IDENTIFICATION OF AGE CLASS AND VARIETIES OF RICE PLANT USING SPECTRORADIOMETRY AND CHLOROPHYLL CONTENT INDEX

(Identifikasi Kelas Umur dan Varietas Tanaman Padi Menggunakan Spektroradiometri dan Indeks Kandungan Klorofil)

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Diterima: 12 Desember 2021; Direvisi: 5 April 2022; Disetujui untuk Dipublikasikan: 18 April 2022

ABSTRACT

Rice is the staple food for Indonesian society because more than 90% population eat rice every day. Estimation of the rice production can be monitored from the plant growth phase by utilizing remote sensing data. Spectroradiometry can be used to validate the remote sensing spectral because it has a wide wavelength range. Research objectives are to identify transplanting age class and varieties of rice plant based on spectroradiometry and its vegetation index, to analyze the relationship between spectroradiometry and chlorophyll content index (CCI). The results show that the transplanting date of 14 days, 21-32 days, and 56-68 days in three varieties (Inpari32; Padjadjaran Agritan; Siliwangi Agritan) are difficult to be distinguished at visible wavelength but it easy at infrared wavelength. The plant age class for the Siliwangi Agritan can be distinguished well on NDVI, SAVI, EVI while the Pajajaran Agritan is only on NDVI and EVI. All vegetation indexes, where the plant age of 14 days and 21-32 days for the Inpari32 are difficult to be distinguished between them, but easy to be distinguished with 56-68 days. This is due to the high sensitivity of chlorophyll to infrared wavelengths and the characteristics of rice plants itself (many tillers and plant height). Meanwhile, rice plants of every veriety are difficult to be distinguished, either on visible wavelength, infrared wavelength or on all vegetation indexes. Spectroradiometry has a high correlation with chlorophyll content index (CCI) (R^2=0,88). This shows that the higher chlorophyll content in rice plants, the higher spectroradiometry for infrared wavelength.

Keywords: CCI, chlorophyll, Cianjur Regency, rice plant, spectroradiometry

ABSTRAK

Beras adalah makanan pokok masyarakat Indonesia, karena lebih dari 90% penduduk mengkonsumsi beras setiap hari. Estimasi produksi padi tahunan dapat dimonitor dari fase tumbuhnya dengan memanfaatkan data penginderaan jauh. Spektroradiometri dapat digunakan untuk memvalidasi spektral data penginderaan jauh karena memiliki kisaran panjang gelombang yang lebar. Tujuan penelitian ini adalah mengindentifikasi kelas umur tanam dan varietas tanaman padi berdasarkan spektroradiometri dan indeks vegetasinya, menganalisis hubungan antara spektroradiometri dengan indeks kandungan klorofil (CCI). Hasil menunjukkan bahwa kelas umur tanaman padi (14 HST, 21-32 HST, 56-68 HST) pada tiga varietas (Inpari32, Padjadjaran Agritan, Siliwangi Agritan) sulit dibedakan pada panjang gelombang tampak mata, namun mudah dibedakan pada panjang gelombang inframerah. Kelas umur tanaman padi untuk Siliwangi Agritan dapat dibedakan dengan baik pada NDVI, SAVI, dan EVI, sedangkan Padjadjaran Agritan hanya pada NDVI dan EVI. Pada semua indeks vegetasi, dimana umur tanaman 14 hari dan 21-32 hari untuk Inpari32 sulit dibedakan tetapi mudah dibedakan dengan umur 56-68 hari. Hal ini dikarenakan oleh sensitivitas klorofil yang tinggi terhadap panjang gelombang inframerah dan karakteristik tanaman padi (banyak anakan dan ketinggian tanaman). Sementara itu, tanaman padi dari setiap varietas sulit dibedakan, baik pada panjang gelombang tampak mata, inframerah atau pada semua indeks vegetasi. Spektroradiometri memiliki korelasi yang tinggi terhadap indeks kandungan klorofil dengan nilai R^2=0,88. Hal ini menunjukkan bahwa semakin tinggi kandungan klorofil pada tanaman padi, maka semakin tinggi nilai pantulannya terhadap panjang gelombang inframerah.

***Kata kunci**: CCI, klorofil, Kabupaten Cianjur, tanaman padi, spektroradiometri*

INTRODUCTION

Rice is the staple food that must be guaranteed availability because more than 90% population eat rice every day. Indonesia is the country with the third-largest domestic consumption of rice in the world after China and India. During the 2015-2019 period, Indonesia's domestic consumption averaged around 37,970 million tons (Ministry of Agriculture, 2019), while national rice production was around 109,208 million tons in 2019 (Central Bureau of Statistics of Cianjur Regency, 2021).

The data shows that the national rice production can fulfill the domestic consumption of rice, while the rest for other necessities such as flour, cattle odder, etc. The annual rice production can be estimated by monitoring the growth phase (phenology) of the rice plant using remote sensing data (temporal resolution). The best vegetation index (VI) to estimate canopy chlorophyll content during growing season (vegetative and generative) for two contrasting crop species (maize and soybean) is VI where involve edge red wavelength (e.g. Red Edge NDVI 740 and Chlorophyll Index 740).(Peng et al., 2017).

Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under (Lillesand el al., 2014). Long distances between the object and the sensor will affect the reflectance value received by the sensor due to atmospheric influences. The altitude of the Landsat 8 Satellite and the Sentinel 2A Satellite is 705 km (https://usgs.gov/) and 786 km (https://scihub.copernicus.eu/) respectively. Many studies have discussed atmospheric corrections to obtain better performance on remote sensing data. Atmospheric correction is an important part of the pre-processing of remote sensing data because it can result from true surface reflectance (Gnyp et al., 2012). In order to minimize the influence of the atmosphere on remote sensing data, a Spectroradiometer can be used to capture the reflection of objects with very low altitudes.

A Spectroradiometer is a device that can acquire the earth's surface at a very low altitude so that atmospheric influence will be very low. The Spectroradiometer MS 720 with FOV 45^o, the altitude used is 1-1.5 m from the earth's surface (Eko_Instrument, 2016). Spectroradiometry is the radiance of the earth’s surface that is received by a sensor placed on Spectroradiometer device with radiation fluxes (and not intensities) as unit measurement (Kardeván, 2007). The operation of the device tends to be relatively easy and data are collected quickly. However, the interpretation of these data is not dealt with quite as easily (Hueni, 2006). This Spectroradiometry can be used to validate remote sensing data like Landsat 8 or Sentinel 2A. However, the measurements are taken on the same day of the satellite passage, a maximum time interval of ±3 hours to capture the image (Ariza et al., 2018). This research used Portable Spectroradiometer MS-720 with wavelength 350-1050 nm (Eko_Instrument, 2016) to capture the rice plant of different ages and varieties. The sunlight at red 600-700 nm and blue 400nm-500nm will be absorbed by chlorophyll for photosynthesis, while wavelength more than 700 nm will be reflected by chlorophyll (Taiz and Zeiger, 2002). Some of the reflected energy can be received by a sensor that is put on the Portable Spectroradiometer MS-720. The spectroradiometry will be linked to the chlorophyll content index as measured by the Chlorophyll Meter CCM 200 Plus to compare the results.

The Chlorophyll Meter CCM 200 Plus is a device that can estimate the leaf chlorophyll content using Chlorophyll Content Index (CCI) approach. This device works on a wavelength of 653 nm (red band) and 931 nm (infrared band) (Apogee_Instrument, 2011), and the CCI can be read when the leaf is claimed on the device. Validation of a crop above-ground biomass (AGB) between estimation from a chlorophyll content index (CCI) and observation (plant analysis) are obtained good results (Liu et al., 2019). Estimation of chlorophyll content of Robusta Coffee Plant using NDVI of Landsat 8 have a strong correlation (R^2=0,72) (Mukhlisin & Soemarno, 2020).

Individual bands often perform images on limited contrast to identify vegetation parameters, whereas combination bands will improve the image contrast, like vegetation index (VI). Simple VIs combining visible and NIR bands have significantly improved the sensitivity of the detection of green vegetation (Xue & Su, 2017). The NDVI value of Sentinel 2A was the best one to be distinguished the growth phase of rice plants compared with SAVI, and AVI values (Munibah et al., 2019). Predictably, research, and development of VIs, which are based on hyperspectral and UAV platforms, would have wide applicability in different areas (Xue & Su, 2017). This paper will analyze VIs based on spectroradiometry of rice plants.

The aims are (i) to identify the age class and varieties of rice plant based on spectroradiometry and chlorophyll content index and (ii) to correlate between spectroradiometry with chlorophyll content index.

METHODS

Study Area

The research location is in the irrigated rice field (block 7A and 1B) belonging to Rice and Palawija Seed Center, Department of Food and Horticulture, West Java Province (**Figure 1**). Its office is located in Cihea Village, Bojongpicung Subdistrict, while the irrigated rice fields are located in Neglasari Village and Hegarmanah Village, Bogongpicung Subdistrict, Cianjur Regency, West Java Province.

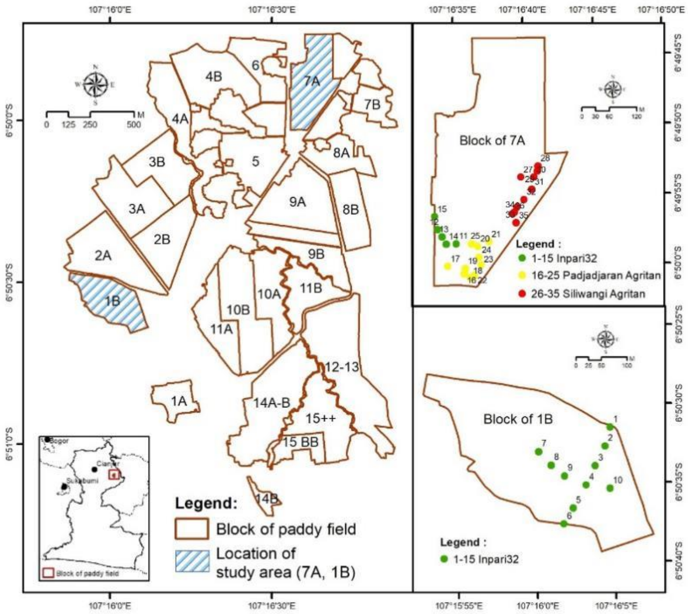

Figure 1. Location of the study area and the rice plant sample

Data Collection

This research used three varieties and three-transplanting age classes of rice plants, namely Inpari32, Padjadjaran Agritan, and Siliwangi Agritan, on age class of 14 days, 21-32 days, and 56-68 days for each variety. There are 70 samples in 35 locations (**Table 1** and **Figure 1**). The data collection time is 09.00-12.00 AM and 01.00-03.00 PM. The sample was selected by stratified random sampling where the strata used were variety and age class, while the location was determined randomly.

Tabel 1. Samples number for each transplanting age class and variety of rice plants.

Varieties	14 day	21-32 day	56-68 day	Sample Location
Inpari32	2	13	15	1-15
Padjadjaran A	2	8	10	16-25
Siliwangi A.	2	8	10	26-35
Total	6	29	35	

The data used are spectroradiometry captured by the Portable Spectroradiometer MS 720, chlorophyll content index (CCI) through the field observation. There is a relationship between diameter FOV and altitude of the Spectroradiometer (Hueni, 2006), see at **Formula 1**.

$D_{FOV} = 2*h*\tan(\alpha)$...(1)

D_{FOV} is the diameter of FOV and h is the height above object and α is the FOV angle.

The Spectroradiometer MS 720 captures the spectroradiometry of the rice plant (FOV 45^o) and the Sun (FOV 180^o) with a wavelength of 350-1050 nm and a height of 1 m from the object. The diameter of the FOV is equal to 2 m (the maximum size of the observation area in the field). However, this study uses a square size 1x1 meters for field observations. Most studies report a nadir view of the optic and a distance of about 1–3 meters to the object (Hueni, 2006).

The measurement of chlorophyll content index (CCI) of rice plants was also done on a square size 1x1 meters using The Chlorophyll Meter CCM 200 Plus. There are 9 (nine) clumps of rice plants on a square size 1x1 meters, and select one leaf randomly from the dominant size in each clump. The CCI was measured in three positions for each leaf (top, middle, base) (Hidayah et al., 2019). Therefore, there are 27 CCI values for each sample location.

Data Analysis

Rescaled Spectroradiometry based on Landsat 8 and Sentinel 2A Wavelength

Rescaled spectroradiometry based on the Landsat 8 and Sentinel 2A wavelengths shown in **Table 2**. Even so, band 7 of Sentinel 2A and bands 6, 8, 7, 9, 10, and 11 of Landsat 8 are not used in this study because these bands are outside the wavelength of the spectroradiometer.

Table 2. Rescaled spectroradiometry based on Landsat 8 and Sentinel 2A wavelength.

Platform	Band	Wavelength (nm)	Rescaling of Spectroradiometry wavelength (nm)
Landsat 8	Band 1:Coastal Aerosol	435-451	436-449
	Band 2:Blue	452-512	453-513
	Band 3:Green	533-590	533-589
	Band 4:Red	636-673	636-673
	Band 5:Near Infrared (NIR)	851-879	850-880
Sentinel 2A	Band 1:Aerosol	433-453	433-453
	Band 2:Blue	458-523	459-523
	Band 3:Green	543-578	543-579
	Band 4:Red	650-680	649-679
	Band 5:Edge Red	698-713	699-712
	Band 6:Edge Red	733-748	732-749
	Band 8:Near Infrared (NIR)	758-900	759-899

Spectroradiometry Vegetation Index based on Landsat 8 and Sentinel 2A Wavelength

Spectroradiometer MS 720 records the irradiance reflected by an object to a sensor and the irradiance received by the object from solar energy. It is necessary to convert the radiance value to the reflectance value (**Formula 2**).

$$\rho = \frac{\pi I_d}{I_u \, \Omega} \quad (2)$$

where:
ρ = Reflectance of object
I_d =The irradiance reflected by the object to sensor ($W/m^2/\mu m$)
I_u = The irradiance received by the object from the solar energy ($W/m^2/\mu m$)
Ω = Solid view angle for FOV 45^o =0,478 sr (Steradians)

The Vegetation Index analysis is based on tabular data only, that is spectroradiometry value that was rescaled by the Landsat 8 and the Sentinel 2A wavelength therefore no spatial data resulted. The vegetation indexes used in this paper are Normalized Difference Vegetation Index (NDVI) (Rouse et al. 1974 in Hartoyo et al., 2021). Enhanced Vegetation Index (EVI) (Liu & Huete, 1995), and Soil Adjusted Vegetation Index (SAVI) (Huete, 1988) (see **Formula 3**, **Formula 4**, and **Formula 5**).

NDVI = (ρNIR-ρRed)/(ρNIR+ρRed)..........................(3)

where:
NDVI = Normalized difference vegetation index
ρNIR = Reflectance of near-infrared band
ρRed = Reflectance of red band

$$EVI = G(\rho NIR - \rho Red)/(\rho NIR + C1 * \rho Red - C2 * \rho Blue + L) \quad (4)$$

where:
EVI = Enhanced vegetation index
ρNIR = Reflectance of near-infrared band
ρRed = Reflectance of red band
G = A gain factor (2.5)
C1,C2 = Coefficients for the atmospheric effects (C1=6, C2 =7.5)
L = A factor accounting for the differential NIR and Red radiant transfer through the canopy

$$SAVI = (1 + L)(\rho NIR - \rho Red)/(\rho NIR + \rho Red + L) \quad (5)$$

where:
SAVI = A soil adjusted vegetation index
ρNIR = Reflectance of near-infrared band
ρRed = Reflectance of red band
L = A canopy background adjustment factor (0.5)

Chlorophyll Content Index of Rice Plants

The chlorophyll content index of the leaf was measured by Chlorophyll Meter CCM 200 Plus on a wavelength of 653 nm (red band) and 931 nm (infrared band) (Apogee_Instrument, 2011). A Chlorophyll content index (CCI) is the ratio of leaf light transmittance between the 931 nm and 653 nm (T931 and T653), which showed at **Formula 6** (Parry et al., 2014; Dong et al., 2019).

$$CCI = \frac{I'_{931}/I_{931}}{I'_{653}/I_{653}} = \frac{T_{931}}{T_{653}} \quad (6)$$

where:
$I'_{931}; I'_{653}$ = Light intensities of the sun source at 931 nm and 653 nm
$I_{931}; I_{653}$ = Light intensities of LED light source at 931 nm and 653 nm
$T_{931}; T_{653}$ = Light transmission at 931 nm and 653 nm

The CCI for each sample (there are 70 samples of rice plants) is the average of all CCI values in each sample (**Formula 7**). Each sample of rice plant has 27 CCI values obtained from nine CCI of each clump and three CCI of each leaf.

$$CCI_z = \frac{\sum_{i=1}^{m}\sum_{y=1}^{n} CCI}{n \, x \, m} \quad (7)$$

where:
CCI = Chlorophyll content index
z = Samples of rice plant (z = 1; 2; 3; 4...70 samples)
n = Number of measurements on each leaf (three position, i.e. base, middle, top)
m = Number of clumps on each sample (nine clumps)

Relationship between Spectroradiometry and Chlorophyll Content Index

The Portable Spectroradiometer MS 720 has a wide wavelength range (350-1050 nm), while the Chlorophyll Meter CCM 200 Plus only has 653 (red band) and 931 nm (infrared band). Therefore, the wavelength of the Spectroradiometer used for correlation analysis is only 653 (red band) and 931 nm (infrared band). The Correlation equation is presented in **Formula 8**.

$$rxy = \frac{n\,(\sum xy)-(\sum x)*(\sum y)}{(\sqrt{n(\sum x2)-(\sum x)2})*(\sqrt{n(\sum y2)-(\sum y)2})} \text{............................(8)}$$

where:

r_{xy} = Relationship between x and y
x = Chlorophyll contain index of rice plant leaf (CCI)
y = Ratio between the Spectroradiometer value on 931 nm and 635 nm

RESULT AND DISCUSSION

Identification of the age class and varieties of rice plant based on spectroradiometry

The original spectroradiometry and rescaled by the wavelength of Landsat 8 and Sentinel 2A on three varieties and three transplanting ages class, namely Inpari32 (14 days, 21-32 days, and 56-68 days); Padjadjaran Agritan (14 days, 21-32 days, and 56-68 days); Siliwangi Agritan (14 days, 21-32 days, and 56-68 days). The relationship between spectroradiometry and wavelength showed in **Figure 2**.

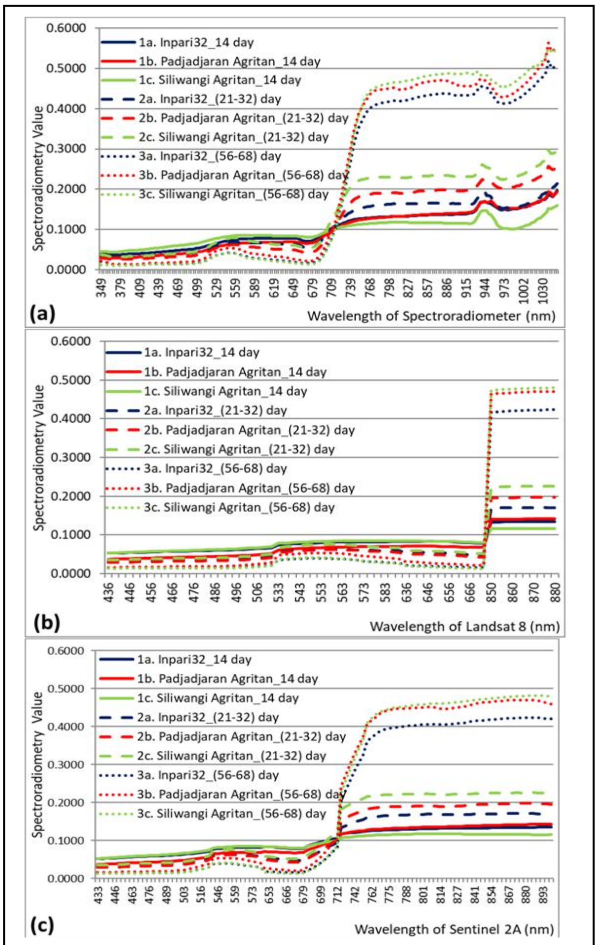

Figure 2. (a) The original spectroradiometry of rice plant; (b) the scaled spectroradiometry of rice plant based on Landsat 8 wavelength; (c) the scaled spectroradiometry of rice plant based on Sentinel 2A wavelength.

The spectroradiometry of rice plants was captured by the spectroradiometer on the wavelength of 350-1050 nm with an interval of 3 nm. The smaller the interval, the more detailed the spectroradiometry can be captured by the sensor so that the remote sensing data will have more information. **Figure 2** show that the sunlight wavelength less than 400 nm and red band 600-700 nm are absorbed by chlorophyll, while more than 700 nm is reflected by chlorophyll. The maximum absorbed sunlight for photosynthesis is a wavelength of 400-500 nm (blue) and 600-700 nm (red) (Taiz and Zeiger, 2002). The green light is reflected into our eyes and gives plants their characteristic green color (Taiz and Zeiger, 2002). The original spectroradiometry at a wavelength of 930-960 nm gives a specific appearance, like a convex curve (**Figure 2a**). It means good leaf water contents. A reflectance in infrared regions 950-970 nm is a weaker water absorption band (Penuelas et al., 1997).

The transplanting age of rice plants (14 days, 21-32 days, and 56-68 days) for all varieties are difficult to be distinguished at blue, green, or red wavelengths but easy to be distinguished at edge red and infrared (**Figure 2 a**, **b** and **c**). This is because the rice plants aged 56-68 days contain more chlorophyll than 21-32 days or 14 days. The higher the chlorophyll content in the leaves, the higher the reflectance value at near-infrared (NIR) and edge red. However, the spectroradiometry change from red to near infrared for the original value (**Figure 2a**), and those scaled with sentinel wavelength 2A (**Figure 2b**) are smoother than that scaled with Landsat 8 (**Figure 2c**). This is because Landsat 8 does not have an edge red band.

Identification of the age class and varieties of rice plant based on the spectroradiometry vegetation index

The spectroradiometry vegetation index (NDVI, SAVI, EVI) are calculated based on a wavelength of Landsat 8 and Sentinel 2A for each variety and transplanting age. **Figure 3** shows that the age and varieties of rice plants where the spectroradiometry vegetation index based on wavelength of Landsat 8 and Sentinel 2A have the same pattern. The age of rice plant of 14 days, 21-32 days and 56-68 days can be distinguished well for Siliwangi Agritan, both in NDVI, SAVI, and EVI, while for Padjadjaran Agritan, it can be distinguished well in NDVI and EVI. The transplanting age of rice plants of 14 days and 21-32 days for the Inpari32 are difficult to be distinguished between them, but easy to be distinguished with 56-68 days, in all vegetation indexes. Similar to the Inpari32 case, it also occurs in Padjadjaran Agritan in SAVI. The reflectance of rice field on 14 days or 21-32 days dominated by water, while on 56-68 days dominated by rice plant. Two conditions appeared contrast on images in infrared band.

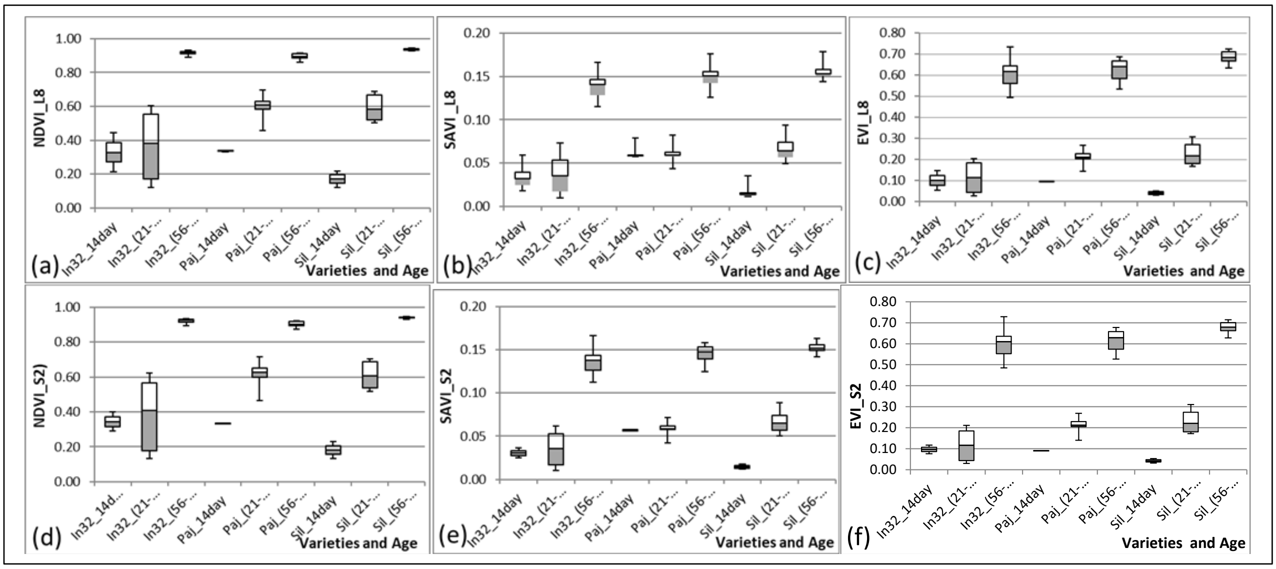

Figure 3. Spectroradiometry vegetation index (NDVI; SAVI; EVI) based on wavelength of Landsat 8 (a; b; c) and Sentinel 2A (d; e; f).

Table 2. The Tiller per clump and high of rice plant.

Variety	Tiller of rice plant per clump			Plant height (cm)		
	Min	Max	Mean	Min	Max	Mean
Inpary32						
14 days	14	15	14.5	39.44	40.00	39.72
21-32 days	16	19	17.6	44.78	52.33	48.10
56-68days	24	32	27.3	86.22	105.22	92.50
Padjadjaran Agritan						
14 days	9	11	10	34.11	35.11	34.61
21-32 days	11	18	14.9	40.06	46.56	43.06
56-68days	20	25	23	81.22	88.22	84.01
Siliwangi Agritan						
14 days	8	8	8	31.56	33.40	32.48
21-32)days	9	18	13.4	42.44	55.00	46.17
56-68 days	20	26	22.3	77.56	84.22	81.14

The above phenomenon, possibly caused by the chlorophyll content in the leaf of rice plants aged 14 days and 21-32 days are not slightly different but they are significantly different from 56-68 days. This chlorophyll content will affect the spectroradiometry according to the wavelength character. The wavelength of blue and red will be absorbed by the leaf, while green red and infrared will not be absorbed by the leaf (Taiz and Zeiger, 2002) they are reflected by the leaf (Lillesand, at al. 2014). The other factors are a rice plant on the field like the number of tillers per clump and the high of rice plant (**Table 2**). The transplanting age of rice plants of 14 days, 21-32 days, and 56-68 days had a higher number of tillers per clump and higher plant height. However, the number of tillers per clump and plant height were not significantly different between varieties at the same age. Therefore, rice varieties are still difficult to be distinguish from the vegetation index even at the same age. Three important factors affecting crop reflectance are (i) soil/residue background, (ii) foliar chlorophyll, and (iii) leaf area index/canopy density (Peng et al., 2017).

Identification of the age class and varieties of rice plant based on chlorophyll content index

Tabel 3 shows that the chlorophyll content index in all rice varieties has the same pattern, where the age class of rice plants at 14 days, 21-32 days and 56-68 days experienced an increase in the chlorophyll content index. However, the increasing at 56-68 days is much higher than at 21-32 days. The maximum chlorophyll content in rice plants occurs at the reproductive stage (55-85 days).

The chlorophyll content index of the three varieties did not show a certain pattern, so it was difficult to be distinguished between them. The three varieties were planted on the land with the same environmental conditions (such as soil, climate) and the same management, so that effect to chlorophyll content may be the same. Leaf chlorophyll concentration was influenced by the process of chlorophyll formation, nutrient absorption (nitrogen, magnesium) and rubisco enzyme content in leaf (Nio Song & Banyo, 2011).

Table 3. Chlorophyll content index of rice plant.

Variety	Chlorophyll Content Index (CCI)		
	Min	Max	Mean
Inpary32			
14 days	1.444	1.644	1.544
21-32 days	1.933	5.300	3.597
56-68 days	16.711	23.478	20.506
Padjadjaran Agritan			
14 days	1.367	1.489	1.428
21-32 days	1.989	5.078	3.482
56-68 days	14.825	20.070	17.037
Siliwangi Agritan			
14 days	1.311	1.378	1.345
21-32 days	2.056	4.044	3.003
56-68 days	13.944	19.863	16.459

Relationship between Spectroradiometry and Chlorophyll Content Index

The data used for this correlation analysis are a sample of rice plants with the transplanting age of 21-32 days and 56-68 days, while 14 days is not used because there is not enough data. The number samples are 29 data and 35 data for 21-32 days and 56-68 days, respectively. The result of the correlation analysis showed in **Figure 4**. The result of correlation analysis indicates a strong positive correlation (R^2=0.88) between the original spectroradiometry and the chlorophyll index. Rice plants aged 56 days are in the generative phase, which contains high chlorophyll, so the reflectance of infrared wavelengths is also high. Likewise, rice plants aged 21-32 days are in the vegetative phase with lower chlorophyll content, so the reflectance of infrared wavelengths is lower. The chlorophyll content of rice plants is indicated by the chlorophyll index (CCI value).

There are two groups of rice plants, namely group 21-32 days and 56-68 days (**Figure 4**). However, group 21-32 days are more clustered than the 56-68 days group. In general, rice plants in the generative phase encountered pests and diseases that affected the chlorophyll content of the leaves. Three important factors affecting crop reflectance are (i) soil/residue background, (ii) foliar chlorophyll, and (iii) leaf area index/canopy density.

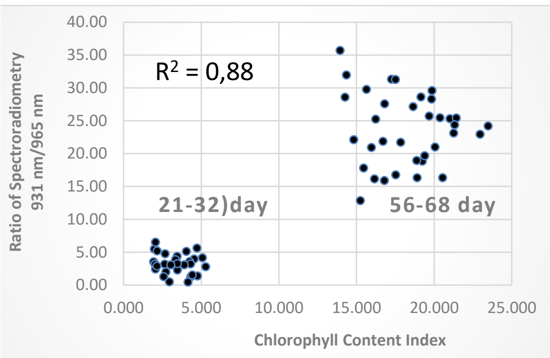

Figure 4. Relationship between the spectroradiometry and the chlorophyll content index (CCI).

CONCLUSION

The smaller wavelength interval fitted in the sensor, the more detailed the information displayed in the remote sensing data. The transplanting age of rice plants is easier to be distinguished at infrared than visible wavelengths because of the chlorophyll content (see CCI). Rice plant varieties are still difficult to be distinguished, both at visible and infrared wavelengths. The spectroradiometry vegetation index can be used to be distinguished the transplanting age of rice plants in the same varieties, but it is difficult to be distinguished varieties of rice plants even at the same age. The chlorophyll content index and spectroradiometry value indicate a strong positive correlation (R^2 = 0.88). The higher chlorophyll content in rice plants, the higher spectroradiometry for infrared wavelength.

For further research, it is necessary to design a continuous period of data collection in the field for the higher opportunity to obtain variations in plant age. Thus, the classification of plant age can be more consistent. The accuracy test of the correlation analysis needs to be done to ensure the results, the composition of the sample should be balanced and have a good distribution so that it is more representative.

ACKNOWLEDGEMENT

Authors would like to acknowledge devices support from IPB through SATREPS (Science and Technology Research Partnership for Sustainable Development) activities. This research topic is part of a large topic of SATREPS activities which is a research collaboration between IPB University, Indonesia and Chiba University, Japan.

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