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The Effect Of Mycorrhizatype And Phosphate Dosage Fertilizer On Growth And Quality Of Patchouli Oil (*Pogostemoncablin*Benth) On Ultisol Soil

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Abstract:
This study aims to determine the effect of the type of mycorrhizal biological fertilizer and the equitable dose of phosphate fertilizer on growth and yield and patchouli oil on Ultisol Aceh Jaya soil. This research was carried out at the Greenhouse and Plant Physiology Laboratory, Faculty of Agriculture, Syiah Kuala University, Darussalam Banda Aceh. The study started from June 2020 to April 2021. The data analysis used in this study was a Randomized Block Design with a Factorial pattern of 4 x 4 with 3 replications. The total of all treatments were 16 treatment combinations with three replications. The factors studied were mycorrhizalbiofertilizers consisting of 3 levels, namely Glomusmosseae, Gigaspora sp. and Mixture (Glomusmosseae and Gigaspora sp.) and phosphate doses consisting of 3 levels, namely 25 kg/ha, 50 kg/ha and 100 kg/ha and continued with a further test of Tukey's Honestly Significant Difference Test (Tukey's HSD test) at 5% level. The results showed that the treatment of mycorrhizal species had a very significant effect on the parameters of plant height at 30 and 60 days after soil relocate, number of leaves at 30, 60 and 120 days after soil relocate, prior to and following P-available soil, wet and dry weight of plant, and root colonization of mycorrhizal (%). Treatment of mycorrhizal species from the growth and yield of the best patchouli was found in mycorrhizal species Glomusmosseae and Gigasporasp (M3). In the phosphate dose treatment, the phosphate fertilizer dose of 100 kg/ha (P3) was able to increase plant height at 30 and 90 days after soil relocate, number of leaves at 60 days after soil relocate and wet weight of plant, prior to and following P-available soil, root colonization ofmycorrhizal (%). significantly between species treatment and dose of phosphate fertilizer on plant P-available soil.

Keywords: ***Mycorrhizal species, phosphate fertilizer and Ultisol soil***

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I. Introduction

Patchouli (*Pogostemoncablin* Bent.) is an essential oil-producing plant and can contribute to foreign exchange for more than 50% of Indonesia's total essential oil exports. [1]In 2016, Patchouli productivity in Aceh was 336 kg ha-1, then in 2017 it decreased to 317 kg ha-1, then in 2018 there was a significant decrease to 178 kg ha. The decline in patchouli productivity in Aceh is suspected to be caused by poor cultivation systems and soil fertility management, such as in ultisol soils.

Ultisol soil is a soil that has problems with soil acidity, low organic matter and has a very low availability of P elements[2]. Several studies also reported that ultisol soil problems such as low to very low cation exchange capacity (CEC) and base saturation, very low organic C (0.13%-1.12%), low total N (0.09-0, 18%), high aluminum content (Al saturation > 60%) which is toxic to plants. Also ultisol soil has high P fixation, iron and manganese content close to the limit of poisoning plants, macro nutrients such as P, K, Ca and Mg are low and sensitive to erosion[3,4,5]. This is a problem for patchouli plant growth. Thus, good soil management is needed to overcome the availability of plant nutrients by means of a combination of fertilization.

Combination of fertilization is an alternative in improving soil fertility for patchouli growth and yield by using mycorrhizal biological fertilizers and phosphate fertilizers. The use of mycorrhizae is one way that can be done in terms of helping the absorption of nutrients, especially phosphate applied to plants and the available phosphate in the soil, namely H_2PO_4 and HPO_4. Mycorrhizae are soil fungi that are obligately symbiotic in nature and are associated with about 80% of terrestrial plant species including the majority of agricultural crops[6]. Mycorrhizae can also increase the growth and yield of chili plants on entisolsoils[7] ,refining fertilizers up to 20-25% N, P, K[8].Mycorrhizaecan expand the area of nutrient uptake for plants[9].

The purpose of this study was to determine the effect of the mycorrhizal fungi *Glomusmosseae* and *Gigaspora*sp which were administered singly or in combination and the addition of phosphate fertilizer on the growth and yield of patchouli on ultisol soils with low soil fertility.

II. Materials And Methods

This research was conducted at the Experimental Garden, Greenhouse, Plant Physiology Laboratory, Faculty of Agriculture, Atsiri Research Center (ARC) Syiah Kuala University and the UPTD Laboratory of the Goods Quality Standards Testing Center, Banda Aceh. This research was carried out from June to December 2020. The material used in this study was patchouli seeds from Lhokseumawe variety, the *mycorrhizae* used in this study were mixed *mycorrhizae* (*Glomusmosseae* + *Gigaspora* sp.) were obtained from the results of mycorrhizal propagation in the Greenhouse of the Faculty of Agriculture, Syiah Kuala University, N, K fertilizer, manure, pesticide, KOH solution, aquadest and Ypan blue solution. The tools used in this study were hoe, polybag (30 x 45 cm), label paper, analytical scale, watering pot, 9 mesh sieve, hand sprayer, filter, object glass, caliper, cover glass, autoclave, ruler, Leaf area meters, and cameras.

The experimental design used in this study is a 4 x 4 factorial randomized block design (RBD) with 3 replications. The total of all treatments were 16 treatment combinations with three replications. The first factor studied was the type of mycorrhizal (M) and the dose of phosphate fertilizer (P). The results of the analysis of variance had a significant effect at the level of 0.05%, then further tests were carried out on the average value of the treatment to determine the difference between treatments using the Tukey's Honestly Significant Difference Test (Tukey's HSD test) procedure. Parameters observed were soil analysis, plant height, number of leaves, stem diameter, initial and final P-available soil, root colonization, patchouli oil yield and patchouli alcohol (PA) content.

III. Result and Discussion

Routine Soil Analysis

Preliminary analysis prior to the application of mycorrhizae on ultisol soils, observations made included soil texture, soil reaction (Soil pH), C-organic, N-total, P-available, exchanged base cations, cation exchange capacity, base saturation and electrical conductivity.

Table 1. Results of soil analysis

No	Type of Analysis and Methods	unit	Analysis Results
	Sample Number		1
	Laboratorium Number		231
	Sample Code		Soil
1	Soil Texture Sand Dust Clay Texture Class	% % %	4 64 32 E
2	Soil Reaction pH (H_2O) (1:2:5) - Electromatric pH (KCl) (1:2:5) – Electromatric		5,73 4,64
3	C-organic (Walkley And Black)	%	2,55
4	N-total (Kjedahl)	%	0,30
5	Phosphorus and potassium reserved (P and K total) • P_2O_2 Extract HCl 25%	%	-
6	P-availability P Bray II P Olsen	 mg kg^{-1} mg kg^{-1}	 3,20 -
7	Cations exchanged bases Exchangeable Ca (Ca) Exchangeable Mg (Mg) Exchangeable K (K) Exchangeable Na (Na)	 Cmol kg^{-1} Cmol kg^{-1} Cmol kg^{-1} Cmol kg^{-1}	 5,86 0,40 0,35 0,14
8	Cation exchange capacity (CEC)	Cmol kg^{-1}	9,80
9	Base Saturation	%	68,88
10	Potential Acidity Exchangeable Al (Al)	 Cmol kg^{-1}	 Tu

	Exchangeable H (H)	Cmol kg^{-1}	0,20
11	Electrical conductivity	mS cm^{-1}	0,34

Based on the results of soil analysis that has been carried out, it shows that ultisol soil is a type of soil with a slightly acidic pH value with a very low availability of phosphate, namely at number (3.20), meaning that this soil is classified as a soil that has problems with the availability of phosphate (P). Phosphate is one of the essential macronutrients needed by plants to increase plant growth and yield. [10]stated that the low availability of P in ultisol soils is generally caused by Al poisoning and other problems, namely the low content of organic matter. P nutrient deficiency will certainly result in slow, weak and stunted plant growth[11]. Base saturation value is less than 35%, low CEC, low N, P, and K content, and very sensitive to erosion, resulting in soil reactions inhibited to support plant growth and yields.

Effect of Mycorrhizal Types on Growth and Yield and Quality of Patchouli Oil

The following is the average effect of mycorrhizal types on the growth and yield of patchouli which can be seen in Table 2.

Table 2. Average Effect of Mycorrhizal Types on Patchouli Plant Growth and Yield

Observed Parameter		Mycorrhizal types				Tukey's HSD test 0,05
		Control (M0)	*Glomusmosseae* (M1)	*Gigaspora* sp. (M2)	Mixture of (*Glomusmosseae* + *Gigaspora* sp.) (M3)	
Plant Height (cm)	30 days*	23,83 a	26,17 ab	29,25 b	33,00 c	3,31
	60 days*	51,96 a	53,17 a	57,54 ab	63,17 b	7,72
	90 days*	73,79 a	74,38 a	72,75 a	82,50 a	9,78
	120 days*	84,58 a	101,08 b	95,08 b	109,67 c	6,71
Stem Diameter (cm)	30 days*	0,52 a	0,57 ab	0,61 b	0,68 c 0,83 b	0,07
	60 days*	0,77 ab	0,74 a	0,77 ab	0,87	0,07
	90 days*	0,83	0,85	0,87	0,98	
	120 days*	0,93	0,98	0,96		
Number of Leaves	30 days*	22,58 a	21,50 a	37,25 b	44,83 b	8,17
	60 days*	104,83 a	109,00 a	140,00 b	152,25 b	18,12
	90 days*	197,42 a	214,17 ab	232,83 b	234,08 b	34,13
	120 days*	236,17	240,58	243,67	259,92	
Wet Weight of Plants (g)		29,25 b	57,54 ab	72,75 a	95,08 b	72,80
Dry Weight of Plants (g)		57,17 a	80,92 ab	83,17 b	94,42 b	24,70
Prior P-available		36,19 a	37,69 a	37,70 a	41,71 b	2,30
Following P-available		40,15 a	41,70 a	41,66 a	45,75 b	2,25
Mycorrhizal colonization percentage (%)		1,28 a	66,90 b	67,01 b	73,45 b	15,61
Patchouli Oil Yield (%)		1,69	1,73	1,56	1,56	
PA (Patchouli Alcohol) content (%)		19,09	27,44	27,77	29,07	

Note : *meaning days after soil relocation

The results showed that the best type of mycorrhizal treatment was found in mixed mycorrhizae (*Glomusmosseae* + *Gigaspora* sp.) which affected the average plant height, stem diameter, number of leaves, wet and dry weight, prior to and following P-available soil, root colonization by mycorrhizae, oil yield and PA (Patchouli Alcohol) content (%) of patchouli oil. This is related to the level of soil fertility due to the application of mycorrhizal*Glomusmosseae* + *Gigaspora* sp. Mycorrhizae are very responsive to poor soil conditions as in ultisol soils, in that way mycorrhizae form a symbiosis with plants by producing many spores and hyphae to provide nutrients for plants and plants then provide carbon for the survival of mycorrhizae. The application of the right types of mycorrhizae certainly determines the increase in soil and plant productivity, one of which is mixed mycorrhizae (*Glomusmosseae* and *Gigaspora* sp.). According to[12] generally the mycorrhizal genus *Glomus* sp. can be used on soils with neutral pH, while the genus*Gigaspora* sp. generally very suitable for use in soils with a slightly acidic pH. However, mycorrhizae generally have the same function as forming hyphae by replacing the role of plant roots to explore nutrients in the soil, both in the form of water and nutrients such as phosphate (P)[13]. In addition, mycorrhizal inoculation was also able to increase the status of gas exchange and

photosynthetic pigments[14], and was able to increase the growth and yield of chili, melon, paprika and patchouli plants[15]. Mycorrhizae can increase the surface area of root uptake up to 80% and affect plant growth[16], and are able to improve soil physical properties by making soil aggregates stable[17].

To find out the results of the analysis of patchouli alcohol (PA) levels, the value of the parameter test results is compared with the specifications for patchouli alcohol (PA) levels issued by the Indonesian Standardization Agency known as SNI. Based on the analysis of patchouli alcohol (PA) patchouli oil, the highest PA value was found in the mixed mycorrhizal type treatment (*Glomusmosseae* + *Gigaspora* sp.) which was 29.07 (%) compared to other treatments. The PA level is still in the low category, but it is almost close to the SNI for PA levels, which is 30%. It is suspected that uncertain climatic conditions at the time of the study could affect the PA content of patchouli to be classified as low even though in this study the varieties used were Aceh superior varieties. According to[18]the low PA value of patchouli oil can be caused by several factors, namely land use, climate, genetics and microorganisms.

In addition, other handling of harvest and post-harvest handling can also be the cause of the decrease in PA levels of patchouli oil, in this case related to time, temperature, and the interaction between temperature and time during the vacuum redistillation process of patchouli oil. This is in line with the results of research by[19]time, temperature, and the interaction between temperature and time can affect the process of vacuum redistillation of patchouli oil which can affect the quality of patchouli oil.

Effect of Phosphate Fertilizer Dosage on Growth and Yield and Quality of Patchouli Oil

The following is the average effect of mycorrhizal types on the growth and yield of patchouli which can be seen in Table 3.

Table 3. The Average Effect of Phosphate Fertilizer Dosage on Growth and Yield and Patchouli Oil.

Observed Parameter		Dosage phosphate (SP-36)				Tukey's HSD test 0,05
		Control (P0)	*25 Kg/ha* (P1)	*50 Kg/ha* (P2)	*100 Kg/ha* (P3)	
Plant Height (cm)	30 days*	26,79 a	27,92 ab	27,00 b	30,54 b	3,31
	60 days*	54,25 76,38	53,17 a	54,67	59,79	
	90 days*	ab	75,04 ab	69,50 a	82,50 b	9,78
	120 days*	95,83	96,17	97,58	100,83	6,71
Stem Diameter (cm)	30 days*	0,58	0,58	0,60	0,61 0,78	
	60 days*	0,78	0,78	0,77	0,86	
	90 days*	0,85	0,85	0,86	0,97	
	120 days*	0,96	0,96	0,96		
Number of Leaves	30 days*	27,92 a	29,67 a	33,83 a	34,75 a	8,17
	60 days*	114,42 a	115,67 a	137,42 b	138,58 b	18,12
	90 days*	218,58	21,67	219,33	229,92	
	120 days*	249,83	249,25	240,33	240,92	
Wet Weight of Plants (g)		358,42 a	334,94	400,68 a	401,71	
Dry Weight of Plants (g)		78,92	71,00	82,50	83,52	
Prior P-available		37,68	38,59	38,17	38,84	
Following P-available		41,64	42,60	42,18	42,80	
Mycorrhizalcolonization percentage (%)		46,94	53,58	51,36	56,75	
Patchouli Oil Yield (%)		1,81	1,85	1,82	1,96	
PA (Patchouli Alcohol) content (%)		23,55	27,44	27,77	29,07	

Note : *meaning days after soil relocation

The results showed that the treatment with phosphate (SP-36) had a very significant effect on plant height at 30 and 90 HSPT, number of leaves at 60 days after soil relocation, wet weight and number of leaves at 30 HSPT, but had no significant effect on plant height at 60 and 120 days after soil relocation, stem diameter at

30, 60, 90 and 120 days after soil relocation, dry weight of plant, number of leaves aged 90 and 120 days after soil relocation, prior to and following P-available soil and root colonization of mycorrhizal (%).

Based on the results of the overall study, the best dose was found in the application of 100% phosphate (100 kg/ha) for the growth and yield of patchouli plant. It is suspected that the application of 100% phosphate dose (100 kg/ha) is able to provide P nutrients for plants in ultisol soils. The availability of element P is very low due to the reaction with heavy metals such as Al. According to[20]application of P to acid soils such as ultisol soils can increase the availability of P for plants and increase soil productivity as seen from the increase in plant height and maize yields, besides being able to increase soil pH and can make P available and Plant roots can absorb phosphate nutrients well, resulting in increasing the yield of seed corn weight[21].

However, several growth parameters and yields had no significant effect on plant growth and yield such as plant height at 60 and 120 days after soil relocate, stem diameter at 30, 60, 90 and 120 days after soil relocate, dry weight of plant, number of leaves at 90 and 120 days after soil relocate, prior to and following P-available soil and root colonization of mycorrhizal (%). It is suspected that the high level of soil acidity and followed by Al saturation causes disruption of plant growth and yield. This is in line with[22] statement that one of the consequences of high soil acidity was followed by Al saturation in ultisol soils and resulted in plants unable to provide optimal results[23].

Interaction phosphate fertilizer dosage with mycorrhizal types onfollowing P-available

Tabel 4. The Average effect of phosphate fertilizer dosage with mycorrhizal typesonfollowing P-available

Mycorrhizal types	Dosage phosphate (SP-36)				Tukey's HSD test 0,05
	Kontrol (P0)	25 % (25 kg/ha) (P1)	50% (50kg/ha) (P2)	100%(100kg/ha) (P3)	
M0	40,47 Aa	48,78 Bc	40,14 Aa	39,21Aa	4,72
M1	39,47 Aa	43,39 Ab	41,25 Aa	42,68 Aab	
M2	42,77 Ba	37,92 Aa	42,97 Ba	42,97 Bab	
M3	43,86 Aa	48,32 Ac	44,36 Aa	46,35 Ab	

Note : The numbers followed by the same letter (horizontal lowercase, vertical uppercase) show insignificant differences at the 5% level (Tukey's HSD test 0,05

Based on Table 4, the results of the Tukey's HSD test of 0.05 showed that the best combination of mycorrhizal types and phosphate dosage to the available P parameter was found in the combination treatment of mycorrhizal species (Glomusmosseae + Gigaspora sp.) and dosage phosphate of 100 kg/ha.It is suspected that because the plants were still able to absorb the P source from SP-36 fertilizer. Although, the Ultisol soil with condition is marginal soil that is poor in P -available, but in this research of phosphate that comes from the SP-36 fertilizer. Inorganic fertilizers are very quickly available to plants. This is in line with the statement of Bachtiar*et al.* (2013), that SP-36 inorganic fertilizer is very quickly available to plants. According to[24], application of SP-36 fertilizer was able to increase P uptake by plants on Ultisol soil.

IV. Conclusion

Mixed mycorrhizal species (*Glomusmosseae* + *Gigaspora* sp.) were able to increase plant height at 30 and 60 days after soil relocate, number of leaves at 30, 60 and 120 days after soil relocation, prior to and following P-available soil, wet and dry weight of plants, root colonization (%), oil yield and PA content of patchouli oil. Phosphate fertilizer dose of 100 kg/ha was able to increase plant height at 30 and 90 days after soil relocation, number of leaves at 60 days after soil relocation and wet weight of plant, prior to and following P-available soil, root colonization of mycorrhizal (%), oil yield and PA content of patchouli oil. The best interaction was found in the treatment of mixed mycorrhizal species (*Glomusmosseae* + *Gigaspora* sp.) with a dose of 100% phosphate (100 kg/ha) on plant height aged 30, 60, 120 days after soil relocation, number of leaves aged 60 days after soil relocation, wet weight of plant, prior to and following P-available soil, dry weight of the plant. The best combination for patchouli plant growth and patchouli oil quality was found in the combination of mixed mycorrhizal species (*Glomusmosseae* + *Gigaspora* sp.) with 100% phosphate dose (100kg/ha).

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