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Research Article

Horizontal Mapping of Root Zone Under Oil Palm Using Resistivity Method

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Abstract

Measurement of tree root systems by conventional methods is a wasting time, labor and cost. The resistivity method offers a method for non-destructive measurement of plant and tree roots. This method can obtain root information more effectively and efficiently. The objective of this research is to understand 2D horizontal mapping so we can investigate the spread of oil palm roots. The research was conducted in the oil palm plantation in Bangka Belitung Islands, Indonesia. Measurement data of resistivity method of Wenner configuration was performed on individual oil palm tree with variations of distance between probes 0.25 to 2 m. Electric current was injected into the earth through two current probes then potential difference was measured through two potential probes. Field data was then interpreted data with software RES2DINV. The results showed that roots of three-year-old oil palms were dominated by primary and secondary roots, as well as a small portion occupied by tertiary and quaternary roots that spreads horizontally as far as 1.5 – 2.5 m from the stand, with less than 30 cm in depth. These conditions enable to prevent competition in the root zone, because each plant species occupies different land space.

Keywords: *Mapping; Oil Palm; Resistivity; Root Zone*

Introduction

Root that is as the main organ of the plant to absorb water and nutrients from the soil determines the growth and development of the plant. Plants with good roots are able to grow, develop and produce maximally. Development of oil palm root spreads vertically and laterally following the development of plant age [1]. The oil palm plant has primary, secondary, tertiary, and quaternary roots. Primary and secondary roots are as a support of the stem of the plant while the tertiary and quaternary roots are used to absorb water and nutrients. The quantitative distribution of the tertiary and quaternary roots of oil palm horizontally is determined by the age of the plant. According to Lambourne [2], for 6 years after planting, oil palm roots distribution reflects the development of the canopy, and often nearly at 2.5 m from the stand at age ≤ 2.5 after planting so it is suspected to limit the environmental carrying capacity for plant growth and development in annual plant which is introduced.

In sampling, the root of oil palm by destruction method takes a long time, and labor intensive but brings less effective. A multidisciplinary study on the root distribution of plants and its relation to soil physical properties have been undertaken to detect plant roots and study soil and root relationships. One of non-destructive method is geo-electrical resistivity method. The resistivity method has been proposed by researchers as a method for non-destructive measurements of plant and tree roots [3,4]. The purpose of this research is to investigate 2D mapping horizontally so that it can investigate the distribution of tertiary and quaternary root.

Experimental Methods

This research utilized three-year-old oil palm plantation. The research was conducted in the oil palm plantation in Batu Penyu Village, Gantung District, East Belitung, Bangka Belitung Islands Province, Indonesia. The study was conducted in October 2013. The study used a set of geo-electric set, sensor probe, meter, and stationery. The material used is three-year-old oil palm area.

Mapping of the distribution of oil palm root zone can be assumed through geo-electrical resistivity method. Data measurement of the resistivity geo-electrical method using the Wenner configuration [5,6] was conducted in 2 sample of 9m of oil palm plot with variation of current stretch (AB) from 0.75 m to 6 m and the probe stretch potential (MN) with a variation of 0.25 to 2m. Distance between probes ranged from 0.25 to 2m. The principle in this method is that the electric current is injected into the ground through two current probes, whereas the potential difference occurring is measured through two potential probes. The result of measurement of current and electric potential difference can be obtained by value variation of electrical resistivity at the layer below the measuring point [7]. The measurement is done by varying the probe current and potential distance from the smallest distance and then gradually enlarge [6]. The field data are in the form of potential difference data (△V) and electric current (I) obtained at each measurement used to calculate geometric factor (K) and apparent resistivity (ρa). Further data obtained are processed and interpreted with RES2DINV software.

Result and Discussion

Geo-electrical resistivity is one of types of geo-electric method that is widely used to study the condition of the subsurface by studying the nature of the flow of electricity in the rock beneath the earth's surface. The resistivity method is generally used for shallow exploration, about 300 - 500m [7]. The geo-electrical resistivity method is performed by injecting an electric current into the earth's surface and then measuring the potential difference between two potential electrodes. This principle is similar to assuming that the earth's material has a resistive or resistor-like property, in which the materials have different capacities for conducting electrical current.

Based on the results of 2D mapping, it can be interpreted that the penetration of the soil depth is half of the distance between the probe. The farther the distance between the probes, the deeper the depth of the soil is measured. This corresponds to the equipotential lines is formed on Wenner's configuration. Loke [7] stated that the greater the range between distance the probe is, the more the scope of the form larger equipotential lines and more layers are investigated.

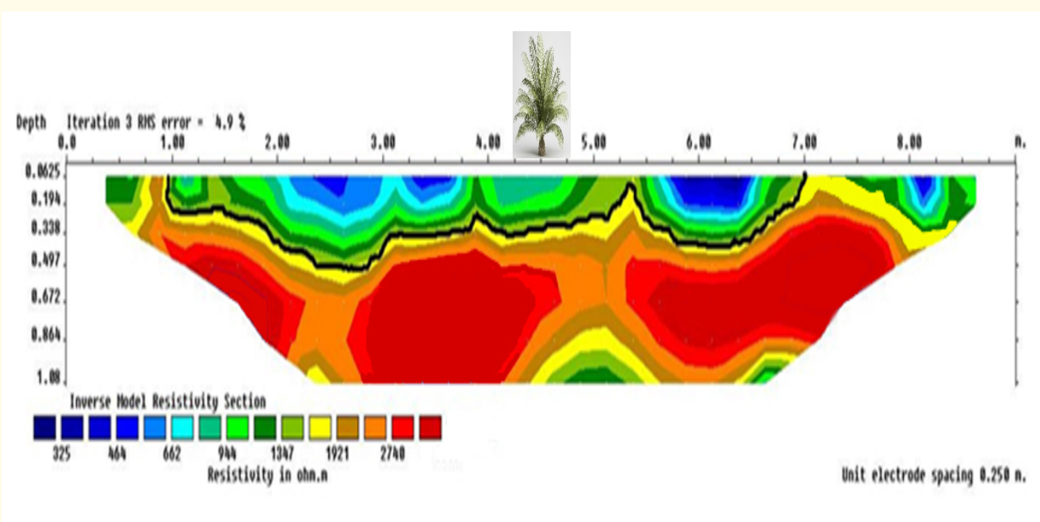

Figure 1: *2D Resistivity of Cross Section of Track I.*

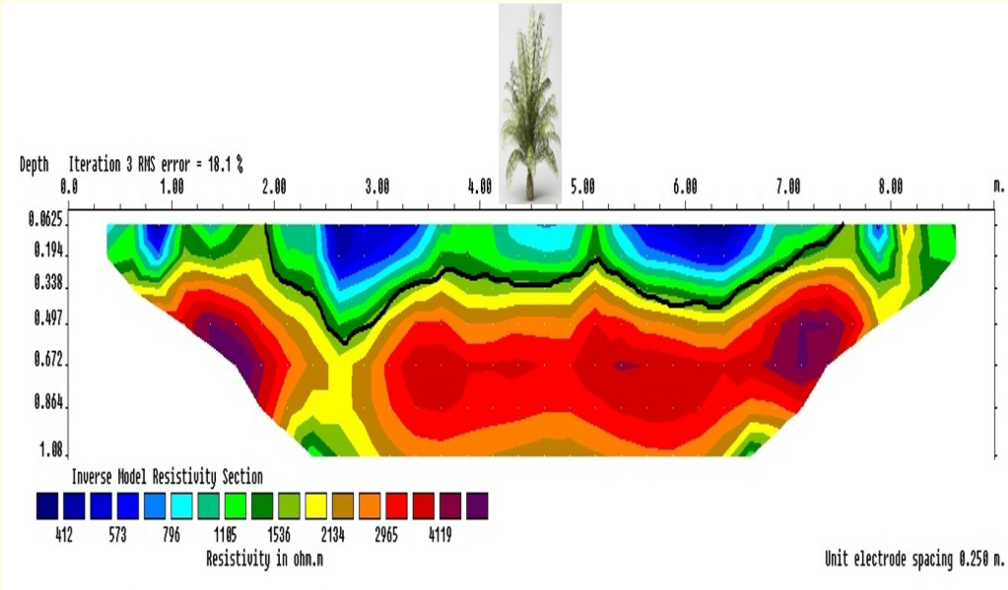

Figure 2: *2D Resistivity of Cross Section of Track II.*

From the results of 2D mapping (Figures 1 and 2), we can see that we have images that have different colors. Each color represents a different resistivity. The smallest resistivity is blue, while the largest is purple. We can mean that the uppermost layer which consists of a material which is injected with electrical current will slightly inhibit electricity compared to the underlying layer. On the surface of the upper layer under the oil palm, there is a discontinuity resistivity pattern at the horizontal distance of the coordinates x = 1.5m and x = 2m from the stand while the oil palm is at the coordinates x = 4.5m, the presence of tertiary and quaternary roots is at the top layer that forms a type of webbing. Discontinuity patterns that have low to medium resistivity in the upper layer indicate the presence of oil palm root zone that has high humidity. This is because it is evident that the occurrence of rain the day before the field measurements. According to Paglis [8], there is more continuity patterns in bare soil compared to under plant roots in topsoil. The black line indicates the border of oil palm roots. The dominance of the root is nearly at 1.5m - 2m. While in the direction of coordinate z (depth) which shows depth seen that at depth < 0.3m, is dominated by low resistivity value. At depth > 0.3m the distribution of soil resistivity varies from medium and high, but most are high. This is because it contains dry gravel materials that have resistivity value > 600 Ωm. Primary and secondary roots show higher resistivity values (green) compared to tertiary and quaternary roots (blue). The roots of quaternary have no lignin so the resistivity value is the lowest compared to the roots that appear on the dominance of the blue color in the topsoil.

The existence of a low resistivity value that has deep < 0.3m is closely related to the dominance of the presence of tertiary and quaternary root. This is because tertiary and quaternary roots are very active in absorbing nutrients and water from the soil. According to Nazari and Sota [6], nutrients and water are absorbed by plants in the form of ions that are electrically charged so it will easily conduct electrical current resulting resistivity value to be very small. In terms of soil physical properties, small resistivity values are associated with type of soil. In porous soil, it has a rapid rate of water infiltration, low water holding capacity, low nutrient content, low adsorption capacity, good for rooting system, and easy to tillage. Thus, the total root distribution of tertiary and quaternary of the horizontal direction is 3 - 4m with a depth < 0.3m so there is still a space of about 5m between the oil palm. These conditions enable to prevent competition in the root zone, because each plant species occupies different land space.

Conclusion

Root zone of oil palms were dominated by primary and secondary roots, as well as a small portion occupied by tertiary and quaternary roots that spreads horizontally as far as 1.5 - 2.5m from the stand, with less than 30 cm in depth. These conditions enable to prevent competition either nutrition or water in the root zone. This will be beneficial for further planting strategy.

Conflict of Interest

I declares that the submitted manuscript has no any conflict of interest.

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