Vertical farming application with several growing media for coffee nurseries

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Abstract. Coffee is one of the plantation commodities that play an important role as a source of foreign exchange for the country. One alternative to overcome the land decrease in rural area is to utilize urban farming in the form of a vertical planting system. This study aimed to obtain alternative techniques for planting coffee seedlings using vertical farming and to determine the effect of vertical planting with several growing media on the growth of coffee seedlings. The study was arranged in a non-factorial Randomized Block Design (RBD) with four treatments, namely: 1) conventional nursery; 2) topsoil verticulture nursery; 3) topsoil and compost media verticulture, and 4) topsoil, compost, and husk charcoal media verticulture. The data were analyzed using the Duncan Multiple Range Test (DMRT). The observed variables included observations of the morphology of coffee seedlings and verticulture environmental factors. The results showed that vertical planting on the vegetative growth of coffee seedlings was not significantly different from conventional planting. Topsoil planting media and husk charcoal in vertical planting did not significantly affect the morphological growth of coffee seedlings. The combination of topsoil, husk charcoal and compost gave the best plant height of 12.4 cm at 13 weeks after planting.

1 INTRODUCTION

Coffee is one of the plantation commodities that has a fairly high economic value compared to other plantation crops and plays an important role as a source of foreign exchange for the country. The taste and psychological effect of its freshness make it much in demand by consumers around the world and even become one of the main menus in various official banquets. Indonesia itself is the fourth largest coffee bean producer in the world after Brazil, Vietnam and Colombia [1].

The area of coffee plantations in Indonesia is 1.236 million hectares with the largest exploitation or around 96% by smallholder plantations. Indonesian coffee bean production fluctuates throughout the year. The production of large state and private coffee plantations in 2017 decreased by 4.95% from 2016 and in 2018 decreased again by 7.1%. Likewise, with smallholder plantations, coffee production in 2018 reached 685,790 tons or decreased by 0.002% compared to 2017. The decline in national coffee production was mainly because the

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area of coffee plantations owned by state and private plantations decreased from 46.82 thousand hectares to 42.17 thousand hectares in 2018 [1]. The decline in production occurred due to replanting land, lack of technical understanding of Good Agricultural Practices (GAP) on smallholder plantations, prolonged drought, and a decrease in land area due to land conversion. If this continues, the national coffee production will continue to decline.

Coffee plantation land is usually located in rural or rural areas far from the city, the land is currently experiencing a lot of land use change. One alternative to overcome the decrease in land area in rural areas is to utilize urban farming. Urban communities in Indonesia are currently promoting urban farming. According to [2] several agricultural methods in urban areas that have been developed and applied in Indonesia are verticulture farming and hydroponics. Verticulture is an agricultural cultivation system that is carried out vertically or stratified [3]. Verticulture is a farming model that can be done in a narrow area such as a yard or roof of a house.

Verticulture farming so far has focused on cultivating horticultural crops, especially leaf and fruit vegetables, these vegetables are generally seasonal crops that are harvested within 1-3 months. In vertical farming plantations, it can be applied in the nursery phase. Sari's research [4] conducted morphological observations of oil palm plants in the early nursery phase vertically and the results on physical observations of plant morphological growth that were planted vertically were better than conventional methods.

The growth of coffee seedlings in the pre-nursery still has short roots and morphological growth that is not too high so that it is in accordance with plant requirements for vertical planting. Vertical planting media must be able to support plant growth and nutrient requirements during the nursery period. Planting media with a combination of soil and compost is a planting medium that gives the highest dry weight yield of a vegetable verticulture system [5]. The combination of the planting media also gave the best yields in Sitawati's [6] research on optimizing planting media to support vertical crop yields.

The potential for vertical coffee breeding in urban areas will support the development of coffee cultivation technology in the upstream sector which is still conventional. The use of appropriate planting media for coffee seedlings needs to be considered to support the availability of superior seeds for the success of vertical coffee cultivation in Indonesia.

The purpose of this study was to obtain alternative techniques for planting coffee seedlings using vertical racks, to determine the effect of vertical planting on the growth of coffee seed morphology, and to determine the effect of several planting media on vertical planting on the growth of coffee seedlings morphology.

2 METHODS

2.1 Time and Place

This research was carried out in the Field Laboratory of the nursery area of the Gunung Gede Campus, College of Vocational Studies IPB University which is at an altitude of 350 meters above sea level and an average temperature of 25 degrees Celsius. The research was carried out from August 15 to December 4, 2020.

2.2 Materials and Tools

The tools used in this research were 5 sets of vertical planting, pump, net pot using 220 ml plastic cup, fiber tube, caliper, analytical balance, EC meter, lux meter, thermohygrometer,

pH meter, image-J software. The materials used were catimor coffee seeds from Puslitkoka (Coffee and Cocoa Research Center), NPK fertilizer, topsoil, compost and husk charcoal.

2.3 Research Methods

This study used a randomized block design (RBD) with 4 treatments with 3 replications. Each treatment contained 20 plants so that 12 experimental units and 240 coffee plant seeds were obtained. The treatments used were:
P0 : conventional coffee nursery (control)
P1: verticulture with top soil planting media
P2: verticulture with top soil + husk charcoal
P3: verticulture with top soil + husk charcoal + compost
If the results of the variance show a significant effect on the 5% level of the F test, then a comparison is made between the treatment mean and the DMRT (Duncan Multiple Range Test) test at the 5% level.

2.4 Observations

The variables observed in this study included observations of coffee plant morphology and verticulture environmental factors. The first vegetative observations were observed after the coffee plant had germinated and the cotyledons had separated. Each experimental unit was randomly selected 10 sample plants. Observations were carried out every 2 weeks. Observations of vegetative growth observed were plant height, number of leaves and stem diameter. Observation of environmental factors for vertical growth consists of Electrical Conductivity, pH, temperature and humidity of the vertical environment.

Observation Environmental factors observed were Electrical Conductivity or EC was carried out to determine the amount of fertilizer in water solution, EC observations were carried out using an EC meter carried out every day in the morning from the results of observations the average EC on plant nutrition was 1.5 - 2 ms. The EC is in accordance with the needs of coffee plant seeds. Subsequent observations, namely pH, were carried out to determine the pH in aqueous solutions, pH observations were carried out using a pH meter every day in the morning.

3 RESULTS AND DISCUSSION

3.1 Results

The results of observations of the average pH of 5.8 and still in accordance with the requirements for growing coffee plants. The temperature and humidity of the vertical environment were observed using a thermohygrometer placed in the nursery area and observed every day. The results of observations of the average temperature in the morning are 21ºC and during the day 25ºC with an average humidity of 83%.

Observations of plant vegetative growth observed were the number of leaves, plant height and stem diameter. The growth of the number of leaves on coffee seedlings in several treatments in Table 1 The growth of the number of leaves did not show significant differences in either conventional or vertical nurseries with several growing media. Number and length of coffee leaves
Prenursery breeding period is more influenced by genetics and less responsive to the treatment given

Table 1. The growth of the number of leaves on coffee seedlings in several treatments

	Seedling age (Week After Plant)				
Treatments	5	7	9	11	13
Conventional	2.1	2.4	2.9	4.1	5.4
Verticulture top soil	2.1	2.5	2.7	3.9	4.8
Verticulture top soil + husk charcoal	2.2	2.4	2.5	3.1	47
Verticulture top soil + husk charcoal + compost	2.1	2.6	2.7	3.2	4.7

The growth of plant height in Table 2 shows that conventional treatment and top soil verticulture and husk charcoal did not show a significant difference. The best and significantly different plant height growth was shown by the verticulture treatment of top soil, husk charcoal and compost at weeks 11 and 13. Verticulture planting media that had high aeration and water absorption could support the high growth of coffee seedlings. Mixed husk and compost media provide high porosity, husk charcoal contains C and SiO_2 which affects P availability, compost provides slowly available macro nutrients [6].

Table 2. Growth of plant height (cm) on coffee seedlings in several treatments

	Seedling age (Week After Plant)				
Treatments	5	7	9	11	13
Conventional	10.5	10.7	11.0	11.1 b	11.5 b
Verticulture top soil	10.4	10.6	11.0	11.1 b	11.4 b
Verticulture top soil + husk charcoal	9.8	10.0	10.1	10.4bc	10.6bc
Verticultuer top soil + husk charcoal + compost	11.0	11.5	11.8	12.1 a	12.4 a

Note : a number followed by the same letter indicates that there is no significant difference in the 5% DMRT test.

Table 3 shows that from all treatments, both vertical and conventional, there was no significant difference in the growth of coffee seedling stem diameter. Annual plants have relatively slow seedling growth, so the resulting stem diameter results are not much different.

Table 3. Growth of stem diameter (mm) in coffee seedlings in several treatments

	Seedling age (Week After Plant)				
Treatments	5	7	9	11	13
Conventional	1.43	1.62	1.60	1.60	1.65
Verticulture top soil	1.55	1.55	1.55	1.57	1.56
Verticulture top soil + husk charcoal	1.46	1.45	1.45	1.52	1.52
Verticultuer top soil + husk charcoal + compost	1.56	1.56	1.56	1.59	1.59

The vegetative growth of coffee seedlings verticulture was only significantly different in plant height after 11 WAP, meaning that plant growth remained normal even though it was

planted vertically. The number of plants that can be planted vertically with a size of 1 m^2 is 80 plants, while conventionally only 50 seeds (Fig. 1.)

Fig. 1. Vertical farming set up that is applied to coffee seedlings

3.2 Discussion

Coffee is a type of plantation plant that has long been cultivated and has high economic value. From the results of the study, the temperature in Bogor City, especially in this research environment, in the morning the average temperature is 21°C and during the day 25°C. The coffee grown in this study is Robusta Coffee, depending on the growing conditions for environmental temperature, planting in the city of Bogor is suitable for the requirements for growing Robusta coffee. Robusta coffee is a type of coffee plant that can grow in the middle to lowland areas. Robusta coffee grows in the lowlands with an altitude of 400-700 m above sea level with an average daily temperature of 25-26°C. In general, coffee plants can grow in areas with loose and fertile soil conditions with a pH of around 4.5-6.0 [7]. The results of the measurement of the average pH of the nutrients given to vertical planting have a pH of 5.8 so that it is in accordance with the requirements for growing coffee plants.

Vertical farming is the vertical cultivation of plants, which began to appear in Europe when greenhouse technology was applied in the early 1700s, initially the installation still used wood and soil planting media for planting ornamental plant [8]. Vertical farming then developed for the cultivation of leaf vegetables, fruits and herbs. Further developments in the early 1900s verticulture cultivation in England has used automatic fertigation with pumps that deliver water and nutrients to plants automatically according to plant needs and monitored using a computer. Verticulture comes from the English words, namely vertical and culture, so verticulture is a system of agricultural cultivation that is carried out vertically or stratified, both indoor and outdoor. This vertical or stratified agricultural cultivation system is a greening concept that is suitable for urban areas and limited land. The vertical requirement is that the installation is strong and easy to move around. Plants to be planted

should be adapted to the needs and have high economic value, short life, and short roots [3]. Vertical farming is a farming technique that is very prospective in terms of economy and architecture. In times of crisis, this vertical farming method can increase food security in urban areas, if it is integratedly applied it will certainly reduce poverty, unemployment and can meet food needs in a sustainable manner [9].

The results of the study, it can be seen that verticulture planting has no significant effect on the growth of leaf number and stem diameter compared to conventional methods, meaning that plant growth remains normal the same as when conventional planting. The growth of plant height was significantly different in the verticulture treatment of top soil, husk charcoal and compost. The number of plants that can be planted in an area of land with the verticulture method is more than conventional. In this study, a vertical plant with a size of 1 m^2 can be planted with 80 medium plants with the conventional method of only 50 seeds so that it is more land efficient.

In this study, three types of planting media were used, namely soil only, soil and husk and soil charcoal, husk charcoal, compost. The results of the analysis of variance showed a significant difference in the verticulture treatment with top soil, husk charcoal and compost media. Planting media is a place where plants grow to support roots. From this planting medium, plants absorb nutrients in the form of nutrients through their roots. According to [10] The media of soil, husk and manure had a significant effect on the percentage of coffee seed germination and seedling height. In verticulture planting media must also use media that have aeration and high water absorption, the media that are often used in verticulture are top soil, cocopeat, spagnummoss, husk charcoal, compost, rockwool [11]. According to [12] coffee seedlings treated with coffee husk and skin compost had plant height growth, number of leaves, stem diameter, leaf surface area, total wet weight. plants and higher plant total dry weight than soil media alone.

4 Conclusion

Morphological growth of coffee seedlings in vertical cultivation was as good as conventional methods. Top soil planting media and husk charcoal in vertical planting had no significant effect on the morphological growth of coffee seedlings. The combination of topsoil of husk charcoal and compost gave the best plant height. The vertical planting technique can be used as an alternative for land efficient coffee seedlings.

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