Interaction between mycorrhizal fertilizers and varieties to increase organic patchouli production in the Entisol soil of Aceh Besar

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Abstract. The purpose of this study was to determine the interaction effect of the use of mycorrhizal biofertilizers and varieties to increase the production of organic patchouli on the Entisol soil of Aceh Besar. This study used a factorial randomized block design with three replications. The first factor observed was mycorrhizal biofertilizer from the various genus, namely Glomus mossea, Gigaspora sp. and the mixed genus of Glomus mossea and Gigaspora sp. While the second factor is the use of varieties, namely Tapak Tuan and the Lhokseumawe variety. The results showed that the best interactions on the growth and production, P205 uptake, and oil content were found in the mixed mycorrhizal biofertilizers and the Tapak Tuan variety by 30%.
1. Introduction

Aceh’s Patchouli is very well known and has a high chance of being used as organic patchouli by fixing the cultivation actions carried out. Patchouli is one of the plantation crops that supports the community's economy, which has multiple functions. As a raw material for manufacturing perfumes, biopharmaceuticals, and cosmetics, it is necessary to develop organic patchouli. One of the patchouli productions centers that seek patchouli on Entisol soil is Aceh Besar District. Meanwhile, in other areas, Aceh patchouli was developed on Ultisol soil in South Aceh, Aceh Jaya, and North Aceh. Patchouli has a good production rate and oil quality on Entisol and Ultisol soils. This is evidenced by Syafruddin et al. (2000) [1] with a study on the evaluation of patchouli land and its production level in Ultisol Sawang, southern Aceh. Further research by Syafruddin et al. (2020) [2] found that Entisol soil was very good for patchouli growth and production combined with the provision of mycorrhizal biofertilizers of the genus *Glomus mosseae*. However, there is no precise information on how to produce patchouli on Entisol soils and the effectiveness of mycorrhizal biofertilizers and appropriate varieties, even though the wide potential and use of Entisol soil in Aceh for patchouli are very promising.

Characteristics of Entisol soils have base saturation varying from acidic, neutral to alkaline, cation exchange capacity < 20, coarse texture with lower organic matter and N content compared to fine-textured soils. Although this soil is rich in nutrients except for N, this element has not undergone weathering. The weathering rate will accelerate by giving the fertilizer of organic matter, manure and green manure, and mycorrhizal biological fertilizers [3,4]. Mycorrhizal biofertilizers provide an opportunity for Entisol soils to overcome the problem of low water holding capacity. Mycorrhizae have hyphae that can absorb nutrients and water better in Entisol soils [5].

In using mycorrhizal biological fertilizers, the existing genus is very decisive for increasing the productivity of the soil used and the production of patchouli varieties. According to Fikrinda and Syafruddin [6,7], the mycorrhizal genus *Glomus generally* can be used on soils with a neutral pH. In contrast, the genus *Gigaspora* sp is generally used for soils with acidic pH (< 6). Mycorrhizal biofertilizers used in some plants prove that crop production increases due to increased absorption of nutrients, especially phosphate and external hyphae in mycorrhizae which also help the process of maximum water absorption [7].

In addition to mycorrhizal biological fertilizers, the use of varieties also determines the increasing patchouli production. Some of the patchouli varieties in Aceh or Indonesia are the Tapak Tuan variety, the Lhokseumawe variety, and the Sidikalang variety. Specifically, the Tapaktuan variety is mostly used by the people of South Aceh on Ultisol soil and the Lhokseumawe variety, which is mostly cultivated on Ultisol soil in Lhokseumawe. There is no complete information about the two varieties and their yield levels when cultivated on Entisol soils. Generally, the Lhokseumawe variety has a high oil extraction yield compared to the Tapak Tuan variety when cultivated on Ultisol soil [1]. Meanwhile, the information about the production and quality of patchouli oil of the two varieties is unknown if cultivated on Entisol soils. Based on the description above, it is necessary to investigate the effectiveness of mycorrhizal biological fertilizers from various strains and the use of several patchouli varieties cultivated on Entisol soils.

2. Material and methods

This research was carried out at the Screening House of Agriculture Faculty, Syiah Kuala University, Banda Aceh, Soil and Plants Laboratory, Atsiri Research Center, Syiah Kuala University, Banda Aceh, and the UPTD Laboratory of the Goods Quality Standards Testing Center, Banda Aceh. This research has been carried out from March 2021 to August 2021.
2.1. Materials
Patchouli seedlings of Tapak Tuan and Lhokseumawe varieties aged 4 weeks after sowing, biological fertilizers for mycorrhiza genus *Glomus mosseae*, *Gigaspora* sp and Mixed (*Glomus mosseae* and *Gigaspora* sp), SP-36 fertilizer, NPK Mutiara fertilizer (16:16:16), Entisol soil of Aceh Besar district.

2.2. Tool
The tools used in this study were polybags with a volume of 20 kgs of soil for patchouli planting and polybags with a volume of 500 g of soil for seeding patchouli cuttings, para net, Gas Chromatography-Mass Spectrometry (GC-MS) to measure the content of Patchouli Alcohol (PA%) in patchouli oil, grinder to refine patchouli samples that have been dried for analysis of P uptake by plants, pH plug, patchouli distilled flask, and monel cloth.

2.3. Research design
The experimental design used in this study was a 3 x 2 factorial randomized block design with 3 replications, so there were 12 treatment combinations and 36 experimental units. There are 2 factors to be studied, namely mycorrhizal biofertilizer genus and patchouli variety. The first factor is mycorrhizal biofertilizer genus consisting of: M1 = genus *Glomus mosseae*, M2 = *Gigaspora* sp and M3 mixture of *Glomus mosseae* and *Gigaspora* sp. While the second factor is the patchouli variety, namely V1 = Tapak Tuan variety and V2 = Lhokseumawe variety.

The parameters observed were plant height, stem diameter, number of leaves and branches, oil yield, and PA content at 90 days after transplanting. Meanwhile, P\(\text{O}_5\) uptake was observed 45 days after transplanting. Data analysis was carried out using ANOVA and, if there was a significant difference, then tested by using the LSD 0.05 as a further test.

2.4. Research implementation
2.4.1. Soil preparation. The soil used in this study is Entisol soil from Aceh Besar. Soil is taken from the topsoil and air-dried. After drying, the soil was sieved through a 16-mesh sieve. Then the soil is put into a pot with a volume of 12 kgs.

2.4.2. Planting and mycorrhizal giving. Seedlings of Lhokseumawe and Tapak Tuan varieties were planted by giving 10 g of mycorrhizal biofertilizer from the genus *Glomus mosseae*, *Gigaspora* sp, and Mixture to each seedling that was 1 month when transplanting. Patchouli seedlings must be the same with the height criteria and number of leaves. Seedlings planted are placed in a screen house until they are harvested 90 days after transplanting.

2.4.3. Provision of basic fertilizer. The basic fertilizer given is NPK Mutiara fertilizer which is leaked at the beginning of planting with a dose of 25 percent of the recommended dose (150 kgs ha\(^{-1}\)) according to suggestions for organic patchouli management. Besides that, manure equivalent to 10 tonnes ha\(^{-1}\) is also given as basic fertilizer.

2.4.4. Plant cultivation. Plants are watered every day, and if pests and diseases attack them are controlled with botanical pesticides with a concentration of Glio Nasa with a concentration of 14 cc liter\(^{-1}\) of water.

2.4.5. Harvest. Harvesting is done when the plant is 90 days after transplanting and with slightly yellowish leaves criteria.
2.4.6. **Analysis of oil content and patchouli alcohol yield levels (%).** The distillation process carried out analysis of the oil content (%). Distillation is carried out using a distilled flask to obtain patchouli oil. Distillation is carried out using the steam distillation technique. Oil will be produced through the evaporation process. Patchouli alcohol content (PA%) of patchouli was analyzed using GC-MS.

### 3. Results and discussion

#### 3.1. Effect of Interaction between mycorrhizal genus and varieties on patchouli production and P uptake and patchouli oil content

The average interaction between mycorrhizal genus and varieties on plant height, stem diameter measured at 90 days after transplanting (DAT), number of branches, number of leaves, P$_2$O$_5$ uptake, patchouli oil content after being tested with LSD$_{0.05}$ can be seen in Table 1. It shows the best combination of mycorrhizal genus and varieties on plant height at 90 days after transplanting (DAT) found in the Mixed treatment with the Tapak Tuan variety not significantly different from the treatment mycorrhizal genus of *Gigaspora* sp. with the Lhokseumawe variety. As for the stem diameter at 90 DAT.

The best combination of mycorrhizal genus and varieties was found in treating mixed mycorrhizal genus with the Tapak Tuan variety was different from other combinations, but not significantly different from the combination of *Glomus mosseae* and the Tapak Tuan variety. The number of branches showed that the combination of mycorrhizal genus and the best varieties were found in treating the Mixed mycorrhizal genus with the Tapak Tuan variety, which was different from other combinations. But not significantly different from the combination of *Glomus mosseae* mycorrhizal genus and the Tapak Tuan variety. The number of leaves showed that the best combination of mycorrhizal genus and varieties was found in the combination treatment between mixed mycorrhizal genus and the Tapak Tuan variety, significantly different from other combinations.

The P$_2$O$_5$ uptake showed that the best combination of mycorrhizal genus and varieties was found in the combination treatment between mixed mycorrhizal genus and the Lhokseumawe variety which was significantly different from other combination treatments. But not significantly different from the combination of mixed mycorrhizal genus and the Tapak Tuan variety. The best combination of patchouli oil content was found in the mixed mycorrhizal type of treatment with the Tapak Tuan variety, significantly different from the other treatments.

#### Table 1. Interaction between mycorrhizal genus and varieties on plant height, stem diameter at 90 DAT, number of branches, number of leaves, P$_2$O$_5$ uptake, and patchouli oil content

| Parameters        | Mycorrhizal Genus | Varieties          | LSD$_{0.05}$ |
|-------------------|-------------------|--------------------|--------------|
|                   |                   | Tapak Tuan | Lhokseumawe  |              |
| Plant Height (cm) | *Glomus mosseae*  | 69.00 ABa        | 54.63Aa      | 21.63        |
|                   | *Gigaspora* sp.   | 54.50 Aa        | 79.30 Bb     |              |
|                   | *Glomus mosseae*  | 83.60 Ba        | 65.60 Aa     |              |
|                   | *Gigaspora* sp.   | 9.57 Bb         | 8.42 Aa      | 1.02         |
| Stem Diameter (mm)| *Glomus mosseae*  | 9.57 Bb        | 8.42 Aa      |              |
|                   | *Gigaspora* sp.   | 8.40 Aa         | 8.88 Aa      |              |
|                   | *Glomus mosseae*  | 9.61 Aa        | 8.98 Aa      |              |
|                   | *Gigaspora* sp.   | 8.40 Aa         | 8.88 Aa      |              |
| Number of Branches (branches) | Glomus mosseae | 60.00 ABa | 59.00 Aa | 2.62 |
|-------------------------------|----------------|----------|---------|-----|
|                               | Gigaspora sp.  | 59.00 Aa | 59.00 Aa |    |
| Glomus mosseae + Gigaspora sp.| 61.67 Bb       | 58.67 Aa |         |    |
| Number of Leaves (leaves)    | Glomus mosseae | 260.00 Aa | 271.33 Bb | 4.56 |
|                               | Gigaspora sp.  | 267.33 Bb | 254.17 Aa |    |
| Glomus mosseae + Gigaspora sp.| 283.50 Ca       | 282.33 Ca |         |    |
| P2O5 Uptake (ppm)            | Glomus mosseae | 45.33 Ba  | 43.00 Aa | 1.91 |
|                               | Gigaspora sp.  | 46.00 Aa  | 46.33 Ab |    |
| Glomus mosseae + Gigaspora sp.| 46.67 Aa       | 47.33 Ab |         |    |
|                               | Glomus mosseae | 2.93 Ba   | 2.85 Aa | 0.28 |
| Patchouli Oil Content (%)     | Gigaspora sp.  | 2.58 Aa   | 2.62 Aa |    |
|                               | Glomus mosseae + Gigaspora sp. | 3.81 Cb | 3.29 Ba |    |

Note: Numbers followed by the same letter are not significantly different at the 0.05 level tested by LSD. Capital letters represent rows, and lowercase letters represent columns.

Based on the growth and production of patchouli. The best combination was obtained using mixed genus mycorrhizae (Glomus mosseae + Gigaspora sp.) and the Tapak Tuan variety. Syafuddin's research [8] states that mixed mycorrhizae (Glomus mosseae + Gigaspora sp.) is higher in both acidic and alkaline soil conditions and soils with a sandy texture. The research conclusion also obtained the same thing by Nurmasyiyah [3], which stated that growth and some plant commodities were more dominant on Entisol soils with mixed mycorrhizal use.

The choice of the right genus will determine the production of patchouli. Especially organic patchouli. The selection of several AMF (Arbuscular Mycorrhizae Fungi) for a symbiotic response, such as Glomus etunicatum, was identified as the best mycorrhizal symbiont to increase growth and P nutrient uptake for patchouli [9] and stress tolerance to drought stress [10]. The mycorrhizal genus also used greatly determines crop yields, including patchouli. This is due to the ability of mycorrhizal roots to absorb nutrients and protect plants from pathogen attacks. Drought and other extreme conditions [5,7,11], helping the absorption of phosphate and nitrogen[12–14]; and produce hormones such as auxin and gibberallin[15] and can remediate polluted land [16]. In addition, among the mycorrhizal genus commonly used are Glomus sp. Gigaspora sp. and Acaulospora manihotis [17,18].

Mycorrhizal fungi also increase the number and activity of beneficial soil organisms such as nitrogen fixers and phosphate solvents, which are important for patchouli plant growth [2,19]. Another problem in some varieties of patchouli is the vulnerability of these plants to disease. so that mycorrhizae can become bioprotectors to increase patchouli production. Fertilization action. especially with the provision of mycorrhizal biofertilizers can increase the potential chemical. Physical and biological properties of Entisol soil. Mycorrhizae will work effectively on nutrient-poor (marginal) soils and can help absorb N. P and K.
effectively so that it is available to plants. The presence of mycorrhizae for the availability of N, P and K nutrients in the soil. including Entisols is absolutely necessary [20,21].

According to Syafruddin (2000)[1], the factors that cause differences in patchouli oil production are physical properties. Chemical properties. Climate or land characteristics such as altitude. Slope. Rock conditions above the land surface and others. Especially for the production of organic patchouli, the emphasis on the chemical properties of the soil. Especially soil biology. Must receive the main attention. Another problem in some varieties of patchouli is the vulnerability of these plants to disease. so that mycorrhizae can become bioprotectors to increase patchouli production [5]. The use of varieties is no less important in increasing the growth and production of patchouli. The Tapak Tuan variety generally. if managed properly. Will produce high growth. Yield and oil yield [5]. However, the Lhokseumawe variety is one of the leading varieties. When improved with technological input will give the high potential of yields.

3.2 Patchouli Alcohol (%)
Specifically, the analysis of Patchouli Alcohol (PA) obtained in this study is listed in Table 2.

| No | Treatments  | Patchouli Alcohol (%) | SNI Score 06-3953-1995 |
|----|-------------|------------------------|--------------------------|
| 1  | M1V1        | 23.67                  |                          |
| 2  | M1V2        | 25.67                  |                          |
| 3  | M2V1        | 26.78                  | Min. 30 GCMS             |
| 4  | M2V2        | 29.77                  |                          |
| 5  | M3V1        | 29.88                  |                          |
| 6  | M3V2        | 30.57                  |                          |

Note: Letter of M represent mychorrhizal genus; M1 = *Glomus mosseae*, M2 = *Gigaspora* sp and M3 mixture of *Glomus mosseae* and *Gigaspora* sp. and letter V represent patchouli variety; V1 = Tapak Tuan and V2 = Lhokseumawe

Based on Table 2, it can be seen that the highest alcohol content of patchouli was found in the mycorrhizal treatment of the mixed genus and the Tapak Tuan variety (M3.V2). The high yield of oil and patchouli alcohol in patchouli varieties is highly dependent on the input of fertilization technology. Soil type and good cultivation practices[22].

4. Conclusion
The best interactions on growth and production. P205 uptake and oil content were found in mixed mycorrhizal genus (*Glomus mosseae* + *Gigaspora* sp.) and the Tapak Tuan variety. Field research is needed to determine the relationship between growth and yield and the quality of patchouli oil.

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