Red chili performance in acid upland applied with biofertilizer

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Abstract. Conventional red chili farming systems using inorganic fertilizer cause to overcome this problem, alternative technologies. The purpose of this study was to determine the effect of biofertilizer on the growth and yield of red chili in acid upland. The experiment was conducted in Harapan Masa Village, Tapin District, South Kalimantan from May 2016 to December 2016. The Pillars variety was used because of the high production. The study was arranged using a randomized block design with 4 treatments and 5 replications. The treatments consist of Po = manure application without biofertilizer + NPK fertilizer at a dose of 100%, P1 = manure application with biofertilizer + NPK fertilizer at a dose of 100%, P2 = manure application with biofertilizer + NPK fertilizer with a dose of 75%, P3= manure application with biofertilizer + NPK fertilizer at a dose of 50%. Variables observed included percentage of seedling death, plant height, fruit length, fruit diameter, percentage of death plants and crop production. The results showed that the use of biofertilizer on manure used + NPK fertilizer can increase plant height, fruit length and production of chili plant in acid upland also decrease the percentage of death plant.

1. Introduction
Red chili (Capsicum annum L) is a type of vegetable that has high economic value in Indonesia. It also has the highest planted area and has become a priority commodity in the research and development program of the Indonesian Agency for Agricultural Research and Development (IAARD) in the last 10 years [1]. Conventional red chili farming systems using high doses of inorganic fertilizers can increase crop yields but cause problems such as land hardening, depletion of micro nutrients, soil water pollution and the development of certain pests and diseases, and ultimately have an impact on decreasing land and plant productivity [2]. The long-term use of inorganic fertilizers can harden the soil and reduce the stability of soil aggregates [3]. The use of inorganic fertilizers without the use of organic fertilizers can adversely affect soil fertility [4].

To overcome this problem, alternative technologies are needed to reduce the use of inorganic fertilizers [5] One of the prospective alternatives is applying biological fertilizers and pesticides, which contain bacteria or fungi that trigger plant growth and are safe for the environment [6]. The use of organic and biological fertilizers is expected to reduce the use of inorganic fertilizers and maintain soil fertility that could decrease due to the impact of chemical fertilization that exceeds the threshold [7]. Biofertilizer is a functional group of soil microbes that can function as a provider of nutrients in the soil[8].The beneficial microorganisms that live in the soil are very important in plant growth as an acceleration of nutrient supply and also as a source of soil organic matter, the decomposition process of...
Plant residues are broken down into elements that can be used by plants for growth and development [7]. Provision of microorganisms in the form of biological fertilizers (biofertilizer), such as non-symbiotic nitrogen-fixing bacterial inoculants (Azotobacter sp. and Azospirillum sp.) and phosphate solubilizing bacteria (Bacillus megaterium and Bacillus subtilis) in various doses are descriptively known to have an effect on the growth of chili plants which can increase plant height, number of leaves, and fruit weight [9].

The research objective was to determine the effect of the use of biofertilizer on the growth and yield of red chili plants in acid upland. The application of biofertilizers is expected to reduce the use of chemical fertilizers and maintain soil fertility due to the effects of chemical fertilizers.

2. Materials and methods

2.1. Study area
The assessment was carried out on farmers’ land in Harapan Masa Village, Tapin Selatan District, Tapin Regency, South Kalimantan Province at an altitude between 25 m above sea level to 100 above sea level [10] from June to December 2016. The activities were carried out in Karya Bersama farmer groups. It’s a horticultural farmer group with the head of the farmer group is Mr. Sukarlis. It used Pilar variety, which is commonly used by local farmers.

2.2. Methods
The land area used is 1 (one) hectare. The assessment was arranged using a randomized block design with 4 treatments and 5 replications. These treatments are presented in Table 1.

| Code | Treatments                                                                 |
|------|---------------------------------------------------------------------------|
| P0   | manure application without biofertilizer + NPK fertilizer at a dose of 100 % x 1,000 kg ha⁻¹ |
| P1   | manure application with biofertilizer + NPK fertilizer at a dose of 100 % x 1,000 kg ha⁻¹ |
| P2   | manure application with biofertilizer + NPK fertilizer at a dose of 75 % x 1,000 kg ha⁻¹ |
| P3   | manure application with biofertilizer + NPK fertilizer at a dose of 50 %. x 1,000 kg ha⁻¹ |

The dose of NPK fertilizer used by farmer is 1,000 kg ha⁻¹. The variables observed included: (1) percentage of seed mortality in the nursery, (2) plant height, (3) fruit length, (4) fruit diameter, (5) percentage of dead plants, (6) fruit production. The biofertilizer was produced by Ornamental Research Center, IAARD. In the packaging of biofertilizer, it was provided with information that the microbes contained in biofertilizer include: Azotobacter sp. with a population of 1.7 to 5.6 x 10⁷ cfu g⁻¹, has a non-symbiotic N₂ fixing function that produces phytohormones. Azospirillum sp. with a population of 1.5 to 7.3 x 10⁷ cfu gr⁻¹, has a non-symbiotic N₂ fastening function that produces phytohormones. Bacillus sp. with a population of 2.4 to 7.5 x 10⁷ cfu gr⁻¹, has a function as a solvent for of soil. Gliocladium sp. with a population of 1.9 to 3.7 x 10⁷ spores gr⁻¹, functions as a decomposer and maintains plant health.

2.3. Soil characteristics
Soil samples were taken from the study area in a diagonal composite on land that had been given lime and then tested at Soil Laboratory of Indonesian Swampland Agricultural Research Institute. The results are shown in table 2 below:
Table 2. Results of analysis of physical and chemical properties of the research land in Harapan Masa Village, Tapin Selatan District, Tapin District in 2016.

| Described         | Unit     | Value      | Criteria   |
|-------------------|----------|------------|------------|
| pH H₂O            |          | 5.12       | Acid       |
| pH KCl            |          | 4.02       | Very acid  |
| C organic         | %        | 0.585      | Very low   |
| N                 | %        | 0.087      | Very low   |
| C/N               | %        | 6.72       | Low        |
| K-exchangeable    | cmolc kg⁻¹ | 0.042     | Very low   |
| Na-exchangeable   | cmolc kg⁻¹ | 0.154     | Low        |
| Ca-exchangeable   | cmolc kg⁻¹ | 1.552     | Very low   |
| Mg-exchangeable   | cmolc kg⁻¹ | 0.461     | Low        |
| CEC               | cmolc kg⁻¹ | 13.16     | Low        |
| P Bray 1          | ppm P    | 2.298      | Very low   |
| Fe                | ppm      | 36.577     | Very high  |
| Texture:          |          |            |            |
| Sand              | %        | 38.72      | Sandy clay |
| ash               | %        | 10.05      |            |
| Clay              | %        | 51.72      |            |

Source: Soil Laboratory of Indonesian Swampland Agricultural Research Institute.

The type of soil in Harapan Masa Village is sandy clay with a degree of soil acidity (pH) ranging from 4.02 (pH KCl) to 5.12 (pH H₂O) and organic matter content ranging from less-moderate (table 2). The NPK nutrient content ranges from less-moderate. Water sources are rainwater. Dolomite application is 2 t ha⁻¹ spread evenly over the entire land in 2 weeks before planting. Next, the mulch is installed and the planting holes are made. Manure application is carried out after dolomite application in different treatments namely that part of the land was given manure with biofertilizer and some was given manure without biofertilizer. The manure used is goat manure and is applied to the planting holes. After that, the application of TSP fertilizer at a rate of 200 kg ha⁻¹.

Biofertilizer treatment is starting from the nursery, namely by mixing biofertilizer with a dose of 2 g of biofertilizer for 1 kg of soil (seedling medium). After that, the mixing soil is putting into banana leaf roll as a place for seedlings. Treatment without biofertilizer is consisted of a mixture of manure and soil. Put it into banana leaf roll as a place for seedlings.

3. Results and discussion

3.1. Nursery

Based on visual observations, the red chili seed nursery at the age of 25 days after seeding on the seedling medium with biofertilizer looks greener, vigorous, and healthier than the chili seed nursery on the seedling medium without biofertilizer. The mortality percentage of chili seedlings in seedling media without biofertilizer was 30%, while in nurseries using biofertilizer was 5%. The measurement of seed mortality was based on counting the seeds that grew at 7 days after sowing, 14 days after sowing and 25 days after sowing (table 3). If at the age of 25 days after sowing the number of seeds is less than the number of seeds at 7 days after sowing, the percentage of mortality is calculated. The death of chili seeds on media that was not given with biofertilizer was predicted due to soil borne pathogens. Whereas in the seedling medium which was given with biofertilizer, it was suspected that it was due to the presence of microbes such as Gliocladium sp. and Trichoderma sp. which are antagonistic to soil pathogens, the percentage of seed mortality is less [11]. Biofertilizer contains active ingredients of B. subtilis, P. fluorescens, and Trichoderma sp. [12]. These products are effective in controlling several important diseases and can maintain the production of ornamental plants. Biofertilizer application can suppress 30% of pathogens and maintain 1.85% yield of chrysanthemum compared to fertilizers and...
pesticides, and reduce the use of synthetic fertilizers and pesticides by 50%. In the soil around plant roots that were attacked by pathogens, the number of good microbes was less than the pathogens. On the contrary, in healthy plant roots, the proportion of bacteria that attacked plants was higher [13].

Table 3. The mortality of Pilar chili seedlings (%).

| Dose of NPK | 7 DAS | 14 DAS | 25 DAS |
|-------------|-------|--------|--------|
| With biofertilizer |       |        |        |
| 100 (P1)    | 5 b   | 5 b    | 5 b    |
| 75(P2)      | 5 b   | 5 b    | 5 b    |
| 50(P3)      | 5 b   | 5 b    | 5 b    |
| Without biofertilizer | 30 a  | 30 a   | 30 a   |

3.2. Plant height

The response of chili plants to the application of biofertilizer was quite positive, this was indicated by the biological fertilizer combined with NPK fertilizer which gave a plant height that was significantly higher than the height of chili plants that were not given with biofertilizer (table 4).

Table 4. Data of plant height average (cm), fruit length (cm) and fruit diameter (cm) Pilar chili variety at 3 weeks after planting.

| Dose of NPK | Plant height (cm) | Fruit length (cm) | Fruit diameter (cm) |
|-------------|-------------------|------------------|--------------------|
| With biofertilizer |                   |                  |                    |
| 100 (P1)    | 45.95 c           | 12.51 b          | 1.44 a             |
| 75(P2)      | 39.75 bc          | 12.57 b          | 1.44 a             |
| 50(P3)      | 45.95 c           | 12.62 b          | 1.45 a             |
| Without biofertilizer | 28.33 a          | 9.16 a           | 1.42 a             |

Remark: Numbers followed by the different letters in one column showed significant difference of DMRT test.

The height of chili plants treated with biofertilizer was not significantly different in NPK fertilizer with different doses. Plant height measurements were carried out at the age of 3 weeks after planting. The loose media structure on compost media and the mixture produces aeration and drainage which is good for root development and maintains soil moisture that is ideal for plant growth [14]. The friable planting medium produced more fertile growth than the clay media on rooted irish plants [15]. Both biofertilizer and NPK fertilizers contain nitrogen. It is known that nitrogen is a macro and essential nutrient that is absolutely needed for plant growth. Nitrogen is a nutrient which is the main factor affecting plant height. Plants assimilate nitrogen and nitrates which are used for protein biosynthesis and the formation of nucleic acids. In the presence of sufficient nitrogen, the process of cell division will run well. Nitrogen has a major role in stimulating overall growth, especially stem growth, thus spurring plant height growth [16]. From this description, it can be understood why chili plants given with biofertilizer have a higher plant height. This finding is in line with Nuryani et al. [17], which concluded that the addition of biofertilizer can reduce fertilizer use by up to half the dose (50%), from the recommended. This means that the use of biofertilizer with the active ingredient Gliocladium sp. tested has significant effect on plant height growth. Protagonist microbes induce plant growth through changes in the microbial community at the roots (rhizosphere) to produce various kinds of organic compounds [18]. In general, the microbial protagonists can directly influence plant growth through their ability to increase the availability of nutrients (nitrogen, phosphorus, potassium, and other elements) and indirectly control plant pests by producing antibiosis, colonizing plant root tissue, and dominating the rhizosphere environment, not suitable for the growth of plant diseases.
3.3. Fruit length (cm)
Fruit length observation data is presented in table 3. The data presented is the average length of fruit carried out on chili from the first to the fifth harvest. From the observations, it was found that the combination of treatment using biofertilizer and NPK fertilizer did not significantly affect the generative growth of chili plants, namely fruit length and fruit diameter. But the biofertilizer treatment and without biofertilizer significantly affected the length of the chilies. This is because in the plantations of red chilies that are not treated by biofertilizer, the leaves of the chili plants are eaten by caterpillars so that the leaves of the chili plants are torn and perforated. Leaves that are torn and perforated cause the photosynthesis process to take place less optimally so that the resulting photosynthate is also not optimal. Therefore, the resulting generative growth such as chili length is smaller than the chili plantations that received the biofertilizer treatment. On the other hand, the chili plants that received the biofertilizer treatment did not have much caterpillar attack so that the leaves grew well and could carry out photosynthesis optimally.

3.4. Diameter of fruit (cm)
Fruit length observation data is presented in table 3. The data presented is the average length of fruit carried out on chilies from the first to the fifth harvest. From the observations, it was found that the combination of treatment using biofertilizer and NPK fertilizer did not significantly affect the diameter of the chilies.

3.5. Percentage of plants death
Observation of pests and diseases of chili plants is carried out once a week and from the results of observations, the death of chili plants due to wilting is the most dominant plant disease compared to curly leaves and fruit rot. From the observations, it was found that there were two types of wilt that caused plant death, namely dry wilt (possibly caused by a fungal infection of Fusarium sp.) and slimy wilt (possibly caused by bacteria). Data on the percentage of plant mortality due to wilting is presented in table 4. The highest percentage of mortality was in chili plants that did not use biofertilizer. Whereas in chili cultivation using biofertilizer at different NPK doses, the percentage of plant mortality due to wilting was not significantly different. Microbial content and their respective functions in biofertilizer which include: Azotobacter sp. with a population of 1.7 to 5.6 x 10^7 cfu gr^-1, has a non-symbiotic N2 fastening function that produces phytohormones, Azospirillum sp. with a population of 1.5 to 7.3 x 10^7 cfu gr^-1, has a non-symbiotic N2 fastening function that produces phytohormones, Bacillus sp. with a population of 2.4 to 7.5 x 10^7 cfu gr^-1, has a function as a solvent for soil P, Gliocladium sp. with a population of 1.9 to 3.7 x 10^6 spores gr^-1, functions as a decomposer and maintains plant health, helps chili plants to grow well and protects plants from attack by fungi and bacteria that cause withered dead plants.

3.6. Yield
The yield or productivity data (kg tree^-1) of chili plants is presented in table 5. Production data were obtained by weighing chilies per NPK fertilizer treatment, namely 100% NPK, 75% NPK and 50% NPK. Red chili plants that were not given with biofertilizer gave the lowest yields. Meanwhile, chili cultivation using biofertilizer had a production that was not significantly different between NPK fertilizer dosage treatments.
Table 5. Data of chili production

| Dose of NPK | Death (%) | Production (cm) |
|-------------|-----------|-----------------|
| With Biofertilizer |           |                 |
| 100 (P1)    | 10.16 b   | 8.12 b          |
| 75 (P2)     | 10.06 b   | 8.09 b          |
| 50 (P3)     | 10.18 b   | 8.15 b          |
| Without biofertilizer | 35.24 a   | 5.14 a          |
| CV 17 %     | CV = 23 % |                 |

Remark: Numbers followed by the different letters in one column showed significant difference of DMRT test.

The production of red chili plants given with biofertilizer was higher than the production of red chili plants without biofertilizer. This was due to the increasing resistance of red chili plants from pest attack by plant pests, especially fusarium wilt and fruit rot. On the other hand, red chili plants that were not treated with biofertilizer experienced higher fusarium wilt, plant mortality and fruit loss.

Biofertilizer is a live microorganism that is introduced into the soil as an inoculant to help plants facilitate or provide certain elements for plants [19]. The microorganisms contained in biofertilizer are Azotobacter sp., Azospirillium sp., Bacillus sp., and Gliocladium sp.. Azotobacter sp., Azospirillium bacteria are N₂-fixing and phytohormone-producing bacteria. The presence of these two bacteria is beneficial to plants because it helps supply N for chili plants and produces phytohormones which are beneficial for plant growth. Nitrogen is the builder of nucleic acids, proteins, bioenzymes and chlorophyll. With the presence of these two bacteria in the growing medium, it supports plant growth, which in this case is plant height. Bacillus sp. has the ability as a phosphate solvent. Phosphate is a macro nutrient that is very important for growth but its content in plants is lower than nitrogen, potassium and calcium. Metabolic processes and physiochemical reactions such as photosynthesis, electron transformation (energy transfer), signal transduction, macromolecular biosynthesis, and respiration involve phosphorus as the main element [20]. In acid soils P is compound with Al or Fe. While in alkaline soil P is compound as Ca-P. The existence of these binding causes inefficient P fertilizer that is given. Plants use P 10-30% of the fertilizer given [21]. This deficiency can be overcome in several ways, one of which is by utilizing phosphate solubilizing microbes so that plants can be used more where the function of P for plants is for cell growth, root formation and root hair, strengthening plant tissue so that it is not easy to fall down, forming flowers, fruits, and seeds, and strengthen resistance to disease [22]. The mechanism of phosphate solvent microbes in increasing the availability of phosphate in several ways, namely: (1) removing complex mineral compounds such as organic acid anions, protons, hydroxyl ions, and CO₂; (2) liberating extracellular enzymes (phosphate mineralization through biochemical reactions); and (3) liberating phosphate upon substrate decomposition (phosphate mineralization by biological processes) [23,24]. Phosphate solubilizing microbes from certain soils, when inoculated on other soils, may not necessarily maintain the ability to dissolve phosphate. Therefore, research and utilization of superior phosphate solubilizing microbes in accordance with a variety of agricultural land agroecosystems that are more specific is still needed [25].

4. Conclusions
Biofertilizer on manure used + NPK fertilizer can increase plant height, fruit length, and production of chili plant in acid upland also decrease the percentage of death plant. It is suspected that the microbes in biofertilizers suppress the growth of pathogens around the plants and support plant with nutrients to grow optimally.
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