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The effect of intercropping and different dose of goat manure application on growth of Pogestemon cablin Benth

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Abstract

Patchouli (Pogostemon cablin Benth) is a perennial aromatic crop that can produce essential oil which is generally used as a mixture of ingredients for making cosmetics, pharmaceuticals, and aromatherapy which functions as a binder/fixative agent and pharmaceuticals. Although the production of patchouli increases year to year, the productivity per hectare of this plant showed a decreasing pattern. Efforts are needed to increase the productivity of patchouli, such as improving seeds quality and applying best management practices in planting. This study aimed to examine the optimum application of manure doses and intercropping practice on maximum growth of patchouli at first and two months after planting. The RCD (Randomize Complete Design) was conducted by using a cropping system and the application of goat manure in different doses. There were two levels of the cropping system: monocropping and intercropping with mung beans (Phaseolus radiatus) and four-level of manure in different doses were applied, 0 g, 500 g, 1000 g and 2000 g. ANOVA analysis shows that no interaction between cropping system and manure application on the growth of patchouli. All variables of patchouli growth in monocropping are better than in intercropping at two months after transplanting. Furthermore, there was no effect of manure application on canopy width, fresh and dry biomass of patchouli. The effect is only found on plant height and tree basal diameter, while without manure application and 500 g application is greater than 1000 g and 2000 g of manure application.
Keywords: essential oil, patchouli, intercropping, goat manure

1. INTRODUCTION

Patchouli (Pogostemon cablin Benth) is a perennial aromatic crop that can produce essential oil which is generally used as a mixture of ingredients for making cosmetics, pharmaceuticals, and aromatherapy which functions as a binder/fixative agent and pharmaceuticals (Sujianto et al., 1967). This crop is very potential to be developed in Indonesia because this country has a favourable condition to grow (Haryono, 2015). It was reported that in 2014 the total production of patchouli oil in Indonesia was 2.690 tons with a total area of 21.288. In 2014, the main importer of essential oil from Indonesia was Singapore (744 tons), followed by the United States and Spain with 663 tons and 320 tons respectively (Haryono, 2015).

The production of patchouli oil in Indonesia increases from year to year and makes this country become the world's largest patchouli oil exporter. However, the trend of production does not hand in hand with land productivity. Setiawan & Rosman (2013) reported that the decreased productivity was caused by planting in areas that are not suitable and do not practice patchouli cultivation properly. In addition, poor fertilization and diseases infection also became the main problem faced by the farmers. Around 45% of the total plantation area in Indonesia producing patchouli oil lower than 150 kg oil per hectare, whereas in 1999 the productivity of patchouli oil reached its highest point of 553 kg/ha of patchouli oil. Therefore, efforts are needed to increase the

productivity of patchouli, such as improving seeds quality and applying best management practices in planting.

Some practices can be applied to improve the growth and yield of patchouli. Such as, applying manure to the crop. Manure is an organic fertilizer that has many benefits, such as improving the soil structure and root development, increased soil water utilization, supply micronutrients, increased soil microbial activity, resulting in increased soil nutrient utilization and decomposition of harmful elements (Han et al, 2016). Moreover, applying manure with optimum dose is important for achieving maximum biomass and also important for agronomy and economic sustainability. Besides, intercropping practice is also can be applied for these purposes.

The practice of intercropping is popular these days, this management is part of sustainable farming. Intercropping patchouli with turmeric (Curcuma longa) and ginger (Zingiber officinale) has some benefits. Such as improve the abundance of soil microbial, improve the metabolism of soil bacteria and the soil enzymes activities. As well as increase the active ingredient in patchouli (Zeng et al., 2020).

Intercropping causes interaction between different crop species. It could be positive due to facilitation or negative due to competition. These interactions are important for community organizations (Connell, 1983; Jones, Lawton, & Shachak, 1997). Intercropping patchouli with legumes on the one hand can be positive due to nitrogen facilitation which benefits the patchouli growth. On the other hand, growing another plant together with patchouli could decrease the yield of patchouli due to competition. However, intercropping will improve the diversity of production as well as improve the diversity of household income.

The objective of this research was to analyze the impact of intercropping and manure in different doses on the growth of patchouli two months after planting. With improving the knowledge, we aim to find opportunities to improve efficiency through diversified intensification. Consequently, smallholders have changed to improve the management which is directly given an effect on the better performance of the crop. We hypothesize that intercropping with mung beans give a positive impact on the early vegetative growth of Patchouli because of nitrogen facilitation by the bean. Moreover, applying 2000-gram manure in patchouli give a positive impact on the patchouli vegetative growth due to more nutrients that can be taken up by the plant.

2. MATERIALS AND METHODS

2.1 Experimental Set-up & Treatments

The experiment was started on the 1st of July 2021 by transplanting the patchouli seeds var Tapaktuan and the seed of mung bean manually by hand. The seeds were obtained from the farmers in Panga, Aceh Jaya by planting the cutting stem into the polybag. The seeds were covered with concave plastic for 15 days, then the cover was opened. The age of the seeds when it transplanted into the field was 23 days after planting the stem cutting. The field experiment was located in Nino Park, Syiah Kuala University, Darussalam, Banda Aceh, Indonesia. The soil texture is sandy loam. Pruning was applied at 24 DAT (the day after transplanting) by cutting the stem apex and the manure of the goat was applied at 26 DAT. Patchouli was grown under shade conditions (shading net).

The experiment was set up in the field by using Randomize Complete Design (RCD) by using cropping system as the factor with two levels: monocropping patchouli (I0) and intercropping patchouli with mung bean (I1) and the application of goat's manure in different doses with four levels: 0 g manure (M0), 500 g manure (M1), 1000 g manure (M2) and 2000 g goat's manure (M3). This design leads to 24 plots while the spacing between rows was 0.85 m, and the spacing between the plant in the same row was 0.8 m. The dimension per plot was 5m x 1.30 m. The percentage of nutrients in goat manure is 2.10 % of N, 0.66 % for P, 1.97% for K, 1.64% for Ca and 0.60% for Mg (Herliana et al, 2019).

2.2 Plants Processing and Measurement

The first measurement was conducted on the 3rd of August 2021 by measuring the plant height, canopy width, the number of branches with tape meter and tree-basal diameter was measured using a digital calliper. The number of weed species was counted manually by looking at weed species distributed on each plot.

The second measurement was conducted on 3rd September 2021, the variable that was measured was the same as the first measurement, except for the number of branches, because it was mistaken when measuring this variable in the second measurement. Other variables such as patchouli above-ground fresh and dry biomass were added in the second measurement because we did the harvesting.

This process was applied by cutting the stem close to the soil surface with a scissor. Then, a digital scale was used to measure the fresh biomass of the crop. All the harvested plants were stored in plastic bags (correctly labelled) and stored in a fridge for five days, then subsamples of crop-fresh biomass (10 gram) were placed in a tray in the oven. Then it was dried for 16 hours at 105 °C and followed by 70°C for 72 hours. All the dried tissue was carefully weighted again without trying to damage it. Then, data was carefully written in datasheets. To calculate the total dry biomass of the crop, this formula was used:

Total dry biomass (g)=(dry biomass sub sample (g))/(fresh biomass sub sample (g)) x total fresh biomass (g)

2.3 Statistical Analysis

The Barlett's test for homogeneity and Shapiro-Wilk test for normality in all variables were done before conducting the Analysis of Variance (ANOVA). Fisher's protected LSD test as post hock with 0.05 for the significant level was also executed to identify which means of treatments were significantly different. If the data did not pass this test, it had transformed to the natural logarithm. Then, go back to the first data if the logarithm transformation does not work. The statistical analysis was conducted using GenStat 20th Edition (Ver. 20.1, VSN international).

3. RESULTS AND DISCUSSIONS

The results showed that there is no significant interaction between intercropping and manure. So that the results are reported separately for the manure and the cropping system.

3.1 Effect of cropping systems on patchouli characteristics

In the first month after transplanting, the monocropping system produced a bigger tree-basal diameter (F (1,16) = [17.38], p<0.001) and canopy width (F (1,16) = [13.39], p=0.002). However, the plant height (p=0.062), number of branches (p=0.137) and number of weed species (p=0.55) that grow in the plot were similar between monoculture and intercropping systems (Table 1). At the second month after transplanting, the plant height, (F (1,6) = [12.92], p=0.002) tree-basal diameter (F (1,16) = [15.17], p=0.001), canopy width (F (1,16) = [15.17], p=0.001), fresh biomass (F (1,16) = [6.02], p=0.026) and dry biomass (F (1,16) = [6.15], p=0.025) per plant were higher in the monocropping system than in intercropping (Table 2).

Intercropping practice negatively affects the patchouli growth in the first two months after transplanting (Table 1 and Table 2). The significant reduction of patchouli traits in intercropping might be due to competition, where interspecific competition is higher than intraspecific competition. Singh (2008) said that intercropping adversely affects plant dissemination at an early stage, but it recovers later. Moreover, in the research of Singh, (2008), at the harvesting time, total biomass, total essential oil yield and oil quality of patchouli in intercropping were not significantly different from monocropping practice.

Figure 1. Nodule on (A). Phaseolus radiatus grew in Nino Park ARC USK at 3 months after sowing

Growing crops together with legume plants will bring benefit to the environment as well as to the other plant in the surrounding by enhancing the facilitation/complementarity process (Duchene et al, 2017). In this experiment, we hypothesized that the facilitation effect of the mung bean which is one of the legume plants has a positive impact on the patchouli growth due to nitrogen facilitation. But we found that the mung bean causes a negative impact on patchouli growth in intercropping system. This factor might be due to the nitrogen from mung beans is not enough to facilitate the patchouli due to the lower amount of nodule formation (Figure 1). An experiment by Isoi & Yoshida (1991) said that the common bean (Phaseolus vulgaris L.) which has the same genus as Phaseolus radiatus (mung bean) has a lower ability on fixing nitrogen compared to other legumes like soybean.

Tabel 1. Effect of cropping systems on plant traits1 and number of weed species at the first month after planting

Cropping systems	Plant height (cm)	Tree basal diameter (mm)	Canopy width (cm)	No of branches	No of weed species
Monocropping	22.91 ± 6.52a[2]	5.14 ± 0.94b	21.23 ± 3.99b	10.77 ± 2.74a	8.83 ± 1.85a
Intercropping	19.71 ± 3.07a	4.33 ± 0.43a	16.77 ± 2.59a	9.83 ± 1.29a	9.25 ± 1.65a

[1]Plant height; tree basal diameter; canopy width and no of branches

[2]same letters in one column after means indicate that the means do not differ significantly (P ≥0.05) using the Fisher's protected LSD.

Table 2. Effect of cropping systems on plant traits1 at the second month after planting

Cropping systems	Plant height (cm)	Tree basal diameter (mm)	Canopy width (cm)	Fresh biomass (g/plant)	Dry biomass (g/plant)
Monocropping	38.64 ± 7.66b[2]	8.20 ± 1.54b	40.2 ± 8.71b	106.24 ± 47.1b	12.77 ± 7.14b
Intercropping	31.96 ± 3.27a	6.46 ± 0.92a	30.9 ± 7.56a	72.09 ± 31.29a	7.64 ± 3.39a

[1]Plant height; tree basal diameter; canopy width; fresh biomass; and dry biomass

[2]same letters in one column after means indicate that the means do not differ significantly (P ≥0.05) using the Fisher's protected LSD.

Another reason for the negative impact of the intercropping with Phaseolus radiatus is due to the inhibition of nodule formulation which was caused by Furadan application before transplanting or sowing was executed. Furadan is a fungicide, nematicide and insecticide which is applied to the field for pest and disease controlling.

However, the application of this product harms soil organisms, especially microorganisms that decompose organic matter. So that the texture and fertility of the soil will decrease after applying with Furadan (Shabur, 2021). Because the root nodule formation was not developed properly, the nitrogen fixation by the bean is not optimal.

3.2 Effect of manure application on different doses on patchouli characteristics

According to the different doses of manure application, at the first measurement, manure with 0 g and 500 g doses significantly produced higher plant height (F (3,16) = [7.96], p=0.002), bigger tree basal diameter (F (3,16) = [7.42], p=0.002) and a greater number of branches (F (3,16) = [7.07], p=0.003) while no significant differences of the variables were found on canopy width (p=0.082) and the number of weed species (p=0.189) compared to 1000 g and 2000 g of the manure doses (Table 3). Furthermore, in the second month after planting, 0 g and 500 g doses of manure application, only significantly produced patchouli with higher plant height (F (3,16) = [4.24], p=0.022) and tree-basal diameter (F (3,16) = [3.42], p=0.043). However, no significant difference among this treatment was found on the canopy width (p=0.154)0, fresh biomass (p=0.169), and dry biomass (p=0.161) of patchouli per plant (Table 4). The patchouli without and with lower manure application (0 g and 500 g per plant) produced patchouli with higher plant height, bigger tree-basal diameter and have a greater number of branches compared a higher manure application (1000 g and 2000 g) at the first month after transplanting (Appendix 2). It was contradicted with the result of Mustikawati et al, (2019).

They said that 1000 g manure application resulted in significant growth of patchouli (plant height, number of branches and number of leaves) compared to 0 g and 500 g manure application. The difference with the result might be due to the time of measurement. In this research, the data was collected at the first two months of patchouli after transplanting while the Mustikawati (2019) result was conducted in the six months after transplanting. At this time patchouli organs, such as root, stem and leaves have fully developed compared to the patchouli at first two-month-old. Patchouli at this age can take up more resources for increasing their biomass (Fageria & Baligar, 2004; Nielsen, 1979).

At the second month after planting, plant height and tree basal diameter had the same pattern as the first-month measurement. But the canopy width and fresh biomass and dry biomass per plant did not differ significantly (Table 4). According to the fresh and dry biomass, it can be said that no effect of manure application on growth of patchouli at two months after transplanting. As the productivity of patchouli oil was obtained from their biomass (for the Tapaktuan variety contains 3-3.5% of oil level in their total biomass).

Tabel 3. Effect of manure application in different doses on patchouli traits1 and number of weed species at the first month after planting

Manure doses (g)	Plant height (cm)	Tree basal diameter (mm)	Canopy width (cm)	No of branches	No of weed species
0	25.08 ± 4.42b[2]	5.36 ± 1.02b	21.31 ± 4.30a	11.15 ± 2.00b	10 ± 1.01a
500	24.15 ± 5.88b	4.99 ± 0.96b	19.61 ± 4.34a	12.01 ± 2.24b	9 ± 2.00a
1000	17.08 ± 1.26a	4.25 ± 0.25a	18.52 ± 4.43a	9.64 ± 0.97a	8 ± 1.83a
2000	18.95 ± 2.45a	4.35 ± 0.34a	16.55 ± 1.61a	8.40 ± 1.41a	9 ± 1.50a

[1]Plant height; tree basal diameter; canopy width; fresh biomass; and dry biomass

[2]same letters in one column after means indicate that the means do not differ significantly (P ≥0.05) using the Fisher's protected LSD.

Table 4. Effect of manure application in different doses on plant traits1 at the second month after planting

Manure doses (g)	Plant height (cm)	Tree basal diameter (mm)	Canopy width (cm)	Fresh biomass (g/plant)	Dry biomass (g/plant)
0	38.95 ± 8.33b[2]	7.84 ± 1.58b	41.02 ± 8.86a	117.93 ± 48.63a	14.23 ± 8.54a
500	38.24 ± 6.38b	8.08 ± 1.13b	36.75 ± 5.56a	80.31 ± 21.94a	10.02 ± 4.73a
1000	32.27 ± 6.11a	7.13 ± 1.99a	33.34 ± 12.99a	77.63 ± 55.82a	8.09 ± 5.70a
2000	31.73 ± 2.44a	6.24 ± 0.71a	31.12 ± 7.21a	80.81 ± 33.80a	8.51 ± 3.63a

[1]Plant height; tree basal diameter; canopy width; fresh biomass; and dry biomass

[2]same letters in one column after means indicate that the means do not differ significantly (P ≥0.05) using the Fisher's protected LSD.

This result on the manure application has contradicted the experiment conducted by Karyanto et al, (2010) but is hand in hand with the results by Atmaja et al, (2019). The former researcher proved that higher manure application (7.5 ton/ha) improved the biomass of green bean and cherry tomato and the yield gain from these vegetables varied between 2.7 to 5.1 times greater than in control. However, the latter, Atmaja et al, (2019) found that no effect of goat manure application (0 tons/ha, 10 tons/ha, 20 tons/ha and 30 tons/ha) in the growth of Shallot (Allium ascalonicum L). The difference between this experiment is due to the application of inorganic fertilizer. Karyanto, (2010) applied 200 kg/ha of inorganic fertilizer (NPK: 16-16-16) to the crops a week after planting for promoting the initial growth and development of the crops. But no additional fertiliser was applied by Atmaja et al, (2019). It can be said that plants with more developed organs can be beneficial for the higher concertation of nutrients. At that time, applying manure with higher concentration simultaneously improve the growth and development of the plant.

According to what we found in this research, we recommend that the intercropping practice of patchouli with mung beans is not suitable because the competition effect is greater than the facilitation. To make this system more beneficial, adjusting the time for the intercropping between crops, or finding suitable crops for niche differentiation to create a suitable application of intercropping in patchouli cultivation is needed. Moreover, the application of manure to the crop. The time for manure to break down depends on its size, it can take weeks or months. The smaller the pile the faster it will decompose (Saputra et al, 2017). So that we assumed the lower application of goat manure to the young crop is better, the sooner the manure decomposes the better for supporting the growth of the crop. Furthermore, compared to the other manure, goat manure has a slower ability of nutrient elements. Incubating the manure for four weeks before planting causes a better growth of the crops due to increasing the nutrient availability to the plant (Saputra et al., 2017).

4. CONCLUSIONS

Intercropping patchouli with mung beans in the same growing time causes a negative impact on the early growth of patchouli. Moreover, the manure should not be applied to the patchouli in the first months after transplanting because no significant difference was found between manure treatment and control on the fresh and dry biomass of patchouli.

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