*Research Article*

# Assessing soil fertility status and land suitability for patchouli plants (*Pogostemon cablin* Benth.) in Lamala District, Banggai Regency

## *Penilaian Status Kesuburan Tanah dan Evaluasi Kesesuaian Lahan untuk Tanaman Nilam (Pogostemon cablin* Benth.*) di Kecamatan Lamala, Kabupaten Banggai*

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***Abstract:*** Besides influenced by genotype, the quality and quantity of patchouli essential oil were controlled by soil as a growing medium. The development of patchouli plantation in Lamala District is still hampered by negative stigma from the community. It is believed, the strong absorption rate from patchouli could lead to soil nutrient deficiency. The purpose of this study was to determine soil fertility status and evaluate its suitability for patchouli plant in 3 land units (e.g., uncultivated, cultivated with fertilization, and cultivated without fertilization). The method used is an Exploratory-Descriptive Survey. The determination of soil properties was based on physical properties such as texture, and chemical properties such as pH, organic-C and nitrogen, $P_2O_5$ and $K_2O$, base cations and cation exchange capacity/CEC, and Fe. The data then matched to Soil Fertility and Land Suitability Criteria for the patchouli plant. The result showed that the chemical properties in 3 land units had slightly acidic, high CEC, medium base saturation, moderate $P_2O_5$ content, and moderate organic-C content. Meanwhile, the $K_2O$ content of the land without patchouli was very low and the patchouli with and without fertilizer was low. Soil fertility status in 3 land units was classified as marginally suitable (S3-rc,na), this is due to the limiting factors; soil texture (rc) and $P_2O_5$ (na).

*Keywords:* Patchouli, cultivated, physicochemical

***Abstrak:*** Selain dipengaruhi oleh genotip, kualitas dan kuantitas minyak esensial nilam dipengaruhi oleh tanah sebagai media tanam. Pengembangan tanaman nilam di Kecamatan Lamala masih dipengaruhi oleh stigma negatif dari masyarakat. Tanaman nilam dipercaya banyak menyerap hara tanah sehingga menyebabkan tanah kekurangan hara. Tujuan dari penelitian ini adalah untuk mengetahui status kesuburan tanah dan evaluasi kesesuaian lahan pada 3 unit lahan. Metode yang digunakan adalah survey eksploratif-deskriptif. Sifat tanah yang dianalisis antara lain sifat fisik tekstur tanah, serta sifat kimia tanah pH, C-organik, $P_2O_5$ dan $K_2O$, kation basa dan kapasitas tukar kation, dan Fe. Data yang dihasilkan kemudian dicocokan dengan kriteria status kesuburan tanah dan kesesuaian lahan. Hasil analisis menunjukkan bahwa sifat kimia tanah pada 3 unit lahan memiliki pH tanah agak masam, KTK tanah tinggi, kejenuhan basa tanah sedang, kandungan $P_2O_5$ tanah sedang, dan kandungan C-organik tanah sedang. Sementara kandungan $K_2O$ tanah pada lahan tanpa nilam sangat rendah, sedangkan pada nilam dengan dan tanpa pemupukan rendah. Status kesuburan tanah pada ketiga unit lahan tergolong sesuai marginal (S3-rc,na), hal ini karena adanya faktor pembatas yaitu tekstur tanah (rc) dan $P_2O_5$ (na).

*Kata kunci:* nilam, budidaya, fisiko kimia.

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## INTRODUCTION

Patchouli (*Pogostemon cablin* Benth.) is an industrial plant that contains essential oils. The valuation of essential oil imports based on the five largest importing countries reached 40.66 billion US dollars (Statista, 2021). Patchouli production and productivity in Indonesia in 2019 increased by 703.2% and 20.87%, respectively (Ministry of Agriculture, 2021). Considering this fact, research concerning patchouli must be conducted.

Besides being influenced by genotype (Swamy *et al.* 2015), the quality and quantity of patchouli essential oil are influenced by the characteristics of the soil as its growing medium (Singh *et al.* 2002; Singh and Rao, 2009; Swamy *et al.* 2014). Besides its physical function as an anchor point for plant roots, soil provides patchouli nutrients that affect its growth and development (Ritung *et al.* 2011). On the other hand, repeated use of soil will decrease its nutrient; hence, it is necessary to provide adequate fertilizer. The decline in soil physical and chemical properties often present as changes in plant appearance; however, mitigating the risk is needed before it emanates. Quantifying the soil properties through soil test will give valuable information regarding its state related to patchouli requirements.

To interpret the soil data, several approaches had been made by the soil and plant scientist. General fertility interpretation adopted in Indonesia includes SLAN/CCDS (sufficiency level of available nutrients/critical cation deficiency status) and soil fertility assessment based on the five major soil chemical properties (Pusat Penelitian Tanah 1983; Eviati & Sulaeman, 2009). Furthermore, more specific and complex approaches are implemented due to detailed purposes concerning specific land use, such as land capability evaluation or specific-species plant requirements, namely land suitability assessment. The first was developed by the Natural Resources Conservation Service, United States Department of Agriculture (Klingebiel & Montgomery, 1973), while the latter was stipulated by Food and Agriculture Organization/FAO (FAO, 1976). Many research had been carried out using these tools worldwide (*e.g.* Susila & Dharma, 2013; Widyantari *et al.* 2015; Harli *et al.* 2017; Parry *et al.* 2018; Habibie *et al.* 2019); however, no report assessing soil fertility status or patchouli land suitability in Lamala districts.

Lamala District is one of the areas currently developing patchouli plants. Some people perceived that patchouli plants absorb many nutrients in this region, causing the soil to become infertile. From on soil science perspective, assessing soil fertility status and evaluating land suitability before conducting patchouli intensification and extensification is critical. This paper presents soil physicochemical properties, fertility interpretation, and land suitability status of patchouli's cultivated (with and without fertilizer) and uncultivated land in Lamala District.

## MATERIALS AND METHODS

This research was conducted from April to June 2021 using an exploratory-descriptive survey by taking soil samples on the land (Y1: uncultivated land, Y2: cultivated land without fertilization, and Y3: cultivated land with fertilization) in several villages in Lamala District. The distribution of soil sampling points is presented in Figure 1.

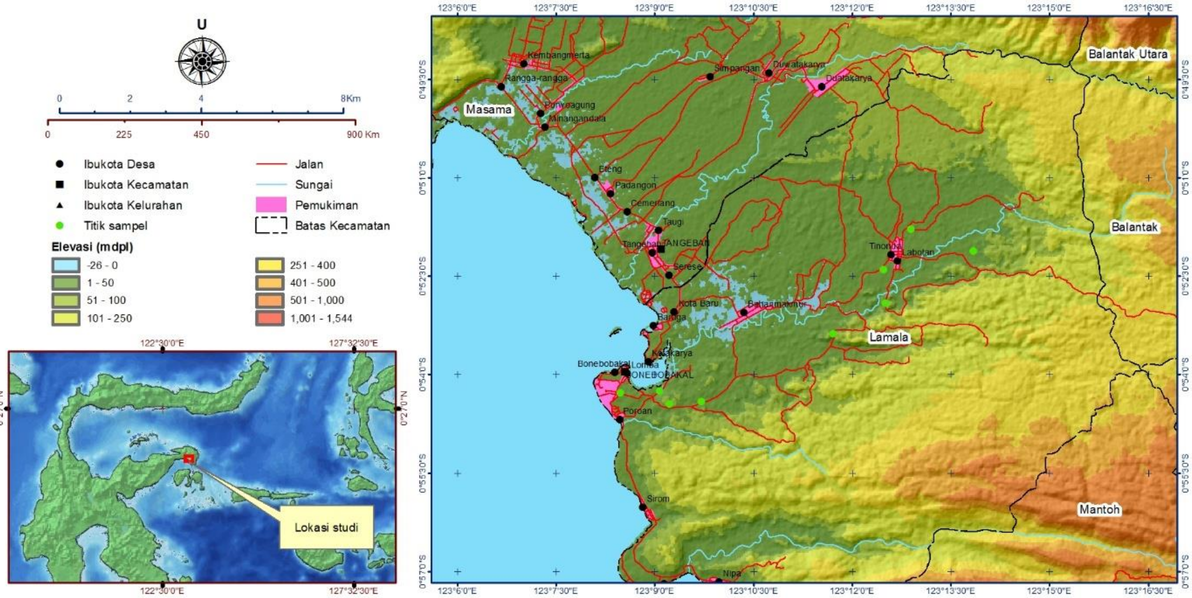

**Figure 1**. Soil Sampling Location

Soil samples (± 2 kg) were taken compositely from the surface horizon (0-25 cm) using a soil drill. Soil physical and chemical properties and were analyzed at Soil Chemistry and Fertility laboratory, Hasanuddin University. Soil texture was assessed based on the pipette method. The C-organic content of the soil was obtained through wet ashing analysis. Soil pH was determined using a soil-to-water mixture in a ratio of 1:2.5. Phosphate and potassium were extracted using 25% HCl solution. Total N was extracted using the Kjeldahl method. Cation base and cation exchange capacity/CEC were extracted using ammonium acetate ($NH_4OAc$) pH 7.0. The final solution P was measured using a PerkinElmer LAMBDA 25 UV-VIS spectrophotometer. The bases K and Na were measured using a flame spectrophotometer BK-FP640 Biobase, while Ca and Mg were calculated using the titration method.

### Data Analysis and Interpretation

Soil chemical properties are interpreted referring to the Technical Guidelines for Chemical Analysis of Soil, Plants, and Fertilizers; Soil Research Institute (Eviati and Sulaeman, 2009). Soil fertility status was determined according to Soil Fertility Status based on the Five Main Soil Chemical Properties, TOR P3MT Type B: Land Suitability Survey (Center for Soil Research, 1983). Evaluation of land suitability was carried out by matching the climatic characteristics of the land with the conditions required for patchouli by Rosman *et al*. 1998.

## RESULTS AND DISCUSSION

### Soil Physicochemical Properties

Soil physical and chemical properties are presented in Table 1. The analysis results showed that the pH is classified as moderately acidic with ranging from 6.33 to 6.45. Soil CEC was observed as a high in the entire sampling point. The total K content ($K_2O$ 25% HCl) is classified as very low (Y1) to low (Y2 and Y3). Meanwhile, the exchangeable K observed in this study was low (Y1) to moderate (Y2 and Y3). All exchangeable Mg were found very low; meanwhile, the exchangeable sites were occupied mainly by Ca.

**Table 1**. Soil physical and chemical properties

| Soil Properties | Y1 | Y2 | Y3 |
|---|---|---|---|
| *Physical Properties* | | | |
| Texture | Sandy Clay | Clay | Clay |
| Sand (%) | 46 | 26 | 26 |
| Silt (%) | 14 | 26 | 27 |
| Clay (%) | 40 | 48 | 47 |
| *Chemical Properties* | | | |
| C (%) | 2.26 (M) | 2.19 (M) | 2.40 (M) |
| N (%) | 0.12 (L) | 0.15 (L) | 0.17 (L) |
| C/N | 18 (H) | 14 (H) | 14 (H) |
| $P_2O_5$ HCl 25% (mg/100 g) | 31.86 (M) | 27.92 (M) | 26.27 (M) |
| $K_2O$ HCl 25% (mg/100 g) | 9.95 (VL) | 15.24 (L) | 17.64 (L) |
| CEC (me/100 g) | 22.43 (H) | 25.44 (H) | 26.57 (H) |
| Clay to CEC ratio (($mol_c$/kg clay) | | | |
| Exchangeable base ($cmol_c\ kg^{-1}$) : | | | |
| K | 0.30 (L) | 0.54 (M) | 0.48 (M) |
| Na | 0.27 (L) | 0.18 (L) | 0.23 (L) |
| Mg | 1.02 (VL) | 1.21 (VL) | 2.45 ( ) |
| Ca | 10.18 (M) | 11.19 (M) | 9.93 (L) |
| Base Saturation (%) | 53 (M) | 52 (M) | 49 (M) |
| Individual Base Cation Saturation (%): | | | |
| K | 1.34 | 2.12 | 1.81 |
| Na | 1.20 | 0.71 | 0.87 |
| Mg | 4.55 | 4.76 | 9.22 |
| Ca | 45.39 | 43.99 | 37.37 |
| Percentage between cation | | | |
| Ca/K | 33.9/1 | 20.7/1 | 20.7/1 |
| Ca/Mg | 10/1 | 9.2/1 | 4.1/1 |
| Ca/Na | 37.7/1 | 62.2/1 | 43.2/1 |
| Mg/K | 3.4/1 | 2.2/1 | 5.1/1 |
| Mg/Na | 3.8/1 | 6.7/1 | 10.7/1 |
| Na/K | 0.9/1 | 0.3/1 | 0.5/1 |
| (Ca+Mg)/K | 37.3/1 | 23/1 | 25.8/1 |
| pH $H_2O$ | 6.35 ($MA_c$) | 6.45 ($MA_c$) | 6.33 ($MA_c$) |

**Note**: Letter inside the brackets indicates soil properties status: VL: very low, L: low, M: medium, H: high, VH: very high, MAc: moderately acid, MC: mixed clay mineralogies; MCM: mixed clay mineralogies with a higher proportion of montmorillonite.

The domination of clay fraction content causes the high value of soil CEC in the study area. According to Rukmi *et al*. (2017), the high clay fraction in the soil greatly affects the exchange of cations because it has a large surface area. Furthermore, Sudaryono (2009) stated that soils with higher clay or colloid content and high organic matter content have a higher CEC than soils with low clay content (sandy soil) and low organic matter content. In line with Suarjana *et al.* (2015), which stated that the soil is dominated by clay and humus fractions, the soil has a high cation exchange capacity and water holding capacity.

Organic C at the research location was categorized as moderate, with an average value of < 3% based on laboratory results. Virzelina *et al*. (2017) stated that low to moderate organic C content indicates that the soil is experiencing a decrease in soil fertility. The intensive use of land without considering the level of soil fertility causes this condition. It is considered necessary to ameliorate compost in order to increase the C-organic content.

The soil's average $P_2O_5$ content at the research site is classified as medium (26.27 – 31.86 mg/100g). This condition indicates that the soil contains sufficient phosphorus minerals. According to Prabowo & Subantoro (2017), phosphorus in the soil is found in various compounds, most of which are unavailable to plants. Plants can not directly consume most P applied from fertilizers because they react with other soil materials (Winarso, 2005). Regarding this condition, fertilizing the soil in the study site is considered a necessity.

Apart from $P_2O_5$, potassium also plays an active role in soil fertility. The $K_2O$ content of the soil in (Table 1) shows that the total K in the soil at the study site is low. The K content in the soil showed a similar value between all study areas. This condition occurs possibly due to a combination of factors such as low K content in the soil due to high K uptake by plants and soil erosion (Al Mu'min *et al*. 2016).

## Soil Fertility Status

The soil fertility status are listed in Table 2. Soil fertility status in the entire sampling point was classified as low status. The status is obtained after combining the cation exchange capacity (CEC), base saturation,organic-C, $P_2O_5$, $K_2O$ based on the reference (PPT, 1983). In determining the status of soil fertility, the primary indicator of the assessment is the value of the Cation Exchange Capacity (CEC). According to Arthagama (2009), soils with a high CEC require high doses of soil fertilization. This condition occurs due to soil's high capacity to retain soil nutrients, competing with plant roots. Differently, the low CEC soil can not retain high quantities of soil nutrients. Fertilizing this type of soil with a high dosage in one application will cause cation leaching (Hardjowigeno, 2010).

**Table 2**. Soil fertility status of the sampling points

| Land Unit | CEC | Base Saturation | $P_2O_5$, $K_2O$, Organic-C | Soil Fertility Status |
|---|---|---|---|---|
| Y1 | H | M | Other combination | L |
| Y2 | H | M | Other combination | L |
| Y3 | H | M | Other combination | L |

Note: Letter inside the brackets indicates soil properties status H: High, M: Moderate, L: Low.

Based on Table 2, although the CEC, base saturation, organic-C, $P_2O_5$, $K_2O$ in the entire land reached medium and high levels, the soil fertility status was classified as low. Furthermore, according to Susila (2013), soil fertility status is a condition of soil fertility at a particular place and time assessed based on standard criteria for soil fertility parameters (PPT, 1983).

The low status of soil fertility in the entire sampling points are due to very low $K_2O$ content. The K content in the soil showed a similar value. This condition occurs due to a combination of factors such as the low K content in the soil due to high K uptake by plants and soil erosion (Al Mu'min *et al*. 2016), as well as the nature of K ions in the soil solution, which is mobile so that it is easily leached out from the soil system (Barber, 1985; da Silva *et al*. 2017). The low capacity of soil minerals to replace lost K, or in other words, K sources in basaltic or ultramafic soil parent materials that contain low K on average. In addition, soil pH also affects the availability of K elements in the soil. The results of the analysis of soil pH at the research site showed that the soil pH was slightly acidic. Acidic soil pH causes an increase in potassium fixation, causing a lack of K in the soil (Gunawan *et al*. 2019). It can be said that the absorption of nutrients needed by patchouli plants is thought to be almost the same as other types of plants in the research location; the same soil fertility status indicates this.

## Land Suitability for Patchouli

Based on the results of soil analysis combined with technical instructions for evaluating land suitability for patchouli, from the three soil samples, are obtained marginal land suitability class (S3) with limiting factor of rooting media (rc) and nutrient availability (na).

**Table 3.** Actual land suitability class

| Land Characteristic | Actual suitability | | |
|---|---|---|---|
| | **Y1** | **Y2** | **Y3** |
| **Root condition (rc)** | | | |
| Texture | S3 | S3 | S3 |
| **Nutrient retention (nr)** | | | |
| pH | S1 | S1 | S1 |
| Organic C | S1 | S1 | S1 |
| Base saturation | S1 | S1 | S1 |
| CEC | S1 | S1 | S1 |
| **Nutrient availability (na)** | | | |
| Total N | S1 | S1 | S1 |
| $K_2O$ | S2 | S1 | S1 |
| $P_2O_5$ | S3 | S3 | S3 |
| **Actual land suitability class** | **S3-rc, na** | **S3-rc, na** | **S3-rc, na** |

The results of the soil fertility status analyses adjusted to the suitability criteria for patchouli in the entire soil sampling point were classified as marginal (S3-rc, na), due to the limiting factor of soil texture (rc) and $P_2O_5$ (na). The clay texture condition of the soil requires the addition of more organic C to increase the aeration pore content in the soil, especially in the top layer of soil. Organic matter must be added because soil organic matter plays an essential role in creating soil fertility. The role of organic matter for soil is to form granulation in the soil and is very important in forming stable soil aggregates (Tolaka, 2013).

The na is not the main limiting factor in assessing the suitability of the land because it can still be managed by adding nutrients to the soil. The importance of $P_2O_5$ content, because it is a nutrient needed in large quantities, is very useful for plants to stimulate root growth, especially in the early stages of growth and plant production formation (Ndekano *et al*. 2021). The lack of P disrupts plant growth and have an impact on the production of a plant.

## CONCLUSIONS

The chemical properties of the soil for uncultivated, cultivated without fertilizer, and cultivated with fertilizer in Lamala District shows that the soil pH is slightly acidic, high CEC, base saturation is moderate, soil $P_2O_5$ content is moderate, and soil C-organic content is moderate. Soil $K_2O$ content on uncultivated land is very low. Meanwhile, cultivated without fertilizer and with fertilizer is low. The soil fertility status in entire sampling points are low. Land suitability classes are classified as marginally suitable (S3) with limiting factors of root condition (rc) and nutrients available (na). Further improvements such as organic matter amendment, phosphate and potassium fertilization are required to tackle the soil constraints observed in this study.

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