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# Effect Application of Cellulolytic Bacteria Consortium And Palm Kernel Ash on Red Chili Plants in Peat Soil

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## ABSTRACT

Limited agricultural land in Indonesia makes peatland an alternative land for agricultural intensification. Peat soil has a low fertility, so applying cellulolytic bacteria and palm oil shoot ash is recommended. This study aimed to determine the effect of cellulolytic bacteria consortium and oil palm shoot ash on the growth and yield of red chilies on peat soils. The research was conducted in Empat Balai Village, Kampar. The study used a factorial in a completely randomized design (3x3) and three replications. The first factor was the cellulolytic bacteria consortium (0, 20, and 30 mL polybag$^{-1}$), and the second factor was palm ash (0, 3, and 6 Mg ha$^{-1}$ equivalent to 0.126 and 252 g polybag$^{-1}$). The application of cellulolytic bacteria consortium and its interaction with oil palm shoot ash had no significant effect on all observed variables. While, the application of palm ashes significantly affected plant height, stem diameter, number of fruits, and fruits weight.

***Keywords***: Cellulolytic bacteria, nutrient, palm ashes, peat soil, red chili

## INTRODUCTION

Increased economic growth in Indonesia has led to a reduction in the productive land area for agriculture. The agricultural sector's conversion of agricultural land to non-agricultural land is the main problem, so agricultural land is decreasing. Along with population growth, the need for food is increasing. Therefore, it is necessary to expand the agricultural area. With its vast potential, a peat soil is one of the alternatives to be used as agricultural land. The Peatland Restoration Agency (2020) states that the peatland area in Indonesia reaches 24,667,804 hectares and is mainly spread across three islands, namely Sumatera, Kalimantan, and Papua. The Ministry of Environment and Forestry (2020) stated that Riau Province has the largest peatland area in Sumatera, which is 5,355,774 ha out of 9,604,529 ha of total peatland area in Sumatera or 55.76% of the peatland area in Sumatera. The peatland area in Riau is about 61.54%, and the mineral land area in Riau is the remaining 38.46% of the total area of Riau Province, which is about 8,702,000 ha. The peatland area in Riau is divided into 2,637,704 ha for the protection function and 2,717,670 for the cultivation function.

The main characteristic of peat soils is their high organic matter content (more than 20%), which results in relatively low productivity. Because high organic matter in peat soils with low N-Total will cause unavailability of nutrients for plant growth. In addition, according to Andriesse (2007), one of the most important inherent characteristics of peat soils in the tropics is that the constituent material comes from woody plants. It is one of the limiting factors in the development of agriculture. The most significant component of woody plants is cellulose, which is difficult to decompose. One of the key strategies to improve the fertility of peat soil is the application of bio fertilizers that can accelerate the decomposition of organic matter. Cellulolytic bacteria, which can produce the enzyme cellulose, play a crucial role in this process. Bio fertilizers are active biological products consisting of microbes identified to at least the genus level and function to provide nutrients directly or indirectly, break down organic matter, and increase fertilizer efficiency, fertility, and soil health (MOA No. 01, 2019).

Cellulolytic microorganisms can grow on cellulose and can decompose these cellulose materials. Environmental conditions that significantly affect microbe growth include pH. Each microbe has a certain pH for growth. Cellulolytic bacteria such as Cythopaga can develop at pH 6.1-9.1, while at pH 5.6-6.0, Sporocythopaga grows abundantly (Sutedjo et al., 1991). Verma et al. (2012) stated that the cellulose activity of Bacillus subtilis is optimal at pH 6.5-7.5. Varma et al. (2021), in their research on media optimization of lignocellulotic waste by cellulolytic bacteria isolated from termite intestines, used a media pH of 7.

Peat soils generally have a low pH (<4). Therefore, for cellulolytic bacteria to grow and develop in peat soils, it is necessary to increase the pH. One way to increase soil pH is by liming. However, due to the limited availability and high price of lime, it is necessary to look for alternative materials other than lime. One of the alternative materials that can be given is oil palm basket ash. According to research by Ramanda et al. (2022), the application of palm kernel ash to peat soil at a dose of 250 g polybag$^{-1}$ significantly increased soil pH, namely 5.3, which up 0.9 or almost one pH unit, when compared to without the application of palm kernel ash whose pH was only 4.4 after incubation for 10 days. Prasetyo's research (2009) stated that palm kernel ash should be applied at a dose of 1 Mg ha$^{-1}$ increased peat soil's pH from 4.41 to 5.56, an increase of 1.15 pH units.

Many research results show that providing cellulolytic bacteria can decompose organic matter. The results of Kurniawan and Gusmawartati's research (2021) showed that the provision of 50 mL of cellulolytic bacteria could accelerate the composting of oil palm empty fruit bunches with a decrease in the weight of compost material by 35.85-49.40%. Moreover, Gusmawartati and Sari (2023) on composting dried oil palm empty fruit bunches showed that the consortium of cellulolytic bacteria was able to reduce the C/N ratio to 10.94 from the initial C/N of 87.76 while the single application of cellulolytic bacteria was only able to reduce the C/N ratio to 21.40. The same results were also reported by Aini and Linda (2020), that the combined inoculum of cellulolytic consortium bio activators in composting the empty oil palm bunches for 30 days produced lower C-organic, higher N-total, and lower C/N ratio compared to other treatments, where the C-organic value was 34.5%, N-total 1.35% and C/N ratio 25.56.

Masganti (2013) states that commodity selection is closely related to overflow typology, seasonality, and the economic value of commodities. Horticultural commodities (vegetables and fruits) are more economically valued than food crops. Among horticultural crops, red chili stands out with its high economic potential. The crop can be developed to meet domestic needs and contribute significantly to the agricultural economy. Based on the BPS report and the Director General of Horticulture (2020), red chili productivity in Riau from 2015 to 2019 averaged 6.79 Mg ha$^{-1}$. This is a promising figure, but it is still low compared to the potential of red chili, which can reach 10-12 Mg ha$^{-1}$.

The research aims to determine the interaction of cellulolytic bacterial consortium bio fertilizer and palm kernel ash and its single factor and get the right combination for the growth and yield of red chili plants in peat soil.

## MATERIALS AND METHODS

The research was conducted in Pulau Empat Hamlet, Empat Balai Village, Kuok District, Kampar Regency, and Soil Science Laboratory, Faculty of Agriculture, Riau University, from May to December 2022. The study used a randomized complete factorial design (3×3) and three replications. The first factor was the consortium of cellulolytic bacteria (0, 20, and 30 mL polybag$^{-1}$), and the second factor was oil palm bed ash (0, 3, and 6 Mg ha$^{-1}$ equivalent to 0, 126, and 252 g polybag$^{-1}$). The data obtained were statistically analysed using analysis of variance (ANOVA) and then further tested with the honest real difference test at the 5% level.

### Research Implementation

Peat soil as planting media was taken from the peat experimental garden of Riau University. After removing the top litter, the soil was collected using a hoe to a depth of ±30 cm. The peat soil was mixed with chicken manure that had been tested not to contain cellulolytic bacteria in a ratio of 3:1 (w/w). This ratio refers to preparing planting media in cultivating plants in polybags. The manure serves as a stimulant source of N for the introduced bio fertilizer. Next, the soil was put into polybags measuring 40 cm × 35 cm by setting aside 2 cm from the lip of the polybag. The soil was then added with palm kernel ash according to the treatment and incubated for three weeks.

### Preparation of Cellulolytic Bacterial Consortium Bio fertilizer

Rejuvenation of cellulolytic bacterial isolates was done by inoculating one ose of cellulolytic bacterial isolate collection into solid CMC media using the scratch method (Streak Plate). Furthermore, it was incubated at room temperature for 1 × 24 hours. One ose of cellulolytic bacterial isolates from rejuvenation was inoculated on 5 mL of liquid CMC media, then incubated for 1 × 24 hours. After that, 5 ml of the results of each isolate were inoculated in each of six 500 ml Erlenmeyer containing 270 mL of liquid CMC media and incubated for 7 hours using an automatic shaker at 150 rpm. Furthermore, cellulolytic bacterial bio fertilizer is ready to be applied as liquid fertilizer with a population of 4.2 × 108 viable cells per mL. The application was done one week before planting by sprinkling evenly on the surface of the planting media that had been watered beforehand.

Before transplanting the chili seedlings into the planting media that has been provided, the planting media is watered first. Seedlings with four leaves were transferred to the planting media. Each polybag was planted with one red chili seedling that had uniform and healthy growth. Maintenance of red chili plants includes watering, replanting, weeding weeds, giving stakes, fertilizing, tapering shoots, and controlling pests and diseases. Observation variables include plant height, stem diameter, flowering age, number of fruits per plant, and weight per plant.

### Supporting Data

Soil analysis was conducted in a composite manner at the beginning and end of the study. Soil chemical properties were analysed, namely pH $H_2O$ (pH meter), C/N ratio, and available P (Bray 1 method) and available K ($NH_4OAc$ extract 1M, pH 7).

## RESULTS AND DISCUSSION

### Soil Analysis Results

Based on soil fertility criteria according to Hardjowigeno (2010), the initial soil analysis results in Table 1 show a low pH (4.20), very high C-organic (41.44), high N-Total (1.00), very high available P (139.86), very high available K (0.90) and very high C/N ratio (41.44). The results of soil analysis after the application of the consortium of cellulolytic bacteria and palm kernel ash showed changes in the chemical properties of peat soil, namely the pH of peat soil increased to neutral, decreased soil C-organic content, increased the content of N-total, P-available, and K-available, and decreased the C/N ratio. These changes indicate that applying cellulolytic bacteria consortium and palm kernel ash can improve peat soil fertility. Table 1 shows that the synergy between the consortium of cellulolytic bacteria and palm kernel ash in decomposing peat soil organic matter increases the availability of nutrients (N, P, K) due to a decrease in C-organic.

### Effect of Cellulolytic Bacteria Consortium and Oil Palm Bed Ash on the Growth and Yield of Red Chilli

The interaction of cellulolytic bacterial consortium and palm kernel ash in Table 2 is not yet apparent because the contribution of palm kernel ash, which is expected to increase the pH of peat soil to support the optimum growth of cellulolytic

Table 1. Results of chemical analysis of peat soil before and after research.

| Treatment | Parameter | | | | | |
|---|---|---|---|---|---|---|
| | pH | Organic-C (%) | Total-N (%) | P-available (ppm) | K-exchangeable (ppm) | C/N ratio |
| S0A0 | 4.52 | 36.56 | 1.13 | 221.94 | 0.87 | 26.88 |
| S0A1 | 4.55 | 33.57 | 1.44 | 183.80 | 2.28 | 23.47 |
| S0A2 | 5.73 | 27.39 | 1.42 | 146.54 | 1.52 | 19.02 |
| S1A0 | 4.77 | 25.57 | 1.53 | 220.52 | 2.53 | 16.71 |
| S1A1 | 4.70 | 24.82 | 1.43 | 182.49 | 2.72 | 17.35 |
| S1A2 | 5.28 | 22.70 | 1.61 | 220.41 | 3.54 | 14.09 |
| S2A0 | 5.21 | 36.51 | 1.41 | 256.87 | 1.59 | 31.20 |
| S2A1 | 5.48 | 30.45 | 1.53 | 184.71 | 3.35 | 19.90 |
| S2A2 | 5.57 | 24.39 | 1.28 | 176.60 | 1.89 | 19.05 |
| Initial soil value | 4.20 | 41.44 | 1.00 | 139.86 | 0.90 | 41.44 |

Table 2. Average growth and yield of red chilies when given cellulolytic bacteria.

| Treatment | Parameter | | | | |
|---|---|---|---|---|---|
| Cellulolytic Bacteria Consortium ($mL.polybag^{-1}$) | PH (cm) | SD (cm) | FA (HST) | NF per plant (fruit) | FW per plant (g) |
| 0 | 39.00 a | 0.49 a | 36.11 a | 40.66 a | 143.12 a |
| 20 | 39.72 a | 0.52 a | 34.61 a | 46.66 a | 165.05 a |
| 30 | 37.83 a | 0.50 a | 35.94 a | 40.83 a | 167.09 a |

Note: Numbers in the same column followed by the same letter are not significantly different according to the Honestly Significance Difference (HSD) follow-up test at the 5% level. PH: Plant Height, NF: Number of Fruits, SD: Stem Diameter, FW: Fruit Weight, FA: Flowering Age, OPBA: Oil Palm Bunch Ash.

bacterial consortium, has not been maximized. After the research, the results of pH analysis only ranged from 4.70 - 5.57 (Table 1). The research results by Wahyuni et al. (2015) show that the optimum pH for the growth of cellulolytic bacteria in peat soil ranges from pH 5-7. It is suspected that the dose of consortium given is still low. The consortium's research improves the classification of organic matter thereby reducing increased nutrient consumption (K, Ca, Mg). These cations increase the pH of the soil. The research results by Aini and Linda (2020) showed that providing 50 mL of cellulolytic bacterial consortium in composting oil palm empty fruit bunches reduced the C/N ratio to 25.56. In other words, there is a mineralization of nutrients that plants can use to grow and develop. However, the combination of 30 mL $polybag^{-1}$ of cellulolytic bacterial consortium and 126 g $polybag^{-1}$ of palm kernel ash tends to produce the best growth and yield of red chili plants with a 25% increase in fruit weight when compared to without the provision of cellulolytic bacterial consortium and palm kernel ash. The results of soil chemical analysis after the study (Table 1) showed that the availability of macronutrients increased compared to before the study. N-total increased to 1.53% (very high), P-available increased to 184.71 ppm (very high), and K-available increased to 3.35 ppm (very high). Plants need these macronutrients to increase vegetative and generative growth. The high nitrogen element increases the vegetative growth of plants, especially stimulating leaf growth. The wider the leaves, the higher the photosynthate formed. The research results by Nopiandi and Anwar (2017) found that the application of 'petrobio' bio fertilizer produced the highest number of fruits per plant, namely 27.17. Research by Ermawati et al. (2021) on red chili plants treated with biological fertilizers and NPK found that applying 75% compound NPK fertilizer resulted in the number of fruits increasing by 7.5% compared to without treatment.

**Effect of Cellulolytic Bacteria Consortium on Growth and Yield of Red Chillies**

Table 2 shows that providing 20 mL $polybag^{-1}$ of cellulolytic bacterial consortium produces the best plant growth and production. However, in variance analysis, it is not significantly different from other treatments. It is due to environmental factors of growth, namely pH, which is not optimal. However, cellulolytic bacteria as a decomposing agent have worked effectively, although not maximally, in decomposing peat soil organic matter to increase plant growth. It can be seen from the results of the chemical analysis of the soil after the research (Table 1) that the C/N value of 16.71 decreased by 60% compared to the soil before the research (C/N 41.44). It shows that the increase in N-total in applying 20 mL $polybag^{-1}$ of the cellulolytic bacterial consortium aligns with the decrease in C-organic in the same treatment. Similar research findings were also reported by Satria Nur et al. (2009), where composting rice straw with the addition of cellulolytic bacteria reduced the C/N ratio from 39 to 23 by the third week of composting. The decrease in the C/N ratio occurs due to the use of carbon as an energy source and is lost in the form of $CO_2$, while microbes use nitrogen for protein synthesis and the formation of body cells. Winarso (2005) stated that the decomposition of organic matter releases several nutrients, such as N, P, K, and S. Microorganisms utilize these released nutrients for their metabolism. The activity of microorganisms will increase, and the decomposition process of organic matter will accelerate.

The C/N ratio will affect the availability of nutrients. The C/N ratio is inversely proportional to the availability of nutrients, meaning that if the C/N ratio is high, then the nutrient content is little available to plants. At the same time, if the C/N ratio is low, then the availability of nutrients is high, and plants

Table 3. Average growth and yield of red chilies when given cellulolytic bacteria and oil palm bunch ash.

| Treatment | | Parameter | | | | |
|---|---|---|---|---|---|---|
| Cellulolytic Bacteria Consortium ($mL.polybag^{-1}$) | OPBA (g $polybag^{-1}$) | PH (cm) | SD (cm) | FA (HST) | NF per plant (fruit) | FW per plant (g) |
| 0 | 0 | 39.16 a | 0.51 a | 35.50 a | 46.83 a | 176.01 a |
| | 126 | 42.83 a | 0.56 a | 34.30 a | 48.66 a | 137.63 a |
| | 252 | 35.00 a | 0.40 a | 38.50 a | 26.50 a | 115.73 a |
| 20 | 0 | 44.16 a | 0.55 a | 34.33 a | 54.50 a | 212.59 a |
| | 126 | 45.00 a | 0.56 a | 33.83 a | 50.83 a | 168.70 a |
| | 252 | 30.00 a | 0.45 a | 35.66 a | 34.66 a | 113.87 a |
| 30 | 0 | 38.83 a | 0.50 a | 38.66 a | 50.50 a | 216.32 a |
| | 126 | 45.16 a | 0.58 a | 32.66 a | 54.66 a | 219.19 a |
| | 252 | 33.50 a | 0.43 a | 36.50 a | 17.33 a | 65.74 a |

Note: Numbers in the same column followed by the same letter are not significantly different according to the Honestly Significance Difference (HSD) follow-up test at the 5% level. PH: Plant Height NF: Number of Fruits, SD: Stem Diameter, FW: Fruit Weight, FA: Flowering Age, OPBA: Oil Palm Bunch Ash.

can meet their needs. (Hapsoh et al., 2016) the decomposition of various combinations of organic waste with the addition of cellulolytic bacteria was found to increase the nutrient content of nitrogen (N), phosphorus (P), and potassium (K), reaching 1.19%, 0.30%, and 0.69%, respectively.

### Effect of Oil Palm Bunch Ash on the Growth and Yield of Red Chilli

Table 4 shows that applying up to 126 g $polybag^{-1}$ of palm kernel ash significantly increased plant height, stem diameter, number of fruits per plant, and weight per plant. It was because applying up to 126 g $polybag^{-1}$ of palm kernel ash increased the soil pH due to the availability of nutrients in peat soil. After the research (Table 1) on the application of 126 g $polybag^{-1}$ of oil palm kernel ash, the soil chemical analysis resulted in a pH value of 4.55. At this pH, nutrients are available for plant growth in peat soil. Increasing the dose of palm kernel ash to 252 g $polybag^{-1}$ significantly reduced the growth and yield of chili pepper plants. According to Winarso (2005), soil pH strongly influences the availability of nutrients that can support plant growth. (Mulyani et al., 2016) the addition of boiler ash during the composting of empty oil palm fruit bunches increased the compost pH from 5.61 to 8.09. When applied to ultisol soil, it improved soil nutrient content, including total nitrogen (N), available phosphorus (P), and available potassium (K), reaching 0.16%, 20.22 mg $kg^{-1}$, and 0.94 me $100g^{-1}$. Respectively Notohadiprawiro (1999) states that nutrients in peat soils become available at pH 4.5 to 5.5. Based on the results of soil chemical analysis after the research (Table 1), the application of 126 g $polybag^{-1}$ resulted in an N-total value of 1.44% (very high), P-availability of 183.80 ppm (very high), and K exchangeable of 2.28 ppm (very high).

Table 4 also shows that the provision of various doses of palm kernel ash has no significant effect on the flowering age of red chili plants. It is suspected that the flowering age is more dominantly influenced by the genetic characteristics of the chili plant variety than the treatment given by the description of the CK 2278 variety (33-35 days after planting). The same thing also happened with the combination of cellulolytic bacteria and palm kernel ash (Table 3) and cellulolytic bacteria (Table 2).

## CONCLUSIONS

The interaction of cellulolytic bacterial consortium and palm kernel ash and the single factor of cellulolytic bacterial consortium has not increased the growth and yield of red chili plants yet. However, the single application of oil palm bed ash at a dose of 126 g $polybag^{-1}$ increased the growth and yield of the best red chili plants. The combination of 30 mL $polybag^{-1}$ of cellulolytic bacteria consortium bio fertilizer and 126 g $polybag^{-1}$ of palm kernel ash gave red chili plants the best growth and yield in peat soil with a 25% increase in fruit weight.

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