AgriHealth
Journal of Agri-food, Nutrition and Public Health
ISSN 2722-0656 (Print) 2722-0648 (Online)

AgriHealth: Journal of Agri-food, Nutrition and Public Health. 5(2), 101-113, 2024
URL: https://jurnal.uns.ac.id/agrihealth/article/view/85885
DOI: http://dx.doi.org/10.20961/agrihealth.v5i2.85885

Educational Attainment on the Production of Organic Fertilizer and Botanical Pesticides in Gumawang, Central Java, Indonesia: A Contribution to Sustainable Development Goals (SDGs) Number 2

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Received: April 3, 2024; **Accepted**: August 16, 2024

Abstract

The successful implementation of organic farming practices often hinges on factors beyond mere technological innovation, with socio-economic and educational variables playing crucial roles, especially in Gumawang, Central Java. This study aimed to provide insights into how educational interventions can contribute to achieving sustainable development goal (SDG) number 2 in rural communities in Gumawang, Central Java, Indonesia. The research investigates the relationship between education levels and the adoption of sustainable agriculture practices using a mixed-methods approach, which includes surveys, interviews, and observations. The results indicate a notable association between elevated educational attainment and the adoption of organic farming methodologies, encompassing the utilization of eco-friendly fertilizers and pesticides. Moreover, the research examines the significance of education in augmenting farmers' understanding, competencies, and consciousness regarding sustainable agricultural methodologies, consequently making a valuable contribution to food security, environmental conservation, and rural advancement. The findings highlight the significance of educational interventions in promoting sustainable agriculture and furthering the sustainable SDGs, especially in rural communities such as Gumawang.

Keywords: community empowerment; food health; organic cultivation; sustainable agriculture

INTRODUCTION

Pursuing sustainable development goals (SDGs) has become imperative for addressing global challenges, including poverty alleviation, food security, and environmental sustainability

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Cite this as: Widijanto, H., Marsal, C. J., Melati, A., Haq, G. Z. T., Adzhani, N. I., Ningrum, N. K. S., Prayoga, R. P., Andjani, S., Pramesthy, S. D., & Lathifa, M. N. (2024). Educational Attainment on the Production of Organic Fertilizer and Botanical Pesticides in Gumawang, Central Java, Indonesia: A Contribution to Sustainable Development Goals (SDGs) Number 2. *AgriHealth: Journal of Agri-food, Nutrition and Public Health*, *5*(2), 101-113. doi: http://dx.doi.org/10.20961/agrihealth.v5i2.85885

(Khetsha et al., 2024). Among these goals, SDG number 2, 0 hunger, holds particular significance, aiming to ensure access to safe, nutritious, and sufficient food for all (Dewi et al., 2022). Achieving this goal necessitates a paradigm shift towards sustainable agricultural practices (Hakimi and Hamdoun, 2023) that minimize environmental impact while enhancing productivity and resilience. Adopting organic farming techniques, such as producing organic fertilizers and botanical pesticides, is central to advancing sustainable agriculture. These methods offer environmentally friendly alternatives to conventional chemical inputs, reducing soil degradation, water pollution, and health risks associated with pesticide exposure. However, the successful implementation of organic farming practices often hinges on factors beyond mere technological innovation, with socio-economic and educational variables playing crucial roles (John et al., 2023).

In rural areas like Gumawang, Central Java, where agriculture serves as a primary livelihood for many communities, understanding the influence of educational attainment on adopting sustainable agricultural practices is paramount. Education enhances farmers' knowledge and understanding of ecological principles and equips them with the skills necessary to implement innovative farming techniques (Zikargae et al., 2022). Moreover, education can foster a mindset shift towards sustainability, instilling a sense of stewardship towards the environment and future generations (Vartanian, 2024). Despite the potential benefits, empirical research examining the relationship between educational attainment and the production of organic fertilizer and botanical pesticides in Gumawang remains limited. This study seeks to address this gap by investigating the impact of education on sustainable agricultural practices, specifically focusing on producing organic inputs.

Gumawang Village is located in Pecalungan Sub-district, Batang Regency, Central Java province, with a total population of about 4,300 people, and 75% of the population are farmers. Geographically, the landscape of Gumawang Village is a hilly area with land mainly used for agriculture and plantations. Most agricultural commodities in Gumawang Village are food, horticultural, and fruit crops. The agricultural sector is the primary income source for most residents in Gumawang Village. However, there are many problems in the agricultural sector, ranging from agricultural production to agricultural distribution. In line with the meaning of the 2nd SDG point, which is to suppress hunger, Gumawang Village always tries to improve the welfare of its citizens through integrated and sustainable agricultural cultivation practices. In addition, implementing a sustainable agricultural system in Gumawang Village has not been very good and massive. This is because farmers still depend on chemicals both for fertilization and pest and disease control. Also, agriculture in Gumawang Village has not implemented various technological innovations.

The main problem experienced by farmers in Gumawang Village in supporting agricultural production is the problem of fertilizer. Chemical fertilizers are used to meet the rapid nutrition of plants. However, the higher price of chemical fertilizers and the lifting of fertilizer subsidies are inhibiting factors in agricultural production. The tendency of farmers to use chemical fertilizers continuously will undoubtedly cause problems in the soil and the environment in the future. The use of inorganic fertilizers on an ongoing basis becomes ineffective. It can disrupt the balance of physical, chemical, and biological soil properties, thereby reducing land productivity, affecting crop yields, and leaving residues that have the potential to damage the environment (Puspadewi et al., 2016). The lack of understanding of farmers about the risks of continuous use of chemical fertilizers certainly requires socialization and assistance in the transition to organic farming. The implementation of organic agriculture by using materials and agricultural production facilities derived from organic materials and not synthetic materials is considered capable of reducing agricultural production costs. Organic farming uses no synthetic chemicals. Sustainable agricultural output and safe food items are the goals of organic agriculture. Organic farming can produce products without pesticide and chemical fertilizer residues (Yuriansyah et al., 2020). Organic agriculture follows the rule of return, which requires returning all organic matter to the soil, including agricultural and livestock waste, to nourish plants (Rachma and Umam, 2020).

Many ways can be done to achieve organic farming, 1 of which is using organic fertilizers. Organic fertilizer is derived from various organic materials such as animal waste, animal body parts, and plants rich in minerals (Roidah, 2013). Organic fertilizers are divided into bases of solid and liquid fertilizers (Hadisuwito, 2012). The liquid organic fertilizer (LOF) is made from organic matter through a fermentation system and is liquid. The LOF, depending on the material of manufacture, is usually divided into 3 types, namely LOF nitrogen, phosphate, and potassium, where each can be made separately or combined in one container (Sitanggang et al., 2022).

The liquid fertilizer production process is more efficient when applied directly to the leaves, flowers, and stems than directly into the soil medium. The LOF acts as a growth stimulant. Especially when the plant is developing buds, it could also transition from the vegetative to generative phase to increase fruit and seed growth. It has the benefit of increasing the formation of chlorophyll, thus increasing plant photosynthesis and nitrogen utilization from the air. In addition, LOF provides benefits to increase soil resistance to drought, increase the number of branches of production, increase the formation of flowers and fruit material, and reduce the number of flowers and fruit material that fall (Febrianna et al., 2018). In addition to organic fertilizers, biological pesticides can achieve organic agriculture. Biological pesticides are 1 of the components of being environmentally friendly. There are 2 types of biological pesticides: botanical and microbial. Biological pesticides, or biopesticides, are organic compounds and microbial antagonists that inhibit or kill diseases and pests. Organic compounds in biopesticides are quickly degraded in nature (Sumartini, 2016). The types of pesticides used in this activity are botanical pesticides.

Khan et al. (2023) stated that pesticides are control components that use natural ingredients, including natural enemies of pests, so they are safe for the environment and consumers. Ayilara et al. (2023) also state that the main pests of food crops use botanical pesticides made from natural ingredients based on local resources, which are easy to obtain, cheap, leave no residue, and are environmentally friendly. One of the advantages of botanical pesticides is their short resistance and rapid degradation (Deresa and Diriba, 2023). There are several criteria of plants that can be used as a source of good botanical pesticides. They are toxicity against low pests, biotoxin more than 1 way of working, the source plant does not compete with cultivated plants, as a solvent used water, extracted from plants that are easily propagated, resistant to suboptimal conditions and do not host alternative, biotoxin is effective at concentrations < 10 ppm (3 to 5% dry weight), and cheap, easily obtained raw materials and available on an ongoing basis (Rohani, 2023).

Using plant pesticides derived from local or soil resources, including *Ceiba pentandra* leaves, sweetsop seeds, *Cosmos caudatus* leaves, neem leaves or seeds, Mindi leaves or seeds, and mahogany seeds, is a viable approach. Plants containing phytochemicals such as alkaloids, polyphenols, tannins, eugenol, and saponins can be botanical pesticides (Sutriadi et al., 2019). In addition, fruit soil that can be used as a natural pest, such as *Anonaceae* family (sweetsop, soursop) and Makassar fruit (*Brucea javanica* Merr.) because many contain quasinoid compounds (Yuriansyah et al., 2018). Socialization and training activities for making organic fertilizers and botanical pesticides are necessary so that Gumawang Village farmers understand more about organic farming transition to organic farming and reduce agricultural production costs. This activity is considered 1 of the efforts to support the government in realizing organic and sustainable Indonesian agriculture. By exploring the interplay between education, environmental consciousness, and agricultural innovation, this research aims to provide insights into how educational interventions can contribute to achieving SDG number 2 in rural communities like Gumawang. Through a comprehensive analysis of educational attainment and its implications for sustainable development, this study informs policy and practice to promote resilient, inclusive, and sustainable agriculture in pursuing global development goals.

MATERIALS AND METHOD

Time and research location

The research was held in Gumawang Village, Pecalungan Sub-district, Batang Regency. The research location (as shown in Figure 1) is astronomically located at 109°52'37.5" to 109°52'27.4" E and 7°01'51.3" to 7°01'51.5" S. This activity involves partners such as farmers and the Pecalungan Sub-district Agricultural Extension Center (BPP). This activity was held at the home of the farmer, Ahmad Taufik, on February 26, 2024.

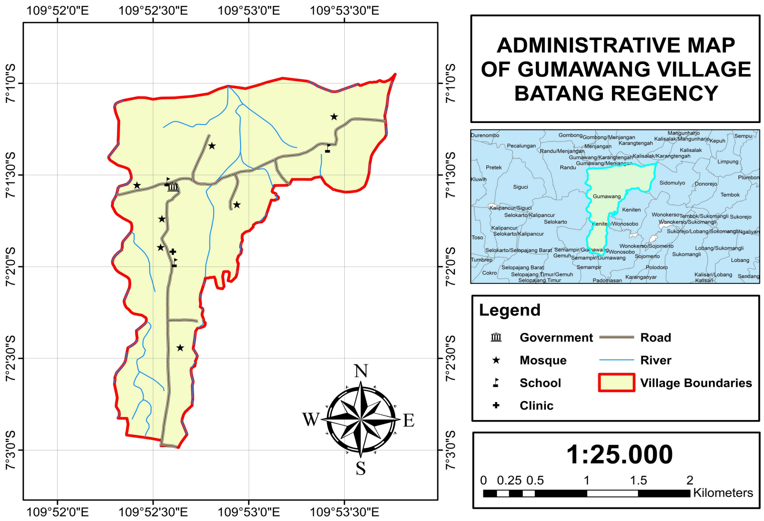

Figure 1. Administrative map of Gumawang Village, Batang Regency

Research design

The socialization and training activities on organic fertilizer production aim to provide farmers in Gumawang Village with new knowledge related to fertilization. It is expected that farmers will apply the practices that have been exemplified to replace the use of chemical fertilizers (inorganic) with organic fertilizers to reduce production costs and the implementation of organic agriculture that is healthier and environmentally friendly. This activity was carried out with a persuasive holistic approach to Gumawang Village farmers through the existing farmer’s group association (gapoktan). The method used is a participatory method combined with interactive learning and practice. The research team had already distributed invitations to participants who targeted this socialization and practice activity. There are 4 stages in the implementation of this activity. The 1st stage is the preparation stage, where the research team surveys the location of activities, surveys fertilizer, and pesticide makers, observes and interviews village officials and BPP related to implementing these activities, and collects data on residents who target this activity. The 2nd stage is the implementation of socialization activities carried out by partner, namely Kans.id. The 3rd stage is demonstration of making liquid organic fertilizer and botanical pesticides. The last stage of the interviews was conducted with 60 farmers who participated in the activity to understand the impact of socialization and training on fertilizers and pesticides in more depth. All of the participants attended this activity, and this number is the maximum limit that has been set.

Socialization and training activities

Socialization and training activities for making organic fertilizers and botanical pesticides began with coordination related to socialization plans for farmers with the Gumawang Village government, chairman of gapoktan Gumawang Village, and the BPP of Pecalungan Sub-district on February 19, 2024. The coordination carried out includes activity plans, goals, and targets of activities, as well as the timing of the implementation of activities. All parties welcomed the action plan presented in Figure 5. Related parties are willing to support and assist in the implementation of activities. Coordination with the BPP obtained an agreement that the activity would be carried out on February 26, 2024, with the target of the activity being Gumawang Village farmers who are members of gapoktan.

Data analysis

The success of these activities can be seen from the many invitations. The activity’s success was also assessed from interviews with several farmers whose results were used to evaluate the activity. The interviews consisted of 8 multiple-choice questions and 2 open-ended questions relating to the ability of farmers to understand the importance of using organic fertilizers and botanical pesticides. In addition, the interview also aims to determine whether farmers have implemented the use of organic fertilizers and botanical pesticides. The results of interviews have been obtained and then analyzed using descriptive-analytical methods. Descriptive-analytical method is a research method that can help describe, explain, or summarize data points so that patterns can be identified according to all the characteristics of the existing data.

RESULTS AND DISCUSSION

Respondent characteristics

This study examines the characteristics of respondents who participated in outreach and training activities focused on producing organic fertilizer and biogas. Specifically, it investigates the age and gender of the respondents. This research aims to modify the cognitive processes and behaviors of farmers engaged in instant farming. It is necessary because instant agriculture heavily relies on chemical production factors, requires minimal energy and time, and farmers often lack the patience to navigate the transitional phases of production decline and subsequent increase. Consequently, it is currently not feasible for farmers in Gumawang Village to fully transition to organic farming. However, there remains a persistent focus on the utilization of chemicals.

Respondent's age

The age of respondents participating in activities counseling and training in Gumawang Village is presented in Table 1.

Table 1. Age of respondents

Age (years)	Population (persons)	Percentage (%)
> 65	10	16.67
40 – 65	11	18.33
30 – 39	25	41.67
20 – 29	14	23.33
< 20	0	0.00
Total	60	100.00

According to Table 1, 25 farmers (41.67%) participate in extension and productive age training within 30 to 39 years. According to Emawati (2020), the productive age group encompasses individuals between the ages of 15 and 64, whereas the unproductive age group comprises individuals aged 65 and above. Farmers in their prime exhibit robust physical capabilities and possess a wide-ranging mindset when cultivating their enterprises. According to Tamsah and Yusriadi (2022), individuals who have reached a productive age have favorable physical health, behavioral patterns, and cognitive capacities. Gunn et al. (2021) suggest that aging influences an individual's cognitive abilities and processes. As individuals age, their mental skills and processes develop further, enhancing knowledge acquisition.

Farmers' interests related to organic farming

At this point in the discussion, data will be presented explaining the status of rice cultivation owned by farmers and their interest in organic farming. The following is presented in Table 2 regarding data on farmers' cultivation status.

Table 2. Land area and rice cultivation system

Rice field cultivation system	Area (ha)	Percentage (%)
Conventional	83.70	59
Semi-organic	39.72	28
Organic	18.44	13
Total	141.86	100

Source: Statistics of Batang Regency (2021)

The research findings presented in Table 2 indicate that the predominant agricultural method employed by farmers in Gumawang Village is conventional. The entire area of conventional rice fields in Gumawang Village is 83.70 ha, accounting for 59% of the total area. Subsequently, semi-organic (28%) and organic (13%) cultivation types are observed, encompassing an area of 39.72 and 18.44 ha, respectively. According to the findings of a study conducted by Winda (2020), it was observed that farmers in Batang Regency predominantly adhere to conventional agriculture practices and express a sense of contentment with this approach (Iqbal et al., 2023). The consequence of this phenomenon is transforming individuals into subsistence farmers (Anggraini, 2020), leading to a decline in land quality and the deterioration of the surrounding environmental ecology (Rather et al., 2022).

Most farmers are confident and at ease with traditional cultivation methods. The study conducted by Soedarto and Ainiyah (2022) examines the correlation between the ease and effectiveness of farmers' efforts in cultivating crops and managing pests and weeds. The current state of monitoring and assessing organic paddy cultivation is constrained (Das et al., 2023). While herbicides are banned in certain regions, residents continue to employ these hazardous substances to reduce labor and expenses (Sarkar et al., 2021). Some locations, like Batang Regency, have implemented agroforestry models to provide training on sustainable production on sloping lands. Nevertheless, stakeholders who were interviewed expressed that the models' sustainability is significantly constrained due to their increased labor requirements and more significant investment costs than conventional cultivation. Additionally, once the support from projects and programs ceases, local individuals reject the enhanced practices.

Before implementing educational initiatives about producing organic fertilizers and vegetable insecticides, the research team gathered data about the perspectives and inclinations of farmers towards organic farming. The participants were presented with a series of questionnaire inquiries that addressed contemporary issues about environmental well-being and the mitigation of hunger, as delineated in the SDGs. Figure 2 displays the data about farmers' perspectives and interest levels regarding organic farming.

According to the provided data, it is evident that despite being conventional farmers, the farmers at the research location have a strong inclination to study organic farming. Approximately 76% of farmers express interest and establish a connection with organic agriculture. A mere 24% of farmers express a sense of contentment and lack of inclination towards transitioning to organic agriculture, indicating a lack of interest in adopting organic growing practices. According to the findings of Rachma and Umam (2020), farmers are increasingly recognizing the importance of public health and are transitioning to organic farming practices. In addition, farmers have also started to recognize the need to enhance food quality (Ardiansyah et al., 2020) and acknowledge that residues from traditional farming methods might diminish food quality and pose health risks (Siregar, 2023).

This statement aligns with the research results in Figure 3, which shows that as many as 56% of farmers understand the negative impacts of intensive use of chemicals in cultivation systems. Only around 44% of farmers are still unsure about the adverse effects on health. Adopting organic farming practices is a significant strategy to mitigate sustainable development's environmental and ecological consequences (Gamage et al., 2023). Incorporating more organic matter in agricultural methods can mitigate the negative impacts on the environment by preserving its natural cycles during the recovery process (Zhou et al., 2021). Additionally, organic farming can improve food quality (Rahman et al., 2021). Organic farming practices sometimes involve deliberately avoiding artificial fertilizers, pesticides, growth hormones, and feed additives commonly used in livestock activities (Yadav et al., 2021).

Following the agreement that has been generated, the activity was carried out on Monday, February 26, 2024, at the home of gapoktan members in Gumawang Village that mainly land used for agriculture and plantations (Figure 4). The actions encompassed in implementing organic farming involve various stages, including preparing production, distributing, and marketing organic agricultural goods (Bhatt and John, 2023). The introduction of

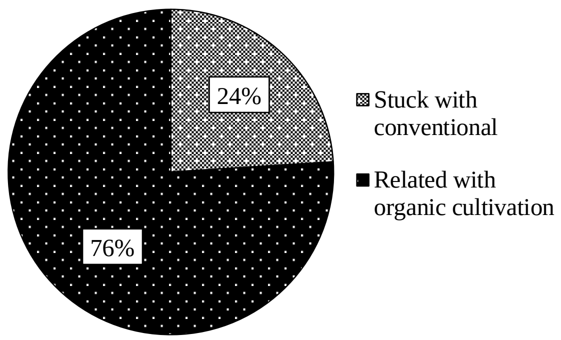

Figure 2. Data about the perspectives and level of interest among farmers regarding organic farming

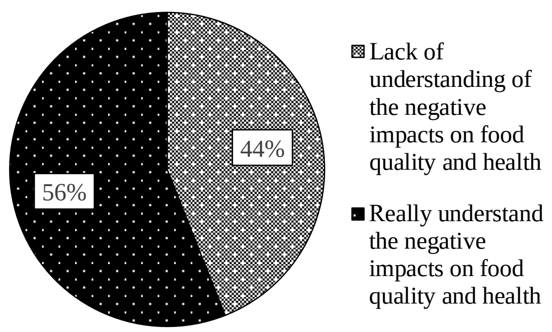

Figure 3. Farmers' awareness of the dangers of the impact of chemicals on food quality and health

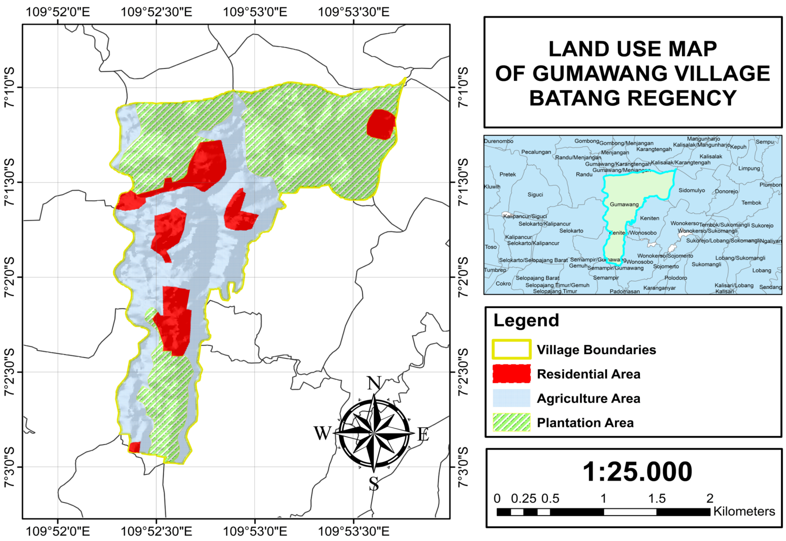

Figure 4. Land cover map of Gumawang Village

organic agriculture further focused on the means of the farm output that supports organic farming. The introduction of organic fertilizers and botanical pesticides, ingredients for making organic fertilizers and botanical pesticides, substances contained in organic fertilizers and botanical pesticides, and the benefits and effects of using organic fertilizers and botanical pesticides were presented to farmers (Campos et al., 2019). Farmers gain new knowledge and understanding related to the application of organic farming (Figure 5 and 6).

Implementation of post-program understanding

After the material on the application of organic farming was presented to farmers in Gumawang Village and agricultural extension officers from BPP Pecalungan, the activity continued with a training demonstration on making LOF fertilizers (Figure 7) and botanical pesticides (Figure 8). The materials utilized in producing LOF encompass nitrogen in the form of soil sourced from beneath the chicken coop, as well as urea and molasses for LOF that incorporate nitrogen. Element nitrogen enhances the development of roots, stems, and leaves. To meet the needs of phosphorus, the materials used include banana weevil, bitter grape, *leri* water, EM4, and molasses. Element phosphorus is beneficial for flower and fruit growth. To meet the needs of potassium, the materials used include coconut fiber, papaya, banana, tea bagasse, *leri* water, molasses, and EM4. Potassium has benefits as an enhancer of plant resistance to disease and to strengthen the roots. The next ingredient used is EM4 as a bioactivator. Jalaludin et al. (2016) argue that EM4 consists of 80 beneficial fermentation microorganisms. These microorganisms are selected to ferment organic matter well and effectively. There are 5 main


Figure 5. Presentation of the application of organic farming


Figure 6. Socialization participants

Figure 7. The practice of making organic fertilizer

Figure 8. The practice of making botanical pesticides

groups of microorganisms: photosynthetic bacteria, *Lactobacillus* sp., *Streptomyces* sp., yeast (yeast), and Actinomycetes. The ingredients are ready to be mashed by chopping, which is then put into a drum with a capacity of 100 l and soaked in water for the fermentation process for 1 to 3 months. This fermentation occurs in anaerobic conditions with a medium concentration (30 to 40%), high sugar concentration, and a temperature of about 40 to 50 °C (Nur et al., 2016).

The manufacture of botanical pesticides is carried out after the manufacture of LOF. The ingredients used to manufacture botanical pesticides include garlic, turmeric, galangal, ginger, cayenne pepper, soursop leaves, mahogany seeds, *petai*, wood ash, and tobacco (Schmidt, 2017). The material is finely chopped or can also be blended and then put into a gallon of 15 l and soaked in water for 1 night. A gallon of 15 l can be used to spray 15 times. The materials used have a wide range of active ingredients capable of effective pest control (Singh et al., 2020). Various pests can be eradicated using mixtures of ingredients that contain elements toxic to insects (Stejskal et al., 2021).

Following the implementation of the program and the farmers' utilization of the acquired materials and the items they had produced, the research team revisited to evaluate the farmers' comprehension. The assessment process also demonstrates the influence on enhancing agricultural yields (Shakoor et al., 2021). The results of farmers' satisfaction with the program's implementation and their effectiveness in incorporating the product into their agricultural operations are depicted in Figure 9.

Up to 72% of farmers expressed high levels of satisfaction with the program that had been implemented. In addition, they effectively incorporated the produce, including organic fertilizer and vegetable insecticides, into their rice fields. A mere 28% of farmers express dissatisfaction with the outcomes derived from the use of organic products. They believe that organic farming necessitates a considerable duration to enhance crop productivity.

Other factors may contribute to the reluctance of certain farmers to embrace or use organic agricultural techniques completely. Some farmers may see organic farming as riskier than conventional methods due to concerns about probable reduced yields and challenges in managing pests and diseases without synthetic pesticides and fertilizers (Łuczka and Kalinowski, 2020). Due to market uncertainties, organic farming frequently necessitates a transitional phase, wherein production may temporarily decline as the soil adapts to organic methods. Farmers may hesitate to embrace this change due to a lack of assurance over the market demand and the higher prices of organic produce (Nkansah-Dwamena, 2023). Some farmers may have developed a dependence on synthetic pesticides and fertilizers due to years of using traditional farming methods. Organic methods may necessitate substantial modifications in farming processes, which might present difficulties and incur expenses. In certain places, the lack of infrastructure and support for organic farming, including limited access to organic seeds, certification procedures, and marketing channels, may deter farmers from engaging in organic production (Kernecker et al., 2021).

Like any other industry, agriculture can resist change (Ali et al., 2021). Farmers may resist embracing novel procedures, mainly if they have previously achieved favorable outcomes with traditional approaches (Schnurr and Dowd-Uribe,

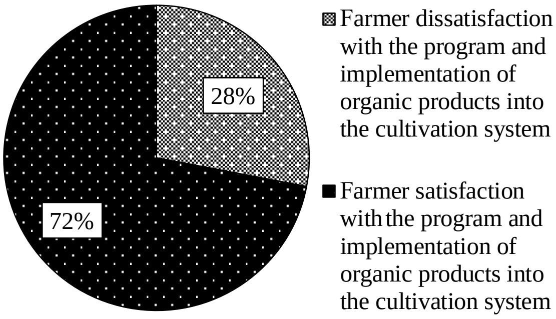

Figure 9. Farmer satisfaction

2021). Notably, many farmers adopt organic farming procedures due to many factors, encompassing environmental sustainability, health considerations, and market needs. Nevertheless, several barriers and challenges hinder the adoption of organic agriculture (Verburg et al., 2022). To overcome these obstacles, policymakers, researchers, and agricultural extension services must collaborate and offer assistance and incentives to farmers, thereby facilitating their transition to organic farming practices.

CONCLUSIONS

This study reveals a link between higher education and the adoption of organic farming methods, highlighting the importance of education in enhancing farmers' understanding and awareness of sustainable agriculture. The study underscores the importance of educational interventions in promoting sustainable agriculture and achieving the SDGs, particularly in rural areas like Gumawang. The study recommends that farmers with knowledge and skills enhance their productivity and foster a more sustainable agricultural ecosystem. With its insightful findings and implications for policy and practice, it is a valuable resource for policymakers, educators, and practitioners striving to advance global efforts toward achieving food security and sustainable development.

ACKNOWLEDGEMENTS

The UNS 118 KKN team would like to thank the Management Unit of Field Study and Community Service (UPKKN), Institute of Research and Community Services (LPPM) Universitas Sebelas Maret which has facilitated the implementation of the Thematic Community Service activities for the period January to February 2024 and the people of Gumawang Village, Pecalungan Sub-district, Batang Regency who have supported and actively participated in community activities.

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