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Application of sugar cane bagasse and mycorrhiza on the growth of *Artemisia annua* in highland area

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Abstract. *Artemisia annua* is a sub-tropic plant and has an active compound that contains artemisinin. Artemisinin is commonly used to prevent the growth of *Plasmodium falciparum* that causes malaria. The research was conducted in July 2017 – February 2018 in Tawangmangu, Central Java. The research was design as completely randomized design (CRD) with two factors. The first factor was sugar cane bagasse consisted of 4 levels, namely B0=0 gram/plant, B1=50 gram/plant, B2=100 gram/plant, B3=150 gram/plant. The second factor was the application of Mycorrhiza consisted of 3 levels, that is M0=0 gram/plant, M1=5 gram/plant and M2=15 gram/plant. There were 12 treatment combinations with three replicates each. Observed variables included plant height, number of branches, age of flowering, root volume, root length, fresh weight of plant, dry weight of plant and mycorrhizal infection percentage. The results showed that utilization of bagasse 150 gram/plant in combination with 15 gram/plant mycorrhiza resulted 90.5 cm plants height. Bagasse 50 gram/plant and 15 gram/plant mycorrhiza performed the highest number of branches that was 2 branches. Bagasse hasten the flowering age (41.22 days) after planting. Mycorrhiza 15 gram/plant performed the highest plant (36 cm), while 15 gram/plant mycorrhiza resulted the highest percentage of mycorrhiza infection (70%).

1. Introduction

Artemisia annua is a plant containing sesquiterpenes artemisinin for antimalarial drugs. Artemisinin reacts quickly with high killing power to fight against Plasmodium. This plant can grow well on the highlands area, with an altitude of 1000-1500 m above sea level [1], so its geographical distribution is very limited. Artemisinin content in *Artemisia* still very low that is about 0.01-0.5%. Efforts to increase artemisinin production in *A. annua* is required including cultivation in various conditions and in different geographic area.

Other factors that support the cultivation of *A. annua* is adequate of nutrients. The soil organic matter is one of factor that determines the level of soil fertility. Soil conditions with optimal nutrients will promote the growth and development of plants optimally as well. The addition of organic material such as bagasse (sugar cane) and arbuscular mycorrhiza may increase the quantity and the quality of crop yields and may fertilize the soil. Arbuscular mycorrhiza is able to infect the roots so that the



nutrients uptake of the plant is greater. This study aimed to investigate the interaction between the addition of bagasse and arbuscular mycorrhiza on the growth of *A. annua*, which is expected to improve the physiological of the plant.

2. Methods

This study was conducted from July 2017 until February 2018, located in Tawangmangu, Central Java with altitude of 1062 m above sea level. The research was designed as completely randomized design (CRD) with two factors. The first factor was bagasse consisted of 4 levels, namely B0=0 gram/plant, B1=50 gram/plant, B2=100 gram/plant, B3=150 gram/plant. The second factor was the addition of Mycorrhiza consisted of 3 levels, namely M0=0 gram/plant, M1=5 gram/plant and M2=15 gram/plant. There were 12 treatment combinations with three replicates, resulting 36 experimental units. Observed variables included plant height, number of branches, age of flowering, root volume, root length, fresh weight of plant, dry weight of plant and mycorrhizal infection percentage.

The results were analyzed by analysis of variance (ANOVA) and if there was significant difference, it was continued with Duncan Multiple Range Test (DMRT) at 95% confidence level.

3. Result and discussion

3.1. General condition of the study

The research was conducted in Tawangmangu, Central Java. This location was chosen in accordance with the requirement of growing *Artemisia*. Geographically it is located at latitude 7°39,880 'S and 111°07,881' E with altitude 1062 m above sea level. Humidity ranged from 78-80% with temperature of 15-23° C.

3.2. Plant height

Based on the results (Table 1), higher *A. annua* was obtained by application a dosage of bagasse. The highest value of plant height was found in the treatment bagasse dose 150 gram/plant. The average yield of plant height was 77.27 cm, while the smallest value was found in the treatment 0 gram/plant with the average yield of plant height 42.91 cm. This showed that bagasse was effective in optimizing the growth of *A. annua* plant. High water and nutrients uptake by plants make the plants grow better, indicated by optimal plant height. Blotong contains many nutrients such as nitrogen, phosphat (P_2O_5), calcium (CaO), humus and others to promote plant growth [2].

Table 1. Plant height of *Artemesia annua*

Bagasse (g)	Plant height (cm)
0	42.91 ^a
50	60.71 ^{ab}
100	60.27 ^{ab}
150	77.27 ^b

3.3. Number of branches

Artemesia is an annual plant with branches that can be used as growth indicators in accordance with the statement of Baihaqi et al. [3]. The more branches of the plant, the more leaves produced and the process of photosynthesis in plants will also increase.

Bagasse had no significant effect to the number of *A. annua* branches. From Table 2 it can be seen that the highest value number of branches was found in treatment 150 gram/plant bagasse with average value of 1.33, whereas the lowest value was found in the treatment 0 gram/plant or treatment without bagasse with average number of branches was 1.11.

Table 2. Number of Branches of *A. annua*

Bagasse (g)	Number of Branches
0	1.11
50	1.22
100	1.22
150	1.33

3.4. Age of flowering

Table 3 showed that the dose of 150 gram/plant bagasse exhibited the fastest average of age of flowering (100.22 days) while the latest (121.89 days) is generated by *A. annua* without bagasse addition, thus the higher dosage of bagasse fastened the age of flowering.

Table 3. Age of flowering

Bagasse (g)	Age of Flowering (days)
0	121.89 ^b
50	116.33 ^b
100	114.44 ^b
150	100.22 ^a

Fertilizer addition at vegetative stage allowed the plants to flower just in time [4]. There was a significant different by adding mycorrhiza and bagasse, which caused by the decomposition process. This finding was in accordance with Utami [5], addition of organic materials such as kettle ash, biochar and bagasse on new soil organic carbon showed an effect after 18 weeks after application

3.5. Root volume

Addition of mycorrhiza showed no significant effect on root volume of *A. annua* (Table 4). The highest value of root volume was found in treatment without mycorrhiza (38.75 ml), whereas the lowest value was found in treatment 20 gram/plant mycorrhizae (28.91 ml). On the contrary, Kusuma et al. [6] showed that the factor that affects root growth was the presence of soil pore space. The pores of the soil were impregnable by the roots and contain air for root respiration. The addition of mycorrhiza did not give a role because the mycorrhizal has not been decomposed to optimally in infecting the root system, led to low nutrients uptake.

Table 4. Root volume of *A. annua*

Mycorrhizae (g/plant)	Root volume (cm ³)
0	38.75 ^a
10	27.50 ^a
20	28.91 ^a

3.6. Root length

Mycorrhiza did not affect the root length of *A. annua*. It can be seen from Table 5 that the highest average root length was found in the 20 g/plant mycorrhiza with average root length of 39 cm. The lowest root length was in treatment without mycorrhiza with an average root length of 24.25 cm. The higher dose of mycorrhiza resulted a longer root. Mycorrhizal applications increased mycorrhizal infections at the root, causing an increase in root length of the plant with the increased dosage of mycorrhizal applied.

Table 5. Root length of *A. annua*

Mycorrhiza (g/plant)	Root length (cm)
0	24.25 ^a
100	26.66 ^a
150	39.00 ^b

3.7. Fresh weight of plant

Table 6 showed higher dosage bagasse improved the growth of *A. annua*. The highest value of fresh weight was found in the treatment 150 gram/plant bagasse (258.55 g), while the lowest value was found in the treatment without blotong (80.11 g). Increasing in plant height and root length leads to increased plant weight [7]. The greater the fresh weight of a plant, the more metabolism of the plant occurs, since fresh weight indicated a constraint in the process of plant metabolism.

Table 6. Fresh weight of plant of *Artemesia annua*

Bagasse (g)	Fresh weight (g)
0	80.11 ^a
50	91.33 ^a
100	189.44 ^a
150	258.55 ^a

3.8. Dry weight of plant

There was no significant effect of the addition of bagasse on dry weight of the plants (Table 7). Increasing the use of blotong resulted the higher dry weight of plant. The highest value of dry weight was found in the bagasse 150 gram/plant (78.50 gram), while the lowest value was found in the treatment 0 gram/plant bagasse (17.29 gram). Dry weight is an indication of plant growth, since it indicates the results of photosynthesis [8].

Table 7. Dry weight of plant *A. annua*

Bagasse (g)	Dry weight (g)
0	17.29 ^a
50	30.43 ^{ab}
100	49.24 ^{ab}
150	78.50 ^b

This result was in accordance with Effendi [9], that the plants received low light in conditions of low shade and low temperatures, led to the slow rate of photosynthesis. Subsequently, this low photosynthate was produced as indicated by reduced the plant weight.

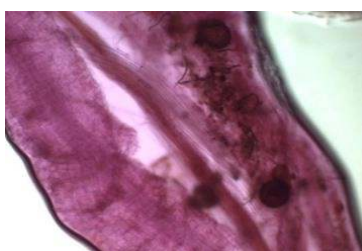
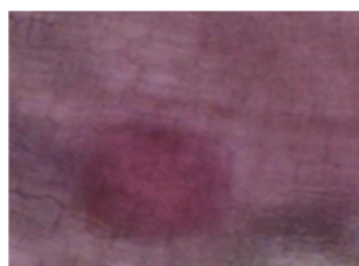
3.9. Mycorrhiza infection percentage

Table 8 showed the dose of mycorrhiza affected the mycorrhiza root infection percentage. Uninfected and infected roots of *A. annua* can be seen in Figure 1 and 2, respectively. The highest rate of root infection was found in treatment in 20 gram/plant that was 34,88 % and the lowest value was in treatment without mycorrhizal or 0 gram/plant mycorrhiza that was 10.49. Treatment of 0 gram/plant mycorrhiza was not different with 10 gram/plant, but significantly different from the treatment of 20 gram/plant.

Table 8. Mycorrhiza root infection percentage

Mycorrhiza dose (g/plant)	Mycorrhiza infection (%)
0	10.49 ^a
10	15.33 ^a
20	34.88 ^b

The higher dosage of mycorrhiza resulted the higher the rate of infection. This is consistent with Alloush and Clark [10]. Gosling et al. [11] reported that sources of organic materials such as manure, compost, and plant residues stimulate mycorrhizal colonization. As the mycorrhizal infected and penetrated the roots of plants, the hyphae grew intracellularly, formed in the cell upon penetration. Stein et al. [12] suggested that fungal hyphae improved the absorption and accumulation of phosphorus.

**Figure 1.** Uninfected root of *A. annua***Figure 2.** Infected root of *A. annua*

4. Conclusions

Addition of bagasse 150 gram/plant increased the plant height of *A. annua* and fastened age of flowering (fertilization). Mycorrhiza 20 gram/plant improved *A. annua* root length and root infection percentage. The addition of bagasse and mycorrhizae did not affect the fresh and dry weights of plant.

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