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Effect of Vermicompost Application to Arabica Coffee Seedlings (*Coffea arabica* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author ID performed the experiment, wrote the manuscript and analyzed the data. Author MB assisted the experiment, prepared all experiment requirement. Author MK Proofread the manuscript, author DA Assisted the experiment. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The research aimed to study the effect of several dose of vermicompost to arabica coffee seedling growth.
Study Design: Completely randomized design.
Place and Duration of Study: The research was conducted in experimental garden of Faculty of Agriculture, Andalas University from September to December 2018. The altitude of research site was 385 meter above sea level (asl).
Methodology: The research aimed to study the effect of several dose of vermicompost to arabica coffee seedling growth. Completely randomized design was used in the research that consisted of 5 treatments (No vermicompost, 5 ton/ha, 10 ton/ha, 15 ton/ha and 20 ton/ha) and replied 3 times. Each experimental unit consisted of 6 seedlings. The data was analyzed by Duncan's New Multiple Test in 5%.

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Results: The result showed that 5 ton/ha of vermicompost dose has affected the growth component of arabica coffee seedling.
Conclusion: The addition of vermicompost dose affected the arabica coffee seedlings growth.

Keywords: Arabica coffee; growth; seedling; vermicompost.

1. INTRODUCTION

Coffee is refreshing drink that consumed by all community and contains many beneficial such as increasing stamina, avoiding cancers, decreasing diabetes and source of anti-oxidant [1]. In 100 ml, it contains 92 mg potassium, 8 mg magnesium, 0.05 mg manganese, 0.01 mg riboflavin and 0.7 niacin [2]. Coffee arabica (*Coffea arabica* L.) is an export commodity of Indonesia and plays role as source of foreign exchange. Composition of coffee ownership in Indonesia was dominated by public plantation with 96% of all coffee plantation and 2% is government plantation and 2% is private ownership [3]. One of arabica producer region in Indonesia is West Sumatera.

West Sumatera is a region as coffee producer for export purpose.The total area under coffee plantation in 2014, 2015 and 2016 was 42,565 ha, 42,510 and 41,229 ha respectively with the production 32,559, 30,929 and 31,904 ton respectively. From 2017-2019

the national productivity of Indonesian coffee was 764 kg/ha, 727 kg/ha and 773 kg/ha respectively. This result is still lower than national productivity (967 kg/ha) [3].

Productivity is main problem in coffee cultivation in Indonesia particularly in West Sumatera. Cultivation improvement in seedling growth process, soil fertility improvement and all aspect of seedling cultivation was an alternative was to solve the problem. To obtain the goal, the good seedling through good management befor moving to the field was required. One of alternative way to solve the problem is vermicompost application.

Vermicompost is worm dung. The composting process involves worms. According the research result, it contains N 3.0%, P and K 2.25% and nutrients in cricket were N 3.34%, P 0.80% and K 2.03%. For chicken manure, it contained N 1.50%, P 1.30% and K 0.80%. Goat manure contained N 0.70%, P 0.40%, and K 0.2%. For cattle manure, it contained N 0.96%, P 1.815% and K 1.00% [4]. The nutrition of vermicompost is better than other organic fertlizer sources and this condition causes this organic matter can be used as potential manure for plant.

Vermicompost was obtained from the the composting of organic matter by worm. Vermicompost is mixture of worm dung and rest of medium or feed in worm cultivation so that it produces the secondary product as vermicompost, a manure can repair physical, chemical and biological of soil [5]. Vermicompost also can hold water 40-60%, supporting to provide the nutrition, improving the soil structure and neutralizing soil pH and provides growth regulator. Improvement of characteristic and type of soil is important for sustainability agriculture to obtain maximum growth and yield of plant. Fatahillah [6] reported that vermicompost application with dose 1 kg in 10 kg of soil affected the vegetative growth of chilli such as germination, plant height, number of leaves, number of branches and stem diameter. Hadiwiyono and Dewi [7] also reported that vermicompost application with dose 20 ton/hectare could increase plant growth. For coffee plant, vermicompost with dose 15 ton/hectare was reported to affect plant height, number of leaves, stem circumference and leaf area of robusta coffee seedling at age 3-6 months [8]. The research aimed to study the effect of several dose of vermicompost to arabica coffee seedling growth.

2. MATERIALS AND METHODS

2.1 Place, Time and Material

The research was conducted in experimental garden and Laboratory of Plant Physiology of Faculty of Agriculture, Andalas University, Padang, Indonesia from August to November 2018. The altitude of experiment was 385 meter above sea level (asl). During the the reserach, the rainfall is high and humidity is moist.

2.2 Method

Completely randomized design was used in the assay. Five treatments were replied 3 time. The treatment was A0 = No vermicompost, A1 = 5 ton/ha or 12.5 g/ 5 kg of soil, A2= 10 ton/ha or 25 g/5 kg of soil, A3= 15 ton/ha or 37.5 g/5 kg of soil

and A4= 20 ton/ha or 50 g/5 kg of soil. The vermicompost was the certified vermicompost.

2.3 Procedure

The used variety of the research was Sigagar Utang, collection of Solok Radjo, a coffee farmer group of Solok, West Sumatera, Indonesia. The coffee seedlings were planted in seedbed for two months and then moved to poly bag sized 30 cm x 30 cm that previously filled in by treatments and organic matter, 5 ton/ha, 10 ton/ha, 15 ton/ha and 20 ton/ha. The seedling planting was conducted in *kepelan* stage. Previously, the seedlings were selected according the normal growth and uniform. The seedling planting was conducted starting from watering the seedbed to facilitate the process of coffee seedling collection. Furthermore, the coffee seedlings in *kepelan* stage were planted in poly bag that the hole was made previously. The observed variables were plant height, number of leaves, diameter of stem, length and width of leaves, fresh and dry weight, fresh and dry weight of root, length of root and total area of leaves. The plant height was measured one in 2 week until 16 weeks after planting (WAP). For number of leaves, it was measured one time in 2 week until 16 WAP.The measurement of stem diameter was started by measuring the stem base 2 cm from soil surface by using caliper. The measurement was conducted one time in 2 weeks until 16 WAP. The length and width of leaves were measured 1 time in 2 weeks until 16 WAP. For fresh weight measurement, 16 WAP of plant was revoked from soil and rinsed by water and dried for a 3 hours. Thereafter, it was weighed in digital scale. For dry weight measurement, the plant was entered into oven in 70ºC for 48 hours. Thereafter, the plants were weighed in digital scale. Total area of leaves was measured by using Leaf Area Meter. The data was analyzed by F test in 5% and followed by Duncan's New Multiple Range Test (DNMRT) in 5%.

3. RESULTS AND DISCUSSION

3.1 Plant Height

The application of vermicompost affected the plant height of coffee plant. According the result, dose 20 ton/ha was the best treatment for plant height of coffee seedling (Table 1). The plant height of arabica coffee seedling of the research can be seen in Fig. 1. The treatment produced the plant height 22.50 cm. The vermicompost application could improve and increase the soil physic such as plant root ability to absorb nutrient for plant growth. Arabica coffee is annual plant that its vegetative phase growth is slow so that the effect of an application can be seen in long term. Azarmi et al. [9] stated that high nutrient content particularly nitrogen and phytohormones caused the better vegetative growth. The plant contained phytohormones encouraged the plant height was higher due to the more cell division and meristematic tissue development in tip of stem [10].

Auxin also play important role in plant height. Weijers et al. (2018) [11] stated that this hormone could affect cell elongation and stimulated plant height. Improvement of soil Structure and texture was caused by microbes and vermicompost so that they could increase nutrients absorption by root. Plant height significantly affected number of leaves. Higher plant produced more leaves and photosynthesis well occurred [12].

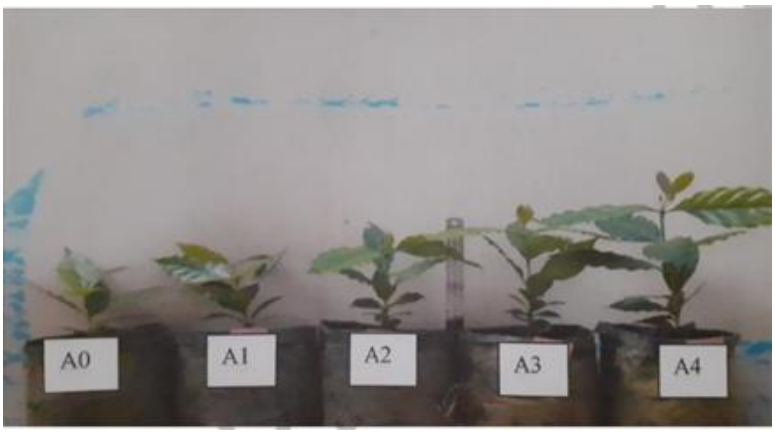

Fig. 1. Plant height (cm) of arabica coffee seedling in several vermicompost doses application

Table 1. Plant height (cm) of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Plant height (cm)	
0	12.75	b
5	17.11	ab
10	18.06	ab
15	19.45	ab
20	22.50	a
CV = 2.15%		

Note: similar letter indicates not significantly different; CV : Coefficient of variation.

3.2 Number of Leaves

According the result, dose vermicompost 20 to/ha was the best treatment for number of leaves (Table 2 and Fig. 1). The most influential element for growth and development of leaves was nitrogen in soil. This element was used by plant in cell division and its content could be absorbed by plant optimally. This condition caused the increasing of metabolism process. The quality of seedling was affected by number of leaves. This process was correlated to the sufficient of nutrients that was easily absorbed and used by plant particularly in leaves formation [13]. Pattnaik and Reddy [14] stated that the vermicompost application increased the number of leaves due to the nutrient content in vermicompost such as N, P, K and Mg.

One of factors that increased the number of leaves was the sufficient supply of nutrients for plant. The essential nutrient content and hormone in vermicompost could accelerate leaves formation rate [15]. The vegetative growth was closely related to number of leaves due to more leaves caused the increasing of photosynthesis process and it produced more photosynthate. This result was distributed for growth and development of leaves [16]. Pathma and Sakhtivel [17] stated that cytokinin in vermicompost played important role in leaves formation.

3.3 Diameter of Stem

The result showed that vermicompost dose affected the diameter of stem of coffee arabica. According the result, dose 10 ton/ha was the best dose (Tabel 3). The growth rate of stem diameter was slower than plant height. This condition due to the plant height growth stimulated cell division in shoots of plant and formed new leaves so that absorbed nutrients was focused in shoots than stem [18]. The annual plant particularly coffee underwent long growth in horizontal direction so that the stem diameter growth needed longer time. In vegetative stage, vermicompost that applied for plant, the stem diameter entirely could not be seen [19].

Previous research has reported the stem diameter of arabica coffee seedlings. Muliasari [20] reported that arabica coffee seedling nursery at 16 weeks after planting (wap), the diameter stem was 3.52 mm. The environmental factor played important role for stem diameter. Low sunlight intensity caused the inhibition of cell division process [21]. In less supportive environmental factor, the plant growth was vertical. The sunlight effect could be seen if plant grew in low intensity, the plant became higher, dense leaves and smaller stem diameter. If plant obtained high sunlight intensity, the growth stunted shorter stem and smaller leaves [22].

Table 2. Number of leaves of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Number of leaves	
0	12.27	b
5	14.33	ab
10	15.00	ab
15	16.27	ab
20	17.51	a
CV = 9.15%		

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation

Table 3. Diameter of stem of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Diameter of stem (mm)	
0	2.10	b
5	2.78	ab
10	2.79	ab
15	2.82	ab
20	3.00	a
CV = 3.92%		

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation

Table 4. Length and width of leaves of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Width of leaves (cm)		Length of leaves (cm)	
0	4.28	b	11.81	b
5	5.79	ab	15.26	ab
10	5.82	ab	15.51	ab
15	5.96	ab	15.81	ab
20	6.21	a	16.10	a
CV (%)	5.56		3.58	

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation

3.4 Length and Width of Leaves (cm)

The result showed that vermicompost dose affected the length and width of leaves of arabican coffee. Dose 20 ton/hectare was the best treatment both length and width of leaves (Table 4). The plant that underwent N deficiency became stunted and smaller leaves. Otherwise, the plant obtained sufficient N for plant growth become higher and leaves became longer [23]. Vermicompost contained nitrogen that played important role for main part of amino acid, nucleic acid and chlorophyll and also increased protein content and accelerated vegetative growth so that the number of leaves well developed [12].

The vegetative growth is not separated from nutrients availability in soil. Leaves played important role in photosynthesis process than produces organic compound for plant growth. Essential nutrient content and hormone in vermicompost could accelerate leaves formation rate. N in vermicompost was used optimally by plant so that photosynthesis process in leaves increased [14]. The photosynthesis result then was distributed to all parts of plant and it affected the length and width of leaves of plant [24].

The other factor affected the length and width of leaves was light intensity. Low intensity in plant caused bigger leaves, thinner in thins epidermis layer [21]. The result of this assay was different due to the temperature fluctuation caused by high rainfall and humidity in planting period. Rainfall affected the micro climate of planting area [25]. Tadesse et al. [26] also added that the plant growth by shade became slower due to low sunlight intensity and high soil humidity caused by rainfall. Shade in not single factor but it was consisted of several factor such as sunlight intensity, temperature, soil humidity and soil temperature [27]. These factors caused the transpiration rate decreased so that nutrient absorption process was slower and it affected the photosynthesis process and translocation of photosynthate. Unoptimal photosynthesis process caused the plant organ was disrupted [12].

3.5 Fresh and Dry Weight of Seedling

The result showed that dose affected the fresh and dry weight of arabica coffee. Dose 15 and 20 ton/hectare was the best treatment both length and width of leaves (Table 5). The result also showed that the increasing of fresh weight is in line to dry weight of arabica coffee seedling. This result indicates that the cell tissue formation increased due to nutrients availability such as N, P and K from vermicompost that required for metabolism process so that the vegetative stage underwent well and supported the increasing of fresh and dry weight of plant. Kashem et al. [19] stated that organic matter could increase soil biology activity, microbes activity in supporting

the decomposition process for soil fertility improvement so that it could increase the nutrient availability and nutrient absorption to increase the fresh and dry weight.

Previous research also revealed that vermicompost application affected the fresh and dry weight of gaharu plant (*Aquilaria malaccensis* Lamk) due to the vermicompost contained growth plant hormone [28]. This hormone not only increased the root system in plant transplant but it also stimulated the root growth of plant in soil, stimulated the shoot of branches [11].

Generally, dry weight was used as growth indicator and result of growth process so that if dry weight was high, it could be concluded the growth process underwent well. Huang et al. (2019)[28] stated that the increasing of dry weight showed the increasing of protoplasm due to the addition of cells. The chlorophyll increasing process increased the photosynthesis activity produced the more assimilate that supported the dry weight [16,29].

3.6 Length of Root (cm)

According the result, Dose 20 ton/ha was the best treatment for length of root (Table 6). The length root of arabica coffee seedling also can be seen in Fig. 2. In root formation, nutrients played important role in this process. The nutrients that played role in photosynthesis process produced photosynthate that used for root formation was available or could be sufficient for plant to grow [16].

Root system grew maximal in well soil physic and chemical due to the root system was positively correlated to growth. Longer root caused the plant availability to absorb water and nutrient became higher so that it produced the optimal growth such as height, number of leaves and stem diameter [30]. Vermicompost application could stimulate root development. This condition caused the root became longer. Light intensity also affected the well nutrient absorption in arabica coffee seedling. In 25% of shade, the photosynthate that was produced was more distributed to root than stem and leaves meanwhile in 40% and 75% intensity, they caused the dry weight of root became low. High shade caused the shorter root due to produced photosynthate was distributed to plant height and leaf area [21].

3.7 Leaf Area

The result showed that 3 treatments were the best treatment for leaf area, dose 20, 15 and 10 ton/hectare (Table 7). For leaf area, nitrogen, phosphorus and potassium significantly affected. N significantly played role for elongation and widening of leaves [12]. Vermicompost application affected the width of leaves due to vermicompost contained microorganism that could improve soil characteristic so that it supported the medium in providing nutrients that was available to be absorbed by plant root [14]. Vermicompost was nutrition for soil microbes. The presence of nutrients, organic matter decomposer microbes well developed and decomposed organic matter rapidly so that it increased soil fertility [5].

Leaf area was used as observation parameter due to analyze photosynthesis rate per plant unit where plant could change light absorption and energy to be plant yield. The increasing of leaf area was caused by growth hormone in vermicompost such as auxin, cytokinin and gibberellin could affect the plant growth. Kieber and Schaller [31] stated that cytokinin role was to encourage side part shoots, apical dominance and leaves expansion. Aalok et al. [5] also stated that vermicompost contained cytokinin. Endogenous cytokinin content could produce hormone for cell division and formed new shoot that affected total leaf area.

Table 5. Fresh and dry weight of arabica coffee seedling in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Fresh weight (gram)		Dry weight (gram)	
0	6.47	b	0.48	b
5	17.12	b	3.11	b
10	17.17	b	3.32	b
15	19.79	a	4.55	a
20	20.86	a	5.37	a
CV (%)				

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation.

Table 6. Length of root (cm) of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Length of root (cm)	
0	12.71	b
5	19.29	ab
10	20.89	ab
15	21.91	ab
20	24.65	a
CV = 8.49%		

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation

Fig. 2. Length of root (cm) of arabica coffee seedling in several vermocompost doses application

Table 7. Leaf area of arabica coffee in 16 weeks after planting in several vermicompost doses

Dose of vermicompost (ton/ha)	Leaf area (cm^2)	
0	84.00	b
5	117.00	ab
10	123.00	a
15	124.67	a
20	132.67	a
CV = 11.55%		

Note : Similar letter indicates not significantly different at 5%; CV : Coefficient of variation

4. CONCLUSION

Dose 20 ton/ha was the best treatment for growth component of arabica coffee seedling. This dose affected the plant height, number of leaves, diameter of stem, length and width of leaves, fresh and dry weight of seedling, length of root and leaf area.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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