Interaction between type of plant growth promoting rhizobacteria and patchouli varieties on growth and yield of patchouli (Pogostemon cablin Benth.)

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Abstract. A group of bacteria living in the rhizosphere area and capable to actively colonize the plant's root system called Plant Growth Promoting Rhizobacteria (PGPR). These bacteria can improve plant growth and yield. We determine the interaction between types of PGPR and patchouli varieties on growth and yield. This research was conducted at the Laboratory of Seed Science and Technology and Experimental Farm, Faculty of Agriculture, Syiah Kuala University, between January to June 2020. The collecting data from experiment were analyzed by factorial randomized block design with three replications. Seven type of rhizobacteria consist used without rhizobacteria, Necercia sp., Pseudomonas capsica, Bacillus firmus, Bacillus bodius, Bacillus alvei, Bacillus stearothermolipillus. The varieties consist of three levels Tapak Tuam, Lhokseumawe, and Sidikalang. There was very significant interaction between rhizobacteria and varieties on the parameters of fresh weight and dry weight and significant interactions on plant height at 60 and 120 DAP, number of branches at 90 and 120 DAP, and leaf area. Variety of Sidikalang combination with P. capsica have very high wet weight (73.43 g), dry weight (18.05 g), and leaf area (84.00 cm²).

1. Introduction
The essential oil from patchouli (Pogostemon cablin Benth.) is an important export commodity from Indonesia. Indonesia is the largest patchouli oil exporter in the world, reaching almost 90% of the world's needs with an export value of 2,074 tones, equivalent to the US $ 27,136 million, and 70% of them have ever come from Aceh [1].

There are three species of patchouli that have been developed in Indonesia, namely Pogostemon cablin, Pogostemon heyneanus, and Pogostemon hortensis. However, the species that is widely planted in Aceh is Pogostemon cablin, called Aceh patchouli. The characteristics of this species are non-flowering plants, downy leaves, and high oil content (2.5-5.0%). Meanwhile, Pogostemon heyneanus is known as Javanese patchouli, with the characteristics of flowering plants, thin leaves, and low oil content (0.5-1.5%). Pogostemon hortensis can be found in Banten and is often referred to as patchouli soap [2].

Considering that patchouli is one of Indonesia's export commodities, it is necessary to increase the quality and quantity of patchouli production. There are several obstacles in increasing patchouli oil production, one of which is the problem of cultivation. Some of these problems include poorly controlled soil fertility, shifting cultivation that causes deforestation, and organic fertilizers, and biopesticides which are difficult to obtain [1]. One of the efforts that can be made to optimize the growth and yield of patchouli is by utilizing indigenous rhizobacteria.
Indigenous rhizobacteria are reported to produce indole acetic acid (IAA) hormone, fix nitrogen and dissolve phosphate, thereby reducing the use of artificial fertilizers [3]. Indigenous rhizobacteria isolated from Gramineae roots produced IAA hormone which increased shoot and root wet weight by 48.7% and 94.8% in banana plants [4]. Patchouli plants inoculated with rhizobacteria grew better, as indicated by the higher crown weight and dry weight of the plant, with an increase in growth of 37.86-84.71% [5], [6].

One type of indigenous rhizobacteria is Bacillus spp. According to several studies, it shows that at a dose of 10^8 cfu mL⁻¹, Bacillus spp can increase the growth of pepper cuttings, the growth of arabica coffee beans by 35.4%, and the growth of patchouli by 23.6% - 57.5% [7]-[9]. The application of indigenous rhizobacteria to stimulate plant growth is known as Plant Growth Promoting Rhizobacteria (PGPR).

Rhizobacteria is a type of soil bacteria that live around the roots of plants, living in colonies covering plant roots in a thin layer of soil between 1 to 2 mm around the root area (rhizosphere). The results of a study conducted by [4] found that the rhizobacteria group Bacillus spp, Pseudomonas fluorescens, and Serratia spp have the ability to produce growth hormones such as IAA which can stimulate plant growth. Inoculation of seeds with the rhizobacteria Pseudomonas spp and Bacillus spp can increase the root length and height of wheat and pea crops. Bacillus spp., P. fluorescens, and Serratia spp are able to synthesize indolic acid (IAA), a siderophore compound, reduce manganese, the ability to dissolve phosphate, and fix nitrogen [10]-[13].

The role of the IAA hormone is to increase cell development, stimulate new root formation and flowering, and increase enzyme activity [14], [15]. According to Ahmat et al., [16] the role of rhizobacteria is to increase the efficiency and effectiveness of nutrient absorption, especially nitrogen (N) and phosphor (P). The role of P is for cell growth, the formation of fine roots and root hairs, strengthening the stems so that plants do not fall off easily, forming flowers, fruit and seeds. In addition, rhizobacteria can also release various types of organic acids such as formic acid, acetic acid, propionic acid, lactic, glycolic, fumaric, and succinic acids [17].

In addition to implementing PGPR, another determining factor for the growth of patchouli is its variety. There are three local varieties commonly found in Aceh, namely Tapak Tuan, Lhokseumawe, and Sidikalang. Each variety has different physical characteristics and chemical content. Tapaktuan variety has green stems with a slightly purple color, Lhokseumawe has a purple stem color, and Sidikalang has a dark purple color. Patchouli alcohol (PA) levels varied, namely: Tapaktuan (28.69-35.90%), Lhokseumawe (29.11-34.46%) and Sidikalang (30.21-35.20%) [2].

Based on the above references, the aim of this study was to determine the best interaction between PGPR and patchouli varieties on growth and yield.

2. Material and methods
This research was conducted at the Laboratory of Seed Science and Technology and Experimental Farm, Faculty of Agriculture, Syiah Kuala University, Darussalam Banda Aceh, from January to June 2020.

2.1 Material
Six rhizobacterial isolates have been used in this study, namely Necercia sp., Pseudomonas cepacia, Bacillus firmus, Bacillus badius, Bacillus alvei, and Bacillus stearothermophilus. These isolates are endophytic rhizobacteria that have been identified from the rhizosphere of patchouli plantations at Kuala Itam Village, Nagan Raya. The shoot cuttings of the three varieties of patchouli, namely Tapaktuan, Lhokseumawe, and Sidikalang were 150 cuttings from Alue Abed Village, Calang, Aceh Jaya. Other materials were 200 g of potatoes, aluminum foil, plastic wrap, dextrose, agar powder, 98% alcohol, 1000 mL of distilled water, 200 kg topsoil of alluvial (ordo entisol, pH 6.8, C-organic Walkey and Black 1.65%, Cation Exchange Capacity (CEC) 31.1 me 100 g⁻¹, soil texture fraction percentage sand: dust: clay 58.2: 16.4: 25.4, 100 kg of manure, and 70 g Basamid G for soil sterilization.

Tools: laminar airflow cabinet, electric oven, spectrophotometer, measuring cup, filter, erlenmeyer, incubator, petridish, measuring pipette, autoclave, label paper, splash of watering, digital scales,
scissors, ruler, plastic wrap, polybag size 35 cm x 15 cm, hoe, bucket, tape measure, and camera have been used gradually on each experiment.

2.2 Methods
This research was conducted using a factorial randomized block design (RBD) with three replications. The first factor was the type of rhizobacteria that acts as PGPR consists of seven levels, namely control (without rhizobacteria), Necercia sp, Pseudomonas capacia, Bacillus firmus, Bacillus bodius, Bacillus alvei, Bacillus stearothermophilus. The second factor was varieties of patchouli consists of three levels, namely Tapaktuan, Lhokseumawe, and Sidikalang. If the F test results have a significant effect, then the analysis is continued with the Duncan New Multiple Test (DNMRT) at the 5% level.

2.3 Implementation of research
Rhizobacteria isolates were cultured on PDA media and incubated for 48 hours until rhizobacteria colonies grew for rejuvenation (Figure 1). The rhizobacterial colonies that had grown were then suspended into 50 mL sterile distilled water by taking them without touching the growth media. Then the population density of the suspension was calculated using a spectrophotometer up to $10^{-9}$ cfu mL$^{-1}$ or equivalent of the absorbance value OD600 = 0.192.

![Figure 1](image.png)

\textit{Figure 1.} Six rhizobacterial isolates were used, Necercia sp (a), Pseudomonas capacia (b), Bacillus firmus (c), Bacillus bodius (d), Bacillus alvei (e), Bacillus stearothermophilus (f).

Patchouli nursery is carried out at Nino Park, Atsiri Research Center, Syiah Kuala University. Patchouli nurseries of the three varieties use shoot cuttings from community gardens in Alue Abet Village, Calang, Aceh Jaya. Patchouli shoot cuttings were grown in nursery polybags measuring 10 cm x 16 cm for 30 days and then transplanted into polybags planting media. The seedlings used as planting material are uniform in size, the plant height is 10 cm and already has 4 leaves.

Preparing the alluvial soil that has been filtered using an 8 mesh sieve and decomposed manure. Then the media is mixed in a 2:1 ratio (soil: manure), then added 70 grams of Basamid G and closed air tightly for 14 days to sterilize the planting medium. Then the media that has been resting for 14 days is filled in polybags measuring 35 cm x 15 cm.

Patchouli seedlings aged 30 days are transplanted into planting polybags measuring 35 cm x 15 cm. Then, rhizobacteria suspension was inoculated on the root area of patchouli by sprinkling it on the planting medium as much as 50 mL per plant unit.

Patchouli seedlings are maintained every day for optimal growth. Patchouli plant maintenance includes (1) watering is done in the morning and evening, (2) weeding is done by cleaning the surrounding area, (3) installation of wooden stakes is carried out at 60 days after planting (DAP) which aims to support the plants so they do not fall, and (4) pest and disease control is carried out using biopesticides when an attack occurs 20% of the population.

Harvesting patchouli is carried out at the age of 120 DAP by removing all parts of the plant including leaves, stems, and roots to weigh the wet stalks weight.
2.4. Observation parameters

2.4.1 Plant height (cm). Measurement of plant height was carried out when plants were 30, 60, 90, and 120 DAP after the seedling was applied to rhizobacteria. Measurements were made starting from the base of the stem to the highest growing point of the plant using a meter.

2.4.2 Number of leaves. The number of leaves is counted as leaves that have opened perfectly. Leaf count observations were carried out at 30, 60, 90, and 120 DAP after the seedlings were applied to rhizobacteria.

2.4.3 Number of branches. Observation of the number of branches was carried out at 30, 60, 90, and 120 DAP by counting the branches that grew on the main stem after the seedling was applied to rhizobacteria.

2.4.4 Leaf area. Leaf area measurements are carried out by calculating the length and width of each leaf with the criteria that the leaves are intact and not damaged. Measurement of area per leaf using ImageJ software application.

2.4.5 Wet weight (g). Weighing the wet weight of the plants was carried out after the 120 DAP plants were dismantled and washed with water at the root, then weighed the plant weight using analytical scales.

2.4.6 Root length (cm). Root length measurement is done by selecting the longest root in the patchouli plant, then measuring the length using a ruler. Root length measurements were carried out at 120 DAP after the seedling were applied rhizobacteria

2.4.7 Root volume (mL). Root volume measurements were carried out at 120 DAS. The root volume is measured by cutting the root base, then putting it in a measuring cup that contains 100 mL of water. The increase in water level is the value of the root volume.

2.4.8 Dry weight (g). Weighing the dry weight of plants is done after the plants have been heated for 2 x 24 hours with a temperature of 60°C or reaching a constant weight. Weighing is done using analytical scales.

3. Results and discussion

The results of the analysis of variance (F test) showed that the interaction between rhizobacteria and varieties had a very significant effect on the parameters of wet weight and dry weight. The interaction of rhizobacteria and varieties significantly affected plant height parameters 60 and 120 DAP, the number of branches 90 and 120 DAP, and leaf area. There was no interaction between rhizobacteria and varieties on the parameters of plant height 30 and 90 DAP, number of branches 30 and 60 DAP, number of leaves 30, 60, 90 and 120 DAP, root length, and root volume.

The highest plant height at 60 DAP was found in the combination treatment of P. capacia and Sidikalang, (9.20 cm), not significantly different from the treatment of B. bodius rhizobacteria but significantly different from all other treatment combinations (Table 1). The highest plant height at 120 DAP was found in the treatment combination of B. alvei and Sidikalang and was not significantly different from other rhizobacterial treatments but significantly different from control. The highest number of branches at 90 DAP was found in the treatment of rhizobacteria B. alvei and Lhokseumawe, namely 12.67 branches, although statistically not significantly different from the treatment combination of Necceria sp and Sidikalang, but different from other treatment combinations. The highest number of branches at 120 DAP was found in the treatment combination of rhizobacteria B. alvei and Sidikalang, namely 23.67 branches which were significantly different from all other treatment combinations. The heaviest plant wet weight was found in the combination treatment of P. capacia and Sidikalang, namely 73.43 g which was significantly different from other treatment combinations. The widest leaf area was
found in *P. capacia* and Sidikalang, which was 84 cm², which was significantly different from other treatment combinations. The heaviest plant dry weight was found in the combination of *P. capacia* and Sidikalang, which was 18.05 g which was significantly different from other treatment combinations.

Table 1. The average growth and yield of patchouli is due to the interaction between the types of rhizobacteria and varieties.

| Parameter | Rhizobacteria                  | Variety of patchouli     |
|-----------|--------------------------------|--------------------------|
|           |                                | Tapak Tuam  | Lhokseumawe | Sidikalang |
| Plant Height (cm) 30 DAP | Control | 10.92 | 11.42 | 15.27 |
|           | *Necercia* sp                  | 14.03 | 15.05 | 16.53 |
|           | *Pseudomonas capacia*          | 11.62 | 13.57 | 18.07 |
|           | *Bacillus firmus*              | 12.12 | 11.55 | 15.87 |
|           | *Bacillus boidius*             | 14.23 | 16.88 | 17.17 |
|           | *Bacillus alvei*               | 11.87 | 16.35 | 17.93 |
|           | *Bacillus stearothermophilus*   | 17.88 | 14.48 | 17.60 |
| Plant Height (cm) 60 DAP | Control | 17.03Aa | 19.60ABa | 22.67Ba |
|           | *Necercia* sp                  | 20.62Aab | 22.80Aa | 24.63Aabc |
|           | *Pseudomonas capacia*          | 17.97Aa | 20.38ABa | 29.20Cc |
|           | *Bacillus firmus*              | 17.97Aa | 20.27ABa | 24.13Bab |
|           | *Bacillus boidius*             | 20.42Aab | 23.20ABa | 28.20Cbc |
|           | *Bacillus alvei*               | 18.15Aa | 22.13ABa | 28.90Cc |
|           | *Bacillus stearothermophilus*   | 25.05Bb | 19.78Aa | 26.80Bbc |
| Plant Height (cm) 90 DAP | Control | 21.43 | 23.22 | 32.87 |
|           | *Necercia* sp                  | 27.17 | 24.77 | 38.03 |
|           | *Pseudomonas capacia*          | 24.27 | 27.55 | 44.77 |
|           | *Bacillus firmus*              | 23.02 | 24.57 | 35.17 |
|           | *Bacillus boidius*             | 23.80 | 26.27 | 39.53 |
|           | *Bacillus alvei*               | 20.72 | 26.27 | 45.63 |
|           | *Bacillus stearothermophilus*   | 29.92 | 26.77 | 40.73 |
| Plant Height (cm) 120 DAP | Control  | 20.73Aa | 20.78Aa | 16.47Aa |
|           | *Necercia* sp                  | 32.83Aa | 34.17Ab | 51.57Bbc |
|           | *Pseudomonas capacia*          | 29.67Aa | 30.58Aab | 60.30Bbc |
|           | *Bacillus firmus*              | 27.10Aa | 31.35Aab | 47.57Bb |
|           | *Bacillus boidius*             | 27.45Aa | 30.02Aab | 55.57Bbc |
|           | *Bacillus alvei*               | 26.77Aa | 29.62Aab | 62.30Bc |
|           | *Bacillus stearothermophilus*   | 27.57Aa | 31.90Aab | 54.87Bbc |
| Number of leaves 30 DAP | Control  | 3.00 | 5.00 | 4.00 |
|           | *Necercia* sp                  | 3.33 | 7.33 | 6.00 |
|           | *Pseudomonas capacia*          | 4.33 | 6.67 | 6.00 |
|           | *Bacillus firmus*              | 6.67 | 6.67 | 5.33 |
|           | *Bacillus boidius*             | 6.00 | 6.00 | 6.67 |
|           | *Bacillus alvei*               | 4.67 | 5.67 | 6.00 |
|           | *Bacillus stearothermophilus*   | 8.33 | 5.67 | 7.00 |
| Number of leaves 60 DAP | Control  | 9.00 | 18.33 | 11.67 |
|           | *Necercia* sp                  | 14.33 | 21.33 | 19.00 |
|           | *Pseudomonas capacia*          | 9.67 | 15.00 | 16.00 |
|           | *Bacillus firmus*              | 14.33 | 16.00 | 15.67 |
|           | *Bacillus boidius*             | 19.67 | 17.00 | 15.67 |
| Number of leaves 90 DAP | Bacillus alvei | Bacillus stearothermophilus |
|------------------------|---------------|-----------------------------|
| Control                | 21.00         | 45.67                       |
| Necercia sp            | 45.67         | 40.00                       |
| Pseudomonas capsia     | 21.67         | 30.67                       |
| Bacillus firmus        | 28.67         | 42.00                       |
| Bacillus bodius        | 40.00         | 33.33                       |
| Bacillus alvei         | 33.00         | 29.67                       |
| Bacillus stearothermophilus | 32.33       | 37.00                       |

| Number of leaves 120 DAP | Bacillus alvei | Bacillus stearothermophilus |
|--------------------------|---------------|-----------------------------|
| Control                  | 33.00         | 47.00                       |
| Necercia sp              | 54.00         | 55.33                       |
| Pseudomonas capsia       | 39.67         | 34.00                       |
| Bacillus firmus          | 34.67         | 69.33                       |
| Bacillus bodius          | 58.33         | 42.33                       |
| Bacillus alvei           | 38.67         | 55.00                       |
| Bacillus stearothermophilus | 39.33       | 51.67                       |

| Number of branches 30 DAP | Bacillus alvei | Bacillus stearothermophilus |
|--------------------------|---------------|-----------------------------|
| Control                  | 1.00          | 1.67                        |
| Necercia sp              | 2.33          | 3.00                        |
| Pseudomonas capsia       | 1.33          | 2.33                        |
| Bacillus firmus          | 1.33          | 2.00                        |
| Bacillus bodius          | 3.67          | 1.33                        |
| Bacillus alvei           | 2.00          | 2.33                        |
| Bacillus stearothermophilus | 2.33        | 2.67                        |

| Number of branches 60 DAP | Bacillus alvei | Bacillus stearothermophilus |
|--------------------------|---------------|-----------------------------|
| Control                  | 2.33          | 5.33                        |
| Necercia sp              | 4.33          | 7.33                        |
| Pseudomonas capsia       | 2.33          | 4.33                        |
| Bacillus firmus          | 3.67          | 4.33                        |
| Bacillus bodius          | 6.33          | 3.67                        |
| Bacillus alvei           | 4.67          | 6.33                        |
| Bacillus stearothermophilus | 4.00        | 5.00                        |

| Number of branches 90 DAP | Bacillus alvei | Bacillus stearothermophilus |
|--------------------------|---------------|-----------------------------|
| Control                  | 4.33Aa        | 5.00Aa                      |
| Necercia sp              | 9.00Ab        | 7.00Aab                     |
| Pseudomonas capsia       | 4.67Aa        | 8.00ABab                    |
| Bacillus firmus          | 7.33Aab       | 6.67Aab                     |
| Bacillus bodius          | 6.00Aab       | 10.33Bbc                    |
| Bacillus alvei           | 4.33Aa        | 12.67Bc                     |
| Bacillus stearothermophilus | 9.33Ab      | 9.33Abc                     |

| Number of branches 120 DAP | Bacillus alvei | Bacillus stearothermophilus |
|--------------------------|---------------|-----------------------------|
| Control                  | 6.33Aa        | 8.33Aa                      |
| Necercia sp              | 11.33ABab     | 8.00Aa                      |
| Pseudomonas capsia       | 13.67ABb      | 10.67ABA                    |
| Bacillus firmus          | 12.67Aab      | 14.00Aa                     |
| Bacillus bodius          | 11.67Aab      | 12.67Aa                     |
| Bacillus stearothermophilus | 11.67Aab   | 13.67Aab                     |
### Wet Weight (g)

|                   | Bacillus alvei | Bacillus stearothermophillus |
|-------------------|----------------|-----------------------------|
| Control           | 18.24Aab       | 27.59Aa                     | 27.95 Aa                        |
| Necercia sp       | 28.26Aabc      | 35.82 Aa                    | 55.85Bbc                       |
| Pseudomonas capcia| 12.94Aa        | 19.38 Aa                    | 73.43Bc                        |
| Bacillus firmus   | 34.06Abc       | 26.39 Aa                    | 52.54Bbc                       |
| Bacillus bodius   | 24.48Aabc      | 35.39 Aa                    | 58.07Bbc                       |
| Bacillus alvei    | 37.38ABc       | 23.36 Aa                    | 50.07Bb                        |
| Bacillus stearothermophillus | 37.93ABc | 25.69 | 48.47Bb |

### Root Length (cm)

|                   | Bacillus alvei | Bacillus stearothermophillus |
|-------------------|----------------|-----------------------------|
| Control           | 25.88          | 31.58                       | 36.13                           |
| Necercia sp       | 31.80          | 45.98                       | 44.63                           |
| Pseudomonas capcia| 22.52          | 35.35                       | 38.50                           |
| Bacillus firmus   | 28.92          | 23.23                       | 39.13                           |
| Bacillus bodius   | 23.25          | 33.15                       | 42.20                           |
| Bacillus alvei    | 23.28          | 25.88                       | 46.47                           |
| Bacillus stearothermophillus | 28.92 | 31.38 | 35.67 |

### Root Volume (mL)

|                   | Bacillus alvei | Bacillus stearothermophillus |
|-------------------|----------------|-----------------------------|
| Control           | 35.75Aa        | 37.61 Aa                    | 67.65Aab                       |
| Necercia sp       | 45.33Aa        | 54.57 Aa                    | 64.85Aab                       |
| Pseudomonas capcia| 41.86 Aa       | 43.81 Aa                    | 84.00Ab                        |
| Bacillus firmus   | 69.74 Ba       | 37.86 Aa                    | 57.70Aa                        |
| Bacillus bodius   | 45.03 Aa       | 41.40 Aa                    | 48.78Aa                        |
| Bacillus alvei    | 42.27 Aa       | 48.44 Aa                    | 61.42Aab                       |
| Bacillus stearothermophillus | 3.58 | 2.25 | 4.00 |

### Leaf area (cm²)

|                   | Bacillus alvei | Bacillus stearothermophillus |
|-------------------|----------------|-----------------------------|
| Control           | 39.06 Aa       | 43.42                       | 67.13Bab                       |
| Necercia sp       | 11.65Aa        | 13.18Ab                     | 14.75Bab                       |
| Pseudomonas capcia| 13.58Ab        | 13.06Aa                     | 16.51Bbc                       |
| Bacillus firmus   | 12.96Aab       | 11.99 Aa                    | 18.05Ac                        |
| Bacillus bodius   | 12.92 Aab      | 13.31 Aa                    | 14.57Aab                       |
| Bacillus alvei    | 12.50 Aab      | 13.28 Aa                    | 14.10Aab                       |
| Bacillus stearothermophillus | 12.51 Aab | 11.89 Aa | 13.83Aa |

### Dry weight (g)

|                   | Bacillus alvei | Bacillus stearothermophillus |
|-------------------|----------------|-----------------------------|
| Control           | 14.05Ab        | 13.80 Aa                    | 12.56Aa                        |

Description: The number followed by the same letter is different and is not real based on the Duncan New Multiple Range Test (DNMRT) at the level of α = 0.05. Capital letters are notations in lines, lowercase letters are notations in columns. DAP = Day After Planting.
The results indicated that certain types of rhizobacteria would act effectively as PGPR depending on the variety of the host plant [8]. Rhizobacterial ability adapting to the type of host plant will determine its effectiveness as a plant growth stimulant. As PGPR, the role of rhizobacteria in competitively colonizing roots and utilizing exudates and lysates released by plant roots [9]. The ability of the rhizobacter to colonize roots is an important step related to their role as rhizobacteria that promote plant growth. In this study, application of rhizobacteria in Sidikalang variety gave the best results from several observed growth parameters. Sidikalang is a national superior variety of patchouli which also has good resistance to bacterial wilt attacks and nematodes. According to Nuryani [2] that Tapak Tuan, Lhokseumawe and Sidikalang are national superior varieties of patchouli which have different morphological and chemical characteristics, namely essential oil content, dry herb, oil production, and patchouli alcohol content. The Tapak Tuan variety has dry matter production and a higher patchouli alcohol content than the Lhokseumawe and Sidikalang varieties. However, it has lower resistance to diseases than others. This condition is often found in patchouli farmers in the field, thus affecting farmers' preferences to choose better varieties. Application of rhizobacteria B. alvei to the Lhokseumawe variety was also able to increase the number of branches at the age of 90 DAP. Application of P. capsica rhizobacteria on Sidikalang variety was able to significantly increase wet weight, dry weight, and leaf area. Meanwhile, the application of rhizobacteria in the Tapak Tuan variety was not able to outperform all growth and yield parameters in this study. The role of rhizobacteria is to provide and mobilize nutrient absorption, synthesizing growth-promoting phytohormones [18]. Pseudomonas capsica can act as a biocontrol agent against pathogens and as bioremediation. Bacillus firmus plays a role in promoting plant growth and providing protection against nematode infections, as well as reducing the population of Meloidogyne incognita in tomato roots and Radopholus similis [19]-[21]. Bacillus alvei can remove salt in contaminated soil and can stimulate plant growth [22]-[24]. Bacillus stearothermophilus is useful for reducing environmental pollutants (bioremediation) which play a role in reducing the Pb concentration in water at a temperature of 55°C [20]. Pseudomonas spp. able to increase the growth of patchouli, namely plants height (6.7 - 26.3 cm), several leaves (4.6 - 30.1 leaves plant⁻¹), leaf dry weight (24.5 - 154.3 g plant⁻¹), and patchouli oil production (4.8 - 22.3 mL plant⁻¹) as well as shoot weight, root weight and root length of patchouli [25].

4. Conclusions

Interaction between rhizobacteria and varieties has a very significant effect on the parameters of fresh weight and dry weight of patchouli plant. The interactions also have a significant effect on plant height at 60 and 120 DAP, the number of branches at 90 and 120 DAP, and leaf area. The best combination was found in the treatment of rhizobacteria P. capsica and Sidikalang varieties. Sidikalang variety then combined with P. capsica rhizobacteria were recommended for increasing yield of patchouli.

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