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The Potency of Organic Fertilizer in Reducing Leaf Curl Disease on Chili (*Capsicum annuum* L.)

Potensi Pupuk Organik dalam Mengurangi Penyakit Keriting Daun pada Cabai (*Capsicum annuum* L.

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Abstrak

Cabai merupakan komoditas penting di Indonesia dengan permintaan yang terus meningkat, namun produksinya kerap terganggu oleh penyakit keriting daun akibat virus. Salah satu solusi potensial adalah penggunaan pupuk organik yang diperkaya dengan mikroba menguntungkan seperti Plant Growth-Promoting Microorganisms (PGPM). Meski berpotensi, peran PGPM dalam mengatasi penyakit virus pada cabai masih jarang diteliti. Penelitian ini bertujuan mengeksplorasi efektivitas pupuk organik dalam menurunkan infeksi keriting daun melalui peningkatan kesehatan tanaman. Dua kultivar cabai yang digunakan adalah 'Gama LBF' (hasil pemuliaan PIAT UGM) dan 'Ponirun' (varietas komersial tahan penyakit). Tanaman cabai diberi perlakuan dengan berbagai konsentrasi pupuk organik, dan efektivitasnya dinilai berdasarkan insidensi (jumlah tanaman bergejala) dan keparahan penyakit (tingkat gejala visual), yang kemudian diolah menjadi indeks. Hasil menunjukkan bahwa konsentrasi 75% menghasilkan insidensi penyakit terendah pada kedua kultivar, yakni 26,5% untuk 'Ponirun' dan 42,85% untuk 'Gama LBF'. Tingkat keparahan gejala juga paling rendah pada konsentrasi 75% untuk 'Ponirun' dan pada 50% untuk 'Gama LBF'. Temuan ini menegaskan pentingnya pemilihan konsentrasi pupuk organik yang tepat untuk menekan penyakit keriting daun pada cabai secara efektif.

Kata kunci: pupuk organikorganik; resistensi penyakit; penyakit keriting daun; intensitas penyakit; cabai

Abstract

Chili is an essential commodity in Indonesia, with demand continuing to rise; however, its production is often disrupted by leaf curl disease caused by viruses. One potential solution is using organic fertilizer enriched with beneficial microbes such as Plant Growth-Promoting Microorganisms (PGPM). Despite its potential, the role of PGPM in controlling viral diseases in chili plants has been rarely studied. This study aims to explore the effectiveness of organic fertilizer in reducing leaf curl infections by improving plant health. Two chili cultivars were used: 'Gama LBF' (a breeding product of PIAT UGM) and 'Ponirun' (a commercial variety known for its disease resistance). The chili plants were treated with various concentrations of organic fertilizer, and their effectiveness was evaluated based on disease incidence (the number of symptomatic plants) and disease severity (the level of visual symptoms), which were then converted into an index. Results showed that the 75% concentration yielded the lowest disease incidence in both cultivars—26.5% for 'Ponirun' and 42.85% for 'Gama LBF'. The lowest disease severity was also observed at the 75% concentration for 'Ponirun' and 50% for 'Gama LBF'. These findings highlight the importance of selecting the appropriate organic fertilizer concentration to suppress leaf curl disease in chili effectively.

Keywords: *organic fertilizer; disease resistance; leaf curl disease; disease intensity; chili.*

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INTRODUCTION

Chili (*Capsicum annuum* L.) is a crucial horticultural commodity in Indonesia, with its demand steadily increasing due to population growth and the expanding processed food industry that relies on chili as a key ingredient [1]. According to the Central Statistics Agency [2], chili demand in 2020 reached 1,508,404 tons, a notable rise from the previous year's 1,374,217 tons. However, this surge in chili demand has not been met with consistent production. Chili production faces fluctuations annually due to several factors, including the prevalence of diseases like leaf curl and yellowing caused by *Begomovirus* infections [3].

Ironically, *Begomovirus* infections spread rapidly within chili cultivation in Indonesia. Chili cultivation areas spanning from 6.2 ha to 60 ha in Central Java, West Java, and Yogyakarta reported *Begomovirus* infections as early as 2003. The affected chili cultivation area expanded rapidly by 2008. Data indicates that chili cultivation areas of 575 ha in Magelang, followed by Aceh (334 ha), Lampung (274 ha), and DI Yogyakarta (240 ha), were infected by *Begomovirus* [4]. Recent conditions show that *Begomovirus* has infected red chili plants in nearly all production centres across Indonesia, with varying incidence percentage rates [5].

Organic fertilizers contain live microorganisms that, when applied to plant surfaces, seeds, or soil, form colonies in the rhizosphere or on plant parts. This promotes growth by enhancing the supply or availability of essential nutrients for the host plant. Organic fertilizers containing specific microbial communities, known as Plant Growth Promoting Microorganisms (PGPM), have enhanced plant physiological performance. Optimal plant physiology influences plants' ability to withstand biotic and abiotic stresses [6], [7]. PGPM can stimulate plant growth through mechanisms such as soil reclamation, growth-promoting substance production, inhibition of harmful microbe/pathogen growth, phosphorus and nitrogen solubilization, nutrient mobilization, disease resistance induction, and stress tolerance enhancement against various pathogens in hosts. Some studies also indicated that organic fertilizer application in chili plants can induce growth and resistance against *Rhizoctonia solani* and *Phytophthora capsici* infections, which are soil pathogens in chili plants [8]. Fertilisers containing B. subtilis GB03 and *B. amyloliquefaciens* IN737a were found to reduce Tomato mosaic virus (TMV) infection in greenhouse-grown tomatoes [9]. Adding organic fertilizer containing microbes could reduce the disease incidence caused by *Tomato spotted wilt virus* (TSWV) by up to 40% in tomato plants [10].

The spread of viral infections in plants is influenced by changes in the environment, the evolution of the virus itself, and the existence and evolution of vectors.

Nevertheless, the options for managing plant viral diseases in Indonesia remain relatively limited, relying mainly on chemical methods to control vectors and developing plant varieties resistant to these viruses. However, relying solely on chemical control is not an ideal approach as it can lead to the development of resistance in vector insects. In addition, developing resistant crop varieties is time-consuming and may eventually be rendered ineffective by the evolution of the viruses [11]. Consequently, there is an urgent need for alternative, environmentally friendly control strategies that are easy for farmers to use.

Extensive research has been conducted on using organic fertilizer for chili cultivation. Studies have shown that the application of organic fertilizer can enhance growth, yield, and nutrient content in various types of chili, including red chili [12], *Capsicum chinense* Jacq [13], chili pepper [14], and jalapeno pepper chili [15]. While organic fertilizer has also been investigated for its ability to control chili plant diseases, most of the research has focused on soil-borne diseases such as collar rot disease caused by *Sclerotium rolfsii* Sacc [16],[17] and chili damping-off disease caused by *Pythium myriotylum* [18]. However, yellow curl disease caused by viruses is the primary problem in chili cultivation in Indonesia, and more research is needed on the application of organic fertilizer for virus control in this country. Previous studies have shown that poultry manure can effectively reduce disease incidence and severity of *Pepper veinal mottle virus* (PVMV) in *Capsicum annuum* in Nigeria [19]. Additionally, recent research has demonstrated that organic fertilizer can reduce the severity of *African cassava mosaic* disease in cassava [20]. This indicates that there is potential for the development of organic fertilizers to control viral diseases.

This study used two chili varieties: 'Ponirun' and 'Gama LBF'. 'Ponirun' is a commercial chili variety claimed to have resistance to viruses that cause leaf curl disease. At the same time, 'Gama LBF' is a chili variety developed through a breeding program by PIAT UGM. Both varieties were used to compare the effects of fertilizer application on two chili genotypes with different levels of resistance to yellow leaf curl disease. The novelty of this research lies in using organic fertilizers that are rich in microorganisms, which can enhance plant performance and resistance to viral infections.

METHODS

This study was conducted from December 2022 to May 2023 at the Agricultural Technology Innovation Center (PIAT) UGM Block 1. The research involved two chili cultivars: 'Gama LBF' chili (a product of PIAT UGM's development) and 'Ponirun' chili (a commercially available cultivar resistant to Geminivirus). The research design employed was a Randomized Complete Block Design

(RCBD), consisting of 6 treatments: 25% liquid organic fertilizer (A), 50% liquid organic fertilizer (LOF) (B), 75% liquid organic fertilizer (C), 100% liquid organic fertilizer (D), 100% compost (E), and 100% chemical fertilizer (F). The number of plants for each cultivar in each treatment ranged from 16 to 21. The liquid organic fertilizer used was derived from the decomposition of organic waste using maggots. The compost used was obtained through the decomposition of leaf litter. The liquid organic fertilizer and compost were processed in the Recycling Innovation Space (RINDU) at PIAT UGM.

Planting and Maintaining of Test Plants

The planting was carried out in an open field. The planting beds were covered with organic mulch composed of shredded leaf litter. This study used a Completely Randomized Design (CRD), in which six different concentration treatments were applied to individual beds, and each variety was randomly planted within the same bed. The plants were watered daily, while fertilization was conducted weekly during the vegetative phase and every two weeks after the generative phase.

Determination of Disease Severity Level

The leaf curl disease observed occurred naturally in the agricultural field. The symptom observations were conducted at 60 Days After Transplanting (DAT). The variables observed included disease incidence and disease intensity. Disease Incidence (DI) is calculated using the formula [21]: DI is the percentage of infected plants divided by the total plants. Subsequently, the disease severity level or Disease Severity (DS) is calculated using the formula [22]:

$$DS: \frac{\sum(ni \times Vi)}{Z \times N} \times 100\%$$

Note: "n" represents the number of plants for each score; "Vi" stands for the infection symptom score; "Z" denotes the highest symptom score observed; and "N" represents the total number of observed plants.

The symptoms of leaf curl and yellowing disease in chili are classified into six groups on a scale: 0 - healthy plants; scale 1 - yellowing spots on leaves; scale 2 - yellow spots and slightly curled leaves; scale 3 - yellow spots and curled leaves; scale 4 - yellow and curled leaves; scale 5 - entirely yellow and curled leaves, stunted plant growth [21]. Based on the Disease Severity (DS) results, plant resistance responses are categorized into five groups: tolerant (T) with an Infection Value (VI) of 0, resistant (RS) with VI = 1-25%, moderately resistant (CT) with VI = 26-50%, moderately susceptible (CR) with VI = 51-75%, and susceptible (R) with VI = 76-100% [22].

RESULTS AND DISCUSSION

Leaf curl disease in chili plants is commonly a result of viral infection. Some virus species reported to cause leaf curl, yellow mosaic, and hindered chili plant growth include *Tomato leaf curl New Delhi virus, Chili leaf*

curl virus, Papaya leaf curl virus, Pepper yellow leaf curl virus, Cabbage leaf curl virus, and others [3]. These symptoms represent the plant's effort to localize the viral infection to prevent it from spreading to other cells or tissues. Yellow mosaic is reported to result from chloroplast malformation, which subsequently disrupts photosynthesis and the transport of photosynthesis [23],[24].

Figure 1. The leaf curl symptoms on the chili 'Ponirun' plant leaves appear at each score.

The study used two parameters - disease incidence (DI) and disease severity (DS) index to measure the impact of leaf curl disease on plants. These parameters were determined based on the visible symptoms, such as curled leaves. The DI value indicated the percentage of plants in the population that showed leaf curling symptoms. On the other hand, the DS value stated the severity of leaf curling experienced by the infected plants. Figure 1 shows the morphological differences in the appearance of leaves exhibiting symptoms of leaf curl disease for each scale. The score of 4 suggested that plants with this score display smaller leaves than healthy plants, and more than 50% of the leaf surface area has chlorosis. The yellow mosaic and leaf curl symptoms are the plant's response to disease infection or biotic stress. The yellow mosaic appears due to necrotic lesions on infected tissues, which help limit the spread of infection to other healthy tissues. Leaf curling occurs because of the difference in size between the upper and lower epidermal cells, which results from the cessation of growth and elongation of mesophyll cells [25].

Table 1. Disease incidence of leaf curl disease

	Disease Incidence (%)	
	Chili 'Ponirun'	**Chili 'Gama LBF'**
25% LOF	50%	66,67%
50% LOF	50%	71,42%
75% LOF	26,7%	42,85%
100% LOF	46,7%	52,38%
100% Compost	42,85%	71,42%
Chemical Fertilizer	53.84%	89.86%

Observational results reveal leaf curl disease incidence variations in 'Gama LBF' and 'Ponirun' chili cultivars. Variations also arise within each fertilization treatment group (Table 1). Based on the number of individuals infected with leaf curl disease, it is evident that the fertilization treatment with 75% liquid organic fertilizer (POC) exhibited the lowest values for both chili cultivars. In 'Gama LBF' chili, 9 out of 21 (42.85%) plants were infected, while in 'Ponirun' chili, 4 out of 15 (26.7%) were infected. The highest number of individuals infected with leaf curl disease for both chili cultivars was observed in the chemical fertilizer treatment. The number of infected individuals in 'Gama LBF' chili was 18 out of 21 plants; in 'Ponirun' chili, it was 7 out of 13. These findings indicate that using organic fertilizer has a more significant impact on improving plant physiology in response to biotic stress. Although organic fertilizers are only applied to the soil, they have the potential to inhibit the development of foliar diseases. It also shows that combining organic and chemical fertilizers is more effective than using either alone in increasing plant resistance to biotic stress.

Plant disease occurrence is influenced by factors known as the disease triangle. The disease triangle comprises the host plant, the pathogen, and environmental factors/conditions. These three factors dynamically interact, resulting in varying disease intensities for different condition variations [26]. In this study, considering the plant factor, the variations in disease incidence intensity might be attributed to differences in nutrient quality and plant genotypes. Different types and compositions of fertilizers in the study led to varying nutrient availability for plants in each treatment. Research by [27] indicated that simultaneous nitrogen and phosphate supply reduction lowered the incidence of Barley Yellow Dwarf Virus (BYDV-PAV). However, a high nitrogen supply increased BYDV-PAV infection success [28]. Nutrient supply ratios are known to control the dynamics of various plant infections and insect-borne diseases. Nevertheless, the specific impacts of the infection stage and their direct implications on pathogens or host plants are still not fully understood [29].

'Ponirun' chili is recognized as a commercial cultivar claimed to be resistant to the virus causing leaf curl. This claim aligns with the observation that the number of infected individuals in 'Ponirun' chili is lower compared to 'Gama LBF' chili. Plant genotype determines cell metabolism in response to biotic stress. Some studies report increased gene expression in virus-resistant cultivars that is not found in other genotypes. Resistant genes also produce specific proteins that affect the interaction between the virus and the host plant. These proteins can reduce symptom intensity or

prevent viruses from entering or replicating within host cells [30].

The severity level of leaf curl disease symptoms in chili plants is determined by converting scoring results into a disease severity index (DS) value. The variations in DS values for each cultivar under different treatments are shown in Table 2.

Table 2. Disease severity of leaf curl disease on chili plants

	Disease Severity Index	
	Chili 'Ponirun'	**Chili 'Gama LBF'**
25% LOF	20,31	34,52
50% LOF	26,56	28,57
75% LOF	15,00	26,00
100% LOF	25,00	34,52
100% Compost	23,21	41,67
Chemical Fertilizer	25,00	39,29

The DS values for both cultivars reveal that the smallest value was observed in the 75% liquid organic fertilizer (POC) treatment (Table 2). The resistance response to the virus infection causing leaf curl disease, as indicated by both cultivars compared to other therapies, is classified as resistant. Meanwhile, the highest DI value for 'Gama LBF' chili was observed in the 100% compost fertilizer treatment, and for 'Ponirun' chili, it was in the 50% POC treatment.

Furthermore, optimal fertilizers can enhance plant biomass and quality, modify soil pH, stimulate nutrient transformation processes, and positively influence soil microbial activity [31]. In this context, organic fertilizers serve as nutrient sources and drivers of soil microbial diversity, critical for plant resilience to abiotic stresses such as drought or salinity and biotic stresses, including pathogen attacks [32]. Soil microbes contribute significantly to plant health through various mechanisms. They produce antibiotics, lytic enzymes, and other bioactive compounds that suppress pathogens and pests. In addition to these direct antagonistic effects, certain beneficial microbes activate the plant's innate immune system, inducing systemic resistance (ISR) via key signaling pathways such as jasmonic acid (JA) and ethylene (ET), thereby enhancing the plant's overall defense capacity [33].

Fertilization with 75% of the total fertilizer as liquid organic fertilizer (POC) is suspected to provide the optimal growth medium for chili plants. The presence of indigenous microbes in the used POC is associated with soil microbes, forming distinct soil microbial

community structures. The direct interaction between plants and soil microbes occurs at the root level. Roots are pivotal in nutrient uptake, substance trafficking, and growth regulation [34]. Changes influence root density and functional traits in soil nutrient status, physical environment, and surrounding microbial communities. Rhizosphere microorganisms are crucial in regulating nutrient availability and biogeochemical nutrient cycles. In other words, soil microorganisms affect nutrient metabolism and plant resistance to pathogens [35]. Several studies have reported that high microbial diversity inhibits pathogen accumulation [36]. A study by [34] reported that healthy plants exhibit higher diversity and abundance of soil microorganisms than virus-infected plants. This is further supported by [10], who reported that the application of organic fertilizers (Biochar and alfalfa straw) decreased disease incidence from *Tomato spotted wilt virus* (TSWV) infection by up to 40%.

The microbial content of organic fertilizers has been recognised for its ability to reduce viral infections in plants through the secretion of extracellular enzymes. A study by [37] demonstrated that the production of ribonuclease can effectively eliminate virus particles present in the sap of tobacco leaves infected with TMV. Microorganisms can also produce elicitor compounds that enhance the activation of resistance genes in plants [38]. In addition, they can disrupt virus replication [39], impede virus transmission [40], or reduce vector populations [41].

CONCLUSIONS

The research has conclusively shown that the concentration and type of fertilizer used could affect the intensity of leaf curl disease in chili plants. The optimal concentration for reducing the incidence of leaf curl disease infection in chili plants is to use liquid organic fertilizer with a concentration of 75%. This reduction effect is consistent in both genetically resistant and non-resistant cultivars. Using an organic fertilizer with an optimal composition can be an environmentally friendly alternative for controlling leaf curl disease in chili plants.

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CONFLICT OF INTEREST

I hereby declare that there is no conflict of interest in writing this scientific work.

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