

# Biofilmed Biofertilizer and Potassium Fertilizer in Reducing Basal Rot Severity and Increasing Garlic Yield on Andisol Soil

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**Abstract.** Garlic (*Allium sativum* L.) is an important horticultural crop cultivated in Indonesia, domestic production remains insufficient to meet increasing demand. One major constraint in garlic cultivation is basal rot caused by *Fusarium oxysporum* f. sp. *cepae*, which significantly reduces yield and bulb quality. Environmentally friendly management practices, such as biofilmed biofertilizer (BiO<sup>2</sup>) and balanced potassium fertilization, offer potential solutions to suppress disease intensity while enhancing plant growth. This study aimed to evaluate the effectiveness of the balance of BiO<sup>2</sup> and potassium fertilizer in controlling basal rot and increasing garlic yield on Andisol soil in Tawangmangu. The experiment was conducted from May to September 2024 using a Randomized Block Design (RBD) with four treatments: P0 (100% K (Without BiO<sup>2</sup>)); P1 (0% K + BiO<sup>2</sup>); P2 (50% K + BiO<sup>2</sup>), and P3 (100% K + BiO<sup>2</sup>), each replicated six times. Data on plant growth, disease intensity, and yield components were analyzed using analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level. The results demonstrated that BiO<sup>2</sup> increased K effectiveness on garlic planted in Andisol soils. The combination of 50% K+ BiO<sup>2</sup> was most effective in reducing basal rot severity, improving growth, and yield of garlic.

## 1 Introduction

Garlic (*Allium sativum* L.) is an economically and medically important horticultural crop. This high demand highlights the importance of domestic garlic availability to reduce dependence on imports and to improve the welfare of local farmers. One of the main challenges in garlic cultivation is basal rot disease caused by the pathogen *Fusarium oxysporum* f. sp. *cepae* (FOCe). This disease leads to yellowing leaves, wilting, and rotting

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at the stem base and bulbs, thereby reducing both the quantity and quality of yields. The problem is exacerbated by high soil moisture, poor drainage, and the unbalanced use of chemical fertilizers, which can damage soil microorganisms and increase plant susceptibility. Basal rot is one of the major constraints in garlic production in Indonesia.

Environmentally friendly control efforts are therefore necessary, one of which is the application of biofilmed biofertilizer (BiO<sup>2</sup>), which can enhance plant health and productivity. [1] reported that biofilm-based biofertilizers improve nutrient availability, soil pH, and organic matter content and support plant growth. In addition, potassium plays a crucial role in carbohydrate metabolism, enzyme activity, osmotic regulation, and plant resistance against diseases [2]. Therefore, this study was conducted to evaluate the effectiveness of BiO<sup>2</sup> and potassium fertilization balance in suppressing basal rot intensity and improving garlic yield on Andisol soils in Tawangmangu.

## **2 Material and Methods**

### **2.1 Site and Duration**

The experiment was conducted in a garlic cultivation area located in Pancot Village, Jetis, Kalisoro, Tawangmangu, Karanganyar Regency, Central Java, Indonesia. The field experiment was carried out from May to September 2024, followed by laboratory analyses until May 2025.

### **2.2 Material and Tools**

The materials used included garlic seeds of the Tawangmangu Baru variety, Urea, SP-36, KCl, and Biofilmed Biofertilizer (BiO<sup>2</sup>). Field tools consisted of hoes, measuring tape, digital scales, a camera, and stationery. Laboratory equipment included a pH meter, oven, analytical balance, microscope, autoclave, and various types of glassware, such as Erlenmeyer flasks, test tubes, and Petri dishes.

### **2.3 Experimental Design and Procedures**

The research was conducted from May to September 2024, in Pancot Village, Tawangmangu, Karanganyar Regency, Central Java, with coordinates 7°39' South Latitude and 111°08' East Longitude. The geographical condition of the experimental land is at an altitude of 1200 meters above sea level. The type of soil in the research area is Andisol soil. The experiment employed a Randomized Block Design (RBD) with four treatments: P0 = 100% K (Without BiO<sup>2</sup>), P1 = 0% K + BiO<sup>2</sup>, P2 = 50% K + BiO<sup>2</sup>, and P3 = 100% K + BiO<sup>2</sup>. Each treatment was replicated six times, resulting in a total of 24 experimental units. Land preparation included weeding, tilling, and constructing plots sized 1.2 × 10 m. Garlic bulbs were planted at a spacing of 10 × 15 cm and a depth of 2–3 cm. BiO<sup>2</sup> was applied weekly starting from three weeks after planting until harvest at a rate of 2 L/ha. Nitrogen and phosphorus fertilizers were applied three times (30, 60, and 80 days after planting) at a fixed rate, while potassium fertilizer was applied according to the treatment. Crop management included irrigation, weeding, and pest and disease control as needed. Harvesting was conducted at approximately 120 days after planting, indicated by yellowing leaves.

### 3 Result and Discussion

The characteristics of Andisol soil are characterized by black color, porous, organic matter content and amorphous clay, namely allophane then a little silica, alumina or iron hydroxide [3].

**Table 1.** Analysis results of soil treated by BiO<sup>2</sup> and some dosage of K

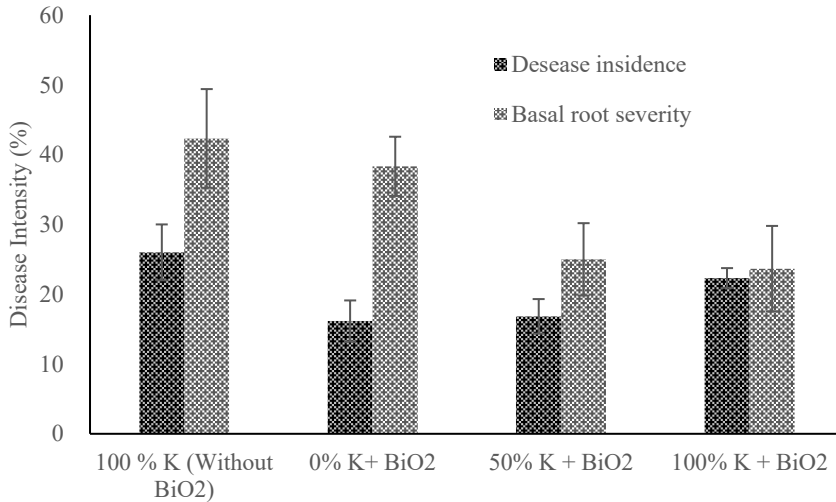
Treatment	pH	Organic Material (%)	Total N (%)	P is available (ppm)	K is available (cmol(+)/kg <sup>-1</sup> )	C/N Ratio
Before Treatment	6.51	2.19	0.23	9.42	0.98	5.42
100% K (no BiO <sup>2</sup> )	6.37	7.74	0.49	216.22	0.36	9.21
0% K + BiO <sup>2</sup>	6.38	7.99	0.57	115.11	0.74	8.07
50% K + BiO <sup>2</sup>	6.39	8.05	0.67	109.81	0.40	7.18
100% K + BiO <sup>2</sup>	6.61	7.48	0.51	239.51	1.22	8.49

Based on the results of soil analysis, there was a change in the chemical properties of the soil after treatment compared to the initial soil condition. The soil pH value before treatment was 6.51, then varied between 6.37-6.61 after treatment. The pH value is still classified as slightly acidic, this pH value is ideal for garlic growth. According to [4], a pH value of 6.0-7.8 is very suitable for garlic growth. The organic matter content increased from 2.19% (low) to 7.48-8.05% (high). The function of organic matter according to [5], is very important because it can improve soil aggregation so that it can increase the number of soil pores which ultimately becomes a suitable medium for planting because the root reach is wider. The total N content also increased from 0.23% (medium) to 0.49-0.67% (medium-high). The balance of K and BiO<sup>2</sup> fertilizers can increase total nitrogen levels in the soil because BiO<sup>2</sup> contains N-fixing bacteria. This is in line with the statement by [6], who stated that total nitrogen in the soil is highly dependent on the presence of N-fixing bacteria in the soil, including *Rhizobium* sp., *Azotobacter* sp., and others, by converting atmospheric N<sub>2</sub> into N for plant use.

Available P increased drastically from 9.42 ppm (low) to 109.81–239.51 ppm (very high), the available P increased in each treatment of potassium fertilizer and BiO<sup>2</sup> balance because BiO<sup>2</sup> contains microbes that produce phosphate-dissolving enzymes. This is in accordance with the statement of [7] phosphate-dissolving microorganisms play an important role in converting insoluble phosphate into soluble forms by releasing organic acids and phosphatase enzymes, thus making phosphorus available to plants while available K increased from 0.98 cmol(+)/kg to 0.36–1.22 cmol(+)/kg, with the highest value in the treatment of 100% K + BiO<sup>2</sup>. BiO<sup>2</sup> has Potassium-Dissolving Bacteria (PBC) in it. According to [8], PBC is able to dissolve K from silicate minerals or rocks containing K through the production and excretion of organic acids.

### 3.1.1 Disease Variable

The ratio of potassium fertilizer and biofilmed biofertilizer significantly affected the severity of wilting and basal rot in garlic. The severity of wilting in garlic plants, depending on the ratio of potassium fertilizer and biofilmed biofertilizer (BiO<sup>2</sup>) (Figure 1).



**Fig. 1.** Effect of BiO<sup>2</sup> and some dosages of K on disease incidence and severity of garlic

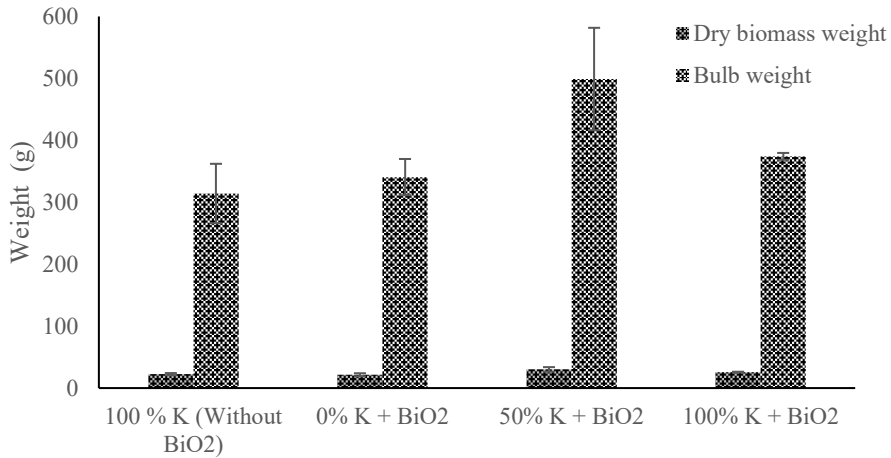
The incidence of garlic diseases varied between treatments, but statistically did not show significant differences between treatments. The highest incidence of disease was found in the 100% K (Without BiO<sup>2</sup>) treatment at 26.00%, while the lowest was found in the 0% K + BiO<sup>2</sup> treatment at 16.17%. This indicates that the balance of K fertilizer with BiO<sup>2</sup> can reduce disease incidence compared to the treatment without BiO<sup>2</sup>. The intensity of basal rot disease showed a significant difference between treatments. The highest intensity was found in the 100% K (Without BiO<sup>2</sup>) treatment, at 42.33%, while the lowest was found in the 100% K + 100% NP + BiO<sup>2</sup> treatment, at 23.67%. However, the 100% K + BiO<sup>2</sup> treatment was not significantly different from the 50% K + BiO<sup>2</sup> treatment. This indicates that the balance of potassium fertilizer with BiO<sup>2</sup> significantly reduced the intensity of basal rot. Even a dose of 50% K was quite effective, so using the full dose was not absolutely necessary.

Biofilm biofertilizer contains beneficial microorganisms (such as *Bacillus* sp., *Pseudomonas* sp., *Azospirillum*, etc.) formulated in a biofilm form that can suppress attacks from pathogens. According to [9], *Bacillus* sp. is able to produce enzymes that can reduce disease-causing pathogens and improve plant health. Potassium is a key nutrient in plant metabolic activities, contributing to photosynthetic efficiency, respiratory processes, enzyme activation, stomatal control, and carbohydrate translocation for starch and protein biosynthesis, and increasing plant resistance to pests and diseases. Potassium application should be neither excessive nor insufficient. Potassium deficiency reduces plant vigor and their resistance to pathogen attacks. According to [10], potassium-deficient plants are highly susceptible to various pathogens due to disruption of ion balance and defense mechanisms

against *Fusarium* spp. in the soil, and supports garlic productivity in Andisol Tawangmangu soil.

### 3.1.2 Yield Parameters

Higher plant height and leaf number resulted in greater biomass weight. Rapid vegetative growth indicates efficient photosynthesis, leading to increased accumulation of photosynthates in plant biomass [11] (Figure 2).



**Fig. 2.** Effect of BiO<sup>2</sup> and Some Dosages of K on the weight of dry biomass and bulb of garlics

Dry biomass weight and bulb weight increased in all treatments with BiO<sup>2</sup> balance, indicating that BiO<sup>2</sup> use increased dry biomass weight and bulb weight, but the effect was not statistically significant. The initial soil conditions, which already had high potassium levels, allowed garlic plants to obtain sufficient potassium, so the additional potassium fertilizer treatment did not significantly affect dry biomass weight or bulb weight. The 50% K + BiO<sup>2</sup> treatment significantly increased dry biomass and bulb weight, with a dry biomass weight of 30.17 g and a bulb weight of 499.00 g. An adequate balance between BiO<sup>2</sup> application and potassium fertilization tended to promote biomass and bulb weight, although the differences were not statistically significant. Excessive potassium application may reduce magnesium uptake, which can subsequently limit bulb productivity and growth [12]. This suggests that moderate potassium input is more favorable for garlic development. The observed increase in biomass is likely related to the role of potassium in photosynthesis, photosynthate translocation, and regulation of water balance within plant tissues. In addition, biofilmed biofertilizer enhances nutrient availability and soil microbial activity, thereby supporting plant growth. Therefore, the application of potassium fertilizer and BiO<sup>2</sup> provides positive physiological responses in garlic plants, despite the absence of significant statistical differences.

### 3.1.3 Plant Growth Variable

Plant growth was observed to determine vegetative growth. Plant height observations were conducted for 10 weeks. After 10 weeks, the garlic entered the generative phase, characterized by a decrease in leaf growth rate and changes in leaf color, starting to turn yellow and wilt.

**Table 2.** Height of garlic plants and number of leaves with the balance of potassium fertilizer and Biofilmed Biofertilizer (BiO<sup>2</sup>)

Treatment	Plant Height (cm)	Number of Leaves
100% K (Without BiO <sup>2</sup> )	48.93±6.35a	6.50±0.81a
0% K + BiO <sup>2</sup>	59.24±0.94b	8.00±0.25b
50% K + BiO <sup>2</sup>	62.58±3.30b	8.03±0.28b
100% K + BiO <sup>2</sup>	60.88±2.10b	8.03±0.28b
Significance	<0.05	<0.05

**Description:** Numbers followed by the same letter in the same column indicate no significant difference according to DMRT with a significance level of 95%.

The treatment of potassium fertilizer and BiO<sub>2</sub> balance significantly affected the plant height and number of garlic leaves. The control treatment using only NPK fertilizer and chemical pesticides showed significant differences compared to other treatments. However, the treatments of 0% K + BiO<sup>2</sup>, 50% K + BiO<sup>2</sup> and 100% K + BiO<sup>2</sup> did not significantly differ in terms of plant height and number of leaves. The treatment of 0% K + BiO<sup>2</sup> is highly recommended because it can increase plant height (62.58 cm) and number of leaves 8.00 strands). This shows that the use of (BiO<sup>2</sup>) can support the growth of garlic plants even without additional potassium fertilizer. BiO<sup>2</sup> contains potassium-solubilizing microbes that are able to release bound potassium through the secretion of organic acids and certain enzymes, thereby increasing the availability of potassium in the soil. Thus, even without potassium fertilizer application, the combination of high soil K availability and the role of BiO<sup>2</sup> is sufficient to meet plant K requirements for optimal growth. [13] reported that inoculation with potassium-solubilizing microbes can increase soil potassium availability while supporting plant growth. Thus, even without potassium fertilizer application, the combination of high soil K availability and the role of BiO<sup>2</sup> is sufficient to meet plant K requirements for optimal growth.

High K content does not always result in the highest number of leaves. Based on the results of soil chemical analysis (Table 1), K availability in the research area is already quite high. Excessive potassium application may cause antagonistic interactions in nutrient uptake. According to [14], surplus K can indirectly inhibit plant growth by interfering with the absorption of other nutrients, particularly nitrogen, which plays a crucial role in leaf development. The 100% K (Without BiO<sup>2</sup>) treatment without BiO<sub>2</sub> resulted in the lowest leaf number, where the application of biofilmed biofertilizer (BiO<sub>2</sub>) significantly increased leaf formation. This finding is consistent with [15], who reported that microbial-based biofertilizers, applied either individually or as consortia, enhance plant growth as indicated by increased plant height and leaf number.

## 4 Conclusions

1. Biofilmed biofertilizer (BiO<sup>2</sup>) was proven to enhance soil fertility and significantly improve the growth and health of plants. The balance of BiO<sub>2</sub> and potassium fertilizer

was effective in increasing plant height, number of leaves, and reducing basal rot severity compared to the control treatment that only used 100% K without BiO<sup>2</sup>.

2. The treatment of 0% K + 100% NP + BiO<sup>2</sup> showed the best results for plant height and number of leaves, while 50% K + 100% NP + BiO<sup>2</sup> was most effective in suppressing basal rot, indicating that BiO<sup>2</sup> plays an important role in supporting garlic growth and productivity even with reduced potassium input number on.

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