Chicken manure and biofertilizer for increasing growth and yield of potato (\textit{Solanum tuberosum} l.) of Granola varieties

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\textbf{Abstract.} The experiment aimed to assess the characteristics of growth and yield of potato due to the application of chicken manure and biofertilizer was conducted. The research began on from February until June 2018, in Pangalengan The experiment arranged as factorialized randomized block design, consisted two factor with three replications. Chicken manure dosage \((k_1 = 5 \text{ ton ha}^{-1}, k_2 = 10 \text{ ton ha}^{-1}, k_3 = 15 \text{ ton ha}^{-1})\) and Biofertilizer concentrate \((h_1 = 2.5 \text{ mL L}^{-1}, h_2 = 5.0 \text{ mL L}^{-1}, h_3 = 7.5 \text{ mL L}^{-1})\). The measured parameters were the growth (plant height, number of stem, number of leaf) and yield of potatoes (weight number of tuber, weight of tuber per plot, number of tuber per plot, weight of tuber per plot, potato weight classification). The result showed that the interactions between the chicken manure dosage and biofertilizer concentrate affected the number of potato tubers per plot, weight of potato tubers per plant, number of potato tubers per plant, and potato yield per plot. The highest yield \((55.50 \text{ kg per plot})\) was obtained by combination \(k_2h_3\) (chicken manure dosage 10 ton ha\(^{-1}\) and biofertilizer concentre 7.5 mL L\(^{-1}\)). These findings concluded that the chicken manure combined with biofertilizers could be applied to increase the growth and productivity of potatoes.

\textbf{Keywords:} biofertilizer , chicken manure, growth, yield, potato, granola

\textbf{1. Introduction}

Potatoes are staple plants as the fourth largest carbohydrate source in the world after rice, wheat, and barley, so they can support food diversification programs. Potatoes are one of the leading commodities that have good National and International market prospects [4]. Every agricultural business aim is to obtain optimal agricultural products without reducing soil fertility. The use of organic fertilizers is still not evenly distributed and become a constraint to support the crop growth and productivity. One of the organic fertilizers that can be used to improve the soils fertility is solid and liquid manure from livestock both ruminants and poultry. Actually, the advantages of manure do not lie in the nutrient content because manure has a low nutrient content. The advantage is that manure can increase topsoil, improve soil structure, and improve the life of decomposing microorganisms [14].

In addition, the application of biofertilizers with organic manure is expected to increase soil fertility, fertilizers efficiency and crop productivity. Biofertilizer is a component that contains living microorganisms that are given into the soil as inoculants to help provide certain nutrients for plants [1]. The interaction between manure and soil microorganisms could improve the aggregate and the soil structure becomes loose. The results of decomposition by soil microorganisms such as extra...
polysaccharides can function as glue or adhesives between soil particles so as to increase the amount of soil pores and eventually become a suitable medium for plant growth because of the wider range of roots so that nutrient absorption is easier. With the expansion of root reach and increasing nutrient uptake, fertilization efficiency is expected to increase so that plants can grow well [13]. This research is aimed to investigate the ability of organic manure and biofertilizers to enhance the growth and yield of potatoes.

2. Materials and Methods

2.1. Materials

This experiment was conducted in Lebak Saat Village, Tribaktimulya Village, Pangalengan District, Bandung Regency, West Java Province. Trial time from February to June 2018. The materials used potato seeds of the Granola G2 variety, NPK Phonska 15:15:15 fertilizer (as a basic fertilizer), chicken manure and liquid Biofertilizers, Chix 25 EC insecticide, fungicide Tamoxanil 60/24 WP, and herbicide Supretox 276 SL. The Soil type is Andosol which the soil texture is sandy loam. The Climate type is C2 (according to Oldeman).

2.2. Methods

The measured parameters were the growth (plant height, number of stems, number of leafs) and yield of potatoes (weight number of tubers, weight of tuber per plot, number of tubers per plant, weight of tuber, potato weight classification). Cultivation of land by shovel as deep as 30 cm until loose, then left for one week. experimental plots were made with width 50 cm, height 30 cm, the distance between the plot is 30 cm.

A plot measuring 3.2m x 4.4 m, which consists of 27 plots with 30 cm distance between replications, and the distance between plots 30 cm. Seeds used potato seed tuber varieties of granola size S, with a weight of 26 grams, a diameter of 4.5 cm with three buds

Planting seed potatoes is done by putting the seed tubers in a groove right in the middle with the buds facing up position. The depth of the planting hole is approximately 10 cm, and the planting distance used is 80 cm x 40 cm. Chicken manure application is given one week before planting. Chicken manure is given by sowing on the surface of the beds, then covered again with soil in each plot according to treatment.

Biofertilizer was applied by spraying fertilizer around the roots of the plants evenly according to treatment. Fertilizer sprayed three times, i.e. when the plants are 10 DAP, 20 DAP, and 30 DAP.

The research method used was the experimental method using a Randomized Block Design (RBD) factorial pattern with two factors where each factor consists of three levels. The first factor was the chicken manure dose (K) which consists of 3 levels of treatment (k1 : 5 ton ha⁻¹; k2 : 10 ton ha⁻¹; k3 : 15 ton ha⁻¹). The second factor was the concentration of Biofertilizer (H) which consists of 3 levels of treatment, (h1 : 2.5 ml L⁻¹; h2 : 5.0 ml L⁻¹; h3 : 7.5 ml L⁻¹).

The F level of significance level of 5% used to test the diversity between treatments. If there is real diversity, then proceed with Duncan's Multiple Distance Test. The average number marked with the same letter in the same column shows that the results are not significantly different according to Duncan's Multiple Distance Test at 5% level.

3. Result and Discussion

Observation of plant height was carried out when the plants were 28, 42, and 56 DAP. The average height of potato plants in various treatments is presented in Table 1. Based on the results of the analysis of variance showed no interaction occurred in the treatment of doses of manure (K) and the concentration of biological fertilizer (H) on plant height at 28, 42, and 56 DAP.

| Table 1. The Effect of Treatment Chicken Manure Dosage and Biofertilizer Concentration on Average of Plant Height at Age 28, 42, and 56 DAP |
It can be seen in Table 1 on 42 DAP and DAP showed the treatment of k2 (10 ton ha\(^{-1}\)) gave the best effect and had a significantly different from the treatment k1 (5 ton ha\(^{-1}\)) and treatment k3 (15 ton ha\(^{-1}\)). Treatment concentrations of biological fertilizers (H) on the observation aged 28, 42 and 56 DAP showed that h3 (7.5 mL L\(^{-1}\)) gave a better effect and significantly different from the treatment h1 (2.5 mL L\(^{-1}\)). On the observation aged 56 DAP, percentage increase in plant height at doses of manure k1 (5 ton ha\(^{-1}\)) and k2 (10 ton ha\(^{-1}\)) was 1.94%, while the provision of a biological fertilizer concentration h1 (2.5 mL L\(^{-1}\)) and h3 (7.5 mL L\(^{-1}\)) are 0.73%.

Growth defined as the increase in weight and size of plants as a result of the formation of new structural elements, was strongly influenced by the availability of nutrients and the availability of nutrients is related primarily to the influence of the overhaul process of manure that occurs, where the overhaul process of manure is very influenced by the activity of microorganisms in the soil. The activity of microorganisms in decomposing manure was influenced by diversity and total population [2]. The dose of k3 manure (15 ton ha\(^{-1}\)) gives a lower yield compared to the dose of k2 manure (10 ton ha\(^{-1}\)). This was related to the higher dose of manure causing the number and activity of microorganisms to increase, resulting in competition between microorganisms. Giving a high dose of manure causes the nutrient balance to be disrupted so that plant growth has decreased [9]. While the concentration of biological fertilizer h1 (7.5 mL L\(^{-1}\)) gave better results than the concentration of biological fertilizer h1 (2.5 mL L\(^{-1}\)) and h2 (5.0 mL L\(^{-1}\)). The higher the concentration of biological fertilizers that are given into the soil shows that plant growth is increasing. Increasing concentrations, allegedly resulting in increased populations of these microorganisms so that its effectiveness against growth for the better [6]. This shows that the microbes contained in biological fertilizers work optimally so that they can provide nutrients that can then be absorbed by plants for plant growth and production.

Nitrogen fixing microbes, Azosprillum sp., Acinetobacter sp., Azotobacter chroococcum, Azotobacter vinelandii, and phosphate solvent microbes, Pseudomonas cepacia, and the Penicillium sp fungus found in biological fertilizers can increase plant growth and yield because they can inhibit free nitrogen from the air and phosphate, namely Pseudomonas cepacia, and the fungus Penicillium sp. dissolve soil phosphate so that it is available to plants, but also can produce growth-stimulating hormones such as IAA (Indole-3-acetic acid), cytokinins, gibberellins, and auxins, which play a role in increasing plant growth and yield [6].

The observation of the number of stems has been done when the plants are 28, 42, and 56 DAP. The average number of potato stems in various treatments is presented in Table 2. Based on the results of the analysis of variance showed that there was no interaction between the treatment of dosing of manure (K) and the concentration of biological fertilizer (H) on the number of stems both at 28, 42, and 56 DAP.

### Table 2. The Effect of Treatment of Chicken Manure Dosage and Biofertilizer Concentration on the Number of Stem at 28, 42, and 56 DAP

| Treatment          | Average Number of Stems |
|--------------------|--------------------------|
|                    | 28 DAP | 42 DAP | 56 DAP |
| Chicken manure (K) |         |        |        |
| k1 (5 ton ha\(^{-1}\)) | 25.22 b | 45.42 a | 69.69 a |
| k2 (10 ton ha\(^{-1}\)) | 25.33 ab | 46.08 b | 69.86 ab |
| k3 (15 ton ha\(^{-1}\)) | 25.81 b | 46.22 b | 70.42 b |

Description: The average number followed with the same letter in the same column is not difference significantly according to Duncan’s Multiple Distance Test at the 5% level.
It can be seen in Table 2 that the treatment of manure (K) and the concentration of biological fertilizer (H) differed insignificantly at each level of treatment of the number of stems both at observations of ages 28, 42, and 56 DAP. The dose of manure and the concentration of biological fertilizer did not affect each treatment level at all age of observation on the number of stem parameters.

The factor of giving manure does not have a significant effect on the growth of the number of stems, this is due to the fact that manure is slow and the content of the nutrients was limited. Furthermore, according to [8] states that each manure contains nutrients, physiological reactions and different ways of working. Furthermore, the application of biological fertilizer does not have a significant effect on the number of stems, this happens because the activity of microorganisms contained in biological fertilizers is influenced by abiotic and biotic factors.

Observation of the number of crop tubers is done when the potato crop has been harvested (115 DAP). The average number of crop potato tubers in various treatments is presented in Table 3. Based on the results of a variety of analysis showed that the treatment of dosing of manure (K) and concentration of biological fertilizer (H) interacted with the number of planted potato tubers.

Table 3. Effect of Interaction on the Treatment of Chicken Manure dosage and Biofertilizer Concentration on number of Potato Tubers per plant

| Treatment | Biofertilizer concentration |  |
|-----------|----------------------------|---|
|           | h₁ = 2.5 mL L⁻¹ | h₂ = 5.0 mL L⁻¹ | h₃ = 7.5 mL L⁻¹ |
| k₁ (5 ton ha⁻¹) | 12.83 a | 13.33 a | 13.83 a |
| k₂ (10 ton ha⁻¹) | A | A | A |
| k₃ (15 ton ha⁻¹) | 14.25 b | 14.67 b | 16.33 b |
| | A | A | B |
| | 14.17 b | 13.42 a | 13.92 a |
| | A | A | A |

Description: The average number followed with the same letter in the same column is not difference significantly according to Duncan’s Multiple Distance Test at the 5% level.

Application of doses of manure k₂ (10 ton ha⁻¹) is the best treatment compared to doses of manure k₁ (5 ton ha⁻¹) and k₃ (15 ton ha⁻¹). The dose of manure (10 ton ha⁻¹) was a sufficient dose to meet the nutrient requirements needed by plants. This is due to in addition to chicken manure having higher nutrients, it was also a fertilizer that was hot, ie manure which decomposes by microorganisms takes place quickly and rapidly ripens so that the availability of nutrients can be fulfilled for use by plants.

[12]

The application of the concentration of biological fertilizer h₃ (7.5 mL L⁻¹) is the best treatment compared to the concentration of biological fertilizer h₁ (2.5 mL L⁻¹) and h₂ (5.0 mL L⁻¹). This shows that the concentration of h₁ (7.5 mL L⁻¹) of microbes contained in biological fertilizers can work optimally in overhauling and facilitating the intake of nutrients needed by plants. Whereas the concentration of biological fertilizer h₁ (2.5 mL L⁻¹) and h₂ (5.0 mL L⁻¹) showed lower results.

The application of liquid organic fertilizer has a significant effect on the number of tubers. Fertilization with liquid organic fertilizer containing microorganisms Streptomyces’s with a concentration of 25 mL L⁻¹ produces a higher number of tubers than the control plant treatment. The number of tubers formed is a response to the size of the seed bulbs used[7].
Furthermore, the results of the research [3], stated that N-fixing bacteria can tether nitrogen in the air, so as to increase the efficiency of the use of nutrients N in the soil. In addition to nitrogen-fixing bacteria, PGPR also contains phosphate solubilizing bacteria that increase the nutrients of P. The increased was due to phosphate solubilizing bacteria capable of releasing organic acids that can dissolve the entangled P, so that the bound phosphorus becomes dissolved and available to plants. giving soil and charcoal husks can increase the nutrients needed by potato plants that can be absorbed by potato plants and encourage the growth of soil microbes, so that the nutrients N and P have increased.

Observation of crop tuber weights was carried out when the potato crop was harvested (115 DAP). The average plant potato tuber weights for various treatments are presented in Table 4. Based on the results of the analysis of variance showed that the treatment of dosing of manure (K) and concentration of biological fertilizer (H) interacted with the weight of the planted potato tuber.

| Treatment | Concentration on Weight Potato Tubers per plant | Biofertilizer concentration |
|-----------|-----------------------------------------------|-----------------------------|
| Chicken manure | 2.5 mL L⁻¹ | h₁ = 2.5 mL L⁻¹ | h₂ = 5.0 mL L⁻¹ | h₃ = 7.5 mL L⁻¹ |
| k₁ = 5 ton ha⁻¹ | A | 1105,83 a | 1109,17 a | 1154,17 a |
| k₂ = 10 ton ha⁻¹ | A | 1173,33 b | 1201,25 b | 1256,67 b |
| k₃ = 15 ton ha⁻¹ | A | 1160,00 b | 1150,83 a | 1135,08 a |

Description: The average number followed with the same letter in the same column is not difference significantly according to Duncan's Multiple Distance Test at the 5% level.

Application of doses of manure k₂ (10 ton ha⁻¹) is the best treatment compared to doses of manure k₁ (5 ton ha⁻¹) and k₃ (15 ton ha⁻¹). This is because doses of manure as much as 2 kg (10 ton ha⁻¹) are sufficient doses to meet the nutrient requirements needed by potato plants. With adequate doses of manure, the physical, chemical and biological properties of the soil become better, such as giving advantages to the physical properties of the soil and improving its structuring. Increasing structuring will cause plant roots to develop properly due to the creation of crumb and loose soil atmosphere. If the physical properties of the soil are good, root development will be deeper and expansive so that the absorption of nutrients and water needed by plants is also getting better which in turn will increase plant productivity. In addition, the greater dosage of manure given shows lower results. This is due to the increasing amount of fertilizer given does not guarantee the plants to grow better or give higher yields, especially if the factors in the soil are less supportive [9]

The treatment of the concentration of biological fertilizer at each level of manure shows the administration of a concentration of biological fertilizer 7.5 mL L⁻¹. the 10 tons ha⁻¹ manure is more able to increase the weight of planted potato tubers and is significantly different compared to the concentration of 2.5 mL L⁻¹ and 5.0 mL L⁻¹.

Observation of the tuber class is done when the potato crop has been harvested (115 DAP). The average class of potato tubers in various treatments is presented in Table 5. Based on the results of the analysis of variance showed that the treatment of dosing of manure (K) and concentration of biological fertilizer (H) did not occur in the interaction of the tuber class both in the Ares, DN, ABC, AB, and AL classes.

| Treatment | Average Class Age (%) at Age 115 DAP |
|-----------|-------------------------------------|
| k₁ (5 ton ha⁻¹) | Ares | DN | ABC | AB | AL |
| 6.98 a | 27.07 a | 37.46 a | 25.33 a | 3.16 a |
The average number followed with the same letter in the same column is not significantly different according to Duncan's Multiple Distance Test at the 5% level.

In Table 5 it can be seen that the treatment of dosing of manure (K) and the concentration of biological fertilizer (H) is not significantly different at each level of treatment of the tuber class both in the observations of the Ares, DN, ABC, AB, and AL classes. The tuber class shows the good or bad quality of the potatoes produced. Factors influencing the quality of potato tubers include nutrients, varieties, soil fertility, and the class of seed bulbs used. The tuber class is based on the weight of each tuber. Based on its weight, tubers can be divided into tubers of Ares size (5-20 g), DN (21-50 g), ABC (51-100 g), AB (101-300 g), and AL (301-500 g). The expected crop tubers for consumption are tubers sized ABC, AB, and AL. If the percentage of Ares and DN bulbs is high, the quality of potatoes is not good because the resulting tubers are small.

Observation of the weight of the tubers was done when the potato crop has been harvested (115 DAP). The average weight of the potato tubers per plot in various treatments are presented in Table 6. Based on the results of the analysis of variance showed that the treatment of dosing of manure (K) and concentration of biological fertilizer (H) interacted with the weight of the potato tubers per plot.

**Table 6. Effects of Interaction on the Treatment of Chicken Manure dosage with Biofertilizer Concentration on Potato Yield per plot**

| Treatment | Biofertilizer Concentration (H) |
|-----------|---------------------------------|
| Chicken Manure dosage (K) | h₁ (2,5 mL L⁻¹) | h₂ (5,0 mL L⁻¹) | h₃ (7,5 mL L⁻¹) |
| k₁ (5 ton ha⁻¹) | 48.66 a | 48.81 a | 50.79 a |
| A | A | A |
| k₂ (10 ton ha⁻¹) | 51.63 b | 52.86 b | 55.30 b |
| A | A | B |
| k₃ (15 ton ha⁻¹) | 51.04 b | 50.64 a | 49.96 a |
| A | A | A |

Description: The average number marked with the same letter in the same column shows no significant difference according to Duncan's Multiple Distance Test at the 5% level.

The treatment of the concentration of biological fertilizer (H) at each level of manure (K) shows that the administration of the concentration of biological fertilizer h₃ (7.5 mL L⁻¹) on k₂ manure (10 ton ha⁻¹) is better able to increase the weight of potato tubers per plot and significantly different compared to concentrations of h₁ (2.5 mL L⁻¹) and h₂ (5.0 mL L⁻¹).

The microbial biological fertilizer consortium breeds in the soil with soil organic matter and manure as a source of carbon and energy. Nitrogen fixing microbes in biological fertilizers provide NH₃ which is then transformed into NH₄⁺ and NO₃⁻ to be absorbed by plants [5].

Furthermore, according to [10,11] stated that the EM4 activator contains various beneficial microorganisms such as yeast or yeast, Lactobacillus sp., Solvent-phosphate bacteria, and Azospirillum sp. Favorable microorganisms that actively affect soil microorganisms to increase soil fertility. Azospirillum sp. is a bacterium that lives in plant roots. This bacterium breeds mainly in the root extension area and base of the root hairs. The energy sources they like are organic acids such as malate, succinate, lactate and pyruvate. Application of organic fertilizer to plants can improve and maintain soil fertility and reduce the negative impact of the use of chemical fertilizers. Fertilizers that are widely used by farmers are chicken manure, where these fertilizers have the power to bind water, add food, enhance humus content, improve soil structure and encourage the activity of microorganisms in the soil to be balanced [5,10]

4. Conclusion
Interaction between chicken manure dosage and biofertilizer concentration influenced the number of potato tubers per plant, weight of potato tubers per plant, and potato yield per plot that is on the combination treatment k$_2$h$_3$, while plant height and grade of potato tubers were not affected. The highest of potatoes yield 55.30 kg per plot was obtained by application of 10 tons of chicken manure and 7.5 mL L$^{-1}$ of biofertilizer concentration. This results about 13.6 % higher than other treatments.

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