Evaluation of land suitability for cultivation of java patchouli 
(*Pogostemon heyneanus* Benth) in the dry land of northern Serang, Banten province

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Abstract. This research aimed to determine (1) land suitability limiting factors for Javanese patchouli cultivation in North Serang Regency, Banten Province, (2) the level of land suitability for Javanese patchouli cultivation in North Serang District, Banten Province, (3) land improvement efforts to be suitable for Java Patchouli Plant cultivation in North Serang Regency, Banten Province. This type of research was descriptive research. The study was conducted in the Dry Land of North Serang Regency, Banten Province including Tirtayasa District, Kramatwatu District, and Waringinkurung District. The research was conducted from October 2018 to March 2019. The research consisted of 5 stages: preparation and secondary data collection, preparation of land unit maps, data collection stage in the field (primary data), analysis of land suitability data and stages making land suitability maps. The method of data analysis was done by matching between the characteristics and quality of land in the study area with the criteria for growing patchouli plants. The results showed that: (1) Land suitability limiting factors for Java Patchouli cultivation included the availability of water, rooting media, nutrient availability, terrain conditions. (2) Land use in Tirtayasa sub-district includes land suitability classes S2 (moderately suitable) and S3 (marginally suitable). Land use in Kramatwatu District includes land suitability classes S2 and S3. Land use in Waringinkurung District includes land suitability classes S3 and S2. (3) Efforts to improve land can be made by making terraces, providing efficient additional irrigation, making drainage channels, liming, fertilizing, adding organic matter.

Keywords : land suitability evaluation, patchouli plant, dry land.

1. Introduction

Patchouli (*Pogostemon* sp.) is one of the essential oil-producing plants known as patchouly oil. Patchouli oil is widely used in cosmetics, perfume, soap, insect killers and medicines industries. In Indonesia there are 3 types of patchouli oil, namely Java (*Pogostemon heyneanus* Benth), Soap (*Pogostemon hortensis* Back), and Aceh (*Pogostemon cablin* Benth.) which are distinguished by morphological character, oil content and quality as well as resistance to biotic and abiotic environmental stress [1]. Patchouli oil from both domestic and foreign countries is increasing, but the increase in the quantity of production of patchouli raw materials is still not optimal. Increasing patchouli crop production can be achieved by extending the patchouli cultivation on marginal lands/ dry land.
Indonesia is an agricultural country with a large potential of land resources. Various crops can be used to develop the potential of farmers so that it is beneficial for improving the standard of living of the community, one of which is in the District of North Serang, Banten Province [2]. The potential of farm land (Huma) which includes dry land in Banten is quite extensive, so that it can be used as an alternative land expansion/extensification for agricultural cultivation, including patchouli. Javanese patchouli is cultivated in East Java and Central Java, which have the advantage of being more tolerant of bacterial nematodes and wilt than Aceh patchouli.

Dry land is a stretch of land that has never been flooded or flooded for most of the year. The term dry land is often used for matching upland, dryland or unirrigated land. The last two terms indicate land use for rainfed agriculture. Upland shows land in a higher-lying area cultivated without water flooding such as wetland rice fields [3]. Dry land is an expanse of land that has never been flooded or flooded most of the time of the year [4].

Land evaluation is part of the land use planning process. The essence of land evaluation is to compare the requirements requested by the type of land use to be used [5]. Patchouli plants can grow in the area of land between the lowest plains to a fairly high plateau, which is up to 2000 masl. The yield of oil produced in the highlands is relatively lower compared to plants grown in lowland areas. Patchouli plants need an ideal temperature between 22 - 28°C or between 22 - 28 capacity of water vapor (g/m³) with humidity above 75%. Patchouli plants need water availability at the beginning of planting until the growth process takes place to achieve optimal growth. Adequate sunlight at the age of more than 3 months until nearing the harvest is also needed [6].

Land evaluation is considered important in the use of agricultural land, because the reality of each type of plant requires different requirements. Besides land varies greatly in various factors such as topography, climate, geology, soil and vegetation. Optimal and sustainable productivity and sustainability of land resources can be expected from the interpretation of plant species according to the quality of the land. The success of patchouli plant cultivation is closely related to the requirements for patchouli plant growth and limiting factors for land suitability. Therefore it is necessary to conduct an evaluation study of land suitability for patchouli cultivation, one of which is Java Patchouli in the dry land of North Serang, Banten province.

2. Methods
This type of research was descriptive research. This research was carried out in Drylands in Tirtayasa Subdistrict, Kramat watu, and Waringin Kurung Sub district, North Serang Regency, Banten Province and in the Land and Agro-climate Laboratory of the Agriculture Faculty of Sultan Ageng Tirtayasa University in August to October 2018.

The tools used in this research were hoe, plastic, sample ring, oven, desiccator, sitting balance, ruler, stationery, tray, clamping pliers, petri dish, dry soil test device, analytic balance, digestion tube and block digestion, boiling 250 ml pumpkin, 100 ml erlenmeyer, 10 ml or 5 ml burette, 25 ml measuring cup, magnetic stirrer, test tube, distillation device or spectrophotometer, GPS, and 4 in 1 soil survey instrument.

The material used was primary data such as soil physical properties data (texture, structure, volume weight, specific gravity) and soil chemical properties (pH, N, P, K, C-Organic), secondary data, namely land use maps, topographic maps, climate data (rainfall, temperature, humidity, irradiation intensity), concentrated sulfuric acid (95-97%), selenium, 1% boric acid, 40% sodium hydroxide (NaOH), Conway pointer and 0.05 N. H2SO4.

Data collection methods were carried out by taking soil samples, laboratory tests, observations, and documentation. Data analysis method is done through map overlay and matching between land characteristics and quality in the study area with criteria for growing patchouli.
3. Results and Discussion

3.1. Field conditions

3.1.1. Slope

Based on Table 1, it was found that land use that has S2 (suitable) land suitability class which was in the slope of 2-8% consists of moor in Tirtayasa district. Land use that had S3 land suitability class (Marginally suitable) on a slope of 8-15% was the use of moor and mixed garden in Kramatwatu sub district as well as the use of mixed garden and vacant land in Waringinkurung sub district. Land use that had land suitability class N (Not suitable) that was on a slope> 15% which consisted of mixed garden land use and vacant land in Tirtayasa sub district, vacant land use in Kramatwatu and moor land use in Waringinkurung sub district.

| Sub district | Land use     | Value (%) | Suitability class | Limiting criteria       |
|--------------|--------------|-----------|-------------------|-------------------------|
| Tirtayasa    | Moor         | 3         | S2                | The slope becomes a non permanent boundary. |
|              | Mixed garden | 16        | N                 |                         |
|              | Vacant land  | 16        | N                 |                         |
| Kramatwatu   | Moor         | 13        | S3                |                         |
|              | Mixed garden | 13        | S3                |                         |
|              | Vacant land  | 16        | N                 |                         |
| Waringinkurung | Moor      | 18        | N                 |                         |
|              | Mixed garden | 12        | S3                |                         |
|              | Vacant land  | 13        | S3                |                         |

Slopes affect erosion in relation to steepness and slope length. Land with a steep slope has a greater gravity effect than land with a slope rather steep and gentle slope. This is due to the greater gravity in line with the more sloping ground surface from the horizontal plane, so that the eroded topsoil will be more and more. This gravity is an absolute requirement for the erosion, transportation and settling process. So, if the slope is getting bigger then the number of soil grains sprinkled down by the collision of raindrops will be more and more [5].

3.1.2 Altitudes

| Sub district | Land use     | Value (masl) | Suitability class | Limiting criteria       |
|--------------|--------------|--------------|-------------------|-------------------------|
| Tirtayasa    | Moor         | 40           | S2                | The altitudes becomes permanent boundary. |
|              | Mixed garden | 50           | S2                |                         |
|              | Vacant land  | 47           | S2                |                         |
| Kramatwatu   | Moor         | 30           | S2                | permanent               |
|              | Mixed garden | 28           | S2                | boundary.               |
|              | Vacant land  | 28           | S2                |                         |
| Waringinkurung | Moor      | 63           | S2                |                         |
|              | Mixed garden | 78           | S2                |                         |
|              | Vacant land  | 60           | S2                |                         |

The ideal altitudes for growing patchouli plants was 100-400 meters above sea level. In general, the district of Serang is located at an altitude of less than 500 meters above sea level. The altitudes of the place was measured in the field using GPS Map 78S, the results obtained that the land use in the District Tirtayasa, District Kramatwatu and District Waringinkurung were in the range of altitudes of 0-100 meters above sea level so that it had a suitability class S2 (moderately suitable) for cultivation of patchouli plants. According to [7], altitude is very influential on plant growth. The altitudes of the place...
affects changes in air temperature. The higher place, for example mountains, the lower the temperature of the air or the cooler the air. Otherwise, the lower area is the higher temperature of the air.

3.2. Temperature

Temperature in Serang Regency based on data from the Climatology and Geophysics Meteorological Agency from 2009-2018 had an average temperature of 27°C. Temperature in Serang Regency had S2 suitability level because it was in the range of 26-28°C, the temperature conditions in the area were moderately suitable for patchouli plant growth requirements. Temperature affects the yield content of patchouli plants.

| Sub district  | Land use       | Value (°C) | Suitability class | Limiting criteria                      |
|---------------|----------------|------------|-------------------|----------------------------------------|
| Tirtayasa     | Moor           |            |                   |                                        |
|               | Mixed garden   |            |                   |                                        |
|               | Vacant land    |            |                   |                                        |
| Kramatwatu    | Moor           |            |                   |                                        |
|               | Mixed garden   |            | S2                | The temperature becomes permanent boundary. |
|               | Vacant land    |            |                   |                                        |
| Waringinkurung| Moor           |            |                   |                                        |
|               | Mixed garden   |            |                   |                                        |
|               | Vacant land    |            |                   |                                        |

Temperature affects the growth and development of plants. Because temperature affects the rate of metabolism, photosynthesis, respiration and plant transpiration. However, high temperatures can damage the enzymes so that metabolism does not work well. Even low temperatures cause enzymes to be inactive and metabolism to stop. Therefore, plants have an optimal temperature between 10-38°C. The plants will not survive on temperatures below 0°C and above 40°C [8].

3.3. Water availability

| Sub district  | Land use       | Value (mm/yr) | Suitability class | Limiting criteria                      |
|---------------|----------------|---------------|-------------------|----------------------------------------|
| Tirtayasa     | Moor           | 1549.3        | S3                | The rainfall becomes a non permanent boundary. |
|               | Mixed garden   |               |                   |                                        |
|               | Vacant land    |               |                   |                                        |
| Kramatwatu    | Moor           | 1549.3        | S3                |                                        |
|               | Mixed garden   |               |                   |                                        |
|               | Vacant land    |               |                   |                                        |
| Waringinkurung| Moor           |               |                   |                                        |
|               | Mixed garden   |               |                   |                                        |
|               | Vacant land    |               |                   |                                        |

Water availability is influenced by rainfall. Rainfall in Serang Regency from 2009-2018 which is average 1549.3 mm / yr [9]. Rainfall in Serang Regency has S3 suitability class that is marginal according to the requirements for patchouli plant growth. Rainfall is a non-permanent barrier for Java Patchouli Cultivation so that improvements can be made to make it more suitable for Java Patchouli Cultivation.

Patchouli plants will grow and produce well in areas with relatively high rainfall, evenly distributed throughout the year and require good drainage because if the stagnant roots become rotten and the plants will die. The water content of plants is influenced by environmental factors, especially the weather. If transpiration evaporates excessively for a long time, for example due to a dry season of 3-5 months causing plants to experience stress or stress resulting in low leaf and plant water potential, leaf surface
area is reduced due to depletion of food reserves due to decreased photosynthetic activity due to decreased the surface of the leaf stomata [10].

3.4. Rooting media

3.4.1. Drainage

Table 5. Drainage suitability

| Sub district | Land use      | Value      | Suitability class | Limiting criteria |
|--------------|---------------|------------|-------------------|-------------------|
| Tirtayasa    | Moor          | Little good| S2                |                   |
|              | Mixed garden  | Little good| S2                |                   |
|              | Vacant land   | Bad        | N                 | drainage          |
| Kramatwatu   | Moor          | Bad        | N                 | non               |
|              | Mixed garden  | Little good| S2                |                   |
|              | Vacant land   | Bad        | N                 | permanent         |
| Waringinkurung| Moor         | Little good| S2                |                   |
|              | Mixed garden  | Little good| S2                |                   |
|              | Vacant land   | Little good| S2                |                   |

The drainage condition in the research area for Tirtayasa vacant land, Kramatwatu moor, Kramatwatu vacant land was bad so it had a suitability class N which is bad for Java Patchouli Cultivation. Of the 3 districts, land use for drainage in Waringinkurung District was more in accordance with the suitability class compared to Tirtayasa District and Kramatwatu District because the land in Waringinkurung District did not have yellow, brown or gray patches in the upper and lower layers.

The function of drainage is very different from the function of irrigation. If irrigation delivers water to the planting media, drainage removes excess water from a medium or agricultural land. With a good drainage system land use can be optimized and also minimizes damage to soil structures for roads and other buildings, besides that with a planned drainage system it can be optimized water management that functions to control the presence of abundant water in the rainy season and drought in the dry season [11].

3.4.2. Soil Texture

Table 6. Suitability of soil texture

| Sub district     | Land use  | Value           | Suitability class | Limiting criteria |
|------------------|-----------|-----------------|-------------------|-------------------|
| Tirtayasa        | Moor      | Dusty clay loam | S3                |                   |
|                  | Mixed garden | Dusty loam     | S2                | Soil              |
|                  | Vacant land   | Dusty clay     | S3                | texture           |
| Kramatwatu       | Moor      | Clay            | S3                | becomes           |
|                  | Mixed garden | Clay           | S3                | permane           |
|                  | Vacant land   | Dusty clay     | S3                | nt                |
| Waringinkurung   | Moor      | Dusty loam     | S2                | boundary          |
|                  | Mixed garden | Dusty clay     | S3                |                   |
|                  | Vacant land   | Dusty loam     | S2                |                   |

Soil texture in the study area for Tirtayasa moor was dusty clay loam, while Tirtayasa vacant land was dusty clay, Kramatwatu moor and mixed garden were clay, Kramatwatu vacant land was dusty clay, and Waringinkurung mixed garden was dusty clay. From the results of the analysis that had been done, the area had a level of conformity S3 that was marginal according to the requirements for patchouli plant growth. Moreover, Tirtayasa soil texture mixed gardens, Waringinkurung moor and vacant land that were dusty loam which had a level of suitability S2 or moderately suitable for patchouli plant growth requirements.
According to [12], good soil is reflected by dust and clay textured soil which has optimum availability for plants, but in terms of nutrient clay soil is better than dust textured soil. According to [13], clay-textured soils make plants unable to grow properly. Clay is a soil that has many micro or porous pores. Micro pores in clay are caused by solid soil structure. Between the aggregates of land there are very few gaps or spaces. This causes very limited air and water trapped easily, so that the clay is difficult to pass water, or in other words the permeability is low. Clay is less supportive to the development of plant roots because of its low porosity so that it affects interferes with respiration carried out by the root.

3.5. Nutrient retention

3.5.1. Soil acidity (pH)

| Sub district   | Land use      | Value  | Suitability class | Limiting criteria                                           |
|----------------|---------------|--------|-------------------|------------------------------------------------------------|
| Tirtayasa      | Moor          | 6.45   | S1                |                                                            |
|                | Mixed garden  | 5.31   | S2                |                                                            |
|                | Vacant land   | 4.87   | S3                | Soil acidity becomes a non permanent boundary.              |
| Kramatwatu     | Moor          | 6.48   | S1                |                                                            |
|                | Mixed garden  | 6.54   | S1                |                                                            |
|                | Vacant land   | 7.63   | S1                |                                                            |
| Waringinkurung | Moor          | 6.72   | S1                |                                                            |
|                | Mixed garden  | 6.14   | S1                |                                                            |
|                | Vacant land   | 6.65   | S1                |                                                            |

Based on Table 7 it is found that the acidity (pH) of the soil in the study area is more dominated by land suitability class S1 (Very suitable) which is in the range of 5.5-7, but besides S1 suitability class there are land uses that are classified as S2 land suitability class (moderately suitable) which is in the range of 5.5-5, namely the use of Tirtayasa mixed garden and for the use of vacant land Tirtayasa sub district has a land suitability class S3 (Marginally suitable) which is in the range of 4.5-5.

Based on matching results for soil acidity, Tirtayasa's vacant land has a pH < 7 which means it is rather acidic. According to [14], the pH level of the soil itself is influenced by several things, one of which is the decomposition of organic material in which microorganisms in the soil will continuously decompose soil organic matter into other forms, namely organic acids, carbon dioxide (CO₂) and water, carbonic acid forming compounds. Then Ca and Mg carbonate in the soil will react to form more soluble bicarbonate, which can be leached out and finally can make the soil become more acidic.

3.5.2. C-Organic

| Sub district   | Land use      | Value (%) | Suitability class | Limiting criteria                                           |
|----------------|---------------|-----------|-------------------|------------------------------------------------------------|
| Tirtayasa      | Moor          | 3.92      | S2                |                                                            |
|                | Mixed garden  | 1.56      | S3                | C-Organic                                                  |
|                | Vacant land   | 3.13      | S2                | becomes a non permanent boundary.                          |
| Kramatwatu     | Moor          | 5.49      | S2                | permanent                                                  |
|                | Mixed garden  | 3.91      | S2                | boundary.                                                  |
|                | Vacant land   | 3.91      | S2                |                                                            |
| Waringinkurung | Moor          | 3.12      | S2                |                                                            |
|                | Mixed garden  | 0.78      | S3                |                                                            |
|                | Vacant land   | 1.56      | S3                |                                                            |
Based on Table 8, it was found that the use of land containing C-Organic was suitable for Java Patchouli Cultivation because it belongs to the suitability class S2 (moderately suitable) in the range < 3-5%, namely the use of moor, mixed gardens, and vacant land in the District Kramatwatu; the use of moor and vacant land in Tirtayasa District; and the land use of moor in Waringin Kurung District.

According to [15], C-Organic states the number of organic compounds as a source of carbon elements contained in the soil, including litter, fraction of lightweight organic matter, biomass microorganisms, organic matter seen in water and stable organic matter or humus. According to [16], C-Organic content tends to decrease with increasing soil depth because organic matter is only applied or falls on the ground. So that the organic material accumulates in the top soil layer and part of it is washed into a deeper layer (sub soil).

3.5.3. Cation Exchange Capacity (CEC)

| Sub district | Land use   | Value (cmol(+)/kg⁻¹) | Suitability class | Limiting criteria                             |
|--------------|------------|----------------------|-------------------|-----------------------------------------------|
| Tirtayasa    | Moor       | 16.53                | S2                |                                               |
|              | Mixed garden | 13.14                | S2                |                                               |
|              | Vacant land | 7.92                 | S2                | CEC becomes a non permanent boundary.          |
| Kramatwatu   | Moor       | 14.25                | S2                |                                               |
|              | Mixed garden | 0.13                 | S3                |                                               |
|              | Vacant land | 7.43                 | S2                |                                               |
| Waringinkurung | Moor     | 7.09                 | S2                |                                               |
|              | Mixed garden | 8.07                 | S2                |                                               |
|              | Vacant land | 6.79                 | S2                |                                               |

Based on Table 9, it was found that the CEC content of the three districts which had a high CEC content, namely moor use in Tirtayasa Subdistrict with CEC value of 16.53 (cmol (+) kg⁻¹) included in the S2 (moderately suitable) land suitability class. Whereas the land use in Kramatwatu and Waringinkurung sub-districts was dominated by land suitability class S2 (moderately suitable) which was in the range of 5-15 (cmol (+) kg⁻¹), but in the mixed garden land use Kramatwatu sub-district had land suitability class S3 (Appropriate marginal) which was in the range <5 (cmol (+) kg⁻¹).

According to [13], cation exchange capacity is a chemical characteristic that is closely related to soil fertility. Land with high CEC is able to trap and provide nutrients better than land with low CEC. Soils with high CEC when dominated by base cations, Ca, Mg, K, Na (high base saturation) can increase soil fertility, but if dominated by acid cations, Al, H (low base saturation) can reduce soil fertility.

3.6. Nutrient availability

3.6.1. K₂O suitability

| Sub district | Land use   | Value | Suitability class | Limiting criteria     |
|--------------|------------|-------|-------------------|-----------------------|
| Tirtayasa    | Moor       | Low   | S3                | K₂O content becomes a non permanent boundary. |
|              | Mixed garden | Low   | S3                |                       |
|              | Vacant land | Medium | S2               |                       |
| Kramatwatu   | Moor       | Low   | S3                |                       |
|              | Mixed garden | Low   | S3                |                       |
|              | Vacant land | Low   | S3                |                       |
| Waringinkurung | Moor     | Low   | S3                |                       |
|              | Mixed garden | Low   | S3                |                       |
|              | Vacant land | Medium | S2               |                       |
The content of $K_2O$ in the study area for Tirtayasa vacant land and Waringinkurung vacant land had a level of suitability S2 that is moderately suitable for patchouli plant growth requirements. The content of $K_2O$ in Tirtayasa moor, Tirtayasa mix garden, Kramatwatu moor, Kramatwatu mixed garden, Kramatwatu vacant land, Waringinkurung moor, Waringinkurung mixed garden have a level of S3 suitability which is marginal according to patchouli growing requirements. The source of potassium contained in the soil comes from weathering minerals that contain K. These minerals when weathered release K soil solubility or soil absorption in the form of exchange. The location of potassium clay is generally in the surface surface (internal surface) which is often occupied by ions $Mg^2+$, $Fe^3+$, $Al^4+$ and $H_2O$ molecules.

Potassium loss in the soil can occur in a number of ways such as being transported by plants together with harvesting, washing, erosion and fixation. Potassium loss that is removed by plants is caused by the nature of potassium which can be absorbed by plants excessively beyond the actual needs. This excessive uptake no longer increases crop production, resulting in a waste of the use of soil potassium.

3.6.2. $P_2O_5$ suitability

| Sub district       | Land use  | Value (ppm) | Suitability class | Limiting criteria                  |
|--------------------|-----------|-------------|-------------------|-----------------------------------|
| Tirtayasa          | Moor      | 41.83       | S3                |                                   |
|                    | Mixed garden | 30.24    | S3                |                                   |
|                    | Vacant land  | 26.28*    | S3                | $P_2O_5$ content becomes a non     |
|                    |            |            |                   | permanent boundary.               |
| Kramatwatu         | Moor      | 13.66       | S2                |                                   |
|                    | Mixed garden | 3.92     | N                 |                                   |
|                    | Vacant land  | 10.09     | S2                |                                   |
| Waringinkurung     | Moor      | 8.51        | N                 |                                   |
|                    | Mixed garden | 7.45     | N                 |                                   |
|                    | Vacant land  | 5.35      | N                 |                                   |

Based on Table 11 it was found that the use of dry land and the use of vacant land in Kramatwatu Subdistrict had S2 suitability class because it was in the range of 10-15 ppm. The 3 land uses in Tirtayasa Subdistrict had S3 conformity class because they were in the range > 25 ppm. The mixed land use of Kramatwatu Subdistrict and the 3 land uses of Waringinkurung Subdistrict had N suitability class because they were in the range of < 10 ppm.

According to [17], the availability of soil P for plants is mainly influenced by the nature and characteristics of the soil itself. P becomes unavailable and insoluble due to fixation by clay minerals and the highly soluble Al, Fe, Mg or Ca ions, forming complex and insoluble compounds. There are several factors that also influence the availability of soil P, clay type, soil pH, reaction time, temperature and soil organic matter. In addition flooding can also affect. There are several ways to lose P from the soil, which are transported by plants, washed and eroded. This substance is absorbed by plants in the form of $H_3PO_4$ and $HPO_4^2-$. The main function of this element is to accelerate root growth especially lateral roots and hair roots, accelerate and strengthen the growth of young plants into adulthood, accelerate flowering and ripening of seeds and increase seed production.

From the description above it is obtained that the suitability of land for Java Patchouli Cultivation in Tirtayasa, Kramatwatu, and Waringinkurung District is as follows (Table 12):

| Sub district       | Moor      | Mixed garden | Vacant land  |
|--------------------|-----------|--------------|--------------|
| Tirtayasa          | N         | N            | S3           |
| Kramatwatu         | S2        | N            | N            |
| Waringinkurung     | N         | N            | N            |

Table 12. Land suitability class for Java Patchouli cultivation at land use in the research area
Based on Table 12, it is found that those suitable for Java Patchouli Cultivation in North Serang with Class S2 (moderately suitable) were the land use of moor in Tirtayasa District, moor and mixed garden land use in Kramatwatu District, vacant land and mixed garden land use in WaringinKurung District. The results of the land use suitability class in the study area were obtained from consideration of efforts to improve based on the matching results of the limiting factors. Based on the results of the analysis it was found that the limiting factors of land use in the study area were water availability, which included Tirtayasa District, Kramatwatu District and Waringinkurung District. The Media of Incense which included vacant land Tirtayasa Subdistrict, and vacant land Kramatwatu Subdistrict. The availability of nutrient covered mixed garden in Kramatwatu Subdistrict, moor, mixed garden and vacant land in Waringinkurung Subdistrict. The condition of field which included mixed gardens and vacant land in Tirtayasa Subdistrict, vacant land Kramatwatu Subdistrict and Waringinkurung District. Therefore, efforts to improve land with moderate and high management are needed for the land of Tirtayasa, Kramatwatu and Waringinkurung sub District to make it more suitable for patchouli cultivation and can increase productivity. Efforts to Improve the Limiting Factors of Land Suitability for Java Patchouli Cultivation are presented in Table 13 below:

| Sub district       | Land use suitability class | Improvement efforts |
|--------------------|---------------------------|---------------------|
|                    | Moor     | Mixed garden | Vacant land |                     |
| Tirtayasa          | S2       | S3          | S3          |                     |
| Kramatwatu         | S2       | S2          | S3          |                     |
| Waringinkurung     | S3       | S2          | S2          |                     |

Table 13. Efforts to Improve Limiting Factors of Land Suitability for Java Patchouli Cultivation

| Sub district  | Parameter | Improvement efforts |
|---------------|-----------|---------------------|
|               |           | Moor    | Mixed garden | Vacant land  |
| Tirtayasa     | Slope (%) | √ Terrace making | Terrace making | Terrace making |
|               | Altitude (masl) | -   | -   | -   |
|               | Average    | -   | -   | -   |
|               | Temperature (°C) | -   | -   | -   |
|               | Rainfall (mm) | -   | -   | -   |
|               | Texture    | -   | -   | √   |
|               | Drainage   | √   | √   | Drainage channel |
|               | pH         | √   | √   | Liming |
|               | C-organic (%) | √   | Fertilization | √   |
|               | CEC (me/100g) | √   | √   | √   |
|               | K₂O (me/100g) | Fertilization | Fertilization | √   |
|               | P₂O₅ (ppm) | Fertilization | Fertilization | Fertilization |
| Kramatwatu     | Slope (%) | Terrace making | Terrace making | Terrace making |
|               | Altitude (masl) | -   | -   | -   |
|               | Average    | -   | -   | -   |
|               | Temperature (°C) | -   | -   | -   |
|               | Rainfall (mm) | -   | -   | -   |
|               | Texture    | -   | -   | -   |
|               | Drainage   | Drainage channel | √   | Drainage channel |
|               | pH         | √   | √   | √   |
|               | C-organic (%) | √   | √   | √   |
|               | CEC (me/100g) | √   | Organic matter | √   |
Table 13 shows land improvement efforts that can be made to improve land quality limiting factors for Java Patchouli Plants in Tirtayasa District, Kramatwatu and Waringinkurung District. Improvement efforts to improve the nature of land suitability constraints for the cultivation of patchouli plant on the slopes by making terraces to facilitate land management and prevent erosion. Improvement efforts to improve the nature of land suitability constraints for the cultivation of patchouli plant in the availability of water by providing irrigation water. According to [18], the purpose of irrigation in an area is an effort to supply and regulate water to support agricultural activities from water sources to areas that need and distribute technically and systematically. While the benefits obtained from irrigation activities are helping soil wetting in areas where rainfall is lacking or erratic, increasing soil fertility by flowing water and sludge containing dissolved nutrients needed by plants in agricultural areas so that the area gets additional soil nutrients. Improvement efforts to improve the nature of land suitability constraints for the cultivation of patchouli plant on the root media (drainage) by making drainage channels. According to [19], there are several benefits of making drainage channels including lowering the surface of ground water at an ideal level so that it does not make the plants experience excess water and control soil erosion, good soil will greatly affect the plants that grow on it. Improvement efforts to improve the limiting nature of land suitability for the cultivation of patchouli plant on nutrient retention (pH) of acidic soil by liming. According to [14], Liming is an effort made to increase soil pH by adding lime to the soil. The purpose of liming is to increase the acidic pH to neutral pH and reduce or eliminate Al poisoning.

Improvement efforts to improve the nature of land suitability constraints for the cultivation of patchouli plant in nutrient retention (C-Organic) by fertilizing using manure, compost or green manure. According to [20], very poor soils should be fertilized with organic fertilizer. Sand soil or soil that is much eroded is better fertilized with organic fertilizer than with artificial fertilizer, because the application of artificial fertilizer on the soil will be easily washed away by rain water. With manure given, the power to hold water and soil cations increases, so that if it is also given artificial fertilizer, washing by rain water and erosion can be inhibited. Improvement efforts to improve the nature of land suitability constraints for the cultivation of patchouli plant on nutrient retention (CEC) with the addition of organic matter. According to [21], the effect of organic matter is to increase the absorption capacity and cation exchange capacity (CEC). About half of the cation exchange capacity of the soil comes from organic matter. Organic matter can increase cation exchange capacity two to thirty times greater than colloidal minerals which account for 30 to 90% of the absorbent power of a mineral soil. The increase in CEC due to the addition of organic material due to weathering of organic material will produce humus (organic colloids) which have a surface that can hold nutrients and water so that it can be said that the

| Waringinkurung | P₂O₅ (ppm) | Fertilization | Fertilization | Fertilization | Fertilization |
|----------------|-------------|---------------|---------------|---------------|---------------|
| Slope (%) | Terrace making | Terrace making | Terrace making |
| Altitude (masl) | - | - | - |
| Temperature (°C) | Irrigation | Irrigation | Irrigation |
| Rainfall (mm) | - | - |
| Texture | - | - |
| Drainage | √ | √ | √ |
| pH | √ | √ | √ |
| C-organic (%) | √ | Fertilization | Fertilization |
| CEC (me/100g) | √ | √ | √ |
| K₂O (me/100g) | Fertilization | Fertilization | √ |
| P₂O₅ (ppm) | Fertilization | Fertilization | √ |

Information:
√: No repair needed
-: Cannot be repaired
provision of organic material can store fertilizer and water given in the soil. The increase in CEC increases the ability of the soil to retain nutrients.

The $K_2O$ content can be improved by adding $K$-containing fertilizers and compound fertilizers containing P and K elements. According to [22], fertilizing with potassium can be done by spreading or sprinkling directly on plants. This type of fertilizer can be combined with other types of fertilizers such as urea and SP-36. Considering that this potassium is soluble, potassium fertilizer is administered the same as N fertilizer. Cereals are given three times, where 1/3 part of $K_2O$ is given consecutively at planting and at primordial time. According to [23], the addition of P into the soil can be derived from various sources, namely from phosphate fertilizer, weathering minerals containing P and from the remains of plants and animals. The addition of P to the soil from the remains of plants and animals is very small, because the consumption of phosphate by plants and animals is also small.

4. Conclusion

1. The limiting factor of land suitability for Java Patchouli Cultivation in North Serang Regency, Banten province in Tirtayasa District, Kramatwatu District and Waringinkurung District is Water Availability. The limiting factor in vacant land of Tirtayasa subdistrict, moor and vacant land of Kramatwatu subdistrict namely rooting media. The limiting factor in mixed garden of Kramatwatu Subdistrict, moor, mixed garden, and vacant land of Waringinkurung District is availability of nutrient. The limiting factor in mixed garden and vacant land of Tirtayasa Subdistrict, vacant land of Kramatwatu Subdistrict and moor of Waringinkurung Subdistrict is field conditions.

2. The level of land suitability for Java Patchouli Cultivation in North Serang District, Banten Province, namely the land suitability class S2 (moderately suitable) consists of moor land use in Tirtayasa District, moor and mixed gardens land use in Kramatwatu Subdistrict, vacant land and mixed garden land use in Waringinkurung Sub-district. While for S3 land suitability class (marginally suitable) consists of vacant land and mixed garden land use in Tirtayasa District, vacant land use in Kramatwatu District and moor land use in Waringinkurung District.

3. Efforts to improve land for the cultivation of patchouli plants in the northern Serang Regency, Banten Province are the construction of terraces, provision of additional irrigation water, drainage, liming and fertilizing.

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