**Growth And Capsaicin Content Of Curly Red Chili (*Capsicum s*p. L.) On Bio-Fertilizer And Sludge Biogas Application**

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***Abstract.*** *Curly red chili (Capsicum sp. L.) is an important agricultural commodity in Indonesia. The pattern of conventional cultivation using inorganic fertilizers has caused high production costs. While the level of spiciness of chili determined by capsaicin levels is strongly influenced by nutrients in the growing media. Bio fertilizer and sludge biogas which is one of the organic fertilizers proved to be able to increase the growth and productivity of rice plants. This study aimed to analyze growth parameters, chlorophyll content and measure capsaicin levels in curly red chili. Which given bio fertilizer and biogas sludge in various dosage and determine the optimum dose of the fertilizer. The study was conducted at an agricultural demonstration plot in Wukirsari Village, Cangkringan, Sleman. The study design used RCBD (Randomized Complete Block Design), the data were analyzed by ANOVA (Analysis of Variance followed by Duncan's multiple distance test (DMRT) at the 95% confidence level. The highest growth parameters and capsaicin content were obtained on curly red chili plants which were given sludge 36 ml + bio fertilizer 10 L / ha. Thus, it can be concluded that the most appropriate dose of curly red chili is 36 ml sludge + 10 bio fertilizer / ha*

*Keywords : Capsaicin, growth, chili, bio fertilizer and sludge biogas*

**INTRODUCTION**

Chili productivity in Indonesia is unstable following the season and environmental conditions. Chili plants can grow well on soil with sufficient moisture content. Some regions in Indonesia, especially marginal areas have limitations, namely low or dry water levels. Dry or too runny farmland will cause root function and growth to be disrupted. As a result, plant growth is also disturbed so that flower and fruit production will decline (Mubarokah et al., 2015) Dry land in Indonesia in the form of ultisol land covering 47.5 million ha and oxisol 18 million ha (Yuwono, 2009).

The requirements for growing chili plants in cultivating chili plants are influenced by climate factors which include sunlight intensity, rainfall, temperature and humidity, wind, altitude factors, and soil conditions. The ideal temperature for chili cultivation is 24-28˚C. At certain temperatures such as 15˚C and more than 32˚C it will produce chili which is not good. Growth will be hampered if the daily temperature in the cultivation area is too cold. According to Tjahjadi (1991), chili plants can grow in the dry season if sufficient irrigation is carried out regularly. Light intensity (irradiation) needed is full irradiation. The desired rainfall is 800-2000 mm / year with 80% plant humidity.

The height of the place for planting chili plants is below 1,400 masl, namely in the lowlands to the highlands. In highland areas, chili plants can grow but are not optimal. Chili plants are very suitable to be planted on flat ground. Chili plants can also grow and adapt well to various types of soil, ranging from sandy soil to clay (Harpenas, 2010). The growth of chili plants will be optimum if planted in soil with a pH of 6-7 with loose, fertile, and a lot of soil containing humus (Sunaryono and Rismunandar, 1984). Whereas, according to Tjahjadi (1991), chili plants can grow in soil conditions that contain essential nutrients such as elements N and K and are not in a waterlogged condition.

The optimum growth of chili plants besides being supported by appropriate environmental factors also requires support from nutrients. Organic liquid fertilizer (bio fertilizer) is very beneficial for plants that have limitations in absorbing solid fertilizers that are applied through the soil. Giving liquid organic fertilizer through the leaves will help overcome these limitations. The advantages of liquid organic fertilizer are nutrients contained in it easily absorbed by plants. The application of fertilizer through leaves, the nutrients from the fertilizer given will be absorbed by the leaves through leaf stomata (Maruapey, 2015).

Cow urine can be used as bio fertilizer. Fertilizing using fermented cow urine can increase vegetable production. Cow urine contains elements of N, P, K and Ca which are quite high and can increase the resistance of plants to disease attacks. Based on laboratory analysis of the urine urine properties before and after fermentation there were differences, before fermentation pH (7.2), N (1.1%), P (0.5%), K (1.5%), Ca (1 , 1%) yellow, and pungent odor, after fermentation pH (8.7), N (2.7%), P (2.4%) K (3.8%), Ca (5.8%) black and smelly are reduced (Rizki et al., 2014).

The urine of the cow contains a growth stimulant and in terms of its nutrient content, liquid manure from the urine of the cow has a higher nutrient content compared to its solid waste (Lingga, 1999). Furthermore, it was explained that cow urine also had a positive influence on vegetative growth of plants. Because the smell is unique, the urine of the cow can also prevent the arrival of various plant pests, so that the urine of the cow can also function as a pest control for plants (Susetyo, 2013).

In addition to the use of cow urine, the use of biogas waste can also increase plant growth and development. Biogas is an alternative energy that is environmentally friendly. Biogas is produced in an anaerobic reactor with its energy components in the form of methane (CH4), carbon dioxide (CO2), nitrogen (N2), and hydrogen sulfide (H2S). Although biogas comes from waste treated in the reactor, biogas produces high energy, which is 26.9 MJ m-3 or 7.5 kWh.m-3 for biogas with 75% CH4. The main advantages of biogas energy production are to generate electricity and heat, reduce methane emissions, and extra profits from commercialization with energy companies (Rosa et al., 2017).

 During the biogas production process as an energy source, biogas liquid waste will be produced in the form of sludge. According to Wahyu (2011), sludge is a by-product of biogas in the form of mud, which contains a lot of nutrients which can be used as plant fertilizer. Nutrients that are high enough in sludge can increase soil fertility by improving soil physical, chemical and biological properties. Sludge has anaerobic fermentation so that it can be directly used to fertilize plants.

Based on the analysis of wet weight, the content in biogas waste liquid fertilizer is organic C-48%, N-total 2.9%, C / N 15.8%, P2O5 0.2%, K2O 0.3% (House Biogas Team, 2013). The use of organic fertilizer from biogas waste from cow manure has several benefits including increasing the formation of leaf chlorophyll, increasing plant vigor so that the plant becomes sturdy and increases plant resistance to drought (Rizqiani et.al, 2007). Sludge has characteristics that are free of pathogens and capable of killing disease-causing organisms in plants, can reduce the growth of weeds, as a good soil moisturizer because it can add topsoil and increase the water content in the soil (Handaka, 2012).

The purpose of this study was to analyze the growth and chlorophyll content of plants, measure the capsaicin content and find the optimum dose of bio fertilizer fertilizer-sludge biogas for curly red chili plants that have the highest growth and capsaicin levels.

**MATERIALS AND METHODS.**

Planting of curly red chili plants (*Capsicum* sp ) was carried out in Wukirsari Village, Cangkringan, Sleman, Yogyakarta. While testing of leaf chlorophyll levels and testing of capsaicin levels was carried out at the FALITMA (Joint Research Facility) of Faculty of Biology UGM and The Organic Chemistry Laboratory of the Faculty of Mathematics and Natural Sciences UGM. The study was conducted in April-September 2018. The growth parameters measured were plant height, leaf number and chlorophyll content using the Arnon method (1949). Capsaicin levels were measured using alkaloid extraction methods (Nugroho et al., 2002)

          This study has a treatment factor including treatment of the use of different fertilizer doses consisting of 8 levels of treatment. The treatment design uses RCBD (Randomized Complete Block Design) with 5 replications. The following is the experimental design of the study.

Treatment :

1. Control (treat with NPK Fertilizer)

2. Sludhe 12 ml

3. Sludge 24 ml

4.Sludge 36 ml

5 Bio fertilizer 10 L / ha

6.Sludge 12 ml + Bio fertilizer 10 L / ha

7. Sludge 24 ml + Bio fertilizer 10 L / ha

8. Sludge 36 ml + Bio fertilizer 10 L / ha

Each treatment with 5 replications so that the total units were 45 experimental samples.

Data were analyzed using ANOVA (Analysis of Variance), followed by DMRT test with a confidence level of 95% (α = 0.05). Data analysis was performed using SPSS software.

**RESULTS AND DISCUSSION**

Measurement of growth parameters was carried out when curly red chili plants were in the vegetative phase. The vegetative phase of curly red chili plants in this study lasted for 8 weeks. The first aspect of vegetative growth measured is plant height. The measurement of plant height is carried out 7 days after the seedling of chili plants is planted and treated until the maximum vegetative phase is 8 weeks. The measurement results are presented in Figure 1.



Figure 1. The high growth rate of curly red chili plants (Capsicum sp. L.) as a result of bio-fertilizer and biogas sludge application per week.

Based on Figure 1., the high growth rate of curly red chili plants shows a positive correlation, namely the growth rate increases in proportion to the age of the plant. Addition of bio-fertilizer and biogas sludge with various dosage variations in general can increase plant growth rates compared to NPK controls. It is known that the highest plant height is found in fertilizer treatment with 36 ml sludge and 10 L / ha bio fertilizer, while the lowest plant height is fertilizer treatment with 12 ml sludge and 10 L / ha bio fertilizer. The results of the measurement of the high average curly red chili plant stem at week 8, are presented in Figure 2.

Figure 2. High average curly red chili (Capsicum annuum L.) yield from bio-fertilizer and biogas sludge at 8th week

Figure 2. shows the high qualitative results of curly red chili plants with analysis using Analysis of Variance ANOVA. Based on statistical analysis using DMRT with a confidence level of 95% (α = 0.05), it showed the highest average yield of curly red chili plants using bio-fertilizer and biogas sludge in various concentrations with NPK applications which were not significantly different.

The application of bio-fertilizer and biogas sludge at various concentrations was able to increase the average height of curly red chili plants but not significantly different from the control (given NPK). Curly red chili plants with the application of 36 ml sludge and 10 L bio-fertilizer / ha have the highest average plant height compared to other doses of sludge and bio-fertilizer and NPK application (control). The lowest average plant height is found in the application of 12 ml sludge and 10 L / ha bio fertilizer. Based on statistical analysis using DMRT with a confidence level of 95% (α = 0.05), there is a significant difference between the mean plant height of application of 36 ml sludge and bio fertilizer 10 L / ha with the average yield of plants both fertilizer application with 36 ml sludge dose and sludge dosage 12 ml and bio fertilizer 10 L / ha.

When compared with the controls, the application of 12 ml sludge; bio fertilizer 10 L / ha; and sludge 36 ml and bio fertilizer 10 L / ha increase the average plant height. The highest concentration of bio-fertilizer and biogas sludge, namely sludge 36 ml and bio-fertilizer 10 L / ha, had the highest plant height compared to other doses and NPK application (control). In the 24 ml sludge application; 36 ml sludge; sludge 12 ml and bio fertilizer 10 L / ha; and sludge 24 ml and bio fertilizer 10 L / ha tend to reduce the high average curly red chili plant. Based on statistical analysis using DMRT with a confidence level of 95% (α = 0.05), it was not significantly different for all fertilizer application doses compared to NPK applications (controls). The absence of significant differences in the application of bio-fertilizer and biogas sludge can be attributed to the fact that the dosage has not been able to play an optimal role in increasing the plant height so that it produces the same height as the control or different from the control but the difference is not significant.

Based on the description, it can be seen that the application of bio-fertilizer and biogas sludge does not have a different effect than the application of NPK fertilizer (control). However, the higher the concentration of bio-fertilizer and biogas sludge given, can increase the high average of curly red chili plants. This can occur because the application of bio-fertilizer and biogas sludge with higher concentration can increase the metabolic rate and accelerate the vegetative phase of curly red chili plants. The vegetative phase marked by the growth of the embryo into seedling which developed into vegetative growth is characterized by an enlarged size of the plant, both elongated growth and growth of the stem circumference (Mangoendidjojo, 2007). When the vegetative phase takes place faster, the plant will soon enter the generative phase.

Sludge biogas applied as an organic fertilizer has a role as a nutrient mineral provider that is important during the growth and development of curly red chili plants (Bansal, 2014). The content of sludge biogas is rich in various plant nutrients such as nitrogen, phosphorus, and potassium which are macro nutrients needed by large amounts of plants (Susilo et al., 2017). The role of these elements, can increase overall plant growth, especially when the plants are in the vegetative phase, able to accelerate the formation of fruit, flowers, and seeds, and increase plant resistance to disease (Endah, 2001). So that by giving increasing doses of biogas sludge to curly red chili plants, it can increase plant growth such as optimal plant height.

The second aspect of vegetative growth measured is the number of leaves. The number of leaves is calculated on the leaves that have opened perfectly. This measurement is carried out 7 days after the seedling of chili plants is planted and treated until the maximum vegetative phase is 8. The measurement results are presented in Figure 3.



Figure 3. The increasing number of leaves of the curly red chili plant (Capsicum annuum L.) as a result of bio-fertilizer and sludge

Based on Figure 3., the rate of addition of curly red chili plants leaves a positive correlation, ie the growth rate increases in proportion to the age of the plant. It is known that the highest number of leaves is in plants with the application of 36 ml sludge and 10 L bio-fertilizer / ha while the number of leaves is the least in plants with 36 ml sludge application. The results of the average measurement of the number of curly red chili plants at 8 weeks were presented in Figure 4.

Figure 4. Average number of curly red chili plant leaves given by bio-fertilizer and sludge at 8th week

Figure 4. shows the qualitative results of the average number of curly red chili leaves with analysis using Analysis of Variance ANOVA. Based on statistical analysis using DMRT with a confidence level of 95% (α = 0.05), it shows that there are differences in the results of the average number of leaves of plants using bio-fertilizer and biogas sludge in various concentrations with controls that are not significantly different.

The application of bio-fertilizer and biogas sludge at various concentrations is able to increase the average number of leaves of curly red chili plants with a considerable amount compared to the control. Curly red chili plants have the highest average number of leaves with the application of 36 ml sludge and bio fertilizer 10 L / ha and bio fertilizer dosage of 10 L / ha, while the average number of leaves is the least in the 36 ml sludge application. Based on statistical analysis using a confidence level of 95% (α = 0.05), there is a significant difference between the average number of leaves of curly red chili plant application of 36 ml sludge and bio fertilizer 10 L / ha with the average number of leaves of both applications of fertilizer with a dose 36 ml sludge and 12 ml sludge and 10 L / ha bio fertilizer. Then, there is a significant difference between the average number of leaves of the application of bio-fertilizer application 10 L / ha with the average number of leaves of both plants application fertilizer with 36 ml sludge dose and 12 ml sludge dose and bio fertilizer 10 L / ha. This shows that the application of bio-fertilizer and biogas sludge with a dose of 36 ml sludge and bio-fertilizer 10 L / ha and a bio-fertilizer dose of 10 L / ha is more effective in increasing the number of leaves in curly red chili plants compared to 36 ml sludge application.

When compared with controls, the application of bio-fertilizer and sludge biogas with 12 ml sludge dose; 24 ml sludge; bio fertilizer 10 L / ha; sludge 24 ml and bio fertilizer 10 L / ha; and sludge 36 ml and bio fertilizer 10 L / ha tend to increase the average number of leaves of curly red chili plants. The application of 36 ml sludge and 10 L / ha bio-fertilizer on curly red chili plants had the highest number of leaf plants compared to other doses and controls. Based on statistical analysis using DMRT with a confidence level of 95% (α = 0.05), there was no significant difference in all doses of fertilizer application compared to the control of the number of curly red chili plant leaves.

Based on the description, it can be seen that the application of 10 L / ha bio-fertilizer and application of 36 ml sludge and 10 L bio-fertilizer / ha increased the average number of curly red chili plant leaves even though statistical analysis did not provide a real difference. The higher concentration of bio-fertilizer and biogas sludge given tend to be able to increase the average number of leaves of curly red chili plants. This can be seen in the application of the highest dosage in the form of 36 ml sludge and 10 L bio-ha / ha of fertilizer, indicating the highest number of leaves formed compared to the application of fertilizers with other doses and with NPK application (control).

The application of 36 ml sludge and bio fertilizer 10 L / ha is the optimum dose to increase the number of leaves of curly red chili plants. This can happen because there is a balance between sludge and bio-fertilizer so that the absorption by plant roots becomes more optimum. If the dosage of fertilizer given is too large, it can cause absorption of nutrients by the roots to be not optimal because of the absorption of nutrients by microbes contained in fertilizers with plant roots. In addition, the high nutrient content in biogas sludge fertilizer and bio-fertilizer can improve the quality of curly red chili plants to produce more leaves. The nitrogen element contained in biogas sludge fertilizer plays a role in leaf growth, the leaves of the plant become wider with greener leaf colors (Sperling, 2007).

The application of bio-fertilizer 10 L / ha on curly red chili plants also showed a higher number of leaves than the control, but did not exceed the number of leaves in the treatment with 36 ml sludge and 10 L / ha bio-fertilizer. The use of a bio-fertilizer dose of 10 L / ha, also provides the optimum dose to increase the number of leaves of curly red chili plants. This can happen due to the fact that bio-fertilizer from cow urine is applied through fertilization on the leaves of plants, so nutrients (nutrients) in bio-fertilizer from cow urine can be easily absorbed by plants through leaf stomata and directly used in plant metabolism . The process of absorption of nutrients by plants is faster through leaves than through roots, so that the application of bio-fertilizer 10 L / ha can increase plant growth such as the number of leaves.

Leaf chlorophyll levels were measured using a spectrophotometer. This measurement was carried out at the maximum vegetative phase of the curly red chili plant which was at the 8th week. The measurement results are presented in Figure 5.

Figure 5. Levels of chlorophyll a, chlorophyll b, and total chlorophyll of leaves of curly red chili plants (Capsicum annuum L.) as a result of biofertilizer and biogas sludge at week 8.

Based on Figure 5., the chlorophyll content of the leaves of curly red chili plants showed varying results at each given dose of fertilizer. Plants with treatment tended to have lower levels of chlorophyll than chlorophyll levels in the control. It is known that the highest chlorophyll content of leaves is in plants with NPK application (control) while the chlorophyll content of leaves is the least in plants with the application of 36 ml sludge both levels of chlorophyll a, chlorophyll b, and total chlorophyll. Chlorophyll a level from all applications of bio-fertilizer and biogas and control sludge is higher than chlorophyll levels b. This is likely to occur because some chlorophyll is still at the stage of chlorophyll a (seen in the chlorophyll a content greater than chlorophyll b) and has not yet become chlorophyll b, because chlorophyll a is a precursor of chlorophyll b (Robinson, 1980). Chlorophyll b is a chlorophyll which acts as an antenna that collects light to then be transferred to the reaction center. The reaction center is composed of chlorophyll a. Light energy will be converted into chemical energy in the reaction center which can then be used for the reduction process in photosynthesis (Taiz and Zieger, 1991). The results of the measurement of the average chlorophyll content of curly red chili plant leaves at week 8, are presented in Figure 6.

Figure 6. Average total chlorophyll content of leaves of curly red chili (Capsicum annuum L.) as a result of bio-fertilizer and biogas sludge.

Based on Figure 6., it can be seen that the average total chlorophyll levels at all doses of bio-fertilizer and biogas sludge treatment have significantly different results with the average total chlorophyll control levels. Red chili plants with curly control with NPK application have the highest total chlorophyll content of the leaves while the application of 36 ml sludge has the lowest average total leaf chlorophyll content.

Based on the description, it can be seen that the application of bio-fertilizer and biogas sludge in various concentrations given has not been able to increase the average total chlorophyll content of curly red chili plants. These results can be caused due to abundant nutrients and are sufficient in plants with the application of bio-fertilizer and biogas sludge capable of accelerating the vegetative growth of curly red chili plants so that the plants have entered the generative phase. When curly red chili plants with the application of bio-fertilizer and biogas sludge have entered the generative phase, the state of the control plants with low nutrient availability causes the plants to be in the vegetative phase at the same planting age. According to Mengel and Ernest (2012), the low nutrient available for plants can cause growth inhibition in these plants. In its generative phase, curly red chili plants optimize nutrients (nutrients) from bio-fertilizers and biogas sludge which are absorbed to form chili fruit and grain seeds on chili fruit, so that these nutrients are not fully used for growth and increase chlorophyll levels in the leaves . In control plants, optimize the nutrients absorbed by plants for growth and increase chlorophyll levels in the leaves. So, it can be seen in the results of the total chlorophyll levels of curly red chili plants in the control having a higher total total chlorophyll level compared to all curly red chili plants with the application of bio-fertilizer and biogas sludge.

The measurement of capsaicin levels was carried out at the maximum vegetative phase of the curly red chili plant which was at the 8th week. The measurement results are presented in Figure 7.

Figure 7. Capsaicin levels of curly red chili fruit (Capsicum annuum L.) as a result of bio-fertilizer and biogas sludge at week 8.

Based on Figure 7., capsaicin levels of curly red chili fruit showed mixed results at each given dose of fertilizer. It can be seen that the most capsaicin levels are in plants with the application of 36 ml sludge and 10 L bio-fertilizer / ha while the capsaicin levels are the least in plants with 36 ml sludge application, 12 ml sludge and 10 L / ha bio-fertilizer, and 24 sludge ml and 10 L biofertilizer. When compared with controls, plants with application of bio-fertilizer 10 L / ha and application of 36 ml sludge and 10 L / ha biofertilizer were able to increase capsaicin levels of curly red chili plants while the application of biofertilizer and sludge biogas with other doses tended to reduce chlorophyll levels.

It is known that the most optimal level of capsaicin is found in 36 ml sludge and 10 L / ha bio fertilizer which is the highest dose. This indicates that an increase in the dosage of application of bio-fertilizer and biogas sludge in susceptible plant tolerance can increase capsaicin levels in curly red chili fruit. Based on the analysis of wet weight, the content in biogas waste liquid fertilizer is organic C-48%, N-total 2.9%, C / N 15.8%, P2O5 0.2%, K2O 0.3% (House Biogas Team, 2013). The content of sludge biogas which is rich in carbon and nitrogen makes the vegetative and generative growth of curly red chili plants balanced and faster, so that they can form more secondary metabolites compared to chili control plants. According to Lingga and Marsono (2004), increasing the dose of nitrogen fertilizer will increase the total content of alkaloids.

Based on the results of the research on the physiological response of the curly chili plant biofertilizer and biogas sludge application, some conclusions can be drawn that the growth of curly red chili plants is best in the application of 36 ml sludge and 10 L / ha biofertilizer. Curly red chili plants with various concentrations have lower chlorophyll content compared to controls. The application of 36 ml sludge and 10 L / ha biofertilizer on curly red chili plants has the highest capsaicin levels.

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