The effect of chicken manure and beneficial microorganisms of EM-4 on growth and yield of kale (Brassica oleraceae acephala) grown on Andisol

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Abstract. Organic manure and beneficial microbes as decomposers play an important role in improving the soil health and the plant growth on Andisol. Andisol is high in organic matter, but the organic matter can be washed away by erosion, especially in a wet area like Berastagi. A field experiment to investigate the effect of chicken manure and beneficial organisms had been conducted from July to September 2017 in Berastagi. The experiment was arranged as randomized block design, consisted of two treatment factors and provided with three replications. The first factor was the dosage of chicken manure (0, 10, 20, and 30 tons/ha) and the second was the dosage of beneficial microorganisms of EM-4 (0, 28.6 and 57.2 liters/ha). The respond (the plant height, total leaves, wet weight and harvested selling weight of the kale) were measured. All observed parameters were not affected by both the dosage of EM-4 and the interaction of dosage of chicken manure and EM-4. The increasing dosage of chicken manure gave a very significant effect on the plant height, total leaves on 20 days after planting, stem diameter on 15 and 20 days after planting, harvested wet weight and harvested selling weight, but had no significant effect on plant height on 5 days after planting and total leaves.

Keywords: chicken manure, beneficial microorganism, dosage, organic matter, andisol, kale

1. Introduction
In conventional agriculture, the excessive use of chemical fertilizers, growth regulators and pesticides would disturb soil ecological balance and made the soil less favorable to plant growth and plants more susceptible to pests and diseases. This might lead to the decrease in crop yield and quality [1]. To change the farming system into a more sustainable one, farmers applied Alternative Agriculture, a system of food production that improve efficiency and maintain production level through practices such as: crop rotation, minimum tillage, integrating crop and livestock, integrated pest management, and
recycling of on-farm wastes as soil conditioner. Effective Microorganism (EM) technology was a potentially valuable tool that could help farmers to develop a more sustainable farming system [2].

Kale (Brassica oleraceaacephala), a dark green vegetable, was a species of Brassicaceae (= Cruciferae) family [3, 5]. It was one of vegetables that contained the largest concentrations of phytonutrients that improve the function of human liver to neutralize toxic substances. Kale was an ideal food not only because it was high in nutrients (it contained over 60 nutrients), but also because it was low in calories, making it a great choice for weight control [4]. It had about six times the recommended daily value of vitamin K. It was also high in vitamin A, vitamin C, and folate, and was a good source of calcium. Kale preferred well-drained, fertile soil high in organic matter with pH of 6.0-7.5, was able to tolerate slightly alkaline soil, preferred plentiful and consistent moisture, was able to tolerate drought but quality and flavor of leaves would suffer [5-6].

Manure was added to meet the kale’s need. The vegetables produced in soils where organic matters were incorporated were improved in its quality and safety because of less chemical residues and better taste [7]. Chicken manure was preferred because of its high concentration of macro-nutrients [8]. It was expected that the cation exchange capacity (CEC), the total exchangeable bases, and the significant increase of nitrogen and phosphorus were gained following the addition of chicken manure [8]. On the other hand, the high pH of chicken manure will greatly influence the nitrification immediately or after a lag phase after the application, causing the loss of N-NO₃ under the favorable condition [9]. Generally, 3 to 10 tons manure per acre was recommended [10]. To maximize poultry litter’s nutrient value, it must be incorporated into the soil immediately after spreading [11]. The addition of chicken-manure composts resulted in significant differences in yield compared with control [12].

The interaction effect between chicken manure and the beneficial microorganism of EM4 was expected since the beneficial microorganisms accelerated the breakdown of organic matter from the manures [13]. Together with the beneficial effect of chicken manure as the source of nutrients and high CEC [8], EM was able to increase crop yields and improve crop quality. The population of beneficial microorganisms in the soil was also increased so it helped in controlling soil-borne diseases through competitive exclusion. The effectiveness of EM can be extended in soils by three applications of EM at 8 - 10 days interval during the first 3 to 4 weeks after planting a crop [13].

The research was done on Andisol Berastagi. Berastagi was well known as a vegetables producer area in North Sumatera, where the farmers apply a conventional, intensive farming system. Andisol has a high water holding capacity, but if it is already dry it is difficult to get wet again. If it is dry, the soil is loose and dusty, so that although soil aggregates are resistant to rainwater destruction, erosion can still occur [14]. Andisol in the Deli area, especially from Mount Sibayak, was formed from the youngest volcanic sediments derived from andesitic materials. The typical formation process produced dark soil containing organic matter up to 17% [15]. The application of the chicken manure and the beneficial microorganisms will show if the high content of organic matter in Andisol has a significant effect in promoting the growth of kale on the soil.

2. Research Methods
The field experiment to investigate the effect of chicken manure and beneficial organisms has been conducted from July to September 2017 in Berastagi, at about 1500 meters above sea level and with average daily air temperature of 19.5°C, and soil type of Andisol with soil pH of 5-6.2. Berastagi is well known by its vegetable production.
2.1. Materials
Kale seed, chicken manure, beneficial microorganisms of EM-4, urea, SP-36 and KCl fertilizers, pesticides of Diazinon 600 EC, Bayrusil and Bordeaux, plastic rope, banner and water were used. Equipments used were: hoe, chopper, calipers, measuring instrument (ruler), water hose, hand sprayer, analytical balance and stationery.

2.2. Experimental Design
The experiment was arranged as randomized block design, consisted of two treatment factors and provided with three replications. The first factor was the dosage of chicken manure (A) that consisted of four levels: $A_0 = 0$ tons/ha (equals to 0 kg/plot), $A_1 = 10$ tons/ha (1 kg/plot), $A_2 = 20$ tons/ha (2 kg/plot), and $A_3 = 30$ tons/ha (3 kg/plot). The second was the dosage of beneficial microorganism of EM4 (E) that consisted of three levels: $E_0 = 0$ liter/ha (equals to 0 ml/plot), $E_1 = 28.6$ liters/ha (2.86 ml/plot), and $E_2 = 57.2$ liters/ha (5.72 ml/plot). Chicken manure contained 57% $H_2O$, 29% organic matter, 1.5% N, 1.3% $P_2O_5$, 0.8% $K_2O$, 4% CaO and had a C / N ratio of 9-11 [19], while the microbes and nutrients contents in EM-4 was presented in Table 1 and Table 2.

| Table 1. Microbes Content in EM-4 |
|-----------------|-----------------|
| **Microbes**    | **Total (cell/ml)** |
| Total plate count | $2.8 \times 10^6$ |
| Phosphate solubilizing bacteria | $3.4 \times 10^5$ |
| Lactobacillus    | $3.0 \times 10^5$ |
| Yeast            | $1.95 \times 10^3$ |
| Actinomycetes    | +               |
| Photosynthetic bacteria | +          |
| E.coli           | 0               |
| Salmonella       | 0               |

| Table 2. Nutrient Content in EM4 |
|-----------------|-----------------|
| **Nutrient**    | **Content**     |
| Organic C       | 1.88 % w/w      |
| Nitrogen        | 0.68 % w/w      |
| $P_2O_5$        | 136.78 ppm      |
| $K_2O$          | 8403.70 ppm     |
| Aluminium       | <0.01 ppm       |
| Calcium         | 3062.29 ppm     |
| Copper          | 1.14 ppm        |
| Iron            | 129.38 ppm      |
| Magnesium       | 401.58 ppm      |
| Manganese       | 4.00 ppm        |
| Sodium          | 145.68 ppm      |
| Nickel          | 0.05 ppm        |
| Zinc            | 1.39 ppm        |
| Boron           | <0.0002 ppm     |
| Chloride        | 2429.54 ppm     |
The observed parameters were: plant height, total leaves, stem diameter, wet weight of plant, and selling weight of plant. For the treatment that significantly affected, the analysis was followed by Duncan Distance Test and regression and correlation test.

There were 12 treatment combinations, those were: A₀E₀, A₀E₁, A₀E₂, A₁E₀, A₁E₁, A₁E₂, A₂E₀, A₂E₁, A₂E₂, A₃E₀, A₃E₁, A₃E₂. With 3 replications, there were a total of 36 plots. The size of the plot used was 1 m x 1 m with a 0.4 m spacing between plots and the distance between replications was 0.6 m. Kale plants were planted using spacing of 20 cm x 20 cm so there were 25 plants in one plot, or the total number of plants was 900 plants. Five plants for each plot were used as samples.

2.3. Experimental Procedure
Seeds were sown on a 1 m x 2 m nursery bed with a ratio of top soil, sand, and compost material was 2:1:1 as growing media. The seeds were evenly distributed on the media and media was maintained in moist conditions. On 10 days after sowing the plants were transplanted into 1 m x 1 m plots with a spacing of 20 cm x 20 cm. The row (replication) was north to south headed. After the plants were transplanted, they were watered until the soil reached moist condition.

Throughout the growing period, the soil was maintained in moist conditions by watering it when it did not rain. Insertion was carried out for kale that did not grow at 4-7 days after transplanting (DAT). The plants used for insertion were the plant that had been in the nursery for 14 - 17 days. Weeding and piling up the soil around the root area were done with caution using a manual mower. Pest control was done since the transplanting time, because caterpillars had attacked by that time, up to 5 days before harvest. The control of cabbage caterpillar (Plutellamaculipennis) used Diazinon 600 EC insecticide with the dosage of 1-2 ml dissolved into one liter of water. Kale was harvested at 32 DAT, when it had shown harvesting characteristics such as: the plants had reached the point of growth, all the leaves were perfectly opened, the plants had a normal growth and a fresh look. Harvesting was done by removing the kale, including its roots, from the soil.

Beneficial microorganism of EM4 was applied by mixing it with 1 litre of water and then spraying it to the surface of kale plant media. This fertilizer (EM4) was applied three times, ie at 3 days before planting, and when the plants were 7 and 15 DAT old. Each level of dosage was applied for three times applications. For example, as for E2 = 5.72 ml/plot, for one application it was given as: (5.72 ml/plot : 3) = 1.9 ml/plot]. The effectiveness of EM can be extended in soils by three applications of EM at 8 - 10 days interval during the first 3 to 4 weeks after planting a crop [11]. Decomposed chicken manure was given once, at one week before planting. According to the dosage level, to maximize chicken manure’s nutrient value, it was incorporated into the soil immediately after spreading [11]. Generally, 3 to 10 tons manure per acre of garden area was recommended [10].

3. Result and Discussion

3.1. Result
A summary of the results of analysis of variance of the effect of dosage of chicken manure, beneficial microorganisms of EM-4 and the interaction between the two on the observed parameters were presented in Table 3. The dosage of chicken manure had a very significant effect on the plant height on the age of 10, 15 and 20 DAT, total leaves on 20 DAT, stem diameter on 15 and 20 DAT, harvested wet weight and harvested selling weight, but had no significant effect on plant height on 5 DAT and total leaves on 5, 10, and 20 DAT. The correlations between the chicken manure dosage and the very significantly affected parameters were shown in Table 4. Both the dosage of EM-4 and the interaction between the two factors had no significant effect on all parameters.
Table 3. Results of Analysis of Variance on the Effects of the Dosage of Chicken Manure and EM-4 Beneficial Microorganism and Interaction Between Both Treatments on the Observed Parameters

| Treatment | Observed Parameter | Plant Height (cm) | Stem Diameter (mm) | Total Leaves | Harvested wet weight (g/plot) | Harvested selling weight (g/plot) |
|-----------|-------------------|-------------------|-------------------|-------------|-------------------------------|----------------------------------|
|           |                   | 5 DAT             | 10 DAT            | 15 DAT      | 20 DAT                        | 5 DAT                           | 10 DAT                          | 15 DAT                          | 20 DAT                          |
| Chicken Manure Dosage (A) | us             | **                | **                | **          | us                            | us                             | us                              | us                              | **                             |
| EM-4 Beneficial Microorganism Dosage (E) | us             | us                | us                | us          | us                            | us                             | us                              | us                              | us                             |
| Interaction = A x E | us             | us                | us                | us          | us                            | us                             | us                              | us                              | us                             |

Note: The sign ** means very significantly, while us means not significantly

Table 4. The Correlations Between Chicken Manure Dosage and The Very Significantly Affected Parameters

| Parameter                  | Age of Kale (days after transplanting) | Correlation | R²   | r    |
|----------------------------|----------------------------------------|-------------|------|------|
| Plant height               | 10                                     | y = 0.47 x + 8.76 | 0.99 | 1.00 |
| Total leaves               | 15                                     | y = 1.01 x + 10.75 | 0.93 | 0.97 |
|                           | 20                                     | y = 1.96 x + 14.72 | 0.91 | 0.95 |
| Stem diameter              | 20                                     | y = 0.35 x + 3.14 | 0.96 | 0.98 |
|                           | 32                                     | y = 0.82 x + 5.07 | 0.97 | 0.98 |
| Harvested wet weight       | 32                                     | y = 4.92 x + 12.49 | 0.93 | 0.96 |
| Harvested sold weight      | 32                                     | y = 4.37 x + 9.81 | 0.93 | 0.97 |

The relationship between the dosage of chicken manure and the plant height, total leaves and stem diameter on 20 DAT and the harvested wet weight and selling weight are shown in Figure 1, 2, 3, 4 and 5, respectively.
3.2. Discussion

3.2.1. The Effect of the Dosage of Chicken Manure on Growth and Production of Kale Plant. The addition of chicken manure to the soil had no significant effect on the parameters observed at the beginning of plant growth. This was due to the relatively slow nature of organic fertilizer responded by...
the plant because it must be decomposed first before it can be available for the plants. Chicken manure was slowly released, but compared to manure derived from other animal waste, chicken manure was relatively quickly decomposed. This was indicated by the results of the research where chicken manure had a very significant effect on kale plant height since the observation at age of 10 DAT, total of plant leaves at 20 DAT and stem diameter at 15 DAT.

The benefits of using manure were: (a) supplying N-NH4, (b) increasing the availability of P and micro-nutrients [8, 10, 11, 17], (c) increasing soil moisture, (d) increasing the infiltration rate and decreasing soil bulk density [11, 17], (e) improving soil structure [11], (f) increasing the buffer capacity to drastic pH changes, (g) binding Al+++ thereby reducing its poisoning ability [17], (h) increasing soil CEC due to the humus decomposed from chicken manure, (i) increasing exchangeable bases [8], and (j) increasing the soil organic matter content [11].

Chicken manure also had a very significant effect on the harvested wet weight and the harvested selling weight of the kale. Chicken manure should be considered as a source of nitrogen [17]. Nitrogen functioned for vegetative growth (leaves, roots and stems). Since N was a chlorophyl material, the plant leaves with the addition of chicken manure became greener. The high concentration of nitrogen would cause the formation of large cells, so the leaves of the plant became wider and more vigorous. The harvested wet and selling weight (the yield of kale) were influenced by the height of the plant and the number of leaves; the higher the plant and the more the number of leaves the weight would increase. The low yields harvested from the soil without manure (control treatment) were due to the insufficient supply of plants in nitrogen, leading at first to limitation of carbon assimilation, resulting in reduction of plant productivity [12].

The composition of chicken manure varied according to age of the chicken, moisture content and age of the manure, kind and amount of litter, and storage and handling practices [10]. On the basis of available nutrients, in average 1 ton of manure provides 2.2 kg N, 0.2 kg P and 1.9 kg K [18], while the chicken manure used in this experiment had a C/N of 17.5 and contained: 2.54% of N, 1.48% of P, 0.80% of K and 44.2% of organic-C. When manure was easily found, it was suggested to use it for vegetable crops [18]. Manure supplied a limited amount of nitrogen, phosphorus and sulfur, plus some micro and chelate elements. If used wisely, manure was a good fertilizer, even if the phosphorus was low [14, 18].

The kale was grown on Andisol. Andisol had to meet the following criteria: (1) more than 60% volume of volcanic material were more than 2 mm in diameter, or (2) had 900 kg/m2 of density (lighter than water), or (3) contained a considerable amount of volcanic glass, (4) very high phosphate retention, and (5) contained mainly amorphous clay materials. Allophane amorphous clay had a very high CEC (up to 150 cmol/kg). This soil was fast and strong phosphate absorb, so the P fertilization efficiency was only about 10%. Andisol had a high water holding capacity, but if it was already dry it was difficult to get wet again. If it was dry, the soil was loose and dusty, so that although soil aggregates were resistant to rainwater destruction, erosion still occurred [14].

Andisol contained a high organic material up to 17% [14, 15]. Yet, this study showed a very significant effect of chicken manure on the growth and production of kale. The response of kale plant to the addition of chicken manure as a source of organic matter was an indication that the original content of Andisol organic material had been much reduced due to intensive agricultural practices conducted in the region. Its erosion-sensitive nature [14] also caused a decrease in soil humus levels.

In many traditional farming systems in the tropics, intensive farming was becoming increasingly important because of the limited availability of agricultural land. An intensive farming system, with more than one plant species planted in a year, will lead to a substantial decrease in soil nutrient contents due to harvesting. Increased production due to the use of N, P and K fertilizers, along with increased planting intensity, tend to cause a deficiency of other nutrients, especially micro nutrients. Organic fertilizers was potentially good in correcting some soil problems at the same time: supplying organic
matter, creating appropriate water regimes and air systems in root areas, and acting as micro nutrient carriers [14].

3.2.2. The Effect of the Dosage of EM4 Beneficial Microorganism on Growth and Production of Kale Plant. The result of analysis of variance showed that the application of EM4 beneficial microorganism had no significant effect on all parameters at any time of observation. This was presumably because the EM4 given was washed away by the rain. During the experiment, rain occurred almost every day. According to rainfall data in the research location, on August 11th (after application I), the 17th (after application II) and the 23rd (after application III) there were heavy rainfalls that was suspected to wash EM4 solution from the soil.

The activity of soil microorganisms was strongly influenced by climate, soil and vegetation factors. It was difficult to define the same conditions for all microbes in the soil because each group had different growth requirements. Generally, many microbes developed in soils that had moisture around the field capacity, pH around neutral, high nutrient content, and temperatures around 30°C [14].

To encourage the development of beneficial microbial populations, several efforts can be done: (1) Inoculate the soil with desirable symbiotic organisms, (2) Lime the soil up to pH value of 6. Do not over lime, (3) Minimize fumigation or soil sterilization, which killed both adverse and beneficial biota, (4) Maintain soil organic matter as high as possible by considering cost, time, and other management issues, (5) Avoid contamination. Infected plants must be burned or thrown away, not buried in soil or in compost piles, (6) Avoid stress conditions: drought, salt accumulation, inundation, addition of excess fertilizer [14]. The use of pesticides since transplanting in this experiment might limit the activity, or even killed, some or all of the microbial population added through EM4 applications.

3.2.3. The Effect of Interaction Between the Dosage of Chicken Manure and EM4 Beneficial Microorganism on Growth and Production of Kale Plant. The result of analysis of variance showed that the interaction between the two treatments had no significant effect on all parameters. This was thought to be due to the fact that the effect of single treatment of chicken manure dosage was much more dominant than the single effect of dosage of EM4 beneficial microorganism. Since the high rainfall allegedly washed away the EM4 solution from the soil, then it seemed as if there was no treatment of EM4. Therefore, no interaction effects appeared; what was observed was the single effect of the dosage of chicken manure only.

4. Conclusions
Increased dosage of chicken manure up to 30 tons/Ha significantly increased kale plant height at the age of 10, 15 and 20 days after transplanting (DAT), total of kale leaves at 20 DAT, stem diameter at 15 and 20 DAT, harvested wet weight and harvested selling weight of kale plant, but it did not affect the height of the kale plant at 5 DAT and the total leaves at 5, 10 and 15 DAT. The relationship between the dosage of chicken manure and those variables were linear. The dosage of EM4 beneficial microorganism and its interaction with the dosage of chicken manure did not affect all of the observed growth and yield variables of kale plants.

An intensive farming system on Andisol was recommended to include the use of organic fertilizer in its management of fertility.
5. References

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