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Abstract. *Artemisia annua L.* is a plant with high artemisin in contents which can treat malaria disease. A proper cultivation method is necessary to improve its growth and development in middle altitude plain. Organic materials addition such as compost increases plant growth. This research aimed to know the effect of compost and *mycorrhiza* to the growth of *Artemisia annua* in middle altitude plain. The research method used Completely Randomized Design with two factors and 3 replications. The first factor is compost dosage with 4 levels 0, 40, 60, 80 g/ plant and *mycorrhiza* dosage with 3 levels: 0, 10 and 20 g/ plant. Observed variables included plant height, number of branches, age of flower emerges, root volume, root length, fresh weight of plant, dry weight of plant and *mycorrhiza* infection percentage. The research results showed that treatment of compost 40 g/plant resulted in the highest plant height, number of branches, fresh weight and dry weight of plant, the addition of 20 g/ plant *mycorrhiza* gave the highest plant height, the number of branches and *mycorrhiza*e infections percentage but has the lowest yield of fresh weight and dry weight of plant and there is no interactions were found between dosage of compost and *mycorrhiza*.

1. Introduction

Artemisia is a plant that contains the active ingredient artemisinin which is very effective to control the cause of malaria disease that has been resistant to quinine [1]. *Artemisia annua* L. contains high level of artemisinin, in nature it varies between 0.1 - 1.8%. However, by using hybrids between Chinese and Vietnamese clones, artemisinin content can reach 2% [2]. Artemisinin content in artemisia is used as a drug for malaria disease.

Artemisia can grow well in upland areas with an altitude of 1000 - 1500 masl. To increase the production of artemisinin low land or lowland areas, proper cultivation efforts are needed. Several factors that influence plant growth process are nutrient availability. The addition of organic materials such as compost and *mycorrhiza*l is one of the efforts undertaken to increase plant growth. *Mycorrhiza* infects the root of the plant that will form the external hyphae tissue and penetrates to the root, increasing the nutrients uptake and water in Artemisia. This research conducted to know the effect and the interaction of compost and *mycorrhiza* with certain dosage on the growth of *Artemisia annua* in medium altitude land (< 500 meters above sea level).

2. Materials and methods

The research was conducted in July 2017 until February 2018, located in two places Tawangmangu and Popongan, Karanganyar, Central Java. The experiment using CRD consisted of 2 factors. The first factor was dosage of compost that consist of 4 level 0 g/plant, 40 g/ plant, 60 g/plant, 80 g/ plant. The second factor was inoculation of *mycorrhiza*e consist of 3 level ie dosage 0 g/plant, 10 g/ plant, 20 g/ plant, there were 12 treatment combinations repeated 3 times and in total of 36 experimental units obtained. Observed variables included plant height, number of branches, age of flower emerges, root length, root volume, fresh weight of plant, dry weight of plant, and *mycorrhiza*l infection percentage. The results were analyzed by Analysis of Variant, and if there is significant effect continued with Duncan Multiple Range Test (DMRT) at 95% confidence level.

3. Result and discussion

3.1. General condition research

The nursery stage is done in Tawangmangu with geographic location 7˚39,8'80 "LS and 111˚07,8'81" BT. The height of the nursery 1062 meters above sea level, at temperatures ranging from 19˚C - 23˚C. After the seeds were around 4 to 5 weeks the plants were transferred to a land located in Popongan area, Karanganyar with geographical location 7036'06.8 "LS and 110058'59.2" BT with a height of 218 meters above sea level. The lowest temperature is 21^0C and the highest temperature is 27^0C.

3.2. Plant height

Plant height is an indicator of the physiological function of the plant. Observation of plant height is the most frequently used measure to determine the effect of the environment and the treatment that is set.

Table 1. Average plant height, number of branches and age of flower emerge *Artemisia annua* on compost dosage treatment until 11 weeks

Compost (g/plant)	Plant height (cm)	Number of branches	Age of flower emerge (days)
0	86.51	1.00	42.00^{b}
40	108.63	1.22	36.56^{ab}
60	98.78	1.33	31.89^{a}
80	100.09	1.89^{a}	31.11^{a}

Table 2. Average plant height, number of branches and age of flower emerge *Artemisia annua* on *mycorrhiza* dosage treatment until 11 weeks

Mycorrhiza (g/plant)	Plant height (cm)	number of branches	Age of flower emerge (days)
0	90.31^{a}	1.17^{a}	38.50^{a}
10	95.88^{a}	1.08^{a}	36.75^{a}
20	109.32^{a}	1.84^{b}	30.92^{b}

Based on **Table 1** it can be seen that the highest plants yield was on compost treatment P1; which was by giving the dosage of compost as much as 40 g, with average height equal to 108.63 cm. The result of observation in **Table 2** showed that the highest yield was at 20 g of *mycorrhiza*l per plant, which was 109.32 cm. There was no significant interaction or treatment was found. Nitrogen in organic matter plays an important role in plant height variable [3].

3.3. Number of branches

Based on the results obtained from the analysis of variance in **Table 2** it was found that treatment without *mycorrhiza*l and *mycorrhiza*l with a dosage of 10 g/ plant was significantly different with the *mycorrhiza*l treatment of 20 g/ plant but no interaction between both treatments. Giving 20 grams of *mycorrhiza* generates the largest number of branches. According to Hertos [4] increased vegetative growth includes plant height, number of leaves and number of branches is strongly influenced by the presence of nitrogen (N), phosphorus (P), and potassium (K). The addition of *mycorrhiza* can help plants in nutrients and water uptake from the soil. Increased macro nutrients uptake by plants increased the yield of plant vegetative growth.

3.4. Age of flower emerge

Table 1 shows that the addition of compost 60 g/ plant and 80 g/ plant crop induce *Artemisia* flower to emerge faster than compost 40 g/plant. Addition of compost significantly affect the age of flowering. According to Amali et al. [5] flowering and harvesting is strongly influenced by nutrients P. This is supported by the statement of Ahmad et al. [6] the application of N (nitrogen) and P (phosphorus) nutrients present in the fertilizer yielded positive results on the expansion of interest.

*Mycorrhiza*l treatments of 20 g/ plant were significantly different from those without *mycorrhiza* and *mycorrhiza* 10 g/ plant. Treatment of 20 g/ plant gives the fastest result in flower emerge. According Firdaus *et al.* [7] *Artemisia* planted in the lowlands will flowering faster that is at the age of 2-3 months after planting. The formation of a more rapid interest due to the shorter vegetative period and accelerate the generative period.

3.5. Fresh weight of plant

The result of the analysis of the variation on the fresh weight of the plant showed no significant effect and no interaction between compost dosage treatment and *mycorrhiza*l addition. Based on table 3 it can be seen that the highest average of plant fresh weight found in compost dosage 40 g/ plant with 240 g and in the highest average in *mycorrhiza*l treatment was *Artemesia* treated 0 g/plant with 207.5 g. According to Marques *et al* (2011) the uptake of nutrients and water will affect the fresh weight of plant because water is the main factor that affect the fresh weight of plant.

Table 3. Average fresh weight of plant and dry weight of plant *Artemisia annua* on compost dosage treatment

Compost dosage (g/plant)	Fresh weight of plant (g)	Dry weight of plant (g)
0	100.00	13.33
40	240.00	73.33
60	213.33	36.67
80	193.33	63.33

Table 4. Average fresh weight of plant and dry weight of plant *Artemisia annua* on *mycorrhiza* dosage treatment

Mycorrhiza (g/plant)	fresh weight of plant (g)	dry weight of plant (g)
0	207.50	62.50
10	187.50	40.00
20	165.00	37.50

Pramitasari *et al* (2016) stated that the application of high fertilizer to the soil can provide nutrients and can be used for optimum growth and faster development of Chinese kale plants. Besides that, the higher the plant height and leaf area, the more plant fresh weight will be.

3.6. Dry weight of plant

Table 4 shows that the lowest dry weight of plant is in the 0 g/plant compost treatment. Low dry weight of plant can be due to the low rate of photosynthesis so that nutrients that can be absorbed by plants are low. This is in agreement with Kumalasari's [9] statement that dry weight is the result of photosynthesis, as long as the plant is still alive with decreasing photosynthesis rate causing the plant's dry weight to be low and if the photosynthesis rate is high then the dry weight of the plant will be high.

3.7. Root volume

Root volume can be a parameter to measure the root range in up taking nutrients and water. According Patra *et al.* [10] in artemisia root hair, there are artemisinin content which can reach 0.4%. Artemisinin in artemisia is synthesized at the root and distributed to other parts of the plant.

Table 5. Mean volume of plant roots, root length and *mycorrhiza* infection *Artemisia annua* on compost dosage treatment

Compost (g/plant)	Root Volume (cm^3)	Root length (cm)	*Mycorrhiza* infection (%)
0	37.45	28.89	18
40	44.45	45.45	37
60	55.00	30.44	43
80	48.34	36.56	34

Table 6. Mean volume of plant roots, root lengthand *mycorrhiza* infection *Artemisia annua* on *mycorrhiza* dosage

mycorrhiza (g/plant)	Root Volume (cm3)	Root length (cm)	*Mycorrhiza* infection (%)
0	49.17	35.25	13^a
10	36.84	33.59	40^b
20	52.92	37.17	47^b

Based on the average root volume, the highest result found in compost at 60 g/plant dosage which is 55.00 cm^3 while the lowest value was in the treatment without compost that is 37.45 cm^3. The highest result of *mycorrhiza* treatment was found in the treatment with 20 g/ plant with 52.92 cm^3 and the lowest value at treatment 10 g/ plant with 36.84 cm^3. It can be seen that the application of compost and *mycorrhiza* gave significant effect to the increase of root volume. Root volume beside influenced by root distribution and nutrient availability, is also influenced by the availability of water in the soil [11].

In a condition of water shortage, plants will respond by reducing the rate of transpiration to conserve water. Giving 20 grams of *mycorrhiza* had the highest average of 52.95 cm^3. A large root volume will increase the absorption of nutrients into the plant. So the availability of nutrients and water in the plant will be optimal in supporting physiological processes. According to Nasution *et al.* [12], the spread of *mycorrhiza*l *hyphae* is so extensive in the soil that it can help maximize water absorption.

3.8. Root length

Based on the analysis of variance indicate that there is no significant effect on compost and *mycorrhiza* treatment on root length. There was no interaction between the compost dosage and the dosage of *mycorrhiza* given to the plant. Observation result in table 5 can be seen the highest observation result of root length found in treatment 40 g/ plant that is 45,45 cm. The lowest result on root length observation is composted treatment of 28.89 cm. *Mycorrhiza*l treatment with highest yield of 37.17 cm at 20 g/ plant treatment. Composting with too high or excessive dosage will lead to an imbalance of nutrient uptake in plant metabolism.

3.9. Mycorhiza infection

The results of observation on the percentage of *mycorrhiza*l infections in artemisia plants showed that *mycorrhiza*l administration at 10 g/ plant and 20 g/ plant was significantly different than the treatment without *mycorrhiza*. Giving *mycorrhiza*e 10 g/ plant and 20 g/ plant gives higher percentage than plants without *mycorrhiza*l treatment. The application of CMA in artemisia plants can increase the number of *mycorhiza* in the soil so that *mycorrhiza*l infection in the host plant increases. Increased activity of microorganisms in the soil will lead to increased availability of nutrients in the soil [13].

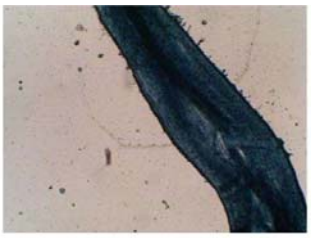

Figure 1. Uninfected *Artemisia annua* root

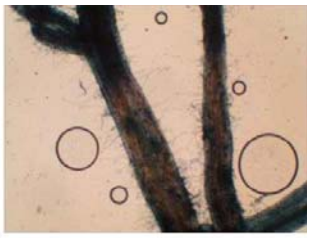

Figure 2. Infected root of *Artemisia annua*

In **Table 6** can be seen that the lowest average result was found in treatment without *mycorrhiza*l (0.12%) and on the treatment of without compost that is 0.18%. According to Saputra et al. [14] The percentage of *mycorrhiza*l fungal infections in plant roots can indicate a crop condition directly. Environmental factors that affect the CMA, especially organic materials, nutrients, pH, temperature and soil water content. According to Kumalawati et al. [15] interest in the use of *mycorrhiza* in the field of agriculture increased because of its role in protecting plants from pests and diseases and increase soil fertility.

4. Conclusion

The conclusions of this study are the treatment of compost fertilizer 40 g/plant resulted the highest value in plant height, number of branches, fresh weight and dry weight of plant. The addition of 20 g/ plant *mycorrhiza* gave the highest result in plant height, number of branches and *mycorrhiza*l infections percentage, but had the lowest yield of fresh weight and dry weight of plant. No interactions were found between dosage of compost and *mycorrhiza*e.

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