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Evaluation of Leaf Total Nitrogen Content for Nitrogen Management in a Malaysian Paddy Field by Using Soil Plant Analysis Development Chlorophyll Meter

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Abstract: Problem statement: Laboratory plant testing is usually time-consuming and high-costing. Hence, plant nutrient variability must be measured rapidly and the information made known to the farmers before the new season starts. Site-specific crop management, well-established in some developed countries, is now being considered in other places such as Malaysia. **Approach:** The application of site-specific management principles and techniques to diverse crops and small-scale farming systems in Malaysia will present new challenges. Describing within-field variability in typical Malaysian production settings is a fundamental first step toward determining the size of management zones and the inter-relationships between limiting factors, for establishment of site-specific management strategies. **Results:** Measurements of rice SPAD readings and nitrogen content were obtained in a Malaysian rice paddy field. SPAD reading data was manually collected on 80DAT and measured using a Minolta SPAD 502. Leaf samples were collected at 60 points at the same time to compare results from sampling with SPAD reading values. Samples nitrogen content was analyzed in a laboratory. Analysis of variance, variogram and kriging were conducted to determine the variability of the measured parameters and also their relationship. SPAD reading and nitrogen content maps were created on the interpretation of the data was investigated. **Conclusion/Recommendations:** Finally the research indicated that SPAD readings are closely related to leaf N content which means the potential for technology of precision farming to understand and control variation in Malaysian production fields and also SPAD chlorophyll meter ability to monitor the N status of rice and recommend the amount of N fertilization. Additional research is needed to confirm the results with data from other fields and crops.

Key words: Site-specific management, precision farming, variability, nitrogen content

INTRODUCTION

Precision farming is conceptualized by a system approach to know the total system of agriculture towards a low input, high efficiency and sustainable agriculture[17]. It is a crop management strategy that employs detailed, site-specific information to well manage production inputs and outputs. The crop management idea is described as knowing the soil and crop characteristics unique to each part of the field to optimize the production inputs within small portions of the field and increase the crop yield. They describe that the philosophy behind precision farming is that production inputs (seed, fertilizer and chemicals) should be applied only at the time that are needed and at the location they are needed for the most economic production in order to obtain the highest output[8].

Site-specific management requires a thorough quantitative knowledge of the factors and interactions that finally affect yield. Topography is frequently highly related to yield and topographical data are easy to obtain compared with time and labor-consuming measurements of plant and soil properties[1].

Plants need primary nutrients in high amounts, so a deficiency in any one of the essential nutrients will restrict plant growth. A nutrient management plan can be developed for each field on the farm[7].

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Nitrogen is absolutely essential for crop growing. Crop plants grown on soils with sufficient amounts of available nitrogen develop thrive, rapid growth with a healthy green color. Nitrogen deficiency results in plants of poor color and quality[5]. They also mentioned that nitrogen is also very important to yield because of its key role in cell division. If cell division is stopped, the leaf area decreases and thereby loses its potential to produce an adequate yield. Adding more nitrogen than needed for optimum yield will generally result in an increase in grain protein until an upper threshold is reached. As previously stated, nitrogen is one of the key limiting nutrients in crop growth; therefore, finding efficiency levels of nitrogen is important for growth, development, protein and yield.

The chlorophyll meter or SPAD meter is a simple, portable diagnostic tool that measures the greenness or relative chlorophyll content of leaves[9-11]. Meter readings are given in Minolta Company-defined SPAD (Soil Plant Analysis Development) values that indicate relative chlorophyll contents. There is a strong linear relationship between SPAD values and leaf nitrogen concentration, but this relationship varies with crop growth stage and/or variety[13,3]. The linear relationship between nitrogen and SPAD values has led to the adaptation of the SPAD meter to assess crop nitrogen status and to determine the plant’s need for additional nitrogen fertilizer[15,16,18]. SPAD readings indicate that plant nitrogen status and the amount of nitrogen to be applied are determined by the physiological nitrogen requirement of crops at different growth stages.

The overall objective of this research was to determine that relationship between chlorophyll meter readings and nitrogen content of leaves using geostatistical analysis and map creation and also to assess whether the chlorophyll meter analysis of rice leaves would be useful in making nitrogen fertilizer side dress recommendations.

MATERIALS AND METHODS

Study area: This study was conducted at the Tanjung Karang rice irrigation scheme. The scheme area is located on a flat coastal plain in the Northwest Selangor agricultural development project (Projek Barat Laut Selangor, PBLS). It is in the district of Kuala Selangor and Sabak Bernam on latitude 3°35"N and longitude 101°05"E. The scheme is composed of eight compartments which is divided into 24 blocks namely blocks A to X. Block C is the study area that contains 118 plots and each plot size is 1.2 ha each with a total area of about 142 ha.

Crop measurement: Leaf samples were collected randomly on 80 Days After Transplanting (DAT) on April 2009. The youngest fully expanded leaf of 7 plants in 60 plots was used for SPAD measurement. Triplicate readings were taken on one side of the midrib of each single leaf blade, midway between the leaf base and tip and then averaged. Furthermore, leaf samples were taken to laboratory to estimate their N content in order to determine SPAD readings and total nitrogen relationship.

Geostatistical analysis: The important information about variables is provided by descriptive statistics using the Statistical Package for Social Science (SPSS) version 15.0. Measures of tendency of variables were determined by mean, median and mode as well as computing the dispersion of a variable in variance, standard deviation, Coefficient of Variation (CV) and range[6]. Geostatistical analyses of SPAD readings were calculated for their semivariogram. A semivariogram indicates autocorrelation as a function of distance (semivariance versus distance separation) to plot spatial variability[19]. It’s components which include fitted model type, nugget variance (C_0), structural variance sill (C_0+C), range (A), Residual Sum of Square (RSS), coefficient (r^2) and proportion (C/[C_0+C]) were calculated by Geostatistical analysis software through GS^+ (Geostatistics for the Environmental Science, Gamma Design Software, Version 7, LLC Plainwell, Michigan).

Variation maps: Variability has been identified as spatial, temporal and predictive. Spatial variability of SPAD readings and N content was obtained in this study to monitor difference in maps of these measured parameters.

These data were interpolated geostatistically by kriging technique using ArcGIS 9.2 through spatial analysis extension on semivariogram results for Geostatistical Software (GS^+).

RESULTS

Relationship between SPAD reading and N content: Regression analysis of the data showed that nitrogen concentration in the flag leaf was linearly correlated with the SPAD reading on 80DAT (R^2 = 0.90) that is displayed in Fig. 1. The linear regression of leaf N concentration and SPAD values was highly significant.

Geostatistical description and semivariogram analysis: Geostatistical analyses of rice leaf SPAD reading on 80DAT was presented according to its semivarioms. As mentioned in material and method section semivariogram has different components those are displayed in Table 1.

Table 1: Summery of Isotropic semivariogram components

	SPAD (80DAT)
Model type	Exponential
Nugget variance (C_0)	0.41
Structural variance Sill (C_0+C)	4.77
Partial sill	4.36
Range (A_o)	354.00
Residual Sum of Square (RSS)	1.75
Coefficient (R^2)	0.56
Proportion (C/[C_0+C])	0.91

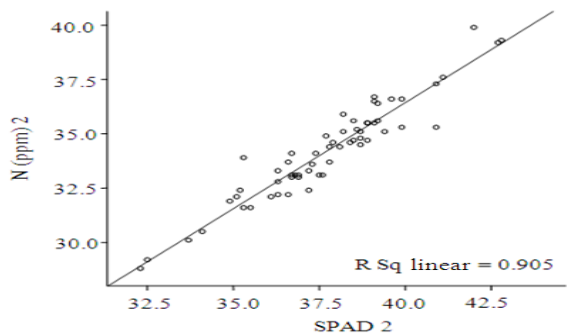


Fig. 1: Relationship between SPAD reading and N content in flag leaf on 80DAT

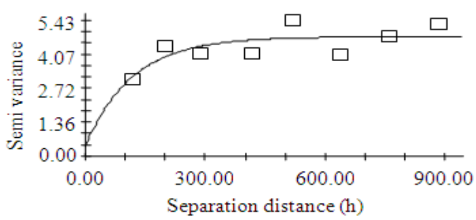
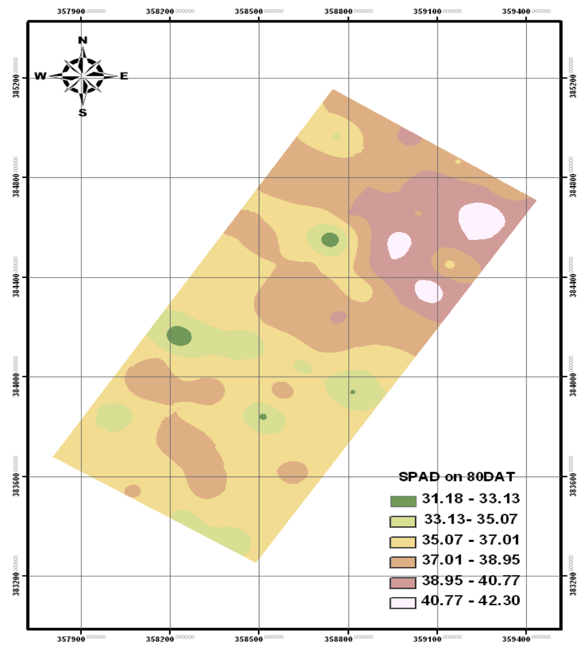


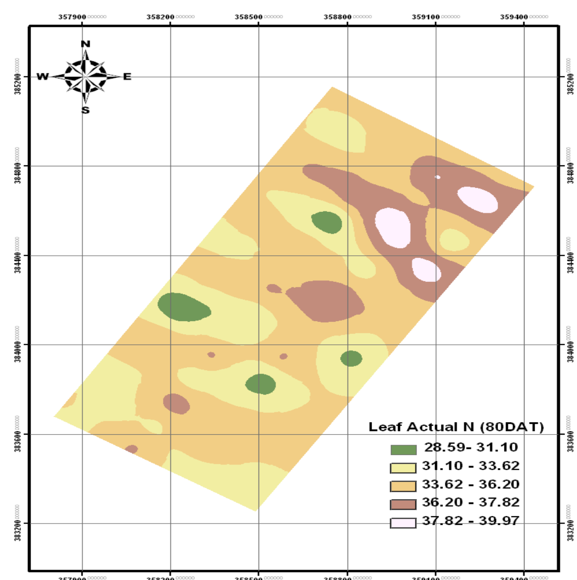
Fig. 2: Isotropic semivariogram of SPAD reading on 80DAT, Exponential model (C_0 = 0.41000; C_0+C = 4.77400; A_o = 118.00; r_2 = 0.557; RSS = 1.75)

Lag distance of variogram was determined based on width of the field. The variograms of SPAD readings on 80DAT was prepared as shown in Fig. 2.

Variation maps: The classification approach using raster calculator, which was available in the spatial analyst for calculating the SPAD reading and calculated maps were produced. Since the standard classification did not visualize much variability, thus the classification technique of manual, which was introduced by ArcGIS software, was selected to visual variability as groups. This study decided to zone the area into 6 and 5 zones (Respectively for SPAD reading and total N) which could be manageable and also easy to compare.



(a)



(b)

Fig. 3: Krigged map for SPAD reading (a): And leaf total N on 80DAT (b): Classified by manual method

According to SPAD reading map on 80DAT (Fig. 3a), the areas were mostly occupied by the moderate range and it seemed to be concentrated on some plots in the south. The low SPAD readings were scattered mostly in the center of the area while, the highest readings were observed in northern plots.

Zonal statistics displayed that in (Fig. 3a) the maximum coverage area (81%), related to values of 35.07-38.95.

The variability map of total N on 80DAT (Fig. 3b) illustrated that class 1 (the lowest amount of N) was the smallest covering area in both map.

DISCUSSION

The linear correlation of SPAD reading and flag leaf N content in this result was corresponded to[5,14,12,20] and results on different plants including rice, they reported that the regression between SPAD reading and N concentration were $R^2 = 0.86$, $R^2 = 0.96$, $R^2 = 0.84$ and $R^2 = 0.80$ respectively[5,14,12,20]. In general, because chlorophyll content in a leaf is closely correlated with leaf N concentration[9,20] and there are also some studies that show there is a high correlation between chlorophyll content and SPAD reading[2], using of SPAD chlorophyll meter provides an indirect assessment of leaf N status.

Relatively high nugget on 80DAT indicates high sampling error. Sill and the proportion of partial sill values were very weak or considered as pure nugget.

As mentioned before maps of SPAD readings on 80DAT and leaf actual N on that time showed the same pattern that also could be because of high correlation between these parameters but in both maps variation in amount and range in SPAD readings and actual N may be due to human activities or farm practices in this stage such as fertilization.

CONCLUSION

Since SPAD readings are closely related to leaf N content, the SPAD meter can be used to monitor the N status of rice and thereby to adjust the rate of N fertilization in order to increase N use efficiency[2,4]. In this study also analyses of data collected on 80DAT was used to determine SPAD data can be used to predict leaf N amount and future crop N need. SPAD readings taken on 80DAT had a good relationship to leaf total N concentration, therefore assessment of crop N status is good to be done based on SPAD reading if we decide to take correct fertilizer amount to achieve higher yield.

Semivariogram showed high sampling error and stronger spatial dependence on 80DAT. Descriptive statistics, semivariance analysis and point kriging were employed to determine the variability maps in the measured parameters. Visual observation and statistical analysis indicated the same trends could be observed in most areas of the field for several SPAD reading and leaf N content.

These findings indicated the potential for technology of precision farming to understand and control variation in Malaysian production fields. Additional research is needed to confirm the results with data from other fields and crops.

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