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# Growth Response of *Artemisia annua* by Effect of Types and Composition of Organic Fertilizer in Lowland

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**Abstract:** *Artemisia annua* is a plant used to cure malaria diseases. *Artemisia* plant contains artemisinin as secondary metabolite that used to eliminate parasite that caused malaria, such as *Plasmodium falciparum*. *Artemisia* growth affects production of artemisinin content in plant. Therefore, necessary environment conditions and appropriate organic manure application are needed to support the growth of *Artemisia.* This research aimed to determine the effect of fertilizer type and proportion in the medium on the *Artemisia* growth. This research was conducted at greenhouse of Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, in October 2015 to January 2016. This research used a completely randomized design (CRD), consisting of two factors of treatment with three replications. The first factor was type of fertilizer that consists of three types: horse manure fertilizer, compost filter press mud and cow manure fertilizer. The second factor was proportion of fertilizer with media consisted of five levels: fertilizer as media, proportion of fertilizer with media 4:1, 3:2, 2:3 and 1:4. Data were analyzed using analysis of variance and Duncan's multiple range test with level of 5%. It can be concluded that treatment with compost filter press mud provided the highest of plant height, root length, days to flowering, root volume, fresh weight and dry weight of crop.

**Key words:** *Artemisia annua*, productivity, compost, manure.

## 1. Introduction

*Artemisia* is a medicinal plant that has been used since ancient times by Chinese people to treat malaria fever. The active ingredient in this plant is called "Qinghaosu" in Chinese or artemisinin [1]. The compound artemisinin is derived from the raw substance extracted from the plant *Artemisia*. Artemisinin is clinically proven to inhibit the development of *Plasmodium* sp., the cause of malaria, therefore, artemisinin is used as an active ingredient for mixture of anti-malarial drugs [2].

*Artemisia* is widely grown in the highlands, because these plants can grow well at an altitude of 1,000-1,500 masl. Increasing of *Plasmodium falciparum* resilience is the main reason why this plant needs to be cultivated on the lowland to support the production of artemisinin in addition to the highlands, for the treatment of malaria. *Artemisia* cultivation can be done in generative and vegetative. In order to increase the productivity of these plants, a treatment is needed to speed up the production, one of which is treatment with organic fertilizers that serves to support the adequacy of nutrients on plant growth. Organic fertilizer is commonly used in agriculture, namely compost.

Compost is a fertilizer decomposition of organic matter. This fertilizer has a function to improve soil structure by increasing the organic matter content and improve soil ability to retain soil water content. Plants fertilized with compost tend to have a better quality rather than plants fertilized with chemical fertilizers. Compost application can improve plant growth and nutrient in a medium [3]. Besides compost, animal manure is a fertilizer that can supply the needs of nutrients for plants. Horse manure is a natural fertilizer that has good organic matter content, where the content of organic C, N and available P and K is generally very high. Horse manure fertilizer is likely

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to accelerate the vegetative phase than generative phase of the plants [4].

Cow manure is an organic fertilizer, which has sufficient nutrient for plant growth. Cow manure has a different nutrient composition than other organic fertilizers [5]. The availability of nutrients from fertilizers is affected by the degree of decomposition or mineralization of organic materials. Nutrients from animal manure are likely to form N, P and other elements contained in the form of complex compounds organic protein or humic acid compounds or lignin. *Artemesia* cultivation, using a combination of horse manure, compost filter press mud and compost cow dung has a purpose to determine the effect of type and proportion of fertilizer with media on the growth of *Artemisia*.

## 2. Research Methods

The research was conducted in October 2015 to January 2016, at greenhouse of Faculty of Agriculture, Universitas Sebelas Maret, Surakarta, Indonesia, with an altitude of 95 masl. The tools used in this research include plastic pots (diameter 30 cm), scissors, measuring cup, towel, bamboo, hoe, scales, oven, rope, ruler, bucket, water hose, watering can, stationary, labels, board and a set of tools for laboratory analysis. Materials used include seeds of *Artemisia*, soil (Inceptisol), horse manure, cow manure and compost filter press mud.

The fertilizer used was dried until it became crumble and easily mixed with the soil. If the drying is enough, fertilizer can be mixed with soil with a medium proportion of 4:1, 3:2, 2:3 and 1:4, then stirred uniformly to soil and mixed with fertilizer. The seeds of *Artemisia* are collected from dried *Artemisia* flowers and then threshed on a clean container.

This study used a completely randomized design (CRD) factorial, consisting of two factors with three replicates in order to obtain 48 combinations of treatments in 24 $m^2$ plot size. The first factor was the type of fertilizer which consisted of three types: horse manure, compost filter press mud, composted cow manure. The second factor is the proportion of fertilizer to the medium consisting of five levels: fertilizer as a medium, proportion fertilizer with the medium 4:1, 3:2, 2:3 and 1:4. Data were analyzed using analysis of variance and Duncan multiple range test with level of 5%.

## 3. Results and Discussion

### *3.1 Plant Height*

The treatment of compost filter press mud with fertilizer as medium showed the highest average plant height of 155.53 cm, whereas the fertilizer treatment horse manure with medium proportion 3:2 showed the lowest average plant height of 70.33 cm (Table 1).

The results of this study showed that fertilizer at high doses will cause increasing response. The relationship between treatment types of fertilizer with a proportion of fertilizer with the medium was that the higher amount of fertilizers applied to crops can increase productivity, while at doses that exceed certain threshold can reduce crop productivity. A fertilizer

**Table 1 Height of plants (cm) on different types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | 85.60$^{ab}$ | 155.53$^{c}$ | 83.07$^{ab}$ |
| Fertilizer:soil (4:1) | 83.73$^{ab}$ | 90.00$^{ab}$ | 120.37$^{abc}$ |
| Fertilizer:soil (3:2) | 70.33$^{a}$ | 98.57$^{abc}$ | 138.57$^{bc}$ |
| Fertilizer:soil (2:3) | 137.17$^{bc}$ | 113.37$^{abc}$ | 100.60$^{abc}$ |
| Fertilizer:soil (1:4) | 118.97$^{abc}$ | 112.97$^{abc}$ | 123.40$^{abc}$ |

Numbers followed by different letters are significantly different in DMRT 5%.

containing cow manure can help increase soil organic matter, as cow dung is an organic fertilizer that contains organic matter [6].

It can be seen from the data of the average height of the plant that the addition of fertilizer with a certain dose percentage can have a positive effect on *Artemisia* plant height. If the addition of organic fertilizer is done with excessive doses, it will cause obstructed growth of *Artemisia*.

### *3.2 Number of Branches*

The lowest number of branches was shown on horses manure treatment with proportion of medium 4:1, which was 40 branches. The highest number of branches was the treatment of compost filter press mud with a proportion of medium 1:4 of 74 branches (Table 2).

Based on the average value, plants treated with compost filter press mud, which have the highest average number of branches, have a positive effect on the number of branches. The availability of nutrients causes a good growth of the plants and easier nutrients absorbance, so the plants will form new branches well [7]. The nutrient P can cause disturbances in metabolism and development of plants, including inhibiting the growth, such as not increasing the number of branches [8]. Increased doses of fertilizer can stimulate lateral meristem activity and nutrient uptake, especially N, because high amount of N is needed to increase vegetative growth, such as the establishment of new branches [9]. The establishment of the branches (lateral buds) in plants is influenced by internal factors, which process the apical dominance related to the proportion auxin-cytokinin hormone produced by the plant [10]. According to Pangli [11], the loose spacing will allow the process of photosynthesis, which is enough to plant, so it will stimulate the growth of productive branches. Based on this, it is expected that plant *Artemisia* with fertilizer treatment has a high number of branches despite growing in lowland greenhouse.

### *3.3 Time of Flowering*

Flowering age was observed from the vegetative phase to the time of flowers' appearance (generative phase). Based on Table 3, the longest flowering time was shown by cow manure compost treatment with medium proportion of 1:4, which is 77.67 d, while treatment with horse manure as a medium treatment showed the fastest flowering time of 42.33 d (Table 3).

**Table 2 Number of branches on various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | 47.00 | 57.00 | 51.00 |
| Fertilizer:soil (4:1) | 40.00 | 47.00 | 48.67 |
| Fertilizer:soil (3:2) | 50.67 | 56.67 | 43.33 |
| Fertilizer:soil (2:3) | 44.00 | 53.67 | 47.00 |
| Fertilizer:soil (1:4) | 49.33 | 74.33 | 51.00 |

**Table 3 Time of flowering (d) on various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | $42.33^{a}$ | $76.33^{fg}$ | $66.67^{cdefg}$ |
| Fertilizer:soil (4:1) | $57.00^{bc}$ | $68.33^{cdefg}$ | $62.00^{bcde}$ |
| Fertilizer:soil (3:2) | $52.33^{ab}$ | $66.33^{cdefg}$ | $71.00^{defg}$ |
| Fertilizer:soil (2:3) | $52.33^{ab}$ | $57.00^{bc}$ | $73.33^{efg}$ |
| Fertilizer:soil (1:4) | $57.67^{bcd}$ | $63.00^{bcdef}$ | $77.67^{g}$ |

Numbers followed by different letters are significantly different in DMRT 5%.

Based on observational data, fertilizer types and proportion of fertilizer with the medium had significant effect on flowering time.

According to Lima et al. [12], application of fertilizer on crops tends to stimulate vegetative growth, causing the plants to flower normally. Good vegetative growth will have an impact on the productivity of a crop that flowering age and harvest time tend to be faster [13]. Flowering time indicates the time it takes for a crop to pass the vegetative phase. Longer vegetative phase made plants to obtain food reserves more by the photosynthetic process, which will be used as energy in the generative phase later [14].

The results of this study showed that as light intensity was high and exposure time was short, it caused the *Artemisia* plant to accelerate the generative process by faster flowering initiation [15].

### *3.4 Length of Root*

The highest length of root was shown in treatment of compost filter press mud with fertilizers as medium of 42.23 cm. The lowest root length was shown by the treatment of horse manure with fertilizers as a medium of 4.2 cm (Table 4). These results indicated that root length of *Artemisia* was affected by their treatment of fertilizers and proportion of fertilizer with the medium.

Roots are parts of the plant that are not normally visible, but it is an important component of plants, especially in providing nutrients and water needed in plant metabolism [16]. The length of the root is expected to widely spread in the field to increase the absorption of nutrients, so the distribution of nutrients from the growing medium is essential for the plant [17]. Table 4 showed that the compost filter press mud was a fertilizer which had a positive impact on the root length of *Artemisia*, which caused that the fertilizer was a good medium for root growth [18]. A fertilizer that had the right medium mix in the supply of soil aeration will allow plant roots to develop properly.

Short plant roots can be caused by that fertilizer given exceeds the limit, as increasing the dose of fertilizer to a high level will have a negative impact in the form of a long decline in plant roots. The high number of roots will assist the water absorbance used for the process of plant growth [19].

### *3.5 Volume of Root*

The highest volume of root was shown in the treatment of compost filter press mud with fertilizer as medium of 14.2 mL. The lowest root volume was shown by the treatment of horse manure with fertilizers as a medium of 2.77 mL (Table 5). These results indicated that the root volume of *Artemisia* was affected by their treatment of fertilizers and proportion of fertilizer with the medium.

Volume of roots showed the ability of roots to absorb nutrients and water in the medium. If the root volume is low, then the ability of the roots to absorb nutrients and water in a medium is low too. Based on average values, it can be concluded that the root volume of *Artemisia* was affected by their treatment of

**Table 4 Length of root (cm) in various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | 4.20$^{a}$ | 42.23$^{c}$ | 6.43$^{ab}$ |
| Fertilizer:soil (4:1) | 15.03$^{ab}$ | 19.23$^{ab}$ | 21.37$^{ab}$ |
| Fertilizer:soil (3:2) | 17.17$^{ab}$ | 19.80$^{ab}$ | 18.30$^{ab}$ |
| Fertilizer:soil (2:3) | 18.33$^{ab}$ | 15.07$^{ab}$ | 18.27$^{ab}$ |
| Fertilizer:soil (1:4) | 25.20$^{bc}$ | 15.03$^{ab}$ | 17.27$^{ab}$ |

Numbers followed by different letters are significantly different in DMRT 5%.

**Table 5 Volume of roots (mL) in various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | 2.77 | 14.20 | 4.47 |
| Fertilizer:soil (4:1) | 7.93 | 7.87 | 7.20 |
| Fertilizer:soil (3:2) | 4.87 | 9.53 | 11.00 |
| Fertilizer:soil (2:3) | 8.73 | 6.37 | 5.70 |
| Fertilizer:soil (1:4) | 9.00 | 6.13 | 6.43 |

**Table 6 Weight of fresh crop (g) on various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | $18.17^{ab}$ | $82.77^{c}$ | $3.78^{a}$ |
| Fertilizer:soil (4:1) | $8.57^{ab}$ | $13.24^{ab}$ | $15.37^{ab}$ |
| Fertilizer:soil (3:2) | $9.30^{ab}$ | $43.56^{b}$ | $30.39^{ab}$ |
| Fertilizer:soil (2:3) | $32.85^{ab}$ | $15.73^{ab}$ | $12.16^{ab}$ |
| Fertilizer:soil (1:4) | $31.50^{ab}$ | $22.21^{ab}$ | $21.27^{ab}$ |

Numbers followed by different letters are significantly different in DMRT 5%.

the type of fertilizer and manure proportion with the medium. The plants that get unlimited water from soil will tend to increase the volume of roots, which will affect the root dry weight [20].

The volume of root was positively correlated with the length of lateral roots and tap root [21]. The surface area of roots of growing medium was related to the surface area of absorption of nutrients. Perfect root system is characterized by long roots and wide root surface area [22].

### *3.6 Weight of Fresh Crop*

The highest fresh weight was shown in treatment of compost filter press mud with fertilizer as medium of 82.77 g. The lowest fresh weight was shown by the treatment of cow manure fertilizer with fertilizer as medium of 3.78 g (Table 6). These results indicated that the fresh weight of *Artemisia* was affected by the treatment of fertilizers and proportion of fertilizer with the medium.

Fresh weight of the plant is a combination of development and expansion of plant tissue, such as the number of leaves, leaf area and plant height, which were affected by the water content and the nutrient content in the cells of the plant tissue. Fresh weight of plants is the parameter of growth and plays a role in determining the quality of yield. Vegetative phase growth rate will affect the weight of the plant [23].

Fresh weight of plant was related closely to the levels of N in the soil and uptake of N by plants. The N absorbed by plants caused N needed of the vegetative phase to be fulfilled, which will increase plant biomass. Increase in plant height and root length caused increase in the fresh weight of the plant [24]. The high value of weight of fresh crop indicated good metabolic processes in plants, and *vice versa*.

### *3.7 Weight of Dry Crop*

The highest dry weight was shown in treatment of compost filter press mud with fertilizer as medium of 60.07 g (Table 7). The lowest dry weight was shown in the treatment of cow dung fertilizer with manure as a medium of 3.38 g.

Dry weight is a measure of plant growth and development. The dry weight of the plant reflects the accumulation of organic compounds, which successfully synthesized by plants. Dry weight of the plant can be used as an indicator that determines whether or not plant growth was derived from the nutrients absorbed. Based on average values, the treatment of type of fertilizer increased the crops dry

**Table 7 Weight of dry crop (g) on various types of fertilizers and proportion of medium composition.**

| Proportion of medium with fertilizer | Fertilizer types | | |
|---|---|---|---|
| | Horse manure fertilizer | Compost of filter press mud | Cow manure fertilizer |
| Fertilizer as medium | 14.50[a] | 60.07[a] | 3.38[a] |
| Fertilizer:soil (4:1) | 7.18[a] | 14.06[b] | 12.44[a] |
| Fertilizer:soil (3:2) | 7.36[a] | 26.63[a] | 23.40[a] |
| Fertilizer:soil (2:3) | 24.77[a] | 12.74[a] | 9.51[a] |
| Fertilizer:soil (1:4) | 24.75[a] | 17.73[a] | 16.41[a] |

Numbers followed by different letters are significantly different in DMRT 5%.

weight. The dry weight of plants reflected that the accumulation of organic compounds was successfully synthesized by plants from inorganic compounds, mainly water and $CO_2$ [25]. The higher value of the dry weight indicates good plant growth and the nutrients are absorbed optimally [26].

The dry weight is an indication of the plant growth, due to that the dry weight showed the ability of plants to take nutrients from the growing medium to support growth. Increased plant dry weight was associated with the metabolism of plants or their growing conditions, and it indicated a better metabolism activity, such as photosynthesis [27].

## 4. Conclusions

It can be concluded that treatment with compost filter press mud provided the highest of plant height, root length, root volume, crop fresh weight, crop dry weight and day to flowering.

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