The effect of organic fertilizer and compost of volcanic ash on growth and yield of red chili (*Capsicum annum* L.)

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Abstract. The purpose of this study is to determine the effect of organic fertilizer and volcanic ash as composting material on growth and yield of red chili. This research was conducted in the village Payung, District of Tanah Karo, North Sumatera Province, started from May to September 2015. This research consists of several steps, those were the producing of the compost, analysis of chemical composition, and biological test by cultivating chili seeds using organic fertilizer and compost of volcanic ash. Factorial randomized block design consisting of two factors and three replications namely organic fertilizer consisted of 3 levels is used on the experiment; without organic fertilizer, with organic fertilizer 5, 10 and 15ml/l, and compost of volcanic ash consists of 3 levels; without compost of volcanic ash, 1, 2 and 3 kg / m². The data were analyzed with the variance α = 5% and continued by Duncan's Multiple Range Test α = 5%. The results showed that using of volcanic dust as composting matter had no statistically significant increase growth and yield of red chilli. Based on the results, chemical analysis of the soil showed improvement in soil fertility. The effect of organic fertilizer gave a real contribution to the plant height, the number of productive branches, fruit weight, also wet root weight and dry root weight.

1. Introduction

1.1. Background

Mount Sinabung is one of the active volcanoes located in the highlands of Karo Regency, North Sumatra, Indonesia. Eruption of Mount Sinabung recently discharged a lava incandescent and bursts of hot clouds, as well as volcanic ash. Volcanic ash that consists from large-sized rock to smooth ones have a negative impact that causes large losses for Karonese farmers. Volcanic ash can condense soils that are affected by the spread of volcanic ash. [1] stated that the more dust given, the more it will be able to condense the soil. Watering every day can move the subtle fraction to deeper ground. On the other hand, the ash covering the agricultural land has a positive impact on soil and crops. Positive impacts on soil includingenriching and rejuvenating soil fertility and plant growth.

Several studies have shown that a layer of volcanic ash that potentially contains soil nutrients can be utilized about ten years after the volcanic ash spread on the ground, but a simple technology can be used to accelerate volcanic ash dissolution by mixing organic matter. Organic materials are able to release nutrients bound in mineralized structures from eruptive ash [2], [3]. Organic materials are also able to maintain the humidity condition, so that physical, chemical, and biological weathering takes place simultaneously to speed up plant nutrients from nutrient-carrying carriers. The release of macro and micro nutrients are both attached to the surface of the dust through condensation and as part of mineralized structure that easily decayed, which are Si, Ca, Mg, K, P, S, Fe, Zn, Mn, and Cu [4].
Liquid Organic Fertilizer is a foliar liquid fertilizer that contains essential macro and micro nutrients (N, P, K, S, Ca, Mg, B, Mo, Cu, Fe, Mn, and organic matter). Liquid Organic Fertilizers are useful to improve the physical, chemical, and biological properties of the soil. They are also used to increase crop production, improve the quality of plant products, and reduce the use of inorganic fertilizers [5]. Usage of liquid organic fertilizer to the optimum limit will increase the number of nutrients received by plants.

Red chili pepper is one of the most important vegetables in Indonesia, both as a commodity that is consumed in the country and also as an export commodity. Red chili pepper’s national productivity still stands very low at 7.34 ton / ha. One effort to increase the productivity of red chili is intensification [6]. Fertilization is one of the important components in the intensification program. However, fertilization using inorganic fertilizer by Karo farmers during this time, with the recommended dose and in the long term, will lead to land degradation (decreasing soil fertility). This is proved by the results of the analysis of some chemical properties of soil in the study, indicating a very low nutrient content (pH: 5.1; C: 2.24%; N: 0.26%; P <001 ppm; K: 0 , 05%). The important materials of organic fertilizer is very useful for the improvement of agricultural production both in quality and quantity, reducing environmental pollution and improving the sustainable quality of the land. The use of organic fertilizers in the long term can increase the productivity of land and prevent land degradation.

Based on the information stated above, it is necessary to do research on the effect of volcanic ash compost and organic fertilizer on growth and yield of red chili (Capsicum annum L.) in the Payung village of Tanah Karo Regency.

2. Materials and Methods
This experiment was conducted from May to September 2015 in the Payung village of Payung district, Tanah Karo Regency, 600 meters above sea level. Materials and equipment used were: Taro F1 of C. annum L variety, volcanic ash, liquid organic fertilizer, bioactivator, chicken manure, dolomite, meter, buckets, plastic mulch, stakes, analytical balance, drill ground, hand sprayer and other supporting materials.

This study used a factorial randomized block design with two factors and three replications. The first factor was compost of volcanic ash with four dosages level i.e: volcanic ash 0, 1, 2, 3 ton/ha and the second factor was liquid organic fertilizer consisting of 0.5,1015 ml/l water. Data were analyzed using analysis variance (ANOVA) followed by DMRT test at α = 0.05 probability level.

Implementations of the research were: composting volcanic ash, nursery, fertilization and inoculation, planting, maintenance and harvesting. The parameters observed were plant height (cm), stem diameter (cm), flowering days (day), harvest age (day), the number of productive branches (branch), the weight of fruit per plant (g) and wet root weight and dry root weight (g).

3. Results and Discussion

3.1. Soil Chemical Analysis

| Table 1. Soil’s chemical characteristics in Payung, Karo Regency |
|--------------------------------|
| Soil’s Chemical Characteristics | Before Treatment | After Treatment |
| pH | 5.1 | 7.2 |
| C | 2.24% | 4.25% |
| N total | 0.26% | 1.83% |
| P | <0.01 ppm | 1.06 ppm |
| K | 0.05% | 0.35% |
Based on the results of the research that has been done on soil samples before being treated, the soil fertility is very low as seen in Table 1. After the treatments were changed, the pH, C, N total, P, and K increased.

3.2. Red Chili Plant Growth

The effect of compost treatment of volcanic ash and liquid organic fertilizer on the growth of red chili plants can be seen in Table 2.

Table 2. The Effect of Compost Treatment of Volcanic Ash and Liquid Organic Fertilizer on the Growth of Red Chili Plants

| Treatment | Plant Height at Age 10 MSPT (cm) | Stem Diameter at Age 10 MSPT (cm) | Flowering Days (day) | Harvest Age (day) | Number of Productive Branches (branch) |
|-----------|----------------------------------|----------------------------------|----------------------|-------------------|---------------------------------------|
| D₀        | 57.44                            | 9.03                             | 65.25                | 111.25            | 12.88                                 |
| D₁        | 59.88                            | 9.21                             | 65.00                | 110.50            | 13.33                                 |
| D₂        | 60.58                            | 9.78                             | 62.75                | 110.25            | 13.57                                 |
| D₃        | 63.47                            | 9.08                             | 59.67                | 109.75            | 14.10                                 |
| N₀        | 54.54a                           | 8.32a                            | 65.75                | 111.00            | 12.21a                                |
| N₁        | 59.93b                           | 8.98a                            | 64.83                | 110.75            | 13.40ab                               |
| N₂        | 62.82bc                          | 9.66ab                           | 61.58                | 110.25            | 13.97ab                               |
| N₃        | 64.08bc                          | 10.13b                           | 60.50                | 109.75            | 14.31b                                |

Description: Figures followed by the same letter in the same column no significant effect on the level of \( \alpha = 0.05 \) by Duncan range test.

From Table 2, it can be seen that the composting of volcanic ash does not affect plant growth, but the application of liquid organic fertilizer of 15 ml/l (N3) causes the plant height and diameter of the largest stems to be significantly different from that without liquid organic fertilizers (N0) and N1 (5 ml/l), but not significantly different from N2 (10 ml/l). The largest number of productive branches found in N3 treatment was significantly different from N0, but the difference was not significant with N1 and N2.

Volcanic ash compost still cannot be used optimally although volcanic ash contains a very complete minerals because the compost has not been perfectly decomposed, so the plant showed a rather slow growth. This is supported by the opinion of [3] who stated that volcanic material is a rich material of nutrients so that it can renew land resources. However, large volcanic material deposits may also negatively impact crop growth, especially on soil as a growing medium. Problem that rose on newly affected volcanic material used as a planting medium is that its physical, chemical and biological properties do not support optimal plant growth.

Increasing growth of plants is due to the application of liquid organic fertilizer with an increasingly high concentration (Table 2). The increment in plant height is due to the formation of new cells and the elongation of the already formed cells in the apical meristem region. The swift growth activity at the shoots depends on the supply of growing factors, especially carbohydrates from plant leaves as the center of photosynthesis. According to [7], the synthesis of carbohydrates occurs in the green parts of plants, especially the leaves that get direct sunlight, using nutrients that are absorbed by plants as raw materials.

Nutrient elements contained in liquid organic fertilizer are N, P, and K. Nitrogen acts as a building agent of amino acids, amides, and adenine. Adenine is a constituent of nucleotides and nucleoproteins such as DNA and ARN. Amino acids, amides and amines are the constituent compounds of proteins and nucleic acids. Nitrogen is a peptide bonding agent that binds to protein amino acids [8]. The chromosomes consist of ADN, ARN, and proteins. Chromosomes are the constituents of the cell nucleus and play a role in cell division. The more chromosome-forming agents available, the more cell
division and elongation can take place actively. This cell division and elongation occurs in the meristematic tissue at the growing point, causing the red pepper plant to be taller[8], [9].

Phosphorus is a constituent of ATP as a source of energy, and the compilers of DNA and RNA as nucleic acid compounds. ATP as an energy source is needed for cell division and elongation activities so that the plant gets taller. Phosphorus encourages cell division, especially in root organs. Increased cell division due to the availability of phosphorus has a positive effect on the growth of canopy organs, because the canopy of plants with roots is interdependent with each other. The root absorbs the nutrients from the soil and is transported to the plant canopy. In the plant canopy, the nutrients are processed into growth compounds and stored in stems as food reserves in the form of fiber [9]. Therefore, the plant becomes taller.

3.3. Production, Wet and Dry Root Weight of Red Chili Plant
The effect of volcanic ash compost treatment and liquid organic fertilizer towards production, also wet and dry root weight of red chili plant can be seen in Table 3.

Table 3. The Effect of Volcanic Ash Treatment (D) and Liquid Organic Fertilizer (N) towards Production, also Wet and Dry Root Weight of Red Chili Plant

| Treatment | Production (g) | Wet Root Weight (g) | Dry Root Weight (g) |
|-----------|----------------|---------------------|---------------------|
| D0        | 73.18          | 35.33               | 12.92               |
| D1        | 75.64          | 36.00               | 13.08               |
| D2        | 76.78          | 38.08               | 13.83               |
| D3        | 79.80          | 38.83               | 13.92               |
| N0        | 69.78a         | 32.67a              | 11.83a              |
| N1        | 75.93ab        | 34.25a              | 12.50a              |
| N2        | 79.38ab        | 39.67b              | 14.42b              |
| N3        | 80.33b         | 41.67b              | 15.00b              |

Description: Figures followed by the same letter in the same column no significant effect on the level of $\alpha = 0.05$ by Duncan range test

The composting of volcanic ash has no significant effect on all observed variables of production, wet weight and dried roots of red pepper plant. The results obtained are in line with the research of [10] in maize crops that stated soil mixed with volcanic ash with varying content and different fertility levels, is not significantly increasing the growth of corn crops. This is due to the increasingly hard soil structure that the roots of the plant that cannot take or absorb nutrients and water, as proofed by no influence on the weight of wet and dry roots [11].

Furthermore,[8], [9] states that a plant will grow and achieve high production levels when the nutrients that plants need are in a sufficient state available and balanced in the soil and elements of N, P, and K which are three elements of the six elements of macro nutrients absolutely necessary for the plant. If one of these elements is lacking or not available in the soil, it will affect the growth and production of the plant. In this study, the nutrients content contained in the compost of volcanic ash is still relatively low, so it is not enough available for the needs of the plant.

The highest production of red chili plant is found in the provision of liquid organic fertilizer of 15 ml/l water (N3) is significantly different from N0, but not significantly different from N1 and N2. The largest wet and dry root weight found in N3 treatment was significantly different from N0 and N1, but the difference was not significant with N2.

The result of statistic test showed that liquid organic fertilizer affected plant height, stem diameter, number of productive branches, fruit weight, wet and dry root weight, but no significant effect on flowering age and harvest age (Table 3). Potassium is essential in the formation of charcoal and translocation of sugars, as well to help the formation of proteins and carbohydrates. This element also has an important role as a catalyst of various biochemical reactions. According to [12], crop production
is highly dependent on vegetative growth. If vegetative growth is good, then the photosynthesis that plants can produce at the time of filling will be high, thus increasing crop production. The increase of photosynthesis results (assimilate) is inseparable from the role of liquid organic fertilizer which is a plant nutrient with a relatively high NPK content.

This increment in the production of red chili plant is due to liquid organic fertilizer that stimulates fertilization that is directly related to the cell nucleus, causing its influence quite important in cell division and elongation. Storage and release of biological energy also requires phosphorus, because high energy-storing compounds such as ATP and ADP contain phosphorus. This biological energy is required by plants in all their metabolic activities [9]. If the process of storage and release of energy can work well, then growth and production activities will run smoothly.

Giving compost volcanic ash and its interactions with liquid organic fertilizer had no real effect on all variables of observation which are plant height, stem diameter, number of productive branch, fruit weight, wet root weight and dry root weight. The influence of this insignificant allegedly still incomplete due to volcanic ash materials that can decompose to fertilize the soil, so it still takes a relatively longer time to make sure that the compost is contributing a complete nutrient in the soil so it can be absorbed by plants. The results of the analysis of volcanic ash mineral nutrient content is quite high and beneficial to plants (P2O5: 0.56%, K2O: 0.27%, MgO: 0.05%, Al2O3: 7.57%, SiO2: 68.43% organic C: 0.45%, N: 0.12%, Fe: 15.11%), while the heavy metal contents are Pb <LOD and Cd <LOD. The result of chemical parameters of composting volcanic ash for one month shown that contents of C-organic, Nitrogen, ratio C/N in succession 4.57%, 2.18%, 2.06%. Satino, et al.2012, meaning in order to produce the good quality of compost from volcanic ash, it must be take longer time. The important parameters to know the quality of compost is the ratio of C/N between 10-20.

The composting of volcanic ash still had not given a real response to all parameters observed. The observed parameters tend to be influenced by the presence of liquid organic fertilizer and cannot be influenced by the presence of volcanic ash compost together with liquid organic fertilizer.

4. Conclusion
The volcanic ash treatment did not provide significant effect on soil fertility status as well as the growth and the yield of red chili. However, the organic fertilizer provided to the soil had provided the significant improvement both on soil fertility status and the growth and yield of red chili. The treatment of using mixed volcanic ash and organic fertilizer had no significant improvement compared to the usage of organic fertilizer improvement.

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