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Integrated pest management farmer field school of Chinese cabbage for young farmers in Batu City

[1]Luqman Qurata Aini, Bayu Aji Pamungkas, [1]Abdul Latief Abadi, [1]Muhammad Akhid Syib`li, [2]Mochamat Nurhadi, [1]Ade Saputra, Amalia Khoirunnisa', [1]Fibrianti Shinta Dewi, [1]Nabilla Alya Anastasya, [1]Kholiza Zhahara, [1]Satria Wahyu Tubagus, [1]Musafir Musafir

[1]Department of Plant Pest and Disease, Faculty of Agricultural, [2]Plant Protection and Horticulture Technical Implementation Unit, East Java, Brawijaya University
Jl. Veteran No. 10-11, Malang, East Java, 65145, Indonesia

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ABSTRACT

The Abinaya Milenial Youth Farmers Group in Sumber Brantas Village, Bumiaji District, Batu City, faces significant challenges in cultivating Chinese cabbage due to a high incidence of clubroot disease caused by Plasmodiophora brassicae, with infection rates reaching 50–80 percent, leading to crop failure. The overuse of synthetic pesticides has resulted in pathogen resistance. Therefore, we adopted an integrated pest management (IPM) approach focusing on long-term prevention by integrating ecologically-based control techniques. The principles of IPM include managing healthy plants, preserving natural enemies, monitoring, and enhancing farmers' ecological understanding to become IPM experts. Through the IPM Farmer Field School (IPM-FFS), we aimed to implement ecological IPM, improve agroecosystem health, and support sustainable agriculture through participatory extension methods. Activities were conducted from June to November 2023 in Sumber Brantas Village, Bumiaji District, Batu City. The activities included surveys, planning, socialization, teaching, training, and follow-up. The IPM-FFS successfully developed standard operating procedures for Chinese cabbage management, increasing farmers' knowledge of IPM by 85 percent. The adoption of IPM reduced the incidence of clubroot disease to 20 percent, increased production by 420 kg, and reduced production costs by IDR 403,000 on an area of 400 m2. Farmers independently produce compost, compost tea, botanical pesticides, mycorrhizae, and fungicides through the IPM-FFS, empowering them in sustainable agriculture.

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1. INTRODUCTION

The partner of this community-based empowerment activity is the Abinaya Millennial Young Farmers Group located in Sumber Brantas Village, Batu City, which consists of 26 young farmers who cultivate horticulture crops such as Chinese cabbage, potatoes, carrots, and cabbage. Recently, they faced a major obstacle in cultivating Chinese cabbage, namely clubroot disease caused by the fungus *Plasmodiophora brassicae*. The disease incidence of club root disease in the field reaches 50–80 percent

Corresponding Author: **Luqman Qurata Aini**: Tel. +62 341 565845 │ E-mail: luqman.fp@ub.ac.id

in Chinese cabbage, cabbage, and cauliflower, resulting in significant productivity decline and economic losses due to crop failure. The pathogen of clubroot disease can spread through farming tools, seeds, and soil that have been infected by the pathogen (Agrios, 2005). The spores of the pathogen can survive in the soil for up to 20 years without the presence of the host (Hwang et al., 2011); hence, they can transmit the pathogen in the next seasons and exhibit more severe disease incidences.

Farmer efforts to control clubroot disease in Chinese cabbage are overly dependent on the use of synthetic pesticides, especially synthetic fungicides that are overused up to three-day intervals. However, the synthetic fungicides are less effective and contribute to the damage to soil health, and the occurrence of pathogen resistance against fungicides leads to increased club root disease incidence. Additionally, fungicide overuse increases input costs, negatively impacts the environment, and increases pesticide residues in Chinese cabbage products, which are harmful to consumers. Therefore, an integrated and ecological disease management approach is needed by implementing Integrated Pest and Disease Management (IPM) to address this issue.

One of the ultimate efforts to control clubroot disease is by implementing sustainable farming systems through integrated pest management (IPM). The IPM approach is an ecologically-based pest and disease control strategy that involves efforts to prevent infestation and interventions with minimal use of synthetic pesticides (Ilhamiyah et al., 2023). The concept of IPM also considers economic, ecological, and sociological consequences, prioritizing the health of the agroecosystem (Deguine et al., 2021). The agroecosystem is a crucial factor to consider for the effective implementation of integrated pest management. Currently, the development of integrated pest management focuses on managing agroecosystems to support sustainable agriculture. IPM is an appropriate solution because it is an ecologically-based strategy that focuses on the long-term prevention of pests and diseases or their damage through control techniques integrated into cultivation practices. The principles of IPM include cultivating healthy plants, preserving and utilizing natural enemies, regular monitoring, and enabling farmers to understand ecology and become IPM experts on their own land (Karlsson Green et al., 2020).

Transferring science and technology to farmers uses a participatory extension technique through farmer field schools. Participatory extension is an approach in agricultural extension that involves farmers in the process of identifying problems, developing solutions, and implementing those (Adenuga et al., 2021). In the context of the issues faced by the Abinaya Millennial Young Farmers Group, it is necessary to conduct field school activities for the ecological management of clubroot disease in Chinese cabbage; hence, farmers can implement sustainable farming systems and control clubroot disease in Chinese cabbage. Some tactics applied include increasing biodiversity, using organic fertilizers, proper soil management, crop rotation, and using disease-resistant varieties.

This community service activity aims to conduct a farmer field school for integrated pest management (IPM) in Chinese cabbage in order to control clubroot disease through an ecological approach, emphasizing the improvement of agroecosystem health towards sustainable agriculture using the participatory extension method. The application of a sustainable farming system through ecological IPM is expected to reduce the use of harmful synthetic chemicals and improve the productivity and quality of cultivated Chinese cabbage. In the long term, implementing sustainable farming systems can also maintain the sustainability of Chinese cabbage production and the surrounding environment.

2. METHODS

Time and Place of Implementation

The IPM farmer field school (FFS) was conducted from June to November 2023. This activity took place in Sumber Brantas Village, Bumiaji District, Batu City. The target participants for this activity include millennial young farmers under the age of 45 who are members of the Abinaya Millennial Farmers Group. A total of 25 millennial farmers were joined in this field school.

Community Service Implementation

The method applied in this IPM-FFS is participatory extension with the aim of transferring ecologically-based Chinese cabbage management, which includes improving agroecosystem health and transforming farmers' behavior in managing Chinese cabbage cultivation. This purpose is achieved by redesigning the agroecosystem in the Chinese cabbage cropping system, applying agroecological principles to design and manage the agroecosystem, and integrating integrated soil management (ISM), integrated plant management (IPM), and integrated pest management (IPM) into the Good Agricultural Practices (GAP) for Chinese cabbage management.

Table 1. Standard operating procedure for Chinese cabbage management with ecological IPM and local farmer practices on IPM study plots

Cultivation Stages	Ecological IPM Practices	Local Farmer Practices
Seedling	Selection of clubroot-resistant varieties and preparation of planting media with compost and cocopeat. Seedling with addition of biological agents i.e. Plant Growth Promoting *Rhizobactera* (PGPR) and *Trichoderma* sp. as seed treatment. Application of compost tea and biological agents every 5 days.	Seedlings are purchased from local suppliers, with no information on treatments applied by the seedling suppliers.
Land Preparation	Soil tillage and formation of raised beds. Soil solarization with clear plastic for 14 days. Planting of refugia crops (e.g., marigold and rosemary). Application of compost (200 kg/400 m^2) and Dolomite lime (25 kg/400 m^2).	Soil preparation and raised bed arrangement with addition of non-fermented raw chicken manure 5-7 days before planting.
Planting	Selection of healthy seedlings and planting. Seedlings' roots are dipped in a biological agent suspension.	Seedlings affected by clubroot disease are still planted if not severe, with the addition of synthetic fungicides and insecticides before planting.
Maintenance	Installation of yellow traps and molasses traps, replaced every 3-7 days depending on conditions. Application of compost tea and biological agents every 5 days. Monitoring through agroecosystem observation and analysis every 7 days. If high pest or disease incidence occurred, the application of botanical pesticides and/or California mix fungicides was performed.	Fertilization with ZA at 25 days after planting (300 kg/ha) and NPK 16 at 45-50 days after planting (200 kg/ha). Application of insecticide and fungicide every 3 days. Application of selective herbicides for weed control.
Harvest	Harvesting and removal of leftover plants. Infected Chinese cabbage roots are burned, while the cabbage leaves are collected for composting.	Leftover plants are directly plowed along with land preparation.

The IPM-FFS consists of a group of 25 farmers who meet regularly over one growing season. The IPM-FFS is guided by facilitators known as Field Guides (FG), who have been previously trained in facilitation and technology skills through a program called Training of Trainers (TOT). The field school uses training methods based on the principles of adult education (AE/andragogy) with discovery learning and participatory methods. The objectives of the IPM-FFS involve two aspects: technology transfer and behavioral change in farmers.

The activities of the IPM-FFS on Chinese cabbage conducted in Sumber Brantas Village are as follows: (1) A survey and tracing of Chinese cabbage cultivation practices commonly conducted by farmers, including land history, land management, cultivation practices, and soil quality analysis, as well as a survey of the farmers' group organization. This activity serves as initial data for planning standard operating procedures (SOP) for crop cultivation; (2) Planning the IPM-FFS activities includes preparing the SOP for Chinese cabbage cultivation, socializing the activities, and selecting potential IPM-FFS participants with the aim to develop a mutual agreement between farmers and facilitators in implementing IPM-FFS; (3) Arrangement of study plots (400 m^2) for Chinese cabbage crop management as the main learning object where the participants observe crops and agroecosystem condition weekly. The study plot consists of two crop management systems: 1) an IPM plot that applies ecological IPM SOP, and 2) a local farmer plot that applies conventional Chinese cabbage cultivation as practiced by farmers (Table 1).

The next is: (4) Weekly IPM-FS meetings guided by field facilitators, including agroecosystem observation activities, agroecosystem analysis (AAES) on study plots, AAES presentation and discussion, and special topics provided by lecturers to deepen farmers' theory and understanding; (5) Special topic training includes: (a) Compost-making; (b) Compost tea making; (c) Seedling management; (d) Integrated pest and disease management; (e) Botanical pesticide making; (f) California mixes fungicides, making; (g) Mycorrhiza propagation; (h) Harvest and post-harvest; (6) To evaluate the farmers' understanding, a pre-test was conducted at the beginning of the IPM-FFS activities and a post-test at the end of the FFS activities. The test consists of distributing a multiple-choice questionnaire with 25 questions; (7) The components of the questions are listed in the Table 1. At the end of the FFS activities, a follow-up planning is developed to evaluate the results of the FFS activities and to prepare a program plan for future implementation.

Table 2. Farmer knowledge test assessment

Assessment Parameters	Number of Test Questions	Target Achievement
Understanding of Chinese cabbage cultivation theory and agroecosystem components	10	Out of a total of 25 IPM-FS participants, 70 percent should score above 70
Integrated pest and disease management techniques	8	
Utilization of appropriate technology (compost, botanical pesticides, biological agents)	7	

3. RESULTS AND DISCUSSION

IPM Farmer Field School

The activities of the participatory extension program were initiated with a survey of field conditions. The survey was conducted through interviews with farmers and direct observation in the cultivation areas of Chinese cabbage (Figure 1). This survey aimed to evaluate and serve as a basis for the development of SOP for Chinese cabbage management (Figure 1). The survey results indicate that clubroot disease has affected the crops for more than 5 years, and the infections have continued to increase, especially during the period from 2020 to 2022. Crop failures often occur, and the average disease incidence was over 80 percent. So far, farmers have only controlled the disease with synthetic fungicides. The fungicides applied by farmers have become resistant and are no longer effective in controlling clubroot disease. Fungicides can cause resistance in pathogens if not managed properly (Yin et al., 2023).

Figure 1. IPM-FFS preparation: (a) Field survey of clubroot disease incidence;
(b) Development of Chinese cabbage management SOP by lecturers' team and young farmers.

A participatory extension is a mentoring program based on voluntary participation where farmers, researchers, and village stakeholders collectively learn by sharing information and experiences to enhance farmers' knowledge and skills on a specific topic (Knook et al., 2020; Läpple et al., 2013). The participatory extension approach focuses on the needs expressed by farmer groups, aiming to improve production and enhance the quality of life in rural areas (Adenuga et al., 2021). This participatory extension was realized by organizing an Integrated Pest Management Farmer Field School (IPM-FFS) with the purpose of transferring ecologically-based crop management to Chinese cabbage by improving agroecosystem health. The approach involved redesigning the agroecosystem in the Chinese cabbage cropping system in the form of an SOP to be more ecologically sound. This SOP was developed based on previous farmer cultivation tracing, local resource potential analysis, and discussions with IPM-FS participant farmers. The SOP should be approved upon by the participating farmers and IPM-FFS facilitators and implemented in the IPM study plot (Table 1).

In this IPM-FFS, meetings were held weekly throughout one planting season with activities that include: (1) Agroecosystem observation in the study plots consisting of two plots, i.e., the IPM and the local farmer plots; (2) Agroecosystem analysis (AAES) by drawing the observation results on a plano paper; (3) AAES presentation and discussion; and (4) Special topics delivered by lecturers. At the end of each learning process, follow-up actions that have been agreed upon within the group were decided to be applied to the study plots. These activities were facilitated by experienced field facilitators from the East Java Center for Food Crops and Horticulture Protection. Meanwhile, the special topics were delivered by lecturers in the form of specific trainings such as the introduction of clubroot disease, soil solarization techniques, training of compost production, production of LOC, mycorrhiza propagation, and the production of botanical pesticides and California slurry fungicides (Figure 2).

To measure and evaluate the success of IPM-FFS in improving farmers' knowledge and skills, a pre-test and post-test were conducted at the beginning and at the end of IPM-FFS activities, respectively. Based on the pre-test results, out of 20 participants, only 50 percent were able to score more than 70 (Table 3), while the result of the post-test showed that 85 percent of participants scored more than 70. This result indicates that IPM-FFS can enhance farmers' knowledge and skills.

Table 3. Results of pre-test and post-test of IPM-FFS participants

Test	Percentage of Participants Score >70 (%)
Pre-Test	50
Post-Test	85

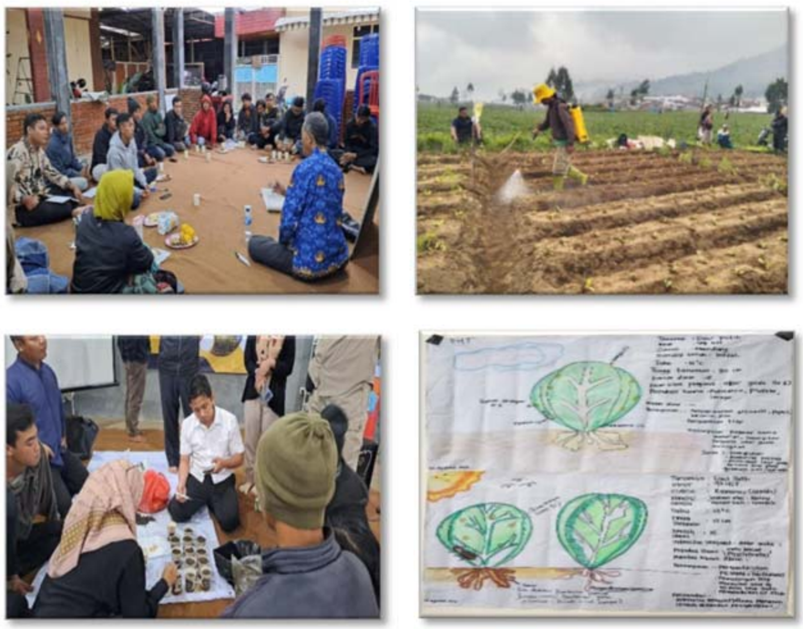

Figure 2. Implementation of IPM-FFS: (a) Delivery of IPM-FFS specific topics; (b) Field application of liquid organic fertilizer and biological control agents; (c) Practice of mycorrhiza propagation; (d) AAES results by farmers

Comparison of Chinese Cabbage Management in The Study Plots

In the study plot, which serves as a learning site for farmers, there were two plots: the IPM plot that implements ecological IPM SOPs, and the local farmer plot that follows the conventional Chinese cabbage cultivation practices typically used by the farmers. The ecological IPM plot was managed based on the SOP agreed upon collectively by the farmers, while the local farmer plot was managed according to the farmers' common practices in cultivating Chinese cabbage (Table 1). The farmers observed, analyzed, and compared these two plots.

The SOP of the ecological IPM was initially implemented in the Chinese cabbage study plot, including land sanitation, seed and seedling selection, antagonistic microbial agent inoculation on the seedling, compost application, soil liming, and the planting of refugia on the surrounding plot. Additionally, the ecological IPM plot was not applied with synthetic fertilizers and pesticides. Compost and compost tea were self-produced to meet the nutritional needs of the Chinese cabbage growth. For pest control, molasses traps and yellow traps were installed to capture and monitor the development of insect pests, while biological agents such as PGPR, entomopathogenic microbes, and antagonistic microbes were applied to control plant pests and diseases. When the pest incidences were high, farmers applied botanical pesticides made from Tithonia leaves and California slurry, which are self-produced by the farmers (Figure 3). In contrast, in the local farmer plot, synthetic fertilizers and pesticides were applied to the Chinese cabbage plants.

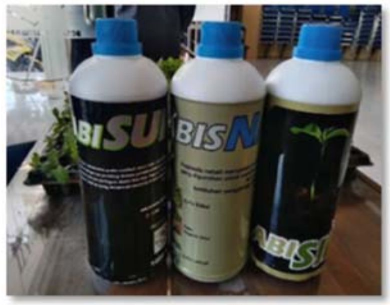

Figure 3. The products resulting from the specific topic training provided to farmers included California slurry fungicides and botanical pesticides.

The implementation of ecological IPM SOPs has impacts in the reduction of clubroot disease incidence as well as synthetic pesticides. No synthetic pesticides were applied in the IPM plot, but only botanical pesticides made from Tithonia leaves were used. Additionally, the incidence of clubroot disease decreased from 80 percent to 20 percent. California slurry pesticides were not applied because, based on monitoring results, clubroot disease has already decreased as a consequence of the ecologial IPM SOP. This results in line with the results of IPM implementation by Peshin et al. (2022), which showed that IPM can reduce pesticide applications by 7 percent compared to traditional farming practices.

At harvest time, it was found that the yield of Chinese cabbage in the ecological IPM plot was higher than the yield in the local farmer plot (Figure 4). The IPM plot produced 3.12 tons/400 m2 of Chinese cabbage, while the local farmer plot produced 2.7 tons/400 m2. The application of ecological IPM increases yields and benefits farmers (Bakker et al., 2021).

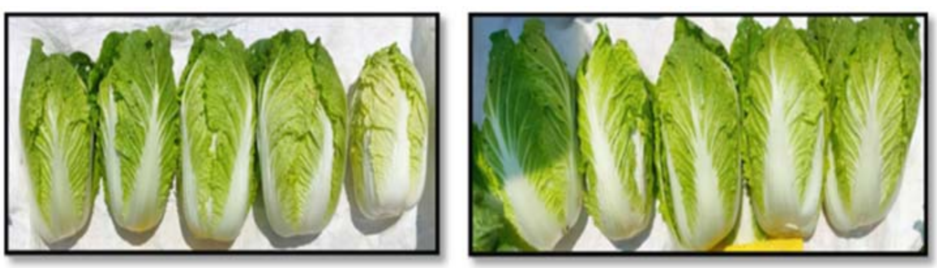

Figure 4. Chinese cabbage harvest yield: (a) Farmer's plot; (b) IPM plot

Farming Feasibility Analysis

A farming feasibility analysis was conducted to determine the expenses and income of farmers in cultivating Chinese cabbage. In the IPM-FFS activity, farmers were also trained in farming feasibility analysis by recording all expenses, from planting preparation to harvest. This activity aimed to educate farmers to continuously evaluate the farming process to achieve profitability. Items recorded include labor, machinery costs, production input costs (seeds, fertilizers, pesticides, etc.), and others.

Based on the farming feasibility analysis, the production costs in the IPM plot were lower than in the conventional local farming plot. The farming costs per 400 m2 in the IPM plot amounted to Rp2,372,000, while the local farmer plot amounted to Rp2,775,000. Thus, the production costs with ecological IPM implementation were Rp403,000 lower. This result was in accordance with the farmer field school, which has a positive impact on increasing farmers' income (Rejesus & Jones, 2020).

At the time of harvest, at the end of the IPM-FS activity, the market selling price was very low, at Rp500/kg for Chinese cabbage. The income obtained from farming with IPM implementation was Rp1,560,000, while the income from conventional farming was Rp1,350,000. When compared with the farming costs, both farming methods resulted in a loss due to the low selling price of cabbage, but the loss in farming with IPM was lower than that in conventional farming.

Program Achievement

IPM-FFS in Chinese cabbage was designed to enhance farmers' knowledge and skills in pest management, leading to reduced use of harmful pesticides and increased crop productivity. In this program, targets and indicators, as well as the achievements attained by participants, have been established. The results indicated that IPM-FS participants have met the set achievement targets (Table 4).

The achievement of the IPM-FFS target indicators was the result of the collaboration between participating farmers and program facilitators. Farmer participation in field school activities is crucial for program success and enhancing farmer empowerment (Maryani et al., 2017). Muqtafiah et al. (2022) stated that the success of this program depends on farmers' positive perceptions of the program, their understanding of IPM, and their attitudes towards sustainable farming practices. Farmers are given practical training, access to resources, ongoing support, and tangible evidence of IPM benefits in the form of increased agricultural productivity and income. The agricultural products from the training were sourced from materials available in the local area of Sumber Brantas village. By utilizing the resources available in the local area, farmers do not need to seek raw materials from outside the region. Thus, farmers become self-sufficient in providing inputs for their farming production, including fertilizers, biological agents, and pesticides. With this holistic approach, IPM-FFS can improve farmers' welfare, reduce chemical pesticide use, and contribute to more sustainable and environmentally friendly agriculture as previously reported (Peshin et al., 2023; Sehgal et al., 2021).

Table 4. IPM-FFS program achievement

Target Outcome	Indicator	Program Achievement
Farmers possess knowledge and skills to increase soil pH, produce compost independently using local natural materials, and make their own liquid organic fertilizer (LOC).	- 70 percent of farmers understand and can perform soil pH improvement techniques, compost production, and LOC/compost tea preparation. - 1 ton of compost produced - 50 liters of LOC (compost tea) produced	- Farmers' understanding increased after IPM-FS (Table 3). - IPM-FS participants produced 1 ton of compost and 60 liters of compost tea. - -
Farmers can produce biological agents and botanical pesticides using locally available natural materials with cost-effective and easy methods.	- Reduction in synthetic pesticide use by 30 percent - 70 percent of farmers understand and can produce biological agents and botanical pesticides. - Mycorrhiza produced - 50 liters of botanical pesticides produced	- Farmers' knowledge increased after IPM-FS (Table 3). - IPM-FS participants reduced synthetic pesticide use by 100 percent. - IPM-FS participants produced 10 kg of mycorrhiza, 50 liters of botanical pesticides, and 50 liters of California slurry fungicide.
Development of a suitable technology package for club-root disease control specific to Sumber Brantas village.	SOP document for location-specific technology package including compost production, LOC, mycorrhiza propagation, and botanical pesticides.	Documented SOP for location-specific technology package for Chinese cabbage cultivation (Table 1)

4. CONCLUSION AND RECOMMENDATIONS

The IPM-FFS activities with Abinaya Milenial farmers have successfully produced an SOP of ecological Chinese cabbage management specific for Sumber Brantas Village and increased farmers' knowledge of ecological IPM from 50 percent to 85 percent. The implementation of ecological IPM has successfully reduced clubroot disease incidence from 80 percent to 20 percent, increased yield by 420 kg, and lowered production costs by Rp 403,000 for an area of 400 m2. The IPM-FFS activities have assisted farmers in independently producing compost (1 ton), compost tea (50 liters), botanical pesticides (50 liters), mycorrhiza (10 kg), and California slurry fungicides (50 liters).

Some recommendations for the next community services are: (1) The training activities have focused primarily on Chinese cabbage cultivation; hence, there is a need for IPM-FFS activities for other horticultural crops; (2) The field school is still at a basic level and confined to the study plot area, need to follow-up on IPM-FFS to be conducted on each farmer's land; (3) The participants are still limited to the Abinaya Millenial young farmer group; therefore, there is a need to extend the farmer field schools for other farmers in the Sumber Brantas village area.

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