Available at : https://ejournal.unib.ac.id/index.php/terrajournal ISSN 2621-0207
DOI : https://doi.org/10.31186/terra.6.1.33-39

TERRA
Journal of Land Restoration

Soil Moisture Differences Between Continues Measurements of Three Crop Managements

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ABSTRACT

Soil moisture prediction models on a regional scale can be developed by looking for the relationship between water balance and basic soil properties such as texture and organic matter. Our previous research has obtained soil dielectric properties measurement technology as an estimator of soil moisture that can be done quickly in the field. The purpose of this study was to apply this technology in estimating the characteristics of soil moisture insitu in the field on a district scale in Bengkulu Province. The research was conducted for three years in three different districts in Bengkulu Province. The results of the third year to early October 2021 study showed that land under thicket stands and oil palm had higher weekly groundwater fluctuations than under rubber. The highest impedace of groundwater below the thickets and palms are present at depths of 0-20 cm and 0-10 cm, respectively. However thickets have fluctuations in the depth of total groundwater (0-30 cm depth) that are higher than those of oil palms during three months of measurement. In contrast, the soil moisture content profile under the rubber stand is relatively more stable against the influence of weekly rainfall during the measurement. An analysis of the relationship between non-free variables (field capacity moisture content, permanent wilting point and water available) and free variables (sand, dust, clay and C-organic) will be carried out in November 2021

Keywords : *dielectric, palm oil, soil impendace, soil moisture*

INTRODUCTION

Introduction to the different covering management systems such as species or varietas of refer to the height and plant. Oil palm *(Elaeis guineensis* Jacq.*)* is a plantation commodity that has a crucial role in the Indonesian economy (Mangoensoekarjo & Tojib, 2005). The Directorate General of Plantations in 2018 reported that the progressive development of the palm oil industry in Indonesia has soared massively, especially the increase in land area and oil palm production (Nasution *et al.,* 2023). Long-term investment in oil palm plantations is the basis for the high interest of farmers to open up new land for growing oil palm crops. In 2020, the area of plantation oil palm land in Indonesia was affordable 14,586,597 ha, with a production of 44,759,147 tons of Crude Palm Oil (CPO) and 8,951,829 tons of Palm Kernel Oil (PKO) production (Biro Pusat Statistik, 2021).

In addition to abundant production, it also produces waste in empty fruit bunches of 23% for each ton of FFB. Of sufficient quantities, it should be applied as a soil amendment to improve soil health chemically (Irwansyah *et al.*, 2023). The most important climatic factors in the growth of oil palm plants are rainfall, air temperature, air humidity, and solar radiation. IRHO compiles the classification of annual water deficits in oil palm cultivation into several classes as follows (68): 0 – 150 mm (optimal), 150 – 250 mm (still appropriate), 250 – 350 (intermedier), 350 – 400 mm (limit, limit), 400 – 500 mm (critical), and >500mm (non-compliant). Palm oil requires 5 hours of irradiation per day throughout the year although preferably for several months there are 7 hours of irradiation per day. The minimum temperature required for oil palm for vegetative growth is 200 ^{o}C and the annual average temperature is 22 – 23 ^{0}C for fruit production (Awotoye & Dada, 2011).

Today, more than 12 million tons of natural rubber are produced annually, which are used in many industries to produce commercial products such as gloves, tires, balloons, rubber shoes, mattresses, swimming caps, catheters and bottle caps (Jitkokkruad *et al*., 2023; Husaini *et al.*, 2023; Xu *et al.,* 2023). According to Law No. 41 of 1999 Forest is an ecosystem unit in the form of a stretch of land containing biological natural resources dominated by trees in the natural fellowship of the environment, which cannot be separated from each other (Akbar & Najah*,* 2022).

Information about the moisture or moisture content of the soil in the root layers is very important in evaluating the availability of water for plants, the rate of erosion and various other hydrological characteristics. Groundwater is one of the physical properties that directly affects the growth of plants and other aspects of human life because water is the highest component of plants and other living things. The ability of the soil to store water is one of the indicators related to the level of criticality of the land in supplying water for plant growth, as well as absorbing rainwater that falls to the surface so as not to cause erosion and flooding. On a laboratory scale, the research team has managed to find a close relationship between some of the basic properties of the soil, such as texture and organic matter, and the soil moisture content available to plants (Hermawan *et al.*, 2020). The results of the first and second years of research (2019-2020) on the field scale showed that the sand and clay content showed a fairly close relationship with the water content of the field capacity and the available water content (Fitriani *et al.*, 2022).

Models of soil moisture prediction in the field on a district scale can be developed by looking for the relationship between water balance and basic soil properties such as texture and organic matter. But when implemented on a wide regional scale, the study of the correlation between components of the groundwater balance, such as moisture at saturated conditions and permanent wilting points, with the basic characteristics of such soils requires a very large number of samples. Our previous research has obtained soil dielectric properties measurement technology as an estimator of soil moisture that can be done quickly in the field even though it is only on a limited scale in one plantation area. The tool used in the first year of this reported study showed more accurate and stable performance than the tools produced in previous studies (Hermawan *et al.*, 2017).

The specific purpose of this study is to apply dielectric technology in estimating soil moisture characteristics insitu in the field on a district scale in Bengkulu Province. The urgency of this study is the need for a model to predict soil moisture characteristics that have been tested at the district scale through basic soil characteristics. The benefit of the study is the availability of information on soil moisture characteristics for land management purposes related to land suitability for certain commodities, as well as irrigation and erosion control measures that need to be carried out on agricultural land.

MATERIALS AND METHODS

This research was conducted from June to October 2021 under adjoining stands of shrubs, rubber, and palm oil in Talang Tengah Village, Pondok Kubang District, Bengkulu Tengah Regency, Bengkulu. Map is located in within a three kilometer weather and soil analysis at the Soil Physics Laboratory of the Bogor Soil Research Center.

Soil profile observation

Soil profile observations were carried out at three research sites, namely under the stands of shrubs, rubber and oil palm in Talang Tengah I Village, Pondok Kubang District, Bengkulu Tengah Regency (Figure 1). Thus, there are three profiles observed at the study site. The soil is dug up with dimensions (length, width, depth) of 1 x 0.5 x 0.3 m, the upright cross-section of the soil is described

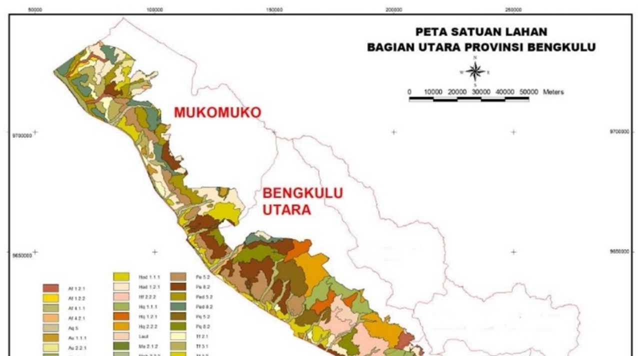

Figure 1. Map of this year research location in Pondok Kubang District, Central Bengkulu Regency, Bengkulu Province

quantitatively and qualitatively. The profile description includes the border and thickness of the horizon, soil color, texture, structure, consistency and root of the plant in each layer. Characteristics of cover vegetation (such as staple plants and understory plants) were also observed around the excavated profiles.

Measurement of moisture Content in the field

The moisture content of the field soil was measured using a Dielectrometer (Figure 6) at each layer of 5 cm to a depth of 30 cm. The measured value is the dielectric property in the form of ground electrical impediency (Z, kilo ohm units) measured by connecting the part of the cable that appears on the ground surface with a Dielectrometer tool developed from the second year of research (Figure 5). The Z value is then converted into groundwater content (θ, g / g units) using the model, namely:

$$\theta = a.Z^{b} \qquad (1)$$

constants a and b are established by performing a regression analysis between the Z and θ values of the disturbed soil instance on the same measurement day. The Z measurements are performed once a week to describe the redistribution of precipitated water within the soil profile during the drying period (discharge phase, July-October 2021 period). After the tool is calibrated in the laboratory, the Z values are further converted using the equation:

$$\theta = 0{,}68.Z^{-0{,}3} \qquad (2)$$

Figure 2. Dielectrometer tool to measure moisture content in the field

Measurement of moisture content in the laboratorium

The main observation variables in the laboratory consist of soil profile characteristics (boundary, thickness, horizon name, color, texture, structure, consistency and root of plants in each layer), in-situ moisture content, field capacity moisture content, permanent wilt point moisture content, pore distribution, moisture content available to planting,, volume weight, and ground-water profile. The supporting variables in this study are particle size distribution, texture class, soil organic matter content, vegetation type and characteristics, and weather conditions.

RESULTS AND DISCUSSION

Description of the research location

The research area has been described in detail which includes geographical position, village, sub-district, altitude from sea level, and land units as presented in Table 1. The land observed and sampled is thickets and agriculture located in community-owned plantation crop cultivation areas. Administratively, the land under study is located in the area of Talang Tengah Village I. Pondok Kubang District, Bengkulu Tengah Regency. The research site included in the coastal area is located at an altitude of about 10 m from sea level.

Description of soil profile

Soil profiles at the three study sites are presented in Figure 4. The soil profile at the site of the thicket and rubber has a black soil layer to a depth of 30 cm indicating the high content of organic matter. On the other hand, the soil profile in oil palm fields is lighter because it has a lower organic matter content. The distribution of root is also deeper on the soil under thickets and rubber, while under the palm it is found only at a depth of 0-20 cm. Such differences in soil profile are likely to affect the characteristics of groundwater between thickets and rubber and oil palm.

The results of the research implementation that have been achieved in the third year (Year 2021) include field data, data analysis results, as well as mandatory external achievements and additional outputs. The field data that has been obtained is electrical impediency measurement data that has been converted to soil moisture content data at various depths. The highest water content at all three sites occurred on July 13, 2021 because the weekly rainfall at the time of measurement reached 240 mm (Figure 5). In contrast, the lowest groundwater content was obtained on August 1, 2021 because no rain fell in the last one before the measurement. The pattern of changes in groundwater profile as in Figure 5 is in line with the results of the study in the previous two years (Hermawan *et al.*, 2016), and its relationship with rain according to the findings (Klik *et al.*, 2015).

Table 1. Summary of three location

Variables	Sample Coordinate		
	Shrub	Harvest	Palm Oil
Coordinates	3^0 41’ 49” S 102^0 19’ 22” E	3^0 42’ 03” S 102^0 19’ 03” E	3^0 41’ 55” S 102^0 19’ 03” E
Vallage	Talang Tengah I, Pondok Kubang	Talang Tengah I, Pondok Kubang	Talang Tengah I, Pondok Kubang
Province	Central of Bengkulu	Central of Bengkulu	Central of Bengkulu
Part of Bengku-lu City	15 km	15 km	15 km
Latitude	10 m	10 m	10 m
Vegetive	Shrub	Harves	Palm oil
Age of Current	15 years of study	20 years	

Figure 3. Three level of soil darkness for the contribution of soil carbon

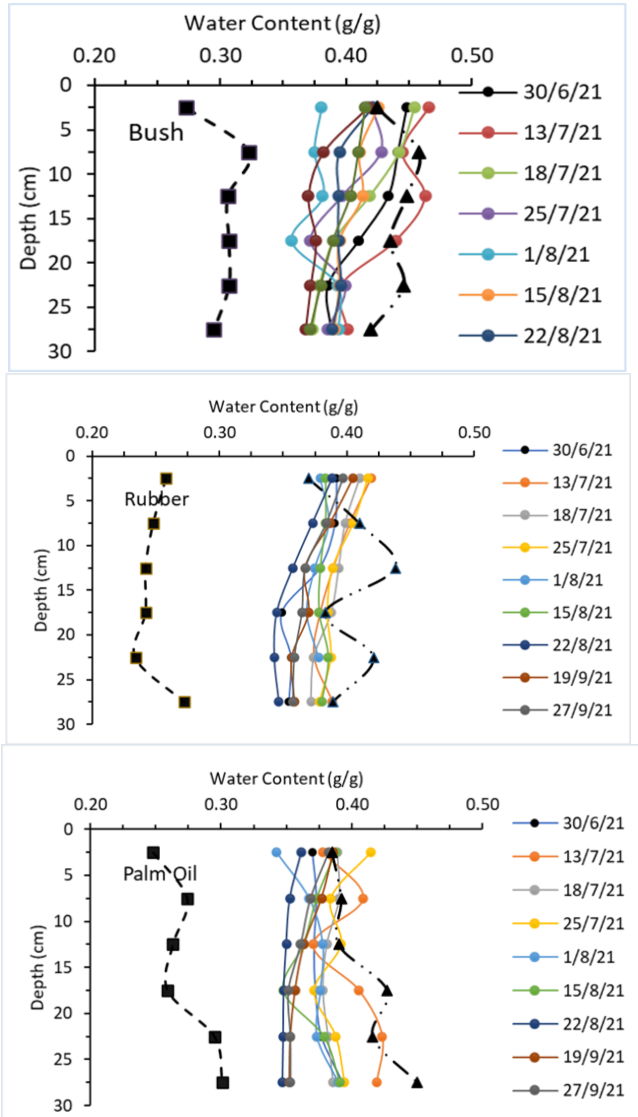

Figure 4. A relation between slow-drainage pores and particle density of study soils

The results of field data analysis show temporal fluctuations in water depth in the soil profile as presented in Figure 6. The amount of water stored in the soil profile was consistently higher under the bush than under rubber and oil palm during the three months of measurement. These findings reinforce the growing assumption in communities that there has been a reduction in water resource stocks when forest and scrub areas are cleared into plantations such as oil palm. However, this finding also shows that the reduction in water resources in plantation areas is not only caused by oil palm commodities but also occurs in rubber commodities. That is the main point of the decline in water resources is the transition of forests and shrubs to plantation land without differentiating the commodities cultivated.

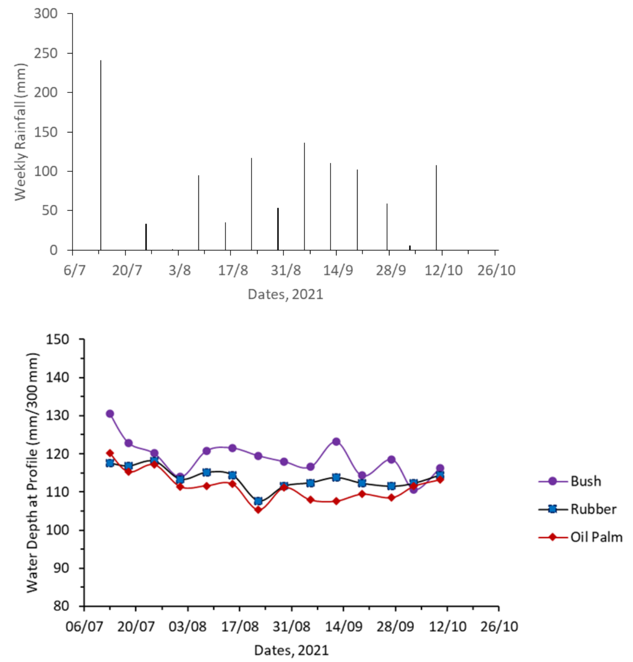

Figure 5. Rainfall and temporal changes into weekly soil water content

Figure 5 above shows that weekly soil moisture under thicket stands and oil palms is more volatile according to rainfall fluctuations than below rubber stands. In other words, the presence of water in various layers within the soil profile of the shrub and oil palm is more volatile following the rain event than in the profile of rubber soil. The phenomenon of fluctuations in soil clearance in different layers under different stands can be explained from the pore size distribution data. The soil profile under the scrub stand has an average total porosity of 61.2% in six layers, below the rubber stand on average 61.4%, and below the oil palm an average of 55.8%. However, temporal fluctuations in soil moisture seem to be more influenced by the moisture content available to plants, the higher the water content available, the more stable the presence of water in the soil when there is a change in rainfall. Under the bush, the average available moisture content in the profile is only 13.6% while below palm oil it is 13.7%, much lower than the average available moisture content of 15.3% below the rubber stand. The higher volume of water available to plants under rubber causes its content per soil volume to not change much when rain occurs or does not occur in one week.

In the third year of research implementation, the research output in the form of a prototype of a Dielectrometer tool measuring soil moisture content has worked well and its performance in the field is much more stable than the tool produced in the previous two years of research (2019 and 2020). The tool developed in 2021 has three alternatives to moisture data storage. First, the data is not stored but rather displayed directly on the digital screen of the tool and recorded manually. Second, data is sent to the internet of things (IoT) and stored in cloud storage, then downloaded via mobile phones and laptops. Third, data is sent via IoT and can be used to operate mechanical systems remotely, for example to open and close irrigation water taps automatically. The use of dielectric sensors to determine soil moisture has also been carried out by previous researchers (Kargas *et al*., 2017).

The 4th Generation Dielectrometer tool produced in 2021 has been successfully integrated with the irrigation network system so that water feeding can be carried out automatically according to the level of soil dryness. When the water content is close to 50% of the field capacity condition, the irrigation water tap will open, and will close again when the groundwater content has risen close to the field capacity. The performance of the tool has been running well.

CONCLUSION

Soil moisture prediction models on a regional scale can be developed by looking for the relationship between water balance and basic soil properties such as texture and organic matter. The results of the third year to early October 2021 study showed that land under thicket stands and oil palm had higher weekly groundwater fluctuations than under rubber. The highest temporal fluctuations of groundwater below the thickets and palms are present at depths of 0-20 cm and 0-10 cm, respectively. However thickets have fluctuations in the depth of total groundwater (0-30 cm depth) that are higher than those of oil palms during three months of measurement. In contrast, the soil moisture content profile under the rubber stand is relatively more stable against the influence of weekly rainfall during the measurement.

ACKNOWLEDGEMENTS

Sincerely appreciation goes to the Institute of Research and Community Services, UNIB for providing the financial support through contract No. 1988/ UN30.15 /PG/2020, 23 June 2020.

References

Akbar, I., & Najah, S. (2022). Literature Review: Potensi dan Pengelolaan Sumberdaya Hutan, *Jurnal Sains Edukatika Indonesia (JSEI),* 4 (2), 38-43. https://jurnal.uns.ac.id/jsei/article/view/70943/39327.

Awotoye, O. & Dada, A.C. (2011) Impact of palm oil processing effluent discharge on the quality of receiving soil and river in South Western Nigeria impact of palm oil processing effluent discharge on the quality of receiving soil and river in South Western Nigeria. *Journal of Applied Sciences Research,* 7(2), 111-118. https://www.researchgate.net/publication/230764102_Impact_of_Palm_Oil_Processing_Effluent_Discharge_on_the_Quality_of_Receiving_Soil_and_River_in_South_Western_Nigeria.

Fitriani, N., Hermawan, B., Putri, E.L. & Hasanudin, H. (2022). Irrigation water supply patterns in several land uses with automated application of soil moisture monitoring based on Dielectric Technology. *TERRA : Journal of Land Restoration*, 5(1), 21–26. DOI: https://doi.org/10.31186/terra.5.1.21-26 .

Hermawan, B., Agustian, I., Suhartoyo, H. & Sukisno. (2016) Rancang Bangun Handheld Soil Moisture Meter untuk Mengukur Kadar Air Tanah Secara Insitu. Laporan Penelitian Unggulan Perguruan Tinggi (PUPT). Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) Universitas Bengkulu (tidak dipublikasikan).

Hermawan, B., Supardjo, E., Hindarto, K.S., Silalahi, R. & Barchia, M.F. (2017) A quick dielectric method to determine insitu soil water content for precision water use under sustainable agricultural practices. *International Journal on Advanced Science, Engineering and Information Technology*, 7(3), 910–915. DOI: 10.18517/ijaseit.7.3.1667.

Hermawan, B., Suhartoyo, H., Sulistyo, B., Murcitro, B.G. & Herman, W. (2020). Diversity of soil organic carbon and water characteristics under different vegetation types in Northern Bengkulu, Indonesia, *Biodiversitas*, 21(5), 1793–1799. DOI: 10.13057/biodiv/d210504.

Husaini, A., Fahrezi, D.D., Arbavella, M.A.& Sadewa, N.P. (2023). Analisis Ekspor Komoditi Karet di Indonesia terhadap Perdagangan Internasional 2016-2020, 2. DOI:10.55681/economina.v2i2.320.

Irwansyah, E., Santoso, A.A., Gunawan & Dzikri, I. (2023). Inteligent systems and applications in engineering estimating oil palm tree yield and soil composition using multi-scale CNN and vegetation indices. *International Journal of Intelligent Systems and Aplications in Engineering,* 11(1), 183–189.

Kargas, G., Ntoulas, N. & Nektarios, P. (2017). Soil moisture determination using the dielectric sensor TDR300 in porous media with increased salinity (January 2018). DOI: 10.17660/ActaHortic.2017.1189.51.

Jitkokkruad, K., Jarukumjorn, K., Raksakulpiwat, C., Chaiwong, S., Rattanakaran, J. & Trongsatitkul, T. (2023). Effects of bamboo leaf fiber content on cushion performance and biodegradability of natural rubber latex. *Polymers*, 15(3),654. DOI: 10.3390/polym15030654 .

Klik, A., Haas, K., Dvorackova, A. & Fuller, I.C. (2015). Spatial and temporal distribution of rainfall erosivity in New Zealand. *Soil Research*, 53(7), 815–825. DOI: 10.1071/SR14363.

Mangoensoekarjo, S. & Tojib, A. T. 2005. Manajemen Budidaya Kelapa Sawit. *In* Mangoensoekarjo, S. & Semangun, H. Manajemen Agrobinis Kelapa Sawit. Gadjah Mada University Press., Yogyakarta.

Nasution, C. P. I., Harahap, F. S. & Sitanggang, K. D. (2023) Improvement of soil chemical properties in oil palm plantations at Supra Matra Abadi Aek Nabara Estate with the application of empty oil palm bunches. *JUATIKA, Jurnal Agronomi Tanaman Tropika*, 5(1), 37-44. DOI: https://doi.org/10.36378/juatika.v5i1. 2723**.**

Xu, Y., Zhang, G. & Liu, W. (2023) Flexible multiterminal photoelectronic neurotransistors based on self - assembled rubber semiconductors for spatiotemporal information processing. DOI: 10.1002/smm2.1162.