Application of biofertilizer and Local Beauveria bassiana Vuillemin on Growth, Production and Resistant of Red Chili Plants (Capsicum annuum L.)

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Abstract. The use of inorganic fertilizers and chemical pesticides in increasing chili production at high doses continuously can damage the environment and resistant to pests. The use of inorganic fertilizers and chemical pesticides can be minimized by environment friendly products. The research was conducted by combining the application of biofertilizers and local Beauveria bassiana to support the growth and production of environmentally friendly plants. This research was carried out experimentally arranged according to a Factorial Completely Randomized Design (CRD) with two factors. The first factor was the application of biofertilizer consisting of 4 levels, namely: zero applications of biofertilizer, one application at 24 DAP, two applications at 24 DAP and 54 DAP and three applications at 24 DAP, 54 DAP and 64 DAP. The second factor was the application of local B. bassiana consisting of 4 levels, namely: zero applications of local B. bassiana, one application at 24 DAP, two applications at 24 DAP and 54 DAP and three applications at 24 DAP, 54 DAP and 64 DAP. The parameters of research consisted plant height, dichotom height, flowering plant age, harvesting age, number of fruits per plant, fruit length, fruit weight, fruit weight per plant, leaf pest attack intensity and fruit pest attack intensity. The data from the analysis of variance were further tested with the DNMRT test at the 5% level. The result showed that no interaction between the application of biofertilizers and B. bassiana on the growth, yield and resistance of red chili plants. However, the combination of application of biofertilizer and B. bassiana three times gave good results on the growth, yield and resistance of red chili plants compared to the application of biofertilizer and B. bassiana zero times.

1. Introduction
Red chili (Capsicum annuum L.) is a type of horticultural commodity that is commercially cultivated. It has high economic value, so it is planted in almost all regions of Indonesia, including in Riau Province. [1] reported that in 2016 land area is 1,775 ha with a total production of 12,003 tons of red chili plants so that productivity was 6.89 tons.ha-1 and in 2017 land area increased by 461 ha with a total production of 15,813 tons so that the productivity is 7.07 tons.ha-1. Although production has increased, the demand for red chili will continue to increase so it still needs to be sought to improve soil fertility.

However, the high production of red chili in Riau is also determined by the high use of inorganic fertilizers and chemical pesticides by local farmers. Whereas excessive use of inorganic fertilizers will
actually cause a decrease in soil quality in providing nutrients so that it will affect plant growth and production. Therefore, the use of inorganic fertilizers needs to be reduced by using environment friendly fertilizers, one of which is biofertilizer.

Biofertilizer is an active biological product containing microorganisms that can increase fertilization efficiency, soil fertility, and soil health [2]. Biofertilizer used in this research is the biofertilizer of the consortium of cellulolytic bacteria based on rice washing water [3]. The application of biofertilizers from the consortium of cellulolytic bacteria has been applied on several plants, specifically rice [4], chili [5], and oil palm seeds [6]. The results of the research showed that as much as 10 ml of biofertilizer gave good results for the plants. Apart from the results of these studies, [7] has also been carried out application of biofertilizers on chili plants.

Pest control is also important in the cultivation of red chili plants, given that one of the difficulties in red chili cultivation is the problem of pests and diseases. Some of the main pests that can attack red chili plants are armyworms (*Spodoptera litura*), trips (*Thrips parvispinus*), fruit fly (*Bactrocera sp.*), whitefly (*Bemisia tabaci*), aphids (*Aphididae*), and mite (*Polyphagotarsonemus latus* and *Tetranychus sp*) These pests can cause a decrease in red chili production [8]. Currently, pest control is generally carried out using pesticides. The use of chemical pesticides continuously will cause damage to the environment. Therefore, it is necessary to have alternative pest control that is environmentally friendly and sustainable, one of which is the use of entomopathogenic fungi *Beauveria bassiana*. It is often referred to as a biological agent in controlling pests of several plants.

The use of the *B. bassiana* as a pest control has several advantages, including having a high reproductive capacity, being able to form spores that are durable in nature, environmentally friendly, and having a high pathogenesis of target pests [9]. The result of the study [10], *B. bassiana* was effective in controlling *Aphis gossypii*. The fastest and highest mortality rate is 80.00% at the spore concentration of 10⁶ on the 4th day after application.

The research aims to determine the interaction between biofertilizer and local *B. bassiana* on the growth, production and resistance of chili plants, to determine the combination of application of biofertilizer and *B. bassiana* on the growth, production and resistance of chili plants and to determine the effect of the application of biofertilizer and local *B. bassiana* on the growth, production and resistance of chili plants.

### 2. Methodology

The research was carried out at the Experimental Garden, Soil Science Laboratory and Plant Pest Laboratory, Faculty of Agriculture, Universitas Riau. This research was carried out experimentally arranged according to a Factorial Completely Randomized Design (CRD) with two factors. The first factor was the application of biofertilizer consisting of 4 levels, namely: zero applications of biofertilizer, one application at 24 DAP, two applications at 24 DAP and 54 DAP and three applications at 24 DAP, 54 DAP and 64 DAP. Application of biofertilizer is carried out by watering it into the red chili planting soil using a 10 ml container. The second factor was the application of local *Beauveria bassiana* consisting of 4 levels, namely: zero applications of local *Beauveria bassiana*, one application at 24 DAP, two applications at 24 DAP and 54 DAP and three applications at 24 DAP, 54 DAP and 64 DAP. Application of local *Beauveria bassiana* by watering it on red chili plants, until the plants become wet. The number of the application factor of biofertilizers and local *B. bassiana* resulted in 16 experimental combinations with 3 replications and resulting in 48 experimental units. Each experimental unit consisted of 10 plants and 2 of them were sample plants. The parameters of research consisted plant height, dichotom height, flowering plant age, harvesting age, number of fruits per plant, fruit length, fruit weight, fruit weight per plant, leaf pest attack intensity and fruit pest attack intensity. The data from the analysis of variance were further tested with the Duncan’s Multiple Range Test (DNMRT) test at the 5% level using the SPSS device.
3. Results and Discussion

3.1. Red chili growth response

The results of variance showed that amount of applications of biofertilizer and biological control agents had no significant effect on plant height, dichotom height, flowering age and harvest age. The application of amount of biofertilizer had a significant effect on dichotomy height. The results of Duncan’s multiple distance further test at the 5% level can be seen in Table 1.

Table 1. Effect of application of biofertilizer and local B. bassiana local on red chili plant growth

| Observation     | Amount of applications biofertilizer | Amount of applications biological control agents |
|-----------------|--------------------------------------|--------------------------------------------------|
|                 | Zero times                           | One time | Twice | Three time | Average |
|                 |                                      |          |       |            |         |
| Plant height    | Zero Times                           | 27.80 b  | 32.46 ab | 33.08 ab | 32.91 ab | 31.56 b |
|                 | One time                             | 39.41 ab | 37.53 ab | 35.73 ab | 32.41 ab | 36.27 ab |
|                 | Twice                                | 34.83 ab | 34.41 ab | 37.40 ab | 35.83 ab | 35.62 ab |
|                 | Three times                          | 37.50 ab | 33.66 ab | 43.50 a  | 40.25 ab | 38.72 a  |
|                 | Average                              | 34.88 a  | 34.52 a  | 37.42 a  | 35.35 a  |         |
| Dicotomy        | Zero Times                           | 16.50 abc| 15.66 c  | 15.58 c  | 16.16 bc | 15.97 c  |
|                 | One time                             | 16.41 abc| 16.66 abc| 16.58 abc| 16.58 abc| 16.56 bc |
|                 | Twice                                | 16.83 abc| 16.91 abc| 17.58 ab | 17.75 ab | 17.27 ab |
|                 | Three times                          | 16.83 abc| 17.08 abc| 17.91 a  | 18.00 a  | 17.45 a  |
|                 | Average                              | 16.63 a  | 16.58 a  | 16.93 a  | 17.10 a  |         |
| Flowering Age   | Zero Times                           | 24.33 b  | 24.66 b  | 23.50 ab | 23.33 ab | 23.95 b  |
|                 | One time                             | 23.50 ab | 22.66 ab | 24.00 ab | 23.33 ab | 23.37 ab |
|                 | Twice                                | 23.00 ab | 22.83 ab | 23.16 ab | 23.83 ab | 23.20 ab |
|                 | Three times                          | 23.50 ab | 23.66 ab | 22.33 ab | 21.66 a  | 22.79 a  |
|                 | Average                              | 23.58 a  | 23.45 a  | 23.25 a  | 23.04 a  |         |
| Harvest Age     | Zero Times                           | 70.33 abc| 70.66 abc| 70.66 abc| 74.66 c  | 71.58 b  |
|                 | One time                             | 72.66 bc | 71.33 abc| 69.66 abc| 71.20 abc| 71.21 b  |
|                 | Twice                                | 72.00 abc| 70.00 abc| 70.33 abc| 72.00 abc| 71.08 b  |
|                 | Three times                          | 67.33 a  | 70.00 abc| 69.00 ab | 69.33 ab | 68.91 a  |
|                 | Average                              | 70.58 a  | 70.50 a  | 69.91 a  | 71.80 a  |         |

Note: The numbers followed by the same lowercase letters in the same column are not significantly different according to DNMRT further tests at the 5% level.

Table 1 shows that the application of biofertilizer and local B. bassiana did not interact with the observation of chili plant growth. This is because biofertilizers and B. bassiana do not support each other in supporting the growth of red chili plants, but the combination of biofertilizers and biological agents with the number of applications three times at dichotomous height is significantly different from the application of biofertilizers zero times biofertilizers with one and two times the application of biofertilizers and biological agents. Biofertilizer helps the absorption of nutrients and B. bassiana helps control the intensity of pest attacks, so that red chili plants become healthy.

The biofertilizer of the consortium of cellulolytic bacteria based on rice washing water is thought to be able to provide good soil conditions so that it can support the availability of nutrients needed for the growth of red chili plants. According to [11], the availability of nutrients in sufficient and balanced quantities causes rapid cell division, enlargement and elongation. The research results of [12], showed that the application of biofertilizers from a consortium of cellulolytic bacteria based on rice washing water three times with a dose of 10 ml was able to increase the height of red chili plants.
According to [13], rice washing water contains B vitamins which play a role in converting high carbohydrate content into energy to drive activities in plants, the converted carbohydrate content can be an intermediary in forming the hormones auxin and gibberellins which are growth regulators. Another factor that is thought to increase the growth of chili plants is the presence of bacteria contained in the biofertilizer. Microbes contained in biofertilizers that have the ability to produce IAA by Bacillus cereus bacteria [14], [15], produce phosphate solvents by Providencia vermicola bacteria [16], and produce urease enzyme by Proteus mirabilis bacteria which is able to decompose urea [17]. The ability of some bacteria to produce these metabolites is thought to be able to increase plant vegetative growth.

Unlike the case with the application of biofertilizers which had an effect on the observation of dichotomous height and harvest age, the application of B. bassiana did not affect each observation parameter, but the combination of three times biofertilizers and three times biological agents on chili plants gave plant growth which is better than only giving biofertilizers. This is because the application of B. bassiana can reduce the intensity of pest attacks on chili, causing plants to become healthier, and their growth is not disturbed. In general, pests attack on the leaves of the plant. Giving biological agents can reduce pest attacks so that the photosynthesis process that occurs in the leaves is not disturbed. The process of photosynthesis will produce energy that will be used to divide, elongate, and enlarge the cells contained in the stem. According [18], the photosynthesis process that runs smoothly will affect the carbohydrates produced, sufficient carbohydrate content will affect plant growth.

3.2. Red chili production responses

The results of the analysis of variance showed that there was no interaction between the application of biofertilizers and B. bassiana on fruit length, fruit weight, number of fruits per plant and fruit weight of plantings, but the application of biofertilizers showed results that significantly affected fruit length, fruit weight, number of fruit per plant and fruit weight per plant. The results of the further test with the DNMRT multiple distance test at the 5% level can be seen in Table 2.

| Observation                  | Amount of applications biofertilizer | Amount of application biological control agents |
|------------------------------|-------------------------------------|-----------------------------------------------|
|                              | Zero times | One time | Twice | Three times | Average |
| Fruit Length                 |            |          |       |             |         |
| Zero                         | 14.01 c    | 14.15 bc | 15.20 abc | 14.21 bc | 14.39 b |
| Times One                    | 14.55 bc   | 14.67 bc | 15.27 abc | 15.19 abc | 14.92 ab |
| time Twice                   | 14.63 bc   | 14.90 abc | 14.80 abc | 15.38 abc | 14.92 ab |
| Three times                  | 14.69 bc   | 16.46 a  | 15.10 abc | 15.88 ab  | 15.53 a  |
| Average                      | 14.47 a    | 15.04 a  | 15.09 a  | 15.16 a   |         |
| Fruit Weight                 |            |          |       |             |         |
| Zero Times                   | 2.58 bc    | 2.57 bc  | 2.71 abc | 2.17 c    | 2.51 b   |
| One time                     | 2.55 bc    | 2.37 bc  | 2.67 abc | 2.69 abc  | 2.57 b   |
| Twice                        | 2.65 abc   | 2.81 abc | 2.71 abc | 2.78 abc  | 2.73 ab  |
| Three times                  | 2.93 ab    | 2.66 abc | 3.03 ab  | 3.31 a    | 2.98 a   |
| Average                      | 2.67 a     | 2.60 a   | 2.78 a   | 2.74 a    |         |
| Total of fruits per plant    |            |          |       |             |         |
| Zero Times                   | 16.33 c    | 22.16 abc | 18.33 bc | 17.50 bc  | 18.58 b  |
| One time                     | 21.33 abc  | 20.33 abc | 20.67 abc | 20.00 abc | 20.58 ab |
| Twice                        | 16.83 bc   | 23.33 ab | 22.67 abc | 23.00 abc | 21.45 ab |
| Three times                  | 20.50 abc  | 20.33 abc | 25.33 a  | 26.67 a   | 23.20 a  |
| Average                      | 18.75 a    | 21.54 a  | 21.75 a  | 21.79 a   |         |
| Fruit weight per plant       |            |          |       |             |         |
| Zero Times                   | 42.38 bc   | 40.24 bc | 45.45 bc | 38.43 bc  | 41.62 b  |
| One time                     | 35.14 c    | 50.13 abc | 43.59 bc | 44.77 bc  | 43.41 b  |
| Twice                        | 44.19 bc   | 44.22 bc | 43.30 bc | 44.30 bc  | 44.00 b  |
Although there was no interaction, the combination of three times biofertilizer and three times local \textit{B. bassiana} tended to produce better fruit length, fruit weight, number of fruit per plant and fruit weight per plant compared to single factors and other combinations. The increase in some yield parameters with the amount of three times was suspected because the content of nutrients and microbes contained in biofertilizers was able to increase yield parameters as well as growth parameters.

According to [19], biofertilizers have a role in facilitating the availability of nutrients, decomposition of organic matter, and providing a better rhizosphere environment for plants that will support growth and increase crop yields. Nutrients N, P and K affect the process of fruit formation and filling [20]. The process is strongly influenced by the nutrients used in the photosynthesis process, namely as a constituent of carbohydrates, fats, proteins, minerals and vitamins which will be translocated to the fruit storage section.

The availability of P in the biofertilizer is thought to have come from \textit{Providencia vermicola} bacteria in the consortium used. This is supported by the opinion of [16], which stated that \textit{Providencia vermicola} is a potential phosphate solubilizing bacterium, so it is suspected that it actively contributes P in biological fertilizers. [21] added that the P element will affect the amount absorbed by plants, and play a role in accelerating the formation or refinement of fruit, flowers and seeds.

The combination of \textit{Beauveria bassiana} biological agents three times and biofertilizers three times gave a better response to plant yields, this was because the biological agents used were quite able to suppress several pest attacks that attacked the growth of yields. [22] has also conducted research on the application of the biological agent Beauveria bassiana with a concentration of 20 ml L\textsuperscript{-1} to effectively prevent \textit{Thrips sp.} in cayenne red chili of Dewata F1 variety by 99.53%, although there are some pests that still cannot be controlled by biological agents.

3.3. Chili plant resistance
The results of analysis of variance showed that the interaction of the number of applications of biofertilizers and biological agents had no significant effect on the intensity of pest attack, but the amount of application of biological agents had a significant effect on the intensity of pest attacks. The results of the further test of pest attack intensity with DNMRT test at a level of 5% can be seen in Table 3.

| Application of biofertilizer | Application of local \textit{Beauveria bassiana} Vuillemin | Average |
|-----------------------------|----------------------------------------------------------|--------|
| Zero times                  | 19.62 c                                                  | 15.78 b|
| One times                   | 17.50 bc                                                 | 14.80 ab|
| Two times                   | 13.51 ab                                                 | 13.69 ab|
| Three times                 | 12.48 ab                                                 | 12.61 a|

Note: The numbers followed by the same lowercase letters in the same column are not significantly different according to DNMRT further tests at the 5% level.
Table 3 shows the application of biofertilizers and *B. bassiana* did not interact with the intensity of pest attack. This is because the application of biofertilizers and *B. bassiana* does not affect each other or is independent. Biofertilizers applied to chili plants will be absorbed by plants through the roots and help the absorption of nutrients, while *B. bassiana* only sticks to the surface of chili plants and attacks plant pests through contact with these pests.

Chili plants that were applied with a combination of biological agents three times gave the lowest attack intensity, namely 12.61%. Meanwhile, the treatment without the application of biological agents showed the highest pest attack intensity, which was 15.93%. This shows that the application of *B. bassiana* with a higher number of applications is able to suppress pest attacks on red chili plants. According to [23], that the higher the concentration applied, the higher the density of the fungal conidia, so the possibility of conidia attached to the insect body is increasing which results in faster penetration into the insect body and results in insect body damaged.

The low percentage of affected plants is thought to be due to the phosphorus content in biofertilizers that is able to form cell walls in the red chili plant tissue to strengthen so that the ability of pests to attack plants decreases. This is in accordance with the opinion of [24], which states that phosphate is needed by plants for plant metabolic processes, including making plant stems strong, so that they are resistant to fall, improve quality, and increase resistance to pests and diseases that attack.

4. Conclusions
Based on the research that has been done, it can be concluded that there is no interaction between the application of biofertilizers and *B. bassiana* on the growth, yield and resistance of red chili plants. However, the combination of application of biofertilizer and *B. bassiana* three times gave good results on the growth, yield and resistance of red chili plants compared to the application of biofertilizer and *B. bassiana* zero times.

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