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Ecological IPM Farmer Field School for sustainable potato pest management in Batu's millennial farmers

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ABSTRACT

The Taruna Tani Abinaya Milenial Group in Sumber Brantas Village faces serious challenges in potato cultivation due to pest and disease attacks. Endemic diseases such as late blight (*Phytophthora infestans*) and potato cyst nematodes (*Globodera sp*.), along with infestations of leaf miner (*Lyriomyza sp*.), have reduced yields by up to 80–100 percent. This condition is further exacerbated by heavy reliance on synthetic pesticides, leading to high production costs, pest resistance, and soil quality degradation. To address these problems, an Ecological Integrated Pest Management Farmer Field School (IPM-FS) was implemented with the aim of improving agroecosystem health while reducing chemical pesticide use. The IPM-FS was carried out through a participatory extension approach using andragogy and discovery learning methods. Activities included the development of site-specific potato cultivation SOPs, establishment of study plots, and training on the production of organic fertilizers, botanical pesticides, and local microorganisms. Evaluation results showed that 50 percent of participants were very satisfied with the learning materials, 44 percent were satisfied with the methods, and 94 percent supported the program's continuation. This program proved effective in enhancing farmers' knowledge and skills in environmentally friendly farming practices. The preparation of ecological IPM-based SOPs serves as a guideline for implementing Good Agricultural Practices (GAP).

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1. INTRODUCTION

The Abinaya Millennial Farmers' Youth Group, located in Sumber Brantas Village, Bumiaji District, Batu City, consists of 25 young members who focus on cultivating horticultural crops such as potatoes, carrots, and Chinese cabbage. In carrying out their farming activities, the group faces several production challenges, particularly those related to pests and plant diseases, with potatoes being the most affected crop.

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Pest and disease attacks on potato plants lead to substantial losses in both yield and quality. The most common diseases in this area are late blight, caused by the fungus *Phytophthora infestans*, and yellowing disease triggered by potato cyst nematodes (*Globodera* sp.). Both are soil-borne diseases capable of surviving for long periods, thereby posing a persistent threat to production. In addition, pest infestations such as leafminer larvae (*Liriomyza* sp.) are frequently encountered. Over time, the prevalence of these diseases has been reported to reach 80–100 percent, resulting in decreased productivity and increased production costs.

Farmers in Sumber Brantas Village predominantly rely on synthetic pesticides as the main strategy for managing pests and diseases. However, this heavy dependence has resulted in several adverse consequences, including the development of pest resistance, soil degradation characterized by high acidity levels (pH 4.5), and increased production expenses, with pest and disease control accounting for more than 60 percent of total farming costs. Furthermore, excessive pesticide application has disrupted the agroecosystem, which in turn diminishes agricultural productivity over the long term.

To overcome these challenges, it is essential to adopt a more sustainable and environmentally sound farming practice through the application of Integrated Pest Management (IPM). IPM emphasizes preventive measures against pest outbreaks while minimizing reliance on synthetic pesticides (Deguine et al., 2021; Ilhamiyah et al., 2023). This approach integrates economic, ecological, and social considerations, while prioritizing agroecosystem health as a fundamental element in ensuring effective pest management (Adenuga et al., 2021; Karlsson Green et al., 2020).

Agroecosystem management represents a central component of Integrated Pest Management (IPM), aiming to establish a natural balance between crops, pests, and the surrounding environment. By adopting this approach, farmers are able to reduce their reliance on synthetic pesticides while fostering farming practices that are both environmentally sustainable and economically viable (Knook et al., 2020; Sehgal et al., 2021). The fundamental principles of IPM include cultivating healthy crops, promoting the use of natural enemies, conducting regular monitoring of crop conditions, and empowering farmers to become knowledgeable IPM practitioners with a strong understanding of their land's ecology (Peshin et al., 2023; Rejesus & Jones, 2020).

To strengthen IPM practices within the Abinaya Millennial Farmers' Cadets (Tauna Tani Abinaya Millennial), a practice-oriented educational program such as the IPM Field School (IPM-FS) is essential. The IPM-FS program focuses on integrated pest and disease management in potato cultivation, with the objective of enhancing farmers' knowledge and skills in applying sustainable pest management strategies (Aini et al., 2024). Strategies promoted through this program include increasing biodiversity, applying organic fertilizers, implementing effective soil management practices, adopting crop rotation systems, and utilizing pest- and disease-resistant varieties (Abbas et al., 2022; Deguine et al., 2021). In addition, the introduction of appropriate technologies is vital to further support farmers, such as techniques for producing organic fertilizers, developing botanical pesticides, applying microbial-based biofertilizers, and employing simple tools for pest monitoring. This integrated approach not only equips farmers with a deeper conceptual understanding of IPM but also enables them to apply innovative and locally appropriate technologies in practice.

Evaluating participant satisfaction within the Field School program serves as an important measure of its effectiveness. Such evaluations encompass several dimensions, including the quality of instructional materials, the extent of knowledge gained by farmers, the adequacy of supporting facilities, and the sustainability of the program in the future. Accordingly, the primary objectives of this initiative are to educate farmers on IPM practices and to analyze the satisfaction levels of IPM-FS participants.

2. METHODS

Time and Place of Implementation

The community service program is scheduled to take place from June to December 2024 in Sumberbrantas Village, Bumiaji District, Batu City. The target participants are millennial farmers under the age of 45 who are members of the Abinaya Millennial Farmers Group, with a total of 25 individuals enrolled in the Field School.

Implementation of IPM Field School

This community service activity adopts a participatory extension approach through Field Schools as a medium for transferring ecologically based potato cultivation technology (Jack et al., 2020). The program is intended to enhance agroecosystem health while encouraging behavioral change among farmers. Its scope covers agroecosystem redesign, the application of agroecological principles, and the integration of Integrated Soil Management (PTnhT), Integrated Crop Management (PTT), and Integrated Pest Management (IPM) into the standard operating procedures (SOPs) of potato cultivation.

Field Schools serve as a non-formal educational platform designed to strengthen farmers' knowledge and skills in managing agriculture in a synergistic and sustainable manner. The learning process applies participatory and discovery learning methods, grounded in andragogical principles. Each group consists of 25–30 farmers who meet throughout a single planting season, guided by Field Guides (PL) trained through a Training of Trainers (TOT) program.

The implementation begins with preliminary activities such as a field survey, participant selection, and coordination with village authorities. This is followed by the identification of site-specific technologies, the development of potato cultivation SOPs, and the preparation of study or demonstration plots. The Field School is conducted in eight weekly sessions using a demonstration plot approach, enabling a comparison between farmers' existing practices and the SOPs developed through the program. Key activities include agroecosystem observation and analysis, land evaluation, and training in soil pH improvement, organic fertilizer production, biological control agents, and botanical pesticide formulation. The program concludes with the formulation of site-specific potato cultivation SOPs and an appropriate technology document endorsed by the participating farmers.

Appropriate Technology Manufacturing Practices

The appropriate technologies introduced in this program include the production of compost, liquid organic fertilizer, local microorganisms, California slurry fungicide, eco-enzyme, and botanical pesticides. Compost is produced through the fermentation of plant residues by applying a decomposer solution at a concentration of 30 ml per liter, covered with a tarpaulin, and left to ferment for three weeks (Yuniwati et al., 2023). Liquid organic fertilizer is prepared using aerobic compost fermentation, in which compost is mixed with water at a 1:9 ratio in a sealed drum and aerated with an aerator, followed by a seven-day incubation period (Phibunwatthanawong & Riddech, 2019). California slurry fungicide is formulated by dissolving 250 g/L of sulfur and 125 g/L of lime in water (Nuñez et al., 2018). The production of local microorganisms (MOL) involves fermenting bamboo roots by chopping 200 grams of roots, placing them in a bottle filled with boiled water, and adding two tablespoons of sugar solution. This mixture is then fermented for 10–14 days until it develops a sweet-sour aroma (Hayatudin, 2022). Eco-enzyme is created by combining 1 liter of molasses, 3 kilograms of organic waste, and 10 liters of water, which is then fermented anaerobically in a tightly sealed drum for three months (Gumilar et al., 2023). Meanwhile, botanical pesticides are produced from paitan leaves (*Tithonia diversifolia*) by thoroughly washing the leaves, chopping them into small pieces, blending them with 2.5 liters of water, and allowing the mixture to stand for 24 hours (Halwiyah et al., 2024).

IPM-FS Participant Satisfaction Survey

This study employed a survey method by distributing questionnaires to all 25 participants of the Integrated Pest Management Field School (IPM-FS). The questionnaire was developed to measure participant satisfaction across several aspects of the program, including learning materials, implementation methods, supporting facilities, and suggestions for future program sustainability. Responses were collected using a four-point Likert scale consisting of the categories dissatisfied, quite satisfied, satisfied, and very satisfied. The collected data were analyzed descriptively to determine the overall level of satisfaction. The results served as the basis for formulating recommendations aimed at improving and further developing the IPM-FS program. This approach was intended to obtain objective feedback to enhance the program's effectiveness.

3. RESULTS AND DISCUSSION

IPM Field School

In general, the solution to the challenges faced by the Abinaya Farmers' Youth Group is implemented through Field School activities on Integrated Pest Management (IPM) using an ecological approach. These activities emphasize improving agroecosystem health to achieve sustainable agriculture, delivered through participatory extension methods. The core component of the Field School involves farmer mentoring, carried out through the application of collaboratively designed and agreed-upon Standard Operating Procedures (SOPs) in study plots or demonstration plots. In addition, special topic sessions are provided in the form of targeted training to address specific problems encountered by farmers, as outlined in Table 1.

Table 1. Solutions to problems identified through situation analysis

Problems	Solutions
Most farmers in the Abinaya Millennial Farmers Group cultivate potatoes using conventional farming systems.	Implement an ecological Integrated Pest Management (IPM) Field School for potatoes to encourage farmers to adopt ecological IPM practices.
Farmers in Sumberbrantas Village are highly dependent on inorganic fertilizers and synthetic chemical pesticides.	Conduct ecological IPM Field Schools on potato cultivation to reduce farmers' reliance on inorganic fertilizers and synthetic pesticides.
Rising prices of pesticides and inorganic fertilizers have significantly increased farming costs, thereby reducing farmers' profits.	Encourage farmers to reduce the use of inorganic fertilizers through IPM Field Schools, which include training in the production of organic fertilizers, botanical pesticides, and local microorganisms (MOL) as cost-effective biological agents.
Potato farmers in the Abinaya Millennial Farmers Group do not yet have standard operating procedures (SOPs) for managing pests and diseases in potato cultivation.	Develop location-specific SOPs for pest and disease management using an ecological IPM approach as the basis for formulating Good Agricultural Practices (GAP).

Farmer Field Schools (FFS) function as non-formal education programs designed to improve farmers' knowledge and skills in recognizing potential, formulating cropping plans, identifying and solving problems, making informed decisions, and applying technologies that are adapted to local resources. These processes are carried out in a synergistic and environmentally sustainable manner to achieve greater efficiency, higher productivity, and long-term agricultural sustainability (Bakker et al., 2021; Jack et al., 2020; Nadhiroh et al., 2023). The learning model in FFS is based on Adult Education (andragogy) principles, applying discovery learning and participatory approaches (Aini et al., 2024). The objectives of the program are twofold: facilitating technology transfer and promoting behavioral change among farmers (Aini et al., 2024).

Within the FFS framework, groups of 25 farmers meet regularly throughout a single planting season. The activities are facilitated by Field Guides (PLs), who have been equipped with facilitation and technical skills through a Training of Trainers (TOT) program.

The ecological potato Field School in Sumberbrantas Village was carried out using participatory principles, ensuring equal interaction between farmers and facilitators. A designated plot of land was utilized as the main learning site, where each session included agroecosystem observation and analysis (AAES) within two comparative plots: the IPM study plot and the farmer-practice plot. Learning activities were experiential in nature, employing practical and effective methods, with the curriculum jointly developed and agreed upon by both farmers and facilitators (Peshin et al., 2023; Sehgal et al., 2021).

The implementation of the IPM Field School began with a site survey to identify cultivation problems and determine potential demonstration plots. Participant selection was then conducted from among members of the Abinaya Farmers' Youth Group (Taruna Tani Abinaya). This process was followed by coordination with village authorities and POPT officers to strengthen community involvement. Subsequent activities included cultivation assessments and the identification of appropriate technologies through field observations, soil analysis, and farmer consultations, which led to the formulation of potato cultivation standard operating procedures (SOPs) adapted to local conditions. Once consensus was reached on the SOPs, the preparation of study plots was carried out under the guidance of the facilitator.

Figure 1. Implementation of IPM-FS: (a) Delivery of material; (b) Demonstration plot practice

Field Schools are conducted on a weekly basis according to a mutual agreement and consist of an opening session, the establishment of a learning contract, regular meetings featuring agroecosystem observation, analysis, and decision-making, as well as special topic sessions delivered by guest lecturers. The training covers materials such as improving soil pH, producing organic fertilizers (both compost and liquid forms), preparing local microorganisms (MOL), and formulating botanical pesticides. Each session combines theoretical instruction supported by electronic teaching media with practical exercises under the guidance of a facilitator. Upon completion, participants are expected to apply the acquired technologies and determine follow-up actions to address agricultural challenges.

The outcomes of these activities are documented in both printed and digital formats, including site-specific standard operating procedures (SOPs) for potato cultivation and technology packages validated collaboratively by farmers, facilitators, and students. This documentation serves to promote the sustainable implementation of innovations developed through the IPM-FS program.

Table 2. SOP for potato cultivation in Sumberbrantas Village

Planting Day	Activities	Activity Description
-30 DAP	Planting preparation	- Field sanitation - Selection of resistant and healthy potato seeds
-20 DAP	Land preparation and refugia planting	- Plowing and ridge formation - Application of organic fertilizer (15 tons/ha) - Application of lime (5 tons/ha) - Application of ash (5 tons/ha) - Application of beneficial microorganisms (antagonistic agents and entomopathogens) - Installation of MPHP mulch - Planting of refugia plants
-3 DAP	Potato seed selection	Selection of potato seeds based on size and health (free from disease symptoms)
0 DAP	Potato planting	- Soaking potato seeds in a solution of biological agents (PGPR and Trichoderma) for at least 1 hour - Planting potatoes at a spacing of 70 × 30 cm - Application of mycorrhiza in each planting hole - Application of PGPR and Trichoderma (10 ml/l concentration) - Application of liquid organic fertilizer (10 ml/l concentration)
1-120 DAP	Crop maintenance	- Application of liquid organic fertilizer every 5 days (10 ml/l concentration) - Application of antagonistic and entomopathogenic agents every 5 days (10 ml/l concentration) - Routine monitoring of pest and disease attacks, with control measures if necessary - Irrigation based on soil moisture conditions and weather
25 DAP	1st fertilization	Application of NPK 16-16-16 fertilizer, ½ of the total required dose
30 DAP	1st hilling	First hilling to optimize tuber formation
50-65 DAP	Flower removal	Cutting flower buds to maximize photosynthesis for tuber development
65 DAP	2nd fertilization	Application of NPK 16-16-16 fertilizer, ½ of the total required dose
75 DAP	2nd hilling	Second hilling to optimize tuber formation
95-120 DAP	Water stress treatment	Withholding irrigation to reduce tuber water content and ease the harvesting process
120 DAP	Harvest and post-harvest	- Harvesting potato tubers - Grading based on tuber size and health - Field cleanup: crop residues are burned into ash (for hard stems) or composted (for soft residues)

Success of IPM-FS

The implementation of IPM-FS resulted in higher potato yields, as indicated by the demonstration plot trials. The IPM plot produced 35.41 tons per hectare, while the farmer-managed plot yielded 28.81 tons per hectare. These results demonstrate that agroecosystem management through IPM-FS has a positive effect on enhancing potato production.

Beyond crop cultivation, IPM-FS also emphasized the development of appropriate technologies. The program produced several innovations, including compost, mycorrhizae, liquid organic fertilizer (POC), California slurry fungicide, and eco-enzymes. A summary of these products is presented in Table 3.

Table 3. Appropriate technology production results

Types of Appropriate Technology	Total Production	Production Results
Compost	1 ton	
Liquid organic fertilizer	100 liters	
Mol	50 liters	
California Slurry Fungicide	50 liters	
Eco-Enzyme	100 liters	
Botanical Pesticide	50 liters	

The successful implementation of IPM-FS was supported by the farmers' willingness to grow and adapt. The Abinaya Millennial Farmers' Group demonstrated a strong commitment to enhancing the quality of their agroecosystem. In addition, the application of an andragogical education approach through participatory extension enabled farmers to effectively acquire new knowledge and skills (Adenuga et al. 2021; Jack et al. 2020; Knook et al. 2020).

IPM-FS Participant Satisfaction Analysis

The IPM-FS program was positively evaluated by participants across four key aspects: training materials, implementation methods, supporting facilities, and program sustainability. As illustrated in the pie chart, the majority of participants expressed high levels of satisfaction, with most rating themselves as either very satisfied or satisfied. These findings indicate the effectiveness of the program in enhancing farmers' knowledge and skills.

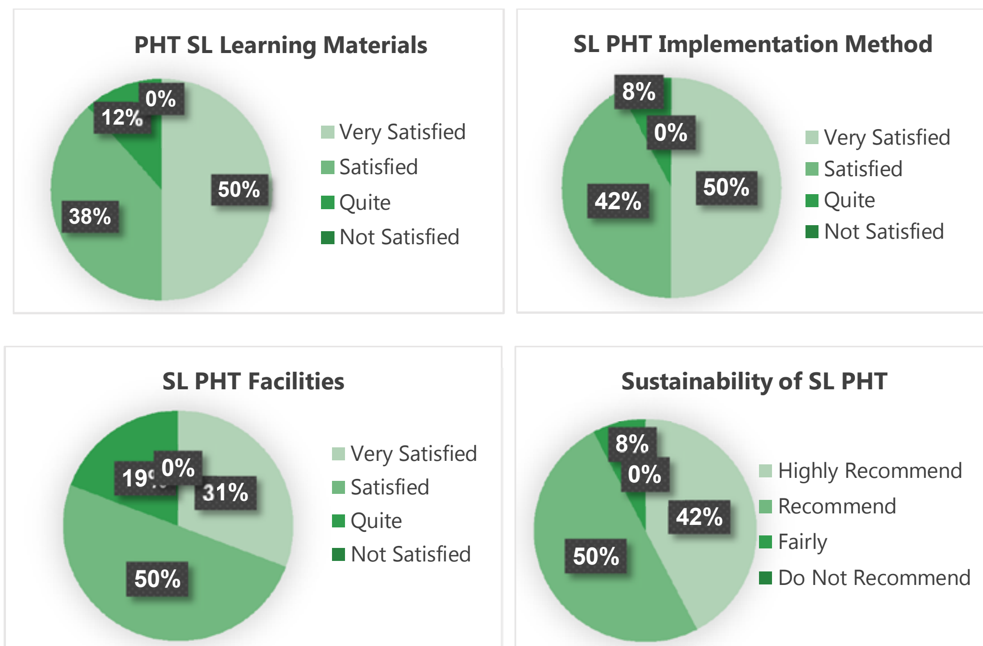

Figure 2. IPM-FS participant satisfaction survey results

The training materials delivered in the IPM-FS program were considered relevant and beneficial by participants. Half of the respondents (50 percent) reported being very satisfied, while 39 percent expressed satisfaction. Only 11 percent rated the materials as adequate, and none expressed dissatisfaction. This high level of satisfaction indicates that the training content was well aligned with farmers' needs in improving cultivation techniques.

The training methods applied in the IPM-FS program were also regarded as effective in supporting participants' comprehension. Fifty percent of participants indicated being very satisfied, and 44 percent reported satisfaction. A small proportion (6 percent) rated the methods as adequate, with none dissatisfied. These results suggest that the participatory and experiential learning approach successfully facilitated both conceptual understanding and field application.

With respect to facilities, most participants expressed satisfaction, although some areas for improvement were noted. Thirty-three percent of respondents reported being very satisfied, 50 percent expressed satisfaction, and 17 percent rated them as adequate. The absence of dissatisfaction suggests that the facilities were sufficient overall, yet enhancements are still needed to further support effective learning.

Finally, the sustainability of the IPM-FS program received strong endorsement from participants. A total of 44 percent strongly recommended the continuation of the program, while 50 percent recommended it, and only 6 percent rated it as adequate. No participants opposed its continuation. These findings indicate that IPM-FS has delivered tangible benefits to farmers, fostering strong motivation to sustain and expand the program.

The success of the IPM-FS program is demonstrated not only by high levels of participant satisfaction but also by measurable improvements in farmers' knowledge and skills. Farmers who were previously unfamiliar with the principles of integrated pest management are now able to understand and apply environmentally friendly strategies in potato cultivation. The introduction of appropriate technologies, including organic fertilizer production, botanical pesticides, eco-enzymes, California slurry fungicides, and simple pest monitoring tools, has further enhanced farmers' practical capacity in agroecosystem management. These outcomes confirm that IPM-FS represents an effective and contextually relevant learning model with strong potential for broader dissemination through policy support, improved facilities, and the integration of agricultural technologies. In addition, the program highlights the critical role of participatory extension in IPM implementation, as farmers are not passive recipients of knowledge but active participants in the learning and decision-making process. By engaging in a learning-by-doing approach, farmers are able to achieve faster and more sustainable adoption of appropriate technologies (Jack et al. 2020; Nadhiroh et al. 2023; Yin et al. 2023).

CONCLUSION AND RECOMMENDATIONS

The Integrated Pest Management Field School (IPM-FS) at the Abinaya Farmers' Youth Group has proven effective in enhancing farmers' capacity to adopt sustainable agricultural practices. Participant evaluations showed high levels of satisfaction with the program's materials, implementation methods, facilities, and sustainability. The ecological approach applied through IPM-FS has successfully shifted cultivation practices, particularly by reducing dependence on inorganic fertilizers and synthetic pesticides. In addition, the development of site-specific potato cultivation SOPs has provided farmers with clearer guidance in implementing Good Agricultural Practices (GAP).

The success of IPM-FS in fostering environmentally friendly agricultural mindsets and practices highlights the need for program continuity and improved learning facilities. Future development should include expanding participation, integrating digital technology for extension and crop monitoring, and strengthening the role of facilitators. Collaboration among farmers, academics, government, and the private sector will be essential to ensure long-term impact. With strong policy support and continuous innovation in agricultural technology, IPM-FS has the potential to serve as a pilot model that can be replicated in other regions to promote more productive and sustainable agriculture.

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