BIOTRICO: A Breakthrough Fertilizer for Sustainable Agriculture

S Irawan¹ and E Antriandarti²*

¹ Study Program of Soil Science, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, 57126, Indonesia
² Study Program of Agribusiness, Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, 57126, Indonesia, ORCID ID: 0000-0002-0948-4000

¹sukoirawan9@student.uns.ac.id, ²ernoiz_a@staff.uns.ac.id

Abstract. The second goal of Sustainable Development Goals is to end hunger, achieve food security and improved nutrition as well as promote sustainable agriculture. Within the framework of sustainable development, agriculture has dimensions as a complex ecosystem of which biodiversity and productivity must be maintained. Accordingly, organic agriculture is an agricultural system that holistically pays attention to the sustainability of biodiversity, biological cycles, and soil biological activities. The problems faced by farmers are the attack of disease-causing pathogens; the level of pathogen attack can even cause crop failure. Phytophthora infestans is a pathogen that causes root, stem, and leaf disease, and this disease is hazardous for plants. Phytophthora infestans are challenging to control, easily transmitted, and have the highest virulence when the plant is in the vegetative period. Therefore, this research aims to determine the level of effectiveness of BIOTRICO in controlling Phytophthora infestans by using experimental method in CV Agrolestari Merbabu. From the experimental results, BIOTRICO was able to minimize the attack of pathogens to only 20%, much lower than the control (60%) and proven capability to become a better option in root, stem, and leaf disease than chemical pesticides for sustainable agricultural practice.

1. Introduction

Agriculture is a labor-intensive sector that significantly influences a country's food security [1]. Food security is defined as the condition of the fulfillment of food for the state to individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable, and affordable, and does not conflict with religion, belief, and culture of the community. The concept of food security is directed at realizing sufficient food availability through domestic food production and trade, achieving stability in food availability and access, sufficient quality and quantity. It is necessary to support macroeconomic policies that can achieve economic stability, ensuring food supply and prices. This condition is in line with the fulfillment of food needs for every citizen who is highly dependent on agricultural productivity [2].

Unfortunately, every policy issued by the government to accelerate food security must have positive and negative impacts on the environment and productivity, for example, the green revolution program launched by the Indonesian government in the period (1950-1960) which brought fundamental changes to agricultural cultivation technology [3], although in general, the green revolution succeeded in
increasing agricultural productivity and even achieved self-sufficiency in rice in 1984. The green revolution program focused on the use of early maturing varieties (120-125 days), responsive varieties of N fertilizer, distribution, and supply of fertilizers and pesticides at low prices for farmers, as well as sustainable irrigation development, have succeeded in increasing national rice production so that production has increased sharply from around 11-13 million tons in the 1950s-1960s, to 45 million tons in 1990, and reached 52 million tons in 2000.

The use of inorganic fertilizers in the long-term can cause a decrease in the physical, chemical, and biological properties of the soil. It causes a decrease in the soil quality index. Moreover, inorganic chemical fertilizers can cause toxicity due to uncontrolled use; too high nitrogen fertilization can lower the pH. The results of impact inorganic chemical fertilizer in rural Java research show that using NPK fertilizers accompanied by pesticides can reduce productivity in the next growing season [4]. Chemical pesticides even have a more hazardous impact than inorganic fertilizers, the research also shows that continuous use of pesticides will leave pesticide residues which become ecological severe problems and pollute the agricultural environment [4]. On the other hand, the uncontrolled use of inorganic fertilizers and pesticides plays a role in driving climate change [5].

Within the sustainable development framework, agriculture activities should maintain the ecosystem, biodiversity and productivity in order to remain socially, economically, and environmentally profitable. Organic agriculture is a holistic agriculture system that pays attention to the sustainability of biodiversity, biological cycles, and soil biological activities [6]. In line with this, the community's need for healthy and safe food increases every year. It is inseparable from the trend of organic food, which consumers increasingly favor. The increase in purchasing power and reasons for living healthier trigger organic food to be increasingly in demand. Especially during this pandemic, communities tend to consume organic agricultural products because they are free from hazardous chemical pesticides. Organic food is considered to have higher benefits than conventional food.

The Regulation of the Minister of Agriculture Number 64/Permentan/OT.140/5/2013 [7] concerning the organic agriculture system. Organic food comes from organic agricultural land by implementing resource management practices that aim to maintain ecosystems in achieving sustainable productivity, controlling weeds, pests and diseases in an integrated manner through selection and crop rotation, water management, good land management, and use of biological materials. Therefore, the challenge of organic agriculture refers to the cultivation sector. Organic farmers are prohibited from using inorganic fertilizers and chemical pesticides. Chemical pesticides and inorganic fertilizers are categorized as sources of pollution in organic agriculture. Meanwhile, to overcome pathogens and diseases, farmers still rely on chemical pesticides. One of the most hazardous pathogens is Phytophthora infestans.

Phytophthora infestans can attack the tubers and roots at the beginning of the vegetative growth period of plants, with leaf damage rates reaching 80-100% [8]. The spread of Phytophthora infestans spores can be through wind, water or insects. If the spores reach the leaves, it will germinate by pulled out zoospores or directly forming a sprout tube, then entering the plant section, thus causing infection, whereas, spores that fall to the ground will infect the bulbs, and cause rot, this can occur in the soil or storage[8]. Cases of leaf rot usually occur in low-temperature highland areas with high humidity [8]. This research attempts to determine the level of effectiveness of BIOTRICO in controlling Phytophthora infestans in CV Agrolestari Merbabu. This research also contributes to provide better choices for the farmers in the prevention of diseases causes by Phytophthera infestans than chemical pesticides, and also brings new information that the researcher can develop the technology in advance to support organic agriculture by using BIOTRICO.

2. Method
This research applied experimental method conducted in August - November 2020 at CV Agrolestari Merbabu, located in Sumberejo Village, Ngablak Sub-district, Magelan District. The experiment used a non-factorial Completely Randomized Design (CRD) with two treatments, namely control and 1 kgm-1 BIOTRICO, each demonstration plot measuring 400 m².
2.1. Case study location and period
CV Agrolestari Merbabu is a company that produces various types of vegetables such as cabbage, chilies and potatoes as their primary commodities. The landscape of CV Agrolestari Merbabu is illustrated by Figure 1(a). CV Agrolestari Merbabu is located in Kragon RT1/RW 3, Sumberejo Village, Ngablak District, Magelang Regency. The obstacle faced by CV Agrolestari Merbabu is the high number of root and leaf diseases caused by Phytophthora infestans. Every year CV Agrolestari Merbabu harvests about 240 tons of Granolla potato varieties with an average of 20 tons per ha. Unfortunately, in 2017 and 2019, the pathogen Phytophthora infestans caused crop failures to reach 80%.

Figures 1. (a) CV Agrolestari Merbabu landscape. (b) Potato tuber rot due to *P. infestans*.

Symptoms of Phytophthora infestans attack that illustrated by Figure 1 (b) can be observed with the characteristics of the root neck and roots turning rotten and black, while on tubers, the symptoms that can be observed are rot and discoloration to gray or black [9]. Conditions in CV Agrolestari can be classified as an epidemic, and the epidemic is a disease condition that has attacked agricultural ecosystems and can spread and attack many plants in a population in a large area and only takes a short time. The interaction between virulent pathogens and susceptible hosts, supported by favorable environmental factors for Phytophthora infestans, causes epidemics [10]. Disease epidemics can occur due to disease-causing pathogens, host plants, biotic environmental factors, and supporting abiotic environmental factors. Phytophthora infestans can grow in a pH range of 2-8.5 and a temperature of 15-25°C [11].

2.2. Data collection and analysis
The BIOTRICO content analysis method is presented in Table 1 [12]. To determine the effectiveness of BIOTRICO in overcoming leaf and root disease, data analysis was carried out by comparing the level of pest attack and productivity in control and treatment.

| Nutrient Content | Unit | Method |
|------------------|------|--------|
| Total – N        | %    | Kjeldahl |
| Availability – P | ppm  | Bray    |
| Availability – K | ppm  | NH4Oac 1 N pH 7 Extraction |
| Ca, Mg and S     | %    | NH4Oac 1 N pH 7 Extraction |
3. Results and discussion

3.1. BIOTRICO Development

The development of BIOTRICO begins with sorting raw materials, followed by cutting organic waste to have smaller dimensions to facilitate the decomposition process of organic matter. The next step is mixing organic waste with a decomposer solution in the form of EM4 and molasses. The BIOTRICO development process is visualized in Figure 2.

The raw materials used for BIOTRICO can come from animal waste (cow and goat) and leaf litter which has a C/N ratio of 16-25. C/N ratio is very influential on the quality and duration of composting. Materials with a high C/N ratio have a longer composting time, and the quality of the fertilizer produced is not good [13]. The finished BIOTRICO has the following characteristics: odorless, soil-like color, pH ranges from 6-7, and has crumb characteristics [14]. The results of the BIOTRICO laboratory analysis were tested at the Sebelas Maret University Soil Chemistry Laboratory, while the nutritional content of BIOTRICO is presented in Figure 3.

Figure 2. BIOTRICO Development.
Nutrient contents such as C (organic carbon) has value 2.2%, N (1.2%), P (0.8 ppm), K (0.5 ppm), Ca and Mg (0.1 ppm), S (0.08 ppm). The content of essential macronutrients NPK (Nitrogen, Phosphorus, and Potassium) BIOTRICO has a medium to high value, and plants need essential macronutrients for physiological processes. While the content of essential micro-nutrients such as Ca, Mg, S and Fe has a low-medium value. Plants indeed need essential micronutrients only in small amounts, and this is because the role these nutrients have for plant physiology is indeed limited. Although limited, organic fertilizers must maintain their concentration in the soil [15].

3.2. BIOTRICO application in CV Agrolestari Merbabu

From the results of the application of organic fertilizers, it was found that the use of organic fertilizers enriched with biological agents showed positive results after 56 DAP / or near the maximum vegetative phase. In this phase, soil-borne pathogens are very effective at attacking the roots of potato plants to cause root lodoh disease, which is very hazardous for potatoes. From the comparative analysis of the attack rate of Phytophthora infestans, the potato demonstration plot is presented in the graph in Figure 4.

The attack rate of Phytophthora infestans in the control demonstration plot was very high, reaching 60%. In comparison, in the BIOTRICO application demonstration plot, the attack of Phytophthora infestans can decrease to 20%. It significantly affects the yield and productivity of potato plants. Yields and productivity are presented in Table 2.

| No | Types   | Application | Yield (400 m²) | Productivity (Kgm⁻¹) |
|----|---------|-------------|----------------|-----------------------|
| 1  | Control | 0 Kgm⁻¹     | 450 kg         | 1.125                 |
| 2  | BIOTRICO| 1 Kgm⁻¹     | 800 kg         | 2                     |

Figure 3. Nutrient content of BIOTRICO.

Figure 4. Level of Phytophthora infestans attack.
By comparing yields and productivity, it can be seen that the BIOTRICO application provides higher production yields than the control. In this aspect, BIOTRICO has succeeded in replacing the function of chemical pesticides. It also provides other advantages such as lower price, more accessibility to be developed independently, a more friendly environment, and healthier product.

3.3. Sustainability status

Based on the results of trials in demonstration plots, BIOTRICO has a positive impact in controlling the pathogen of Phytophthora infestans. It is proven to be able to maintain plant productivity. This finding supports organic agriculture practices. In the concept of sustainable organic agriculture, it must also pay attention to environmental, economic, and social aspects to remain profitable for farmers [16]. BIOTRICO can be a better choice than chemical pesticides in controlling pathogens. Besides being cheap and easy to develop independently, with BIOTRICO, the biodiversity of the agricultural environment can be better maintained.

4. Conclusion

From the analysis of the yield and productivity of potatoes at CV Agrolestrasi Merbabu, it can be concluded that BIOTRICO can minimize the level of pathogen attack to 20%, much lower than the control, which reached 60%. Supported by a reasonably high nutrient content, BIOTRICO can be an option for farmers to support sustainable organic agriculture practices. Future development of BIOTRICO will focus on product commercialization to provide more comprehensive benefits for organic farmers in Indonesia. Ultimately, BIOTRICO supports the sustainable agriculture.

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