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Estimation of Soil C-Organic Content Based on Reflectance Values Generated from Spectrometer

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ABSTRACT

C-Organic is an important component of soil fertility. The intensity of agricultural land use affects the organic matter content in the soil. A spectrometer can be used to measure organic matter content through reflectance values. This study aimed to compare reflectance values and C-Organic content in rice fields with planting Index (IP) of 100 and IP of 300 in Maros Regency, as well as to analyze the relationship between reflectance values and laboratory test results. The method used involved collecting soil samples from both types of rice fields, measuring reflectance using a spectrometer in the Blue, Green, Red, and NIR spectra, and analyzing their relationship with C-Organic content. The results showed that reflectance values and C-Organic content in 300 IP were higher than in 100 IP, with the highest coefficient of determination (R^2) was in red spectrum, i.e. 0.9425. The C-Organic content at the research field was classified as very low, ranging from 0.61 to 1.05%, with a higher average in 300 IP (0.96%) compared to 100 IP (0.74%). This study concluded that a spectrometer can be a fast and accurate alternative for detecting soil C-Organic content, especially at a wavelength of 650 nm.

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1. INTRODUCTION

Indonesian government continues to promote an increase in rice production to meet its demand. One of the efforts made is by increasing the planting index (IP), from 100 IP (one planting per year) to 200 IP (two plantings), and even to 300 IP (three plantings). However, rice fields cultivated intensively or with higher planting frequency (300 IP) may experience a decline in soil fertility and degradation, which can ultimately lead to suboptimal production. This is partly due to the decrease in organic matter content in the soil (Hartatik et al., 2015).

This decline in soil fertility needs to be prevented and addressed; one way to do this is by adding organic matter to the soil or applying fertilizers to maintain optimal rice production. However, currently, fertilizer application for rice, as practiced by most farmers in Maros Regency, is carried out without considering the existing soil conditions. As a result, fertilizer application becomes ineffective, some receive more than needed, while others receive less. This happened because identifying soil conditions takes time and sometimes requires laboratory testing.

Technological developments nowadays have enabled the identification process without the need for lab tests, and even without damaging the observed object. For example, by utilizing reflectance from several wavelengths directed at the object using a spectrometer. This method can be applied in agriculture, from identifying crop productivity in the field (Liku et al., 2024) to fruit classification during the postharvest process (Syarifuddin et al., 2023).

A spectrometer is a tool used to measure wavelength and intensity, functioning to detect light captured by the sensor. Light emitted from the sensor can be used to detect C-organic content (Sari et al., 2023). This tool uses spectral patterns or graphs obtained to determine the amount of C-organic content by observing the reflectance values of Blue, Green, Red, and NIR. In Maros Regency, there are rice fields with IP of 100 and also IP of 300. This study aimed to determine the reflectance values of soil in 100 IP and 300 IP of rice fields, and to examine the relationship between reflectance values and C-organic content based on laboratory test results Thus, it can later be used as an alternative method to detect organic matter content in rice fields.

2. MATERIALS AND METHODS

2.1 Materials

The tools used in this research were spectrometer (wavelength 400 to 1000 nm), SpectraWiz software, soil sample ring, plastic, petri dish, label paper, lamp, cutter, digital scale, hoe, hammer, wood, container, sieve, pen, permanent marker, laptop, and camera. The materials used in this study were soil samples.

2.2 Research procedure

The research procedure was carried out as follows:

2.2.1 Preparation phase

The preparation stage began with a site visit to the research location in Moncongbori Hamlet, Mattoanging Village, Bantimurung Subdistrict, Maros Regency. Subsequently, paddy fields with 100 IP and 300 IP were identified. From each IP, soil samples were collected from 6 rice field plots, with 3 samples taken from different points within each plot. In total, 36 soil samples were collected using ring samples with a depth of 10 cm.

2.2.2 Drying of Soil Sample

The soil that has been taken was weighed and dried using sunlight for 4 days, then weighed again. After the drying process, the soil samples were pulverized using wood and filtered using a sieve, then stored in plastics or containers.

2.2.3 Soil Reflectance Measurements in the Room

The first step was to collect soil samples in plastics or containers, and put them in a Petri dish. Then, prepare two lights with 646 lux on the left and right of the Petri dish. After that, SpectraWiz software was opened and connected the spectrometer to the laptop

2.2.4 Reflectance Value Analysis Stage

Analysis of reflectance values using SpectraWiz by entering the obtained data and determining the Blue, Green, Red and NIR values of each rice fields of 100 IP and 300 IP. Wavelength Analysis 650

In the analysis of the 650 wavelength was good for determining soil C-organic content. It was done by opening the SpectraWiz software, and entering the obtained data. Then, looking at the 650 wavelengths of 100 IP and 300 IP and processed using MS Excel by sorting reflectance values from the smallest to the largest. After that, the value was compared to the result of C-organic from the Soil Laboratory of Agriculture Faculty of Hasanuddin University.

3. RESULTS AND DISCUSSION

3.1 Research Location

Moncongbori is one of the hamlets in Mattoanging Village, Bantimurung Subdistrict, Maros Regency where this research was conducted. A map of the research location of 100 IP and 300 IP can be seen in Figure 1.

Figure 1. Rice Fields of 100 IP Research Location Map.

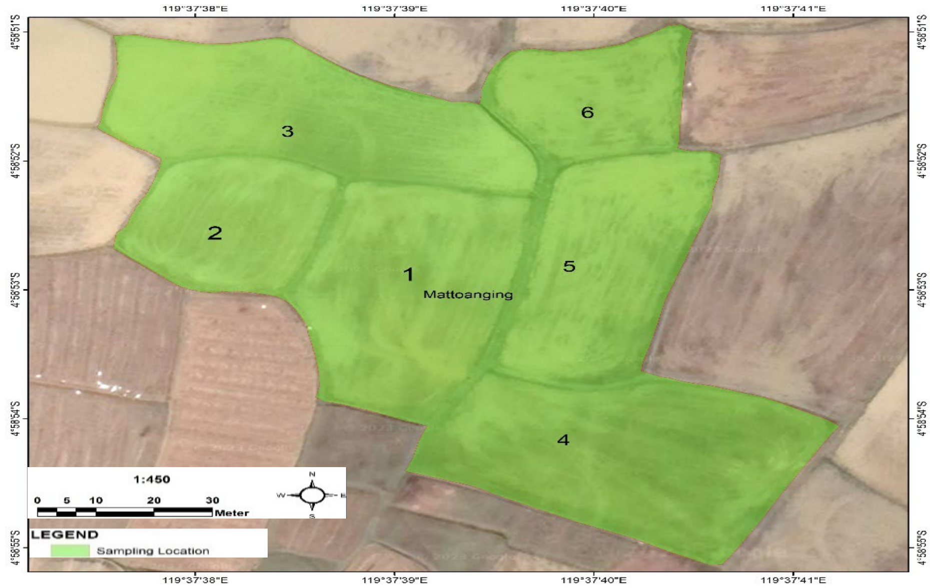

Figure 2. Rice Fields of 300 IP Research Location Map.

Moncongbori Hamlet was one of the rice producer areas with rice fields reaching 25 hectares. Mattoanging Village has an area of 8.72 km2, and located in a lowland area with an altitude of 0-500 meters above sea level. This village has quite extensive rice fields, with the irrigated rice field used Bantimurung irrigation canal, which flows throughout the year in the south.

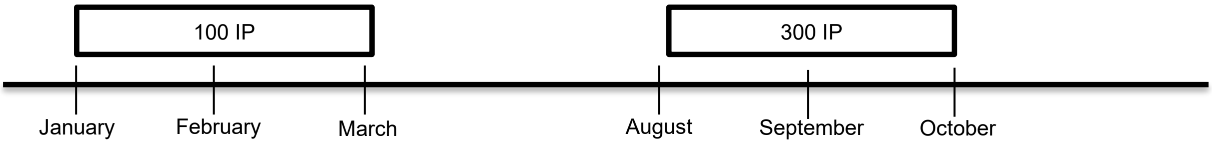

Figure 3. Planting Time of 100 IP and 300 IP Rice.

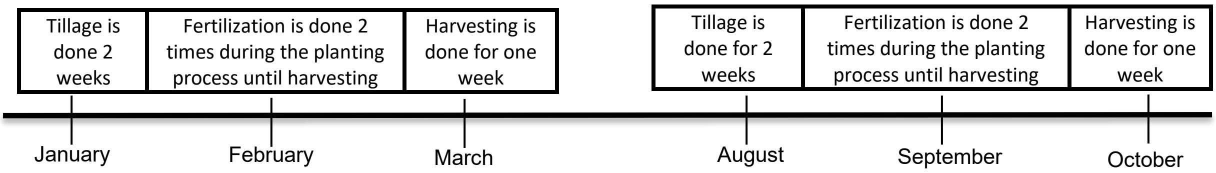

Figure 4. 100 IP and 300 IP stages.

100 IP is a planting index that is carried out once a year while 300 IP is a planting index carried out three times a year. 100 IP planting in Moncongbori Hamlet was carried out by planting rice from January to March, then, no planting activity from May to July, and pllanting watermelon from August to October. 300 IP planting was carried out by planting rice three times a year. The difference in land management patterns carried out on 100 IP and 300 IP rice fields was the source of water in irrigating rice fields. In 100 IP rice fields, water sources from rainfall, while 300 IP water sources from rainfall and groundwater, assisted by water pumps during the growing season with low rainfall and on land.

3.2 Wavelength Graph of 100 IP and 300 IP Rice Fields

The wavelengths generated from the spectrometer and SpectraWiz shortcut software generated from the reflectance value of soil samples in dry conditions for Blue, Green, Red, and NIR values can be seen in Figures 5 and 6.

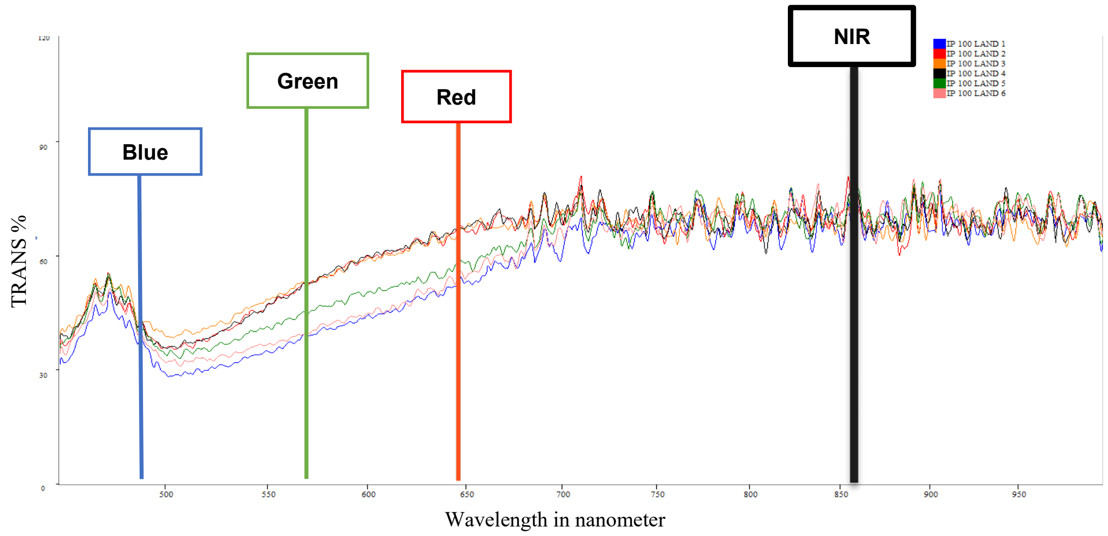

Figure 5. 100 IP Paddy Field Wavelength (Combine).

Figure 5 showed an increase pattern in blue, green, red, and NIR wavelength, with the highest value was in NIR spectrum of 860 nm, while the lowest was in Blue spectrum of 490 nm.

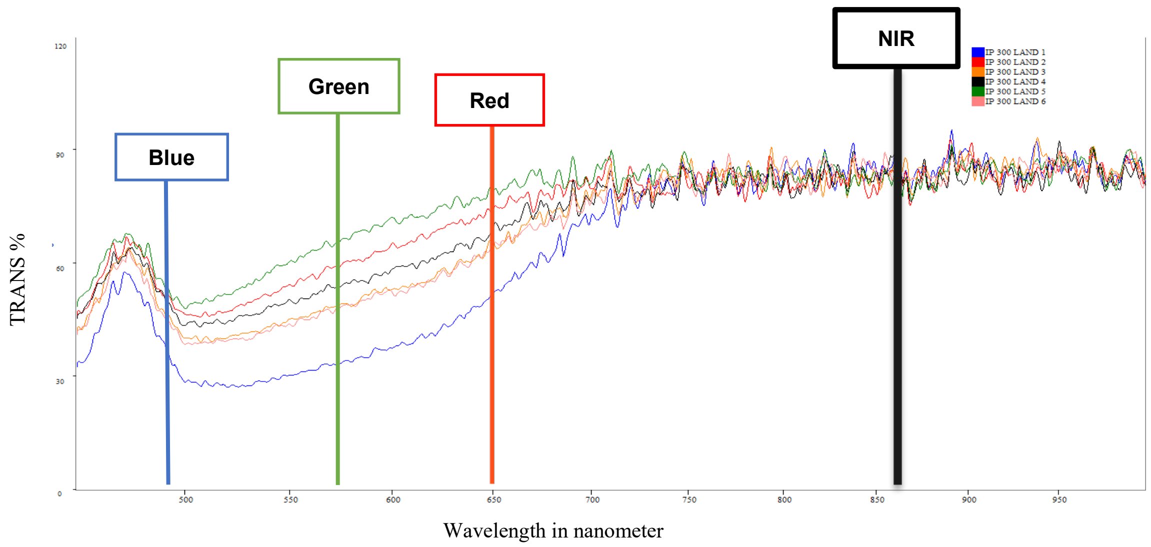

Figure 6. 300 IP Paddy Field Wavelength (Combine).

Figure 6 showed the wavelength of 300 IP rice fields using a spectrometer and SpectraWiz. From the two graphs above, it can be seen that the trend of both planting index types was quite similar. However, in the wavelength range from 500 nm to 700 nm, there was a noticeable divergen in the 300 IP planting index, compared to 100 IP. For 100 IP, the nearly identical shape was due to the fact that the colour of each soil sample were not significantly different, resulting in relatively similar reflectance values. It can also be observed that in the blue spectrum, the reflectance was lower compared to other parts of the spectrum. This was due to the soil's tendency to appear darker because of its organic matter content, where darker colors absorb more light. As a result, at shorter wavelengths, such as the blue spectrum, light was more easily absorbed and scattered within organic compounds. This was consistent with the findings of Hede & Heriawan (2020), which showed that the reflectance of mineral materials at shorter wavelengths (blue spectrum) was lower than in the green, red, and NIR regions.

3.3 Reflectance and C-Organic Content at 100 IP and 300 IP

Reflectance was the energy reflected by an object. By looking at the Blue, Green, Red and NIR values, the reflectance produced quite varied values. These values and the measurements of C-organic content carried out at 100 IP and 300 IP can be seen in Table 1 and 2, and Figures 7 and 8.

Table 1. Reflectance Value and C-Organic Content of 100 IP Soil.

Land	Blue	Green	Red	NIR	C-Organic Soil
Land 1	0.31	0.33	0.37	0.63	0.61
Land 2	0.43	0.46	0.52	0.78	0.79
Land 3	0.45	0.52	0.53	0.79	0.85
Land 4	0.41	0.45	0.49	0.77	0.78
Land 5	0.36	0.39	0.43	0.75	0.77
Land 6	0.35	0.38	0.42	0.73	0.66

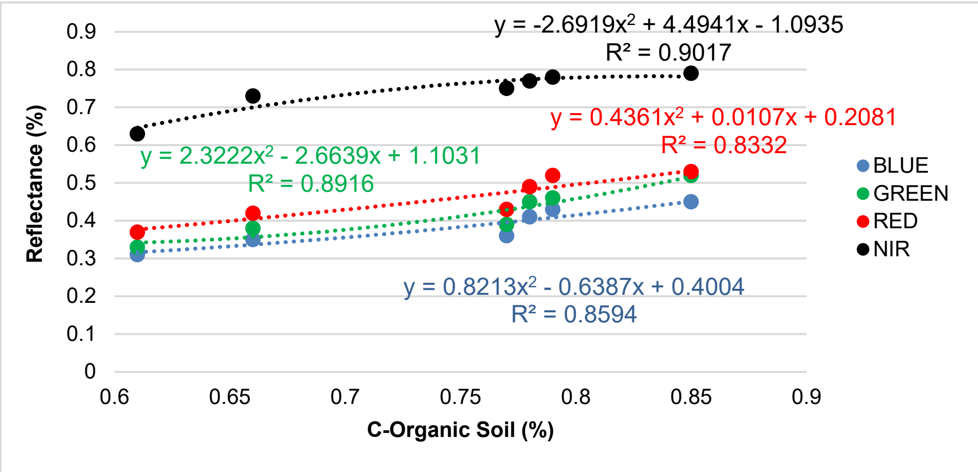

Figure 7. Relationship between Reflectance Value and C-Organic Content of 100 IP Soil.

Figure 7 showed the relationship between C-organic content and soil reflectance in blue, green, red, and NIR spectra. It can be seen that the coefficient of determination for each spectra were greater than 80%, indicating a strong relationship between reflectance and C-organic content in each spectra. The highest coefficient of determination was found in the NIR spectrum, i.e. 90%, while the lowest was in the red spectrum, i.e. 83%. Table 1 showed that the lowest organic matter content in 100 IP was 0.61%, and the highest was 0.85%.

Table 2. Reflectance Value and C-Organic Content of 300 IP Soil.

Land	Blue	Green	Red	NIR	C-Organic Soil
Land 1	0.32	0.34	0.54	0.75	0.91
Land 2	0.46	0.52	0.63	0.86	1.01
Land 3	0.43	0.48	0.61	0.87	0.95
Land 4	0.44	0.51	0.62	0.88	0.97
Land 5	0.48	0.56	0.65	0.88	1.05
Land 6	0.39	0.46	0.55	0.81	0.92

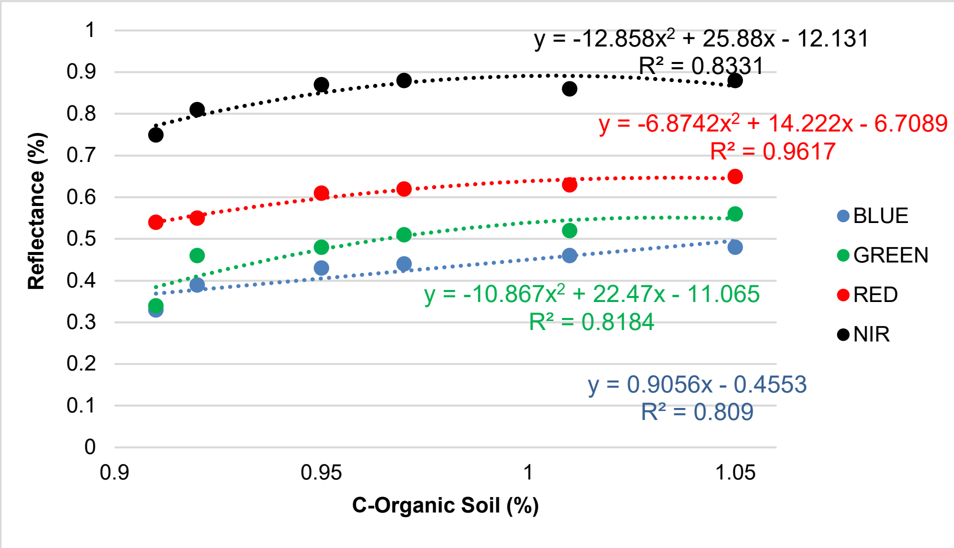

Figure 8. Relationship between Reflectance Value and C-Organic Content of 300 IP Soil.

Table 2 presented the C-organic content, with the lowest value was 0.91%, while the highest was 1.05%. Figure 8 showed the relationship between reflectance of blue, green, red, and NIR and C-organic content. It can be seen that, unlike 100 IP, the highest coefficient of determination in 300 IP was in the red spectrum, i.e. 96%, while the lowest was in the blue spectrum, i.e. 80%. Nevertheless, all four spectra have R^2 values greater than 80%, indicating a strong correlation between reflectance and C-organic content. A correlation value between 0.75 and 1 is categorized as very strong. This demonstrated a significant relationship between wavelength and soil C-organic content (Zhang et al., 2021).

Both IP have very low C-organic content compared to the C-organic content in paddy fields in Pagar Alam City (Bakri et al., 2022), with a rice–rice planting pattern reaching 11.96% and a rice–secondary crops pattern reaching 9.96% (Bakri et al., 2022). This may be due to the absence of organic fertilizer application on the land and the intensive cultivation practices carried out (Bolly & Apelabi, 2022).

It can also be seen that, the average organic matter content for 100 IPwas 0.74%, while for 300 IP it was 0.96%. This may be due to the burning of straw after harvest on 100 IP land, whereas on 300 IP land, the burning was not carried out because land preparation for the next planting was done immediately. The burning of organic material has negative impacts on the soil, such as the volatilization of nutrients (Agbeshie et al., 2022).

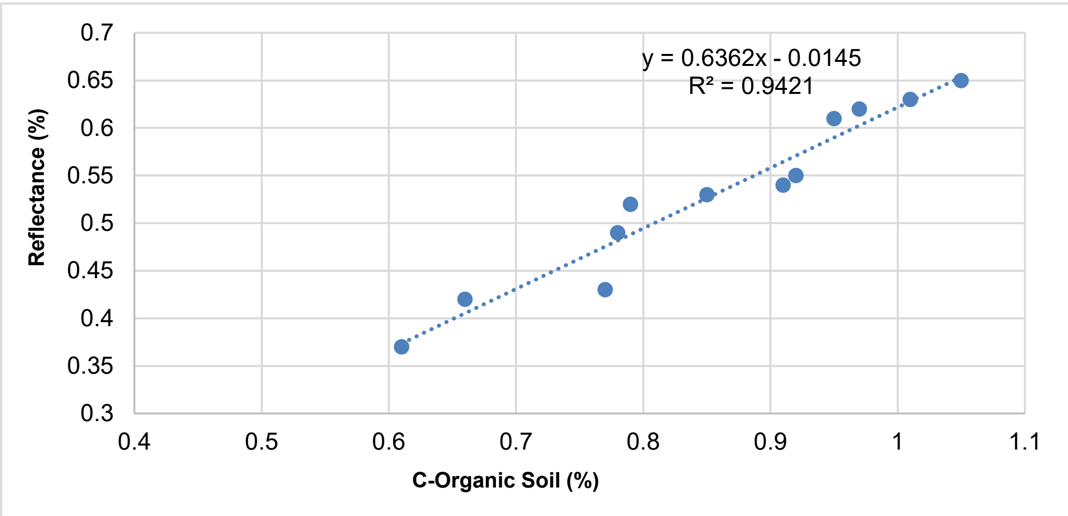

Figure 9. C-Organic Value and Reflectance against Wavelength 650 nm.

The study showed that the highest correlation was in the red spectrum of 650 nm, at 96%. Therefore, a comparison was made at the 650 nm wavelength. Data on organic matter content and reflectance were compared, and showed that the higher the C-organic content, the higher the reflectance value produced, and vice versa. Figure 9 showed the values of C-organic and reflectance of 650 nm with an R^2 value of 0.94, indicating that the relationship between C-organic content and reflectance was very strongly correlated.

4. CONCLUSION

Based on the research, it can be concluded that:

1. Reflectance from the spectrometer can indicate the C-Organic content in paddy soil, with the highest correlation found in the red spectrum, showing a coefficient of determination of 94%.
2. The organic matter content at the research site was very low, ranging between 0.61 and 1.05%, with the highest content found in 300 IP.

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