

Spodosols di Indonesia memiliki luas sekitar 2.16 juta ha dan 70% (1,51 juta ha) berada di Kalimantan Tengah. Spodosols memiliki karakteristik unik seperti tingginya asam organik, rendahnya bahan organik, dan *hardpan* yang menghambat drainase tanah. Tujuan penelitian meliputi: 1) Menilai substansi tanah Spodosols berdasarkan kondisi vegetasi lahan, sifat fisika dan kimia tanah, kelembapan tanah, dan pH air; 2) Mengeksplorasi dampak perlakuan rekayasa media tanam dan *water management system* terhadap perkembangan akar, kadar hara daun, dan produksi kelapa sawit pada tanah Spodosols; 3) Membuat model dan penerapan aplikasi *smart estate technology* sebagai panduan pengelolaan perkebunan kelapa sawit pada tanah Spodosols. *Novelty* penelitian ini adalah “memadukan interaksi antara aspek teknologi, aspek Spodosols dan aspek tanaman kelapa sawit dalam pembuatan model dan aplikasi *smart estate* berbasis perilaku air dan media perakaran, dapat digunakan sebagai mitigasi permasalahan pengelolaan kelapa sawit berkelanjutan di tanah Spodosols, sehingga mampu meningkatkan nilai tambah pada aspek ekonomi, sosial dan lingkungan. Penelitian tentang pengelolaan tanah Spodosols di Perkebunan kelapa sawit Wilmar Group di Sampit, Kalteng, dilaksanakan dari Januari 2022 hingga Desember 2023. Kajian ini meliputi tiga tahap utama: analisis substansi tanah Spodosols, efek perlakuan rekayasa media tanam dan sistem manajemen air terhadap produksi biomassa kelapa sawit, serta aplikasi teknologi smart estate untuk pengelolaan perkebunan. Hasil menunjukkan bahwa identifikasi jenis tanah Spodosols pada area yang belum dibuka untuk pertanian dapat dilakukan melalui 3 metode yaitu *Soil survey* (metode pengeboran), *Biodiversity survey* (tingkat vegetasi), dan *Deep learning* (foto udara menggunakan *drone*). Tanah ini masih dapat memberikan nilai ekonomis untuk Perkebunan kelapa sawit dengan perlakuan pecah *hardpan* dan *mounding* serta *Water Management System* (WMS) agar terjadi peningkatan sifat fisika tanah, sifat kimia tanah, kelembapan tanah, dan pH air. Dampak rekayasa media tanam dan *water management system* pada Spodosols mampu meningkatkan perkembangan akar dan produksi kelapa sawit, serta menjaga kadar hara daun pada level optimum. Terjadi peningkatan produktivitas kelapa sawit hingga 21% pada Spodosols perlakuan (2,88 ton ha<sup>-1</sup> tahun<sup>-1</sup>) dibandingkan kontrol (0,33 ton ha<sup>-1</sup> tahun<sup>-1</sup>). Selama 36 bulan setelah perlakuan (BSP) terjadi peningkatan berat basah akar sebesar 47% (0,52 kg pohon<sup>-1</sup> bulan<sup>-1</sup>), berat kering sebesar 55% (0,20 kg pohon<sup>-1</sup> bulan<sup>-1</sup>), dan volume akar sebesar 46% (52 cm<sup>3</sup> pohon<sup>-1</sup> bulan<sup>-1</sup>) dibandingkan dengan kontrol (0 BSP). Hasil kadar hara daun pada kontrol dan perlakuan secara keseluruhan tidak menunjukkan perbedaan signifikan dan berada pada level optimum yaitu N (2,4 - 2,8%), P (0,15 - 0,18%), K (0,9 - 1,2%), Mg (0,25 - 0,40%), Ca (0,5 - 0,75%), S (0,25 - 0,35%), Cl (0,5 - 0,7%), B (15 - 25 µg/g), Cu (5 - 8 µg/g), Zn (12 - 18 µg/g), Fe (50 - 250 µg/g). Penerapan Smart Estate Technology di perkebunan kelapa sawit pada Spodosols dilakukan dengan menggunakan data perkebunan (SAP system), data iklim (Nusaklim web), dan data perilaku air (Agrieye web) untuk mendukung keputusan yang berbasis perilaku air dan media perakaran secara tepat menuju praktik perkebunan kelapa sawit presisi mampu meningkatkan produksi TBS mencapai 21%.

Kata kunci: Spodosols, Rekayasa Media Tanam, *Water Management System*, *Smart Estate Technology*, Produktivitas Kelapa Sawit.

Spodosols in Indonesia cover an area of approximately 2.16 million hectares, with 70% (1.51 million hectares) located in Central Kalimantan. Spodosols possess unique characteristics such as high organic acidity, low organic material content, and hardpans that hinder soil drainage. The research objectives include: 1) Assessing the soil substance of Spodosols based on land vegetation conditions, soil physical and chemical properties, soil moisture, and water pH; 2) Exploring the effects of engineered planting media treatment and water management systems on root development, leaf nutrient levels, and oil palm production on Spodosols; 3) Developing a model and implementing a smart estate technology application as a guide for oil palm plantation management on Spodosols. The novelty of this research lies in "integrating the interaction between technological aspects, Spodosols, and oil palm plant aspects in developing a model and a behavior-based smart estate application, which can be used to mitigate sustainable oil palm management issues on Spodosols, thus enhancing economic, social, and environmental value-added aspects. Research on Spodosols management at Wilmar Group's oil palm plantation in Sampit, Central Kalimantan, was conducted from January 2022 to December 2023. The study comprises three main phases: Spodosols soil substance analysis, the effects of engineered planting media treatment and water management systems on oil palm biomass production, and smart estate technology application for plantation management. The results indicate that identifying Spodosols soil types in areas not yet opened for agriculture can be done through three methods: Soil survey (drilling method), Biodiversity survey (vegetation level), and Deep learning (aerial photos using drones). This soil can still provide economic value for oil palm plantations with treatments such as hardpan breaking, mounding, and Water Management Systems (WMS) to improve soil physical properties, soil chemical properties, soil moisture, and water pH. The impact of engineered planting media and water management systems on Spodosols can enhance root development and oil palm production, while maintaining leaf nutrient levels at optimum levels. There was a 21% increase in oil palm productivity on treated Spodosols (2.88 tons ha<sup>-1</sup> year<sup>-1</sup>) compared to the control (0.33 tons ha<sup>-1</sup> year<sup>-1</sup>). Over the 36 months post-treatment (BSP), there was a 47% increase in root wet weight (0.52 kg tree<sup>-1</sup> month<sup>-1</sup>), a 55% increase in root dry weight (0.20 kg tree<sup>-1</sup> month<sup>-1</sup>), and a 46% increase in root volume (52 cm<sup>3</sup> tree<sup>-1</sup> month<sup>-1</sup>) compared to the control (0 BSP). Leaf nutrient levels in both control and treatment groups did not show significant differences overall and remained at optimum levels: N (2.4 - 2.8%), P (0.15 - 0.18%), K (0.9 - 1.2%), Mg (0.25 - 0.40%), Ca (0.5 - 0.75%), S (0.25 - 0.35%), Cl (0.5 - 0.7%), B (15 - 25µg/g), Cu (5 - 8µg/g), Zn (12 - 18µg/g), Fe (50 - 250µg/g). The implementation of Smart Estate Technology in oil palm plantations on Spodosols utilizes plantation data (SAP system), climate data (Nusaklim web), and water behavior data (Agrieye web) to support water behavior-based decisions and precise root media practices towards precision oil palm plantation practices, capable of increasing FFB production by up to 21%.

**Keywords:** Spodosols, Planting Media Engineering, Water Management System, Smart Estate Technology, Palm Oil Productivity