INTISARI

Kelapa sawit merupakan salah satu komoditi unggulan Indonesia yang memiliki peran penting dalam mendukung devisa negara. Meskipun telah dibudidayakan secara luas, tingkat produktivitas kelapa sawit di Indonesia secara substantial relatif rendah, terutama pada tanah ultrabasa. Untuk mengatasi tantangan tersebut, penelitian ini bertujuan untuk mengidentifikasi karakteristik lahan yang menjadi faktor pembatas pertumbuhan kelapa sawit pada toposequen ultrabasa, menilai pengaruh imbangan hara terhadap perkembangan sistem perakaran dan hasil tanaman kelapa sawit, serta merumuskan skenario pengelolaan hara yang lebih efektif dan efisien untuk meningkatan hasil tanaman kelapa sawit pada tanah ultrabasa. Ada tiga penelitian untuk memfasilitasi tujuan-tujuan tersebut, yaitu kajian faktor pembatas pertumbuhan dan produksi kelapa sawit pada beberapa toposekuen ultrabasa, kajian manajemen hara perkebunan kelapa sawit dan pengaruhnya terhadap perakaran dan hasil tanaman kelapa sawit di ultrabasa, serta pengembangan model pengelolaan hara pada tanah ultrabasa untuk komoditas kelapa sawit. Pengamatan dilakukan pada 18 profil tanah dari enam lokasi toposekuen perkebunan kelapa sawit yang dikembangkan di atas batuan ultrabasa (Kota Maju, Paka Indah, Langgikima, Wiwirano, Wataraki, dan Andowia), masing-masing pada tiga posisi lereng bebeda (lereng atas, tengah, dan lereng bawah). Setiap profil diamati ciri morfologi lahan dan morfologi tanahnya, serta karakteristik sifat fisika dan kimia tanahnya masing-masing. Pada setiap profil juga dilakukan pengamatan performa pertumbuhan dan hasil kelapa sawitnya masing-masing. Untuk mengkonfirmasi respon tanaman terhadap kondisi tanah juga dilakukan pengamatan perkembangan akar dan analisis jaringan (akar dan daun) tanaman kelapa sawit. Karakteristik morfologi lahan, morfologi tanah, sifat fisika dan sifat kimia tanah di lokasi penelitian sangat beragam, baik antar lokasi toposekuen maupun antar posisi lereng. Berdasarkan hasil analisis pemodelan persamaan struktural (SEM) diperoleh karakteristik lahan yang menjadi faktor pembatas rendahnya produksi kelapa sawit di ultrabasa berupa curah hujan dan hari hujan (iklim); banjir, kemiringan lereng dan elevasi (morfologi lahan); struktur tanah dan konsistensi tanah (morfologi tanah); kadar lengas tanah dan porositas tanah (sifat fisika tanah); kadar bahan organik (BO), C/N rasio dan kadar N total (TN) tanah (sifat kimia tanah). Hasil pengujian juga menunjukkan bahwa terdapat dua faktor yang signifikan mempengaruhi hasil tanaman yaitu iklim dan pertumbuhan tanaman. Pertumbuhan tanaman secara signifikan dipengaruhi oleh morfologi tanah, perkembangan akar tanaman, dan serapan akar. Hasil analisis heatmap yang dikonfimasi dengan analisis komponen utama (PCA) menunjukkan beberapa parameter tanah memiliki korelasi kuat dengan perakaran dan hasil kelapa sawit diantaranya adalah BO, BV, KAT, dan TN pada PC1 serta kadar lempung (C), Fe, N/K, dan P/K pada PC2. Hasil analisis regresi bertahap menunjukkan bahwa kadar BO dan kadar Fe dalam tanah merupakan karakteristik tanah yang secara signifikan berkontribusi terhadap perkembangan akar kelapa sawit pada toposekuen ultrabasa, sedangkan hasil sawitnya lebih ditentukan oleh imbangan hara Ca/Mg dan P/K dalam tanah. Hasil regresi menunjukkan adanya korelasi antara pembentukan jumlah tandan buah dengan jumlah akar kasar yang banyak. Sebaliknya jika didominasi akar halus maka jumlah bunga jantan yang cenderung banyak dihasilkan. Berdasarkan hasil pengembangan model pengelolaan hara menggunakan analisis multikriteria (AMK) menunjukkan bahwa perbaikan morfologi tanah (struktur dan konsistensi tanah) melalui penerapan teknik budidaya berbasis konservasi tanah dan air merupakan kunci keberhasilan model pengelolaan hara yang lebih efisien dan efektif dalam meningkatkan hasil kelapa sawit pada ultrabasa, karena berpengaruh signifikan dan secara konsisten terhadap kondisi fisika-kimia tanah, perkembangan perakaran, pertumbuhan dan hasil sawit di ultrabasa.

Kata kunci: *Elaeis guineensis* Jacq., karakteristik tanah, manajemen hara, perkembangan akar, SEM

ABSTRACT

Oil palm is one of the primary commodities from Indonesia that plays an important role to support the country revenue. Despite it has been widely cultivated, the productivity of oil palm in Indonesia is substantially lower, primarily in ultramafic soils. To anticipate this challenge, this study aims to identify the land characteristics that become the limiting factors for the growth of oil palm on ultramafic toposequence, to evaluate the influence of nutrient balance on roots development and yield of oil palm, to determine more effective and efficient of nutrient management strategies for improving oil palm yield in ultramafic soils. There are three studies to facilitate these goals, namely the study of the limiting factors of oil palm growth and production in several ultramafic toposequences, the study of nutrient management in oil palm plantations and their effects on roots and yields of oil palm plantations in ultramafic soils, and the development of a nutrient management model on ultramafic soils for palm oil commodities. Observations were made on 18 soil profiles from six sites of oil palm plantations developed on ultramafic rocks (Kota Maju, Paka Indah, Langgikima, Wiwirano, Wataraki, and Andowia), each at three different slope positions (upper, middle, and lower slope). Each profile was observed morphological characteristics of the land and soil morphology and the characteristics of each soil's physical and chemical properties. In each profile, the growth and yield performance of each oil palm was also observed. To confirm the response of plants to soil conditions, root development observations and analysis of oil palm plant tissue (roots and leaves) were also carried out. Characteristics of land morphology, soil morphology, physical properties, and chemical properties of the soil at the study site were very diverse, both among toposequence locations and among slope positions. Based on the results of structural equation modeling (SEM) analysis, it was found that the land characteristics as the limiting factors for the low production of oil palm in ultrabasic were rainfall and rainy days (climate); flooding, slope, and elevation (land morphology); soil structure and soil consistency (soil morphology); soil water content and soil porosity (soil physical properties); soil organic matter (SOM), ratio C/N, and total N content (TN) of the soil (soil chemical properties). The test results showed two factors significantly affecting oil palm yields, namely climate and plant growth. Plant growth was significantly influenced by soil morphology, plant root development, and root uptake. The results of the heatmap analysis which were also confirmed by principal component analysis (PCA) showed that several soil parameters had a strong correlation with roots and oil palm yields including SOM, BD, SWC, and TN on PC1 as well as clay content, Fe, N/K, and P/K on PC2. The results of the stepwise regression analysis showed that the SOM and Fe content in the soil were soil characteristics that significantly contributed to the development of oil palm roots in the ultramafic toposequence, while the yield of palm oil was more determined by the balance of Ca/Mg and P/K nutrients in the soil. The regression results showed a correlation between the formation of the number of fruit bunches with a large number of coarse roots. Conversely, if it is dominated by fine roots, the number of male flowers that tend to be produced. Based on the results of the development of a nutrient management model using multi-criteria analysis (MCA), it showed that improving soil morphology (soil structure and consistency) through the application of cultivation techniques based on soil and water conservation was the key to the success of a more efficient and effective nutrient management model in increasing oil palm yields on ultramafic, because it had a significant and consistent effect on soil physico-chemical conditions, root development, growth, and yield of oil palm in ultramafic.

Keyword: *Elaeis guineensis* Jacq., nutrient management, root development, soil characteristic, structural equation modeling