Effect of zeolite and cow manure application on soil nitrogen content in ramie (Boehmeria nivea) plant growth

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Abstract. Ramie productivity can achieve optimum through improving soil fertility and adding cow manure and zeolite to the soil. The research was conducted in 2018 at Karangploso Research Station-ISFRI. The research design used was a completely randomized design with two factors of manure and zeolite, three replications. Cow manure treatments consisted of no cow manure (P0), 2 tons cow manure (P1), 4 tons cow manure (P2), 6 tons cow manure (P3), while zeolite treatments consisted of no zeolite (Z0) and 4 tons zeolite/ha (Z1). The results showed that the application of zeolite and cow manure affected soil properties and the growth of ramie. The combination treatment of fertilizer and zeolite gave various values of pH, N, C-organic, plant height, and the number of leaves, although there was no interaction. The best results were found in treating 6 tons/ha of cow manure and 4 tons/ha of zeolite with pH values: 6.37 and 6.26; N-Total 0.14% and 0.15%; C-Organic: 1.14% and 1.13%, respectively. Treatments of 6 tons cow manure and 4 tons zeolite gave the best hemp growth, namely plant height at 84 (Days After Planting), DAP 123.23 cm and 98.5 cm, and the number of leaves 104 80.

1. Introduction

Hemp (Ramie), as an annual crop, produces natural fiber, which is harvested every two months. Ramie fiber is one of the strongest, natural fine textile fibers in the world, obtained from the bark of the plant, grown mainly in tropical and temperate regions [1, 2, 3]. It possesses the highest strength, good durability, excellent luster, and micro resistance property. Based on this, ramie is cultivated to grow well so that vegetative growth is optimal and produces large biomass [4, 5]. Approach through land improvement is a wise step. Providing ameliorant materials in the form of zeolite and organic matter can increase soil fertility and stimulate the availability of nutrients needed by ramie plants. The requirements for growing ramie are loose soil and a good level of fertility [4]. The development of ramie on less fertile soil will affect ramie productivity and fiber quality.

At the time, imports of cotton fiber raw materials reached 99% for the textile industry and textile products in Indonesia [5]. Meanwhile, domestic cotton is decreasing because many farmers prefer to grow food crops such as rice, corn, soybeans, and sesame. Ramie is a fiber-producing plant that can be used as a substitute for cotton. The textile industry in Japan uses 70% cotton and 30% ramie fiber as raw materials. In general, Japan prefers textiles from a blend of cotton and ramie because Japan has a subtropical climate, whereas, in winter, the textiles made from cotton and ramie blend feel warm when worn. The increase in population is followed by the increase in the need for textiles [6].
The soil amendments are substances added to soil to improve or modify the quality and condition of the soil, including physical, chemical, and biological properties. The choice of soil improvement material depends on what we want to improve, such as the level of soil degradation, composition, microclimate, and other specifications [7]. Soil amendments can be used to increase the fertility of ultisol soil. Commonly used soil amendments are lime, organic matter, natural phosphate material, biochar, and zeolite. Geologically, Indonesia has big potential to produce zeolites such as those found in Lampung, West Java, Central Java, East Java, East Nusa Tenggara, and Sulawesi, with the estimated resources of 447,490,160 tons [8].

Applications of zeolites are based on their characteristics. Initially, natural zeolites were used as industrial materials, improvement of agricultural production, and environmental protection. Zeolite is a material that can hold water and no nutrients in the soil. In addition, zeolites have a high cation exchange capacity (CEC) (120-180 me/100g). According to [9] stated that zeolite is useful as an adsorbent, binding, and cation exchange. Applications of zeolites can be used directly to soils as materials for growth media, mixed with manures during the decomposition process, and for mixing with urea as a slow-release agent.

Optimal crop productivity level is achieved in stable soil aggregates and good soil fertility. Sandy soil has a low fertility rate. One of the efforts to increase the fertility of sandy soil is to add organic matter. Cow manure that has been fermented is classified as organic matter. Cow dung manure can improve soil structure and texture, improve soil water absorption, improve living conditions in the soil, and as a source of nutrients for plants [10]. The objective of this study was to determine the effect of zeolite and cow manure applications on the growth of ramie plants and soil fertility.

2. Materials and methods

The research was conducted in 2018 at the Greenhouse of Karangploso Research and Assessment of Agricultural Technology – Indonesian Sweeteners and Fiber Crops Research Institute (ISFCRI). The materials used consisted of soil, organic matter (cow dung manure), zeolite, polybag, Phonska, Urea and KCl fertilizer, fungicides, ramie variety of Ramindo 1. While the equipment used is a scale, measuring cup, meter gauge, hygrometer, caliper, pruning shears, and hoe. The Research design used a completely randomized design with two factors and three replications. Cow manure treatments consisted of no cow manure (P0), 2 tons cow manure (P1), 4 tons cow manure (P2), 6 tons cow manure (P3), while zeolite treatments consisted of no zeolite (Z0) and 4 tons zeolite/ha (Z1). The eighth combination of cow manure and zeolite treatment is presented in Table 1.

| Code   | Treatment Dose                                      |
|--------|-----------------------------------------------------|
| P0Z0   | No manure and zeolite                               |
| P0Z1   | Zeolite 4 tons/ha                                   |
| P1Z0   | Cow manure 2 tons/ha                                |
| P1Z1   | Cow manure 2 tons/ha and zeolite 4 tons/ha          |
| P2Z0   | Cow manure 4 tons/ha                                |
| P2Z1   | Cow manure 4 tons/ha and zeolite 4 tons/ha          |
| P3Z0   | Cow manure 6 tons/ha                                |
| P3Z1   | Cow manure 4 tons/ha and zeolite 4 tons/ha          |

Basic analysis was conducted before the research activity took place with intending to know the actual nutrient status and actual land conditions. The basic analysis was be done at East Java Assessment Institute for Agricultural Technology in Malang Regency. The basic analysis included complete soil chemical properties, namely N-total, available P, pH, C-organic, K, Ca, Mg, Na, Cation exchange capacity (CEC), and texture. Soil sampling was carried out in a composite of five different points with a depth of 20 cm.
The planting medium used in this study was 20 kg of air-dried soil, which was then treated with cow manure fertilizer and zeolite. The soil used was taken from the topsoil layer at a depth of 0-20 cm. The soil was dried for three days, then put into a 20 kg polybag. Ramie cultivation in the form of rhizomes cuttings obtained from Indonesian Sweeteners and Fiber Crops Research Institute (ISFRI). Rhizomes of 12-15 cm length and 1.2-2.5 cm diameter (each weighing about 10-15 g) taken from 4 years old plantations are suitable for planting. The planting used one rhizome in each polybag 7-8 cm diameter. Ramie seedlings are planted at a depth of 5-6 cm by forming an angle of 45 degrees, and the shoots are faced upwards so that growth is faster [4].

The treatment application was carried out at planting time, with 4 grams of urea and 8 grams of Ponska per polybag given as basic fertilizer. Ramie is a heavy feeder of nutrients and should be fertilized optimally to get a better yield. Cow manure fertilizer used that has been sifted and applied together with zeolite according to the treatment. Observations of plant growth were carried out in the vegetative phase to the beginning of the generative phase. Parameters observed included plant height and the number of leaves of ramie plants. Plant height was measured using a roller meter, while the number of leaves was observed manually by counting leaves that had fully opened and grew normally. Observations began when the ramie plant was 14 days after planting with an interval of 14 days, namely 14, 28, 42, 56, 70, and 84 days after planting (DAP).

Parameters observed consisted of plant height growth and the number of leaves. Measurement of plant height growth was carried out at the soil surface to the shoot tip of the ramie plant. The calculation of the number of leaves is carried out on leaves that are in all branches. Analysis of the soil to be used as a planting medium was carried out before the research activity. The data were processed using the Genstat application. If the analysis results show that there are differences between treatments, then it is continued with the Duncan’s Multiple Range Test (DMRT) test at 5%.

3. Results and discussion
Basic analysis was carried out to determine soil characteristics, chemical properties, and soil texture. Chemical properties carried out include pH, C-organic, and N-total (Table 2). Based on the results of soil analysis, it was shown that the texture of the growing medium used in the ramie plant experiment
was sandy loam with a composition of 39% sand, 32% silt, and 29% clay. The soil content was dominated by the sand fraction, had many macropores, so the water and nutrient holding capacity were very low. The soil used in this study has a pH value of 5.60 with a slightly acidic criterion, and low C-organic content of 0.87. This agrees with Darlita, Joy and Sudirja [11], who stated that generally, sandy soils have a low C-organic content. The total N-content of the soil is 0.10%, which is relatively low. With low N-total and C-organic content, nitrogen fertilizer application is needed at the beginning of ramie plant growth.

### Table 2. Results of experimental soil analysis before treatments.

| Test Parameter     | Value | Criteria     | Method/Tool       |
|--------------------|-------|--------------|-------------------|
| Water content %    | 3.62  | -            | Gravimetry        |
| pH H$_2$O          | 5.60  | A bit acid   | pH meter          |
| C-organic %        | 0.87  | Very low     | Walkley & Black Kkedahl |
| N-Total %          | 0.10  | Low          |                   |
| Fraksi             |       |              |                   |
| Sand %             | 39    |              |                   |
| Dust %             | 32    |              |                   |
| Clay %             | 29    |              |                   |
| Texture class      | Sandy loam |            | USDA texture triangle |

The results of soil analysis after treatment showed changes in pH, N-total, and C-organic values, as shown in Table 3. Table 3 shows the effect of manure and zeolite on the value of pH, N-total, and C-organic. The value of pH, N-total, and C-organic increased with increasing doses of both manure and zeolite. The addition of cow manure at doses of 2, 4, and 6 tons/ha could increase soil pH 6.07, 6.21, and 6.37, although it still belongs to the slightly acid category. The results of soil analysis showed that the application of zeolite could increase soil pH. This phenomenon is because the negative charge on the zeolite can bind H$^+$ ions, where H$^+$ cations are one of the main factors causing soil acidity, so soil pH increases. These results are in accordance with Suwardi [9], who stated that zeolite was alkaline and undergoes silicate hydrolysis to produce OH$^-$ ions which can bind H$^+$ ions in the soil and has an impact on increasing soil pH. According to Santoso and Sastrosupadi [4], which states that optimal growth of flax can be achieved at the desired soil (pH) in the range of 5.4-6.5, with an average annual rainfall of 1,500-2,500 mm. There was no interaction between cow manure and zeolite treatment.

### Table 3. Effect of fertilizer and zeolite on pH, N-total, and C-organic values at 84 DAP.

| Treatments | pH   | N-Total (%) | C-Organic (%) |
|------------|------|-------------|---------------|
| Manure     |      |             |               |
| P0         | 5.95 | 0.13        | 0.92          |
| P1         | 6.07 | 0.14        | 1.11          |
| P2         | 6.21 | 0.14        | 1.14          |
| P3         | 6.37 | 0.14        | 1.14          |
| Zeolite    |      |             |               |
| ZO         | 6.04 | 0.12        | 1.06          |
| Z1         | 6.26 | 0.15        | 1.13          |
| P x Z Interaction | ns* | ns          | Ns            |

*Not significant

Cow manure and zeolite both function as soil enhancers. Giving cow dung fertilizer combined with zeolite can increase soil pH. This phenomenon was supported by the statement of Evanita, Widaryanto...
and Suwarsono [12] that manure, apart from being a nutrient supply, can also improve soil physical properties such as soil permeability, soil porosity, structure, water holding capacity, and soil cations.

In general, the addition of manure or zeolite alone can increase the total N-value of the soil, although there is no interaction between both factors. The addition of cow manure 2, 4, and 6 tons/ha can increase the total N-value from 0.13 to 0.14. The application of zeolite 4 tons/ha had a significant effect on increasing the total N-value of the soil from 0.12 to 0.15. The addition of zeolite to the soil can increase the capacity of $K^+$ and NH$_4^+$ high nutrient absorption. Besides that, it can reduce nitrogen loss due to leaching and nitrification. Thus, more nutrients are available to plants to support growth and production. Ramie plants, in order to grow optimally, require fertile and loose soil with textures of loam, sandy, loamy loam, loam, and dusty clay loam, which are generally dominated by ultisol, andisol, and entisol soil types [6, 13].

The results of the analysis of variance showed that the combination of cow dung and zeolite treatments had no interaction at all ages of observation on the parameters of plant height and number of leaves (Tables 4 and 5). However, the application of cow manure and zeolite separately showed a significant effect on increasing the plant height of ramie at 42 days after planting (Table 4). In contrast, the application of zeolite showed no significant difference in plant height at other ages of observation.

### Table 4. Effect of fertilizer and zeolite on the number of leaves at various ages of observation.

| Treatments | 14 DAP$^b$ | 28 DAP | 42 DAP | 56 DAP | 70 DAP | 84 DAP |
|------------|------------|--------|--------|--------|--------|--------|
| **Manure** |            |        |        |        |        |        |
| PO         | 9.83 a     | 16.17 a| 23.00 a| 48.67 a| 58.33 a| 69.83 a|
| P1         | 9.83 a     | 19.67 b| 30.50 b| 53.83 ab| 72.00 b| 88.00 b|
| P2         | 9.50 a     | 20.50 b| 31.50 b| 59.83 bc| 87.00 c| 101.00 c|
| P3         | 11.83 b    | 26.00 c| 37.00 c| 66.00 e | 101.00 d| 123.33 d|
| **ZeoBo**  |            |        |        |        |        |        |
| Z0         | 9.63       | 19.80  | 28.50 a| 55.20  | 77.30  | 92.50  |
| Z1         | 10.66      | 21.60  | 32.50 b| 58.90  | 81.80  | 98.50  |

$^a$ Numbers in the same column followed by the same letter are not significantly different at the 5% Duncan’s Multiple Range Test
$^b$ DAP = Day After Planting

Table 4 showed that plant height at various ages of observation was increased with increasing manure application rate. Increasing manure rate from 0 to 6 tons/ha manure was increased plant height, respectively. In comparison, the application of zeolite has not shown a significant difference in plant height, although there is a tendency that the addition of zeolite can increase plant height growth.

The parameter of the number of leaves, the combination treatment of cow manure with the application of zeolite showed an interaction at 56 days after planting (Table 5), while the observations at 14, 28, and 42 days after planting did not show any interaction.

### Table 5. Effect of fertilizer and zeolite on the number of leaves at various ages of observation.

| Treatments | 14 DAP$^b$ | 28 DAP | 42 DAP | 56 DAP | 70 DAP | 84 DAP |
|------------|------------|--------|--------|--------|--------|--------|
| **Manure** |            |        |        |        |        |        |
| PO         | 8.50 a     | 14.83 a| 17.33 a| 42.33 a| 43.00 a| 50.17 a|
| P1         | 9.33 a     | 17.17 ab| 23.83 b| 44.67 a| 52.83 ab| 70.50 b|
| P2         | 8.50 a     | 17.50 b| 24.17 b| 48.33 b| 61.50 bc| 88.83 c|
| P3         | 10.50 b    | 21.83 c| 25.17 b| 51.33 b| 71.00 c | 104.17 d|

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The important characteristics of zeolites are the increase in cation exchange capacity (CEC), the ability to absorb ammonium ions, and the porosity of the structure. Some of these characteristics have the potential as a soil ameliorant, slow-release for nitrogen fertilizer, and improvement of plant growth media. Zeolite application has a positive effect on soils with low CEC, such as Oxisols, Ultisols, and some Inceptisols with a dose level of 10-15 tons/ha. In this study, the application of zeolite on ultisol soil as much as 6 tons/ha was still below the optimal dose, so it had not been able to significantly increase plant height growth and number of leaves.

According to [9] that the addition of zeolite can increase the surface area of plant roots, thereby increasing the roots ability to absorb nutrients. Thus, the nutrients added through cow manure are more efficiently absorbed by the roots of the ramie plant to support the growth in the form of an increase in plant height and number of leaves. In addition, the addition of zeolite into the soil can increase the capacity for absorption of high $K^+$ and $NH_4^+$ nutrients. Besides that, it can reduce nitrogen loss due to leaching and nitrification. Thus, more nutrients are available to plants to support growth and production. The ability of zeolite to absorb ammonium can inhibit the conversion of ammonium to nitrate so that the loss of N in the form of nitrate can be suppressed. Furthermore, the nitrogen adsorbed by the zeolite will be released slowly according to plant needs [14].

The application of zeolite and cow dung can increase ramie plant growth in height, and the number of leaves, because the addition of zeolite and cow dung can improve soil aggregation and increase the soil ability to absorb nutrients, and water. In addition, the addition of cow manure and zeolite can increase soil air pores, thereby expanding root range and increasing plant growth [15]. In sandy soil, adding cow manure fertilizer and zeolite can increase the soil's ability to hold water, thus maintaining soil moisture, and speeding up the rewetting process. The mixture of cow manure fertilizer and zeolite makes fertilizer available slowly, controls water reserves, is able to absorb and exchange cations [16]. The combination of zeolite and cow manure can have a positive effect on plant growth, because zeolite and manure can store water and nutrients, which can then be reused to be absorbed by plant roots [17].

Zeolite can bind and store water and fertilizer temporarily, and then it is easily released back to be used by plants, as zeolite functions as a slow-release agent. Zeolites only function as carriers in regulating the release of nutrients and water for plants. The addition of zeolite without being accompanied by the addition of fertilizers and other materials needed by plants will have a negative effect on plants because some of the nutrients will be absorbed by the zeolite.

4. Conclusion
The treatment of giving 6 tons of cow manure increased the growth of plant height and number of leaves at each age of observation. Zeolite had no effect, but there was an increase in the value of pH, N-total, and C-Organic by 6.26, 0.15%, and 1.13%, respectively. The N content in the soil increased with the application of zeolite and cow manure. This research needs to be continued in field conditions using higher doses of zeolite, observing plant nutrient uptake and fiber production.

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