pest Management, Precision Farming, and Stakeholder Collaboration* (pp. 1 - 33). IntechOpen. <https://doi.org/10.5772/intechopen.114936>
- Purnama, I., Novianti, F., Mutamima, A., Saidi, N. B., Das, K., Apriyanto, M., ... & Singh, S. P. (2024c). The Bridging Gaps in Tropical Agriculture Through Collaborative Community Efforts. *Symbiosis Civicus*, 1(1), 22-33.
- Purnama, I., & Mutamima, A. (2023). Pestisida dalam Produk Pertanian: Dampak, Analisis, dan Strategi Pengelolaan. Soega Publishing: Bojonegoro.
- Purnama, I., M Malhat, F., Mutamima, A., Ihsan, F., & Amalia, A. (2023a). A comparative study on pesticide residue profiles in locally grown rice from conventional and sustainable agricultural methods. *Jurnal Ilmiah Pertanian*, 20(3), 219-231.
- Purnama, I., Mutryarny, E., & Wijaya, R. T. (2023b). Avanzando en el Crecimiento de Porang (*Amorphophallus muelleri*) en Suelos Podzólicos Rojo-Amarillos: Un Análisis Experimental de la Interacción entre el Guano Sólido y el Fertilizante Orgánico Líquido. *Idesia (Arica)*, 41(3), 9-14.
- Sarma, H. H., Borah, S. K., Dutta, N., Sultana, N., Nath, H., & Das, B. C. (2024). Innovative approaches for climate-resilient farming: Strategies against environmental shifts and climate change. *International Journal of Environment and Climate Change*, 14(9), 217-241.
- Saxena, P., Singh, A. K., & Gupta, R. (2021). Adverse environment and pest management for sustainable plant production. *Plant performance under environmental stress: Hormones, biostimulants and sustainable plant growth management*, 535-557.
- Trigo, A., Marta-Costa, A., & Fragoso, R. (2021). Principles of sustainable agriculture: Defining standardized reference points. *Sustainability*, 13(8), 4086.
- Worku, A. A. (2019). Factors affecting diffusion and adoption of agricultural innovations among farmers in Ethiopia case study of Ormia regional state Westsern Sewa. *International Journal of Agricultural Extension*, 7(2), 137-147.