Study Relationship of Rice Chlorophyll Content Index (CCI) Value with Rice Prediction Yield Production on Rice Cultivation in West Sumatera

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Abstract. Yield mapping is conducted to inform farmers about the variability of production that is used as an illustration of the yield of rice plants in a particular rice field area, so that it can be a reference for farmers in increasing their agricultural yields for the next planting season and determining the point area of land that produces the highest production. Through a yield mapping, the production results in an area of land can be predicted by looking at the correlation value and mapping between the values of Chlorophyll Content Index (CCI) of rice plants at different ages and yields at each point of observation area. Measurement of CCI values was carried out on rice plants at the age (25, 40, 60, and 70 DAP). Measurement of CCI values was carried out at 20 observation points in the Banda Langik rice field area located on the Sungai Bangek, Lubuk Minturun, West Sumatra. CCI values and yields of rice plants obtained on each field are then processed into maps of CCI values and yield mapping using GIS (Geographic Information System) applications with the kriging method. Based on research that has been carried out during one planting season shows that the CCI value has a relationship with the yield of rice plants. This is evidenced by the correlation values generated (r) 25 DAP (r = 0.815), 40 DAP (r = 0.877), 60 DAP (r = 0.810) and 70 DAP (r = 0.917). Based on the mapping of CCI values and mapping of production results, it was shown that production results in a land area could be predicted based on an overview of the CCI values of rice plants at different ages.

Keywords: Chlorophyll Content Indeks (CCI), Kriging, Yield Mapping, Spatial Variability

1. Introduction
The rice plant (Oryza sativa L.) is a food commodity that is used as a staple food for the Indonesian people. At present, rice plants in Indonesia have decreased productivity [10]. There are various ways that can be used to prevent a productivity decline, one of them is the development of pre-existing technologies to help increasing the productivity of rice plants.
The plants chlorophyll value is closely related to plant health. [12] explains the chlorophyll value obtained from the measurement of SPAD values on plants that have a close relationship with the health of plants determined based on yields of harvest on rice plants obtained through the method of cropping (Crop Cutting Test (CCT)). The fertile and enough nutrient plants will look green on the leaves and indicate sufficient Nitrogen (N) content, on the contrary, if the nutrient content is adequately fulfilled, the productivity of the plant will rise [4]. By knowing the SPAD value contained in plants will also provide information about the N content contained in the leaves, and the number of N in the leaves correlated with the chlorophyll value in the leaves of rice plants [7].

The number of N values contained in rice leaves varies at each stage of growth. In increasing the productivity, farmers face some obstacles such as crop development in the area of right time and difficulties in monitoring crop development quickly in an area of land observed, therefore a calculation technology is needed to increase the predicted rice productivity based on the index value of chlorophyll content and yields on rice plants, which can cover a wide, reliable area, with fast time and accurate results [2].

The development of methods to predict crop yields in Indonesia based on spatial variability of plant fertility has not been widely carried out and to observe the development of rice plants cannot be conducted quickly, be proper and cover a large area of land if measurements use only chlorophyll meters. For this reason, measurements of greenness were carried out on plants of different ages that had been determined for harvest time and mapping of production results that could predict yields and describe yields on rice plants, based on the Chlorophyll Content Index (CCI) obtained from reading Chlorophyll meter CCM-200 Plus on leaves and yields from rice plants, and looked at the relationship between yields with the value of Chlorophyll Content Index (CCI) from CCM-200 Plus readings at different ages of rice plants.

This mapping of production is known as yield mapping. Yield mapping is a part of the concept of precision farming, which is a principle of integrated and sustainable agricultural technology [6]. Through yield mapping, it is expected to provide information to farmers regarding the variability of production results that will be used as an illustration of the yield of rice plants in a particular rice field area, so that it can be a reference for farmers in increasing their agricultural yields for the next planting season and determining the area points that produces the highest production.

The purpose of this study was to evaluate the relationship between the amounts of Chlorophyll Content Index (CCI) content and yield on rice plants which was seen based on the variability of the yield (yield) in the field plot obtained through the Crop Cutting Test (CCT) method and through Mapping the production of rice is expected to be a determination of the results of production predictions and can be a picture of land for sustainable agriculture in the future.

2. Materials and Methods

2.1 Tools and Materials
The tool used in this study consisted of CCM-200 plus chlorophyll meter, stationery (pencils and books), measuring instruments (meters and scales), a set of data processing equipment consisting of laptops and USB, software for data processing and data analysis consists of Microsoft Word, Excel, Statistical Product and Service Solutions (SPSS), GIS and SAS.

In this study rice plants with an area of 0.5 ha were used as research samples. For the data sample, 5 clumps of rice were collected in each plot of rice fields at each of the designated observation points.

2.2 Method of Collecting Data
The collection of data samples in this study was carried out in two ways: Grid Sampling and Crop Cutting Test (CCT).
2.2.1 **Grid Sampling Point.** Grid sampling point is the process of data collection carried out to describe the condition of the land based on the fertility level of the plant by dividing plant samples into several parts. The trick is to divide the paddy fields into several groups and then divided them into plots. Furthermore, the data collection process is carried out directly in the field to get information directly from the plants, which are used as sample data to be processed. For 0.5 ha of land divided into 20 grids, then determine the observation points of each plot. For the sampling grid process can be seen in Figure 1.

![Figure 1. Grid Sampling Point](image)

Figure 1 is a method of dividing land into several plots which are used as observation points. Giving observation points on research land is done sequentially to facilitate the process of data collection, observation and management.

2.2.2 **Tile Method or Crop Cutting Test (CCT).** Crop Cutting Test (CCT) is a method of taking and collecting plant data samples that is conducted directly in the field used at harvest time for each plot of land that is used as a research sample (Putri et al., 2016). The steps to do CCT are: (1) Determining and marking the plot of the rice fields that are used as experiments and determine the sizes of the selected fields, (2) harvesting by CCT, (3) threshing crops from harvested crops from the CCT area, (4) winnowing and weighing rice or wet grain obtained from CCT rice fields.

2.3 **Data Collection of Chlorophyll Content on Plant Leaves Using CCM-200 plus Chlorophyll Meter**

Observation of the amount of Chlorophyll Content Index (CCI) of leaves was carried out in accordance with the specified observation points on the land. Then taking data on chlorophyll values in plants is done and collected according to the observation points that have been selected to be used as data samples. The process of reading the CCI status in the leaves was carried out in four stages of growing plants, namely when the rice was 25, 40, 60, and 70 days after planting (DAP). The first data collection was carried out when the rice plants were 25 DAP, the data was collected on the 25th day of the DAP because it was still a vegetative phase on rice plants. In this phase is the phase of plant development that will be the determinant of rice productivity, then the determination of data collection time on the 40th, 60th, and 70th days after planting because it is a generative (reproductive) phase in rice plants [1].

Plants used as data samples were examined at each stage of growth in each plot of rice fields, each of which consisted of 20 observation points. In this study 5 clumps, 5 stems, 5 leaves and 3 reading points of CCI values on the leaves of rice plants were taken using CCM-200 plus chlorophyll meter. Collecting and retrieving data on CCI values in leaves using chlorophyll meter CCM-200 plus randomly. Then the CCI value obtained from each reading on each plant sample at each point is then taken the average value. The average value of CCM-200 plus chlorophyll readings is used as a data sample. The measurement of the chlorophyll value contained in the leaves will be collected between 10:00 - 15:00 noon. When measuring
sunlight it must be relatively bright to avoid noise in the data. Measurements are taken at the very top of the leaf, the topmost leaf before the flag leaves out and leaves the flag after leaving, because this is an area commonly used in the practice of collecting data on the greenish value of leaves [12]. The part of the leaf that will be measured for its CCI value is located at the end, middle and base of the rice leaves. The CCI measurement techniques carried out during the field are:
1. Measurements are conducted at each sample point that has been selected
2. Sampling data according to the midpoint of each map.
3. Selection plants randomly and making measurement readings three times on each leaf selected, so that the data taken is accurate.

2.4 Location and Point of Each Coordinate Map Rice Fields
The process of taking the coordinate points at each point that has been determined as an observation point on the research land is done using GPSmap 62sc GARMIN to determine the coordinates of each plot of rice fields from each field.

| No Point | Coordinat     | No Point | Coordinat     |
|----------|---------------|----------|---------------|
| 1        | 00° 49' 52.0" | 11       | 00° 49' 51.8" |
|          | 100° 21' 18.1"|          | 100° 21' 18.9"|
| 2        | 00° 49' 51.7" | 12       | 00° 49' 51.6" |
|          | 100° 21' 18.1"|          | 100° 21' 18.9"|
| 3        | 00° 49' 51.4" | 13       | 00° 49' 51.3" |
|          | 100° 21' 18.0"|          | 100° 21' 18.8"|
| 4        | 00° 49' 51.2" | 14       | 00° 49' 50.9" |
|          | 100° 21' 18.0"|          | 100° 21' 18.7"|
| 5        | 00° 49' 50.9" | 15       | 00° 49' 50.7" |
|          | 100° 21' 17.8"|          | 100° 21' 18.6"|
| 6        | 00° 49' 50.5" | 16       | 00° 49' 50.4" |
|          | 100° 21' 17.8"|          | 100° 21' 18.6"|
| 7        | 00° 49' 50.2" | 17       | 00° 49' 50.1" |
|          | 100° 21' 17.8"|          | 100° 21' 18.5"|
| 8        | 00° 49' 49.9" | 18       | 00° 49' 49.9" |
|          | 100° 21' 17.7"|          | 100° 21' 18.4"|
| 9        | 00° 49' 49.7" | 19       | 00° 49' 49.5" |
|          | 100° 21' 17.6"|          | 100° 21' 18.3"|
| 10       | 00° 49' 49.4" | 20       | 00° 49' 49.3" |
|          | 100° 21' 17.5"|          | 100° 21' 18.3"|

2.5 GIS Data Management
At this data management stage, the process of collecting all data obtained from the measurement results is carried out, then the data is processed into raw data before the map making process is done using a GIS (Geographic Information System) application. The data processed in the GIS is spatial data, namely the data of CCI values contained in rice leaves which are measured using CCM-200 plus chlorophyll meter and harvest data on rice plants.
The method used for processing the map of the CCI value of rice plants is by the kriging method. Kriging is a geostatistical interpolation technique that considers both distance and variation between data from sample points when performing data retrieval can estimate values in unknown areas. Estimations that has been discovered by this method use a linear weighted combination of data values at all points to be predicted [3]. This kriging method was selected due to this method can predict, which is continuous from a group of data samples. Data retrieval is done using interpolation techniques (estimating values at certain location points). The stages of map making according to (PT. WMT-II 2012) are:

1. Collection and collection of CCI value data on leaves
2. Data processing
3. Determination of CCI leaf values based on the age of rice plants
4. Preparation
5. Data management by kriging method
6. Analyzing test results
7. Visual analysis resulting from the interpolation of the greenness of rice plants
8. Making a map of the model
9. Visual analysis of model maps
10. Decision making
11. Making the results of the analysis of the results of prediction based on the map of greenness on the leaves of rice plants

2.6 Data Correlation Test

Correlation test on the data was conducted to see the strong relationship between the two data, namely the data of CCI values and the yield of rice plants on a land area. Regression analysis is basically the study of the dependence of the dependent variable (bound) with one or more independent variables (explanatory variables or independent variables), with the aim of estimating and / or predicting the average population or the average value of the dependent variable based on the value of the independent variable known [7]. Correlation analysis aims to measure the strength of linear associations between two variables. For the correlation test data in this study will be tested using the SPSS program. The strong relationship between the data will be expressed in the form of numbers between 0-1, if the number generated by the correlation of data is 0, it indicates that there is no relationship between the data and if it shows the number 1, it shows the perfect relationship between the data. If the smaller the correlation coefficient, the greater the error to make predictions. Data from the CCI value mapping and production results are said to be interconnected if the data shows more than 0.6 and less than 1. As a reference to see the strong relationship between leaf CCI data and harvest yield, it can be seen in Table 1.

Table 1. General Guidelines for Determining Correlations

| r     | Relationship Criteria                  |
|-------|----------------------------------------|
| 0     | There is no correlation                |
| 0-0.5 | Weak correlation                       |
| 0.5-0.8 | Medium correlation                    |
| 0.8-1 | Strong / tight correlation             |
| 1     | Perfect correlation                    |
3. Result and Discussion

3.1 Description of Research Sites

This research was carried out in the rice field area of Sungai Bangek Village, Lubuk Minturun, Koto Tangah District, Padang City. The land used is agricultural land from the Banda Langik farmer group, the name of the farmer group comes from the name of the rice field area. The condition of the research land has a clay sand soil type, based on the measurement of the texture triangle the soil type is a sample of soil A, and has a good irrigation, so it is good for rice cultivation. Geographically on the rice field map, Banda Langik is located at the coordinate point (00° 49' 52.2" SL - 100° 21' 17.8" EL). The rice seedlings used in the study were IR 42 rice and the land consisted of 20 observation points in the form of plots / tiles, the size of each plot of land was 25x10 m.

3.2 Relationship of Chlorophyll Content Index (CCI) with Production Results on Rice Crops

Data correlation test between CCI value and production results in this study was conducted to find out that the CCI value has a relationship with the production results. Through the data correlation test, the relationship and the influence of CCI values on different ages and production results will be seen. The data that will be tested is the CCI value data from the measurement results obtained from the field at different ages, ie at the age of 25, 40, 60 and 70 DAP plants and the yield of rice plants at each observation point.

| Production Result (kg/m²) | 25 DAP | 40 DAP | 60 DAP | 70 DAP |
|---------------------------|--------|--------|--------|--------|
| 25 DAP                    | .815   | 1.000  |        |        |
| 40 DAP                    | .877   | .775   | 1.000  |        |
| 60 DAP                    | .810   | .808   | .866   | 1.000  |
| 70 DAP                    | .917   | .832   | .903   | .880   | 1.000 |

In Table 2 shows that the CCI value has a relationship with production results, can be seen from the correlation values of each at different ages, namely at the age of 25, 40, 60, and 70 DAP. At the age of 25 DAP shows the correlation value is $r = 0.815$, based on the correlation value produced at the age of 25 DAP, the CCI value has a relationship with the production results, but the CCI value has not had a major effect. CCI values have a relationship with production because in this phase the CCI value affects the peranakan process, growth, leaf growth and growth in rice plants.

At the age of 40 DAP the correlation value between CCI values and production results has increased that is $r = 0.877$, based on this correlation value shows the CCI value has a strong relationship to production results compared to the age of 25 DAP. In this phase the CCI value affects the production, because the CCI value can determine the health of rice plants during growth. Plant health affects the number of tillers that will be produced in each clump. CCI values in rice plants have increased during fertilizing. Fertilization is done to meet the nutritional needs of plants. This increase in CCI value in rice cultivation at age 40 DAP shows that fertilization can increase the CCI value in plants and chlorophyll values affect the growth process in plants because according to [12] explains that the value of SPAD has a close relationship with plant health which can be determined based on results harvest production. The first fertilization was carried out at the vegetative period, which was at the age of 23. The increasing in CCI value in the paddy cropping age of 40 DAP showed an increasing in the N value so that it increased the
CCI value in plants, and this also indicated that fertilization in the vegetative period was very influential in supporting growth.

At the age of 60 DAP the correlation between the value of CCI and production results decreased. At the age of 60 DAP the correlation value between the CCI value and the yield of \( r = 0.810 \) based on the correlation value showed that the relationship between CCI value and yield at the age of 60 DAP was lower than when the rice plants were 25 and 40 DAP. Based on observations that have been conducted in the field, this is caused by, at the age of 60 DAP the CCI value in plants is low. The decline in CCI values that occurred at the age of 60 DAP because fertilization had not been carried out. The second fertilization on the land was done at the age of rice 63 DAP, thus causing a decrease in CCI values on rice plants, if it was correlated between the correlation value with fertilization showed that there was an influence of N value on the development of chlorophyll values in rice plants so that the correlation between CCI values and yield at the age of 60 DAP decreased.

Correlation value between CCI value and yield at 70 DAP is \( r = 0.917 \). Based on the correlation value shows that at 70 DAP the CCI value has a strong relationship with production results, seen from the correlation value produced. At the age of 70 DAP the chlorophyll value greatly determines the yield of rice because at the age of 70 DAP the panicle of the rice plant has been released.

At the age of 70 the required DAP nutrients must be fulfilled as needed by the plant because it is a generative (reproductive) period of rice plants. Plant growth phase which is suspected to have a close relationship with the productivity of rice plants is a plant in the early generative phase (pinnacle initiation) when rice plants are being produced [11].

Based on observations at each stage of growth of rice plants at each age of different plants showed that the relationship most related between the value of chlorophyll and production compared with other ages is when rice is 70 DAP. According to [12] explained in his research that at the age of 70 DAP the value of chlorophyll in rice plants was higher than the age of other rice plants. In this study showed that the highest CCI value on plants and the most influential on production results was at the age of 70 DAP, therefore at the age of 70 DAP it was very important to determine the yield of rice for this period get sufficient nutrients and must get farmer’s attention.

### 3.3. Mapping of Chlorophyll Content Index (CCI) and Production Results on Rice Crops

The mapping of chlorophyll values and yields of rice plants in this study was carried out to see the overall distribution of data on the land. The CCI value mapping function and production results are used to predict the yield of rice plants based on the CCI value level predicted through the colors contained on the map. Mapping on the CCI value of rice plants is based on the age of different rice plants, then at each point observations were made which areas produced the highest yields predicted through maps of chlorophyll values in rice plants.

This mapping will also function as a means of detecting nutritional needs in rice plants which are predicted through the level of CCI values of rice plants projected by the map. To see the data distribution of CCI values and yields of rice plants on the map along with how their relationship at the ages of 25, 40, 60 and 70 DAP can be seen in the map below which was made with the GIS program using the Krigging method.

1. **Chlorophyll Content Index (CCI) Value Map on Land Age 25, 40, 60 and 70 DAP**

   On the land map, it will be seen how the data distribution of CCI values of rice plants at each observation point and on the map can also be seen how the increase in CCI values based on different ages in Figure 2.
Based on Figure 2 in the CCI value mapping it can be seen that the CCI value in rice plants changes at different ages. In Figure 2a can be seen mapping the CCI value of rice plants at the age of 25 DAP. In Figure 2b is mapping the CCI value of rice plants at the age 40 DAP. In Figure 2c is a mapping of CCI values at the age of 60 DAP and Figure 2d shows a mapping of chlorophyll values at the age 70 DAP. In the CCI land value mapping map legend can be used as a benchmark for detecting CCI values at each observation point.

Based on the colors in the map legend, it can be determined that, green indicates the CCI value (very low), yellow (low), orange (medium), purple (high) and white (very high). In Figure 2a can be seen the map of rice plants at the age of 25 DAP, based on the legend map shows that at the age of 25 DAP the CCI value is very low, namely (2.5 – 3.1) low (3.1 – 3.7) medium (3.7 – 4.3), high (4.3 – 4.9) and very high (4.9 – 5.5). In Figure 2b at the age of 40 DAP, based on the legend of the map shows that the CCI value is very low, namely (13.57 – 15.42) low (15 – 17.26) medium (17.26 – 19.11) high (19.11 – 20.96) and very high (20.96 – 22.81). In Figure 2c it can be seen the map of rice plants at the age of 60 DAP, based on the legend the map shows that at the age of 60 DAP a very low value (14.83 – 16.81) is low (16.81 – 18.79) medium (18.79 – 20.76) high (20.76 – 22.74) and very high (22.74 – 24.72) and in Figure 2d can be seen the map of rice plants at the age of 70 DAP, based on legend shows that at 70 DAP the value was very low, namely (17.11 – 18.39) low (18.39 – 19.66) medium (19.66 – 20.94), high (20.94 – 22.22) and very high (22.22 – 23.5).

Based on the CCI value level map can be seen which observation points have low CCI values and those that require nutrition. For areas that have very low value, fertilization should be carried out to meet the needs of plant nutrients to support plant growth in the area of the land.

2. Map of Production Results

Mapping of production results on the land is done to see the production results at each observation point to be used as an illustration for the production of subsequent crops. This production map can be used as a benchmark to increase production in the following season (Figure 3).
Based on the colors in the map legend Figure 3 can be seen green indicates the area of the plant that has a CCI value (very low) yellow (low) orange (medium) purple (high) white (very high). From the legend the map on land 1 shows very low values, namely (0.43 – 0.56), low (0.56 – 0.67) medium (0.67 – 0.79), high (0.79 – 0.92) and very high (0.92 – 1.1). Based on the legend on the map for observation points that produce the least production can be used as an illustration to determine which observation points that require additional nutrients to support plant growth on the land, to increase production yields on rice plants.

CONCLUSION
From the observations that have been conducted it can be concluded that the CCI value of plants can be used as an illustration to see the health and conditions of plant growth. Based on the research that has been carried out during one planting season shows that there is indeed an influence of CCI values on the yield of rice plants obtained through the CCI value mapping measurement does not need to be done one by one against the leaves of rice plants, because the nondestructive method used in the process of measuring the CCI value carried out, can cover a large area and also through CCI value mapping we can predict the nutritional needs of plants to increase production in areas of land that require adequate nutrition. The evaluation results that have been carried out during one planting season shows that CCI values have a relationship with production results on rice plants seen from the yield produced at each observation point.

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