BROWN PLANT HOPPER DAMAGE MONITORING IN RICE USING FIELD IMAGING SPECTROSCOPY

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ABSTRACT— Currently, the brown plant hopper is a serious problem of rice crop. It is the cause of reduced productivity of rice crop in Thailand. In this paper, we investigate the hyperspectral remote sensing to study affectation of brown plant hopper on rice crop by using property of spectral reflectance vegetation indices. The brown plant hopper damaged in rice crop had lower reflectance in near infrared (NIR) and higher reflectance in visible (VIR) of electromagnetic spectrum compared with normal rice crops. The difference of various wavebands for study reflectance of BPH damage levels is very important in this research because we used a wind range wavebands to calculate spectral vegetation indices. The spectral vegetation indices calculated based on spectral reflectance are Moisture Stress Index (MSI), Normalized Difference Vegetation Index (NDVI), Green Normalized Difference Vegetation (GNDVI), Optimized Soil Adjusted Vegetation Index (OSAVI) and Normalized Pigment Chlorophyll Index (NPCI). In this research, we study the brown plant hopper of rice crop damaged area in Chai Nat. Experimental results showed that the proposed method can reveal relation of transformation of time series graph between non-brown plant hopper and added brown plant hopper.

1 INTRODUCTION

Rice culture is very important for Thailand in terms of domestic consumption and export value. However, brown plant hopper (BPH) is a major pest affecting rice production in Thailand, which outbreaks in central and Lower Northern part of Thailand. The brown plant hopper is a serious problem in agriculture and it eats rice plants as food. The brown plant hopper has caused big damages to the rice crop. The rice is main agriculture for export business in Thailand; however, the BPH populations have greatly increased and caused severe yield losses in several countries. The BPH infest the rice crop at all stages of plant growth. The result of BPH has effect to rice plants change to yellow and dry respectively. The BPH is the main insect pest of rice in Thailand. Therefore, the dramatically severe damage it causes to reduce productivity of rice in Thailand. The BPH is pest has damage to rice agriculture, which is difficult to monitoring for BPH in rice crop. The BPH damage is a kind of hidden factor to the significant reduces of rice productivity. Therefore, the timely detection of BPH in rice crop monitoring is the key to effective management of agriculture. [1].

This research is difference among the BPH damage levels based on spectral characteristics at the VIS and the NIR regions under controlled condition. The locations for test of the BPH in rice in 6 regions are HR1, HR2, HR3, HNR1, HNR2 and HNR3 in Chai Nat for study about behavior for rice crop. This study aims to understand the biology of violence or damage to belongings of BPH, which could lead to the development of prevention and elimination by development of rice breed varieties resistant to BPH more effectively.

2 MATERIALS AND METHODS

Currently, technology of remote sensing is very important for study about agriculture. This paper used information of spectral reflectance to determine behavioral changes of the rice crop when the brown plant hopper appears.

2.1 Spectral measurements

Spectral reflectance of the rice crop in 6 regions in Chai Nat, having differential BPH damage, was measured over wavelengths between 350 to 2500 nm with a FieldSpec4 portable spectroradiometer [1]. The FieldSpec4 is a high resolution spectroradiometer, very accurate spectral data measurements for an extensive array of remote sensing applications. The spectral (VNIR and SWIR) resolution of the FieldSpec4 spectroradiometer has more performance across the full range solar irradiance spectrum (350 - 2500 nm). The enhanced spectral resolution in the SWIR has range between 1000 to 2500 nm, which is particularly useful for detecting and identifying compounds with narrow spectral features in the longer wavelengths such as alteration mineralogy and gases for atmospheric analysis.

2.2 Study area

In this study, the state of Chai Nat is selected as the experiment area. Chai Nat is rice and other agriculture and is one of the most important rice production areas in Thailand. Chai Nat is located in the middle of Thailand and its area is mainly dominated by rice agriculture, and therefore is suitable for the study about brown plant hopper in rice.

Figure 1 Study area of BPH in rice crop at Chai Nat

2.3 Moisture Stress Index (MSI)

Moisture Stress Index is a lack of water in the root of plant, which happen when the plant cell has water is reduced than normal levels. This problem has main effect for absorption and transportation water in the roots, while could occur due to an inability to absorb water due to a high salt content in the soil water or loss of roots due to transplantation. Moisture stress is more strongly related to water potential than water content.

Moisture stress also has an effect on stomatal openings of a plant, mainly causing a closure in stomata as to reduce the amount of carbon dioxide assimilation. From the value of spectral reflectance MSI can be calculated by the following equation [2].

$$MSI = R_{1600}/R_{820} \tag{1}$$

2.4 Normalized Difference Vegetation Index (NDVI)

The Normalized Difference Vegetation Index is a measure of green vegetation over the surface. This is a value indicator that uses the spectral reflectance of visible (VIS) and near-infrared (NIR) bands of the electromagnetic spectrum for calculate, and is used to analyze remote sensing measurements and assess whether the target being observed contains live green vegetation [3].

NDVI is basic value used to studies for estimate crop yields in remote sensing technique. This is powerful for study the growth of rice crop. The NDVI is calculated from the visible (VIS) and near-infrared (NIR) light reflected by vegetation.

$$NDVI = (R_{nir} - R_{red})/(R_{nir} + R_{red}) \tag{2}$$

2.5 Green Normalized Difference Vegetation Index (GNDVI)

The Green Normalized Difference Vegetation Index (GNDVI) an indicator of plant photosynthetic activity, which can be used to indicate to nitrogen uptake the crop canopy and determine water of plant [4]. The GNDVI is different from NDVI because GNDVI basically replaces the red range of standard NDVI collection with a very specific band of light in the green range to obtain different useful information. Water is also a leading factor required for photosynthesis. Using GNDVI value of plant we can address water in a more efficient way. This index is similar to NDVI except that it measures the green spectrum from 540 to 570 nm instead of the red spectrum. This index is more sensitive to chlorophyll concentration than NDVI.

$$GNDVI = (R_{750} - R_{550})/(R_{750} + R_{550}) \tag{3}$$

2.6 Optimized Soil - Adjusted Vegetation Index (OSAVI)

Optimized Soil – Adjusted Vegetation Index is similar to NDVI, but it detects the effects of soil pixels. It uses a canopy background adjustment factor, which is a function of vegetation density and often requires prior knowledge of vegetation amounts [5]. It uses a standard value of 0.16 for the canopy background adjustment factor for determine that this value provides soil variation for low vegetation cover. We can calculate the OSAVI following this equation

$$OSAVI = (1 + 0.16)(R_{800} - R_{670})(R_{800} + R_{670} + 0.16) \tag{4}$$

2.7 Normalized Pigment Chlorophyll Index (NPCI)

The NPCI used to estimate the ratio of total pigments to chlorophyll in vegetation. We study the spectral for reflect physiological of vegetation based on previous work using absorbance ratios to calculate the ratio of total pigments to chlorophyll in vegetation. The ratio of total pigments to chlorophyll should be increase when decaying plants and decrease in healthy plants. We tested the utility of a normalized total pigment to chlorophyll a ratio index (NPCI) [6], defined as

$$NPC= (R_{685} - R_{445})/(R_{685} + R_{445}) \tag{5}$$

3 RESULTS AND DISCUSSION

In this research, we examine the time series graph of spectral vegetation indices calculated based on spectral reflectance of the rice crop damaged by the brown plant hopper. A set of 3 location are selected for add brown plant hopper are hr1, hr2, and hr3 while the other 3 location are without brown plant hopper of nhr1, nhr2, nhr3.

3.1 MSI

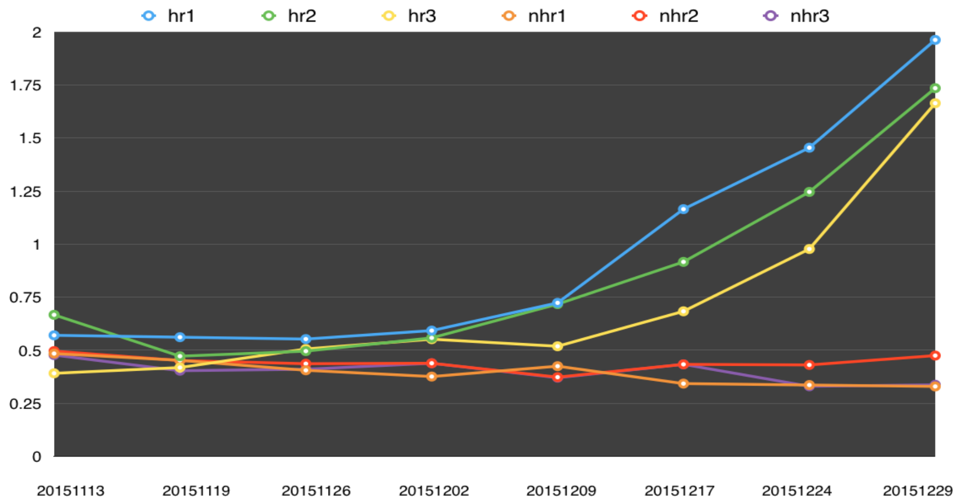

Figure 2 MSI time series graph of rice crop between BPH and Non-BPH

Figure 2 shown the moisture stress index over the area of rice crop. The values of moisture of hr1, hr2 and hr3 increase after 09/12/2015. The maximum value is 1.9627 from hr1. On the other hand, the minimum value is 0.337 from nhr1. The brown plant hopper is resulting from crops that stopped growing and eventually died. When plants die the absorption of water in the soil is reduced. Therefore, this area has an increase of moisture stress index.

3.2 NDVI

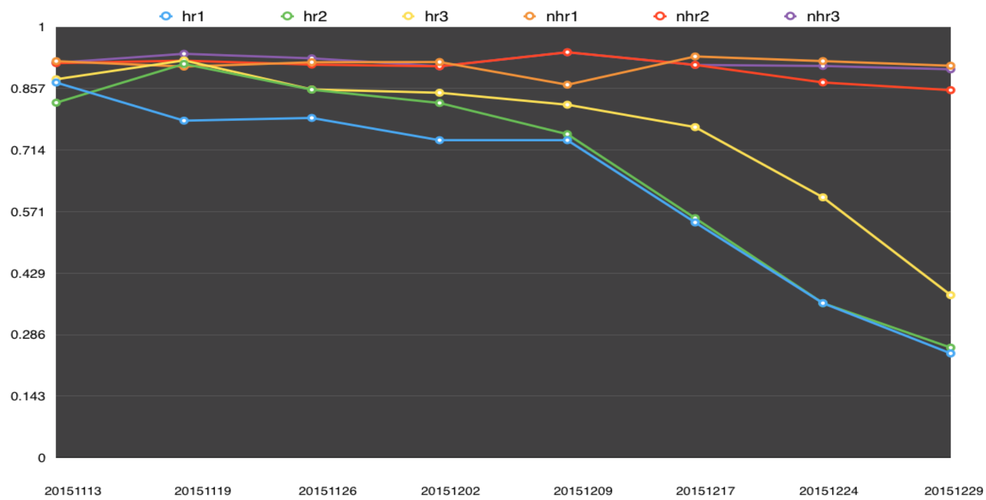

Figure 3 NDVI time series graph of rice crop between BPH and Non-BPH

Normalized Difference Vegetation Index in Figure 3 shows the value of green agriculture covering the area of rice crop. The value of moisture of nhr1, nhr2 and nhr3 decrease after 09/12/2015. The maximum value is 0.9016 from nhr1. On the other hand, the minimum value is 0.2420 from hr1. NDVI value indicates the percentage of vegetation-covered surface. When the rice crop is damaged the main effect in decline of NDVI.

3.3 GNDVI

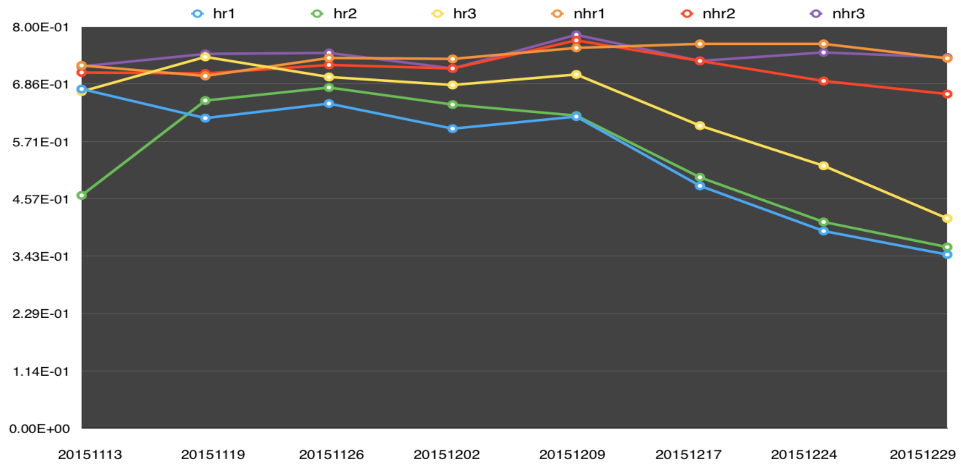

Figure 4 GNDVI time series graph of rice crop between BPH and Non-BPH

Green Normalized Difference Vegetation Index in Figure 4 shows the value of green agriculture covering the area of rice crop. The BPH graph of GNDVI value was decrease after 09/12/2015. The most value is 0.784 from nhr3. On the other hand, the minimum value is 0.346 from hr1.

3.4 OSAVI

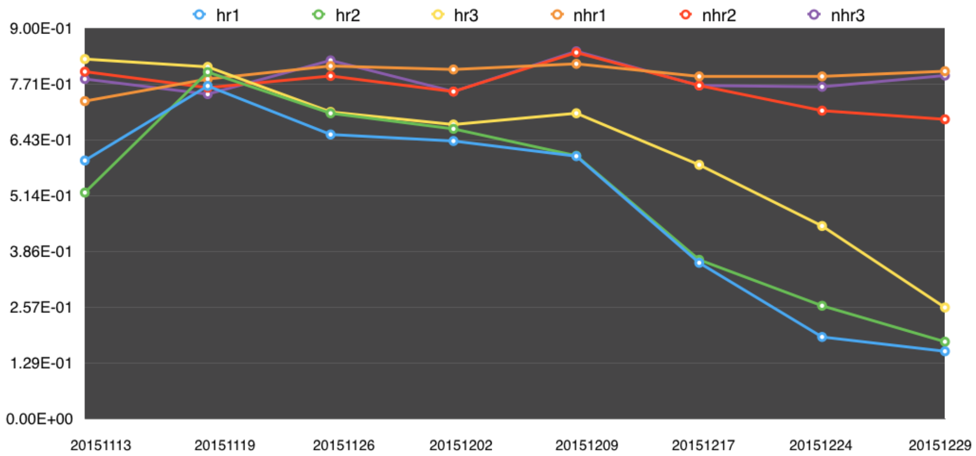

Figure 5 OSAVI time series graph of rice crop between BPH and Non-BPH

Optimized Soil Adjusted Vegetation Index in Figure 5 shows the value of green agriculture covering the area of rice crop. The maximum value of OSAVI is 0.847 from nhr3. On the other hand, the minimum valuable is 0.155 from hr1. The optimized soil adjusted vegetation index was developed as a modification from the Normalized Difference Vegetation Index to correct for the influence of soil brightness when vegetative cover is low. When the rice crop is lost, this graph will decrease.

3.5 NPCI

Figure 6 shows Normalized Pigment Chlorophyll Index over the area of rice crop. The values of NPCI are increase over time with a maximum is 0.435 from hr2. On the other hand, the minimum value is -0.011 from nhr3. NPCI behaved as a rough estimate of the ratio total pigments chlorophyll. It will decrease in healthy plants and increase in stressed or senescence plants. In this research, the graph of the BPH area is increase more than non-BPH area. Therefore, the BPH is the cause of senescence of rice crop.

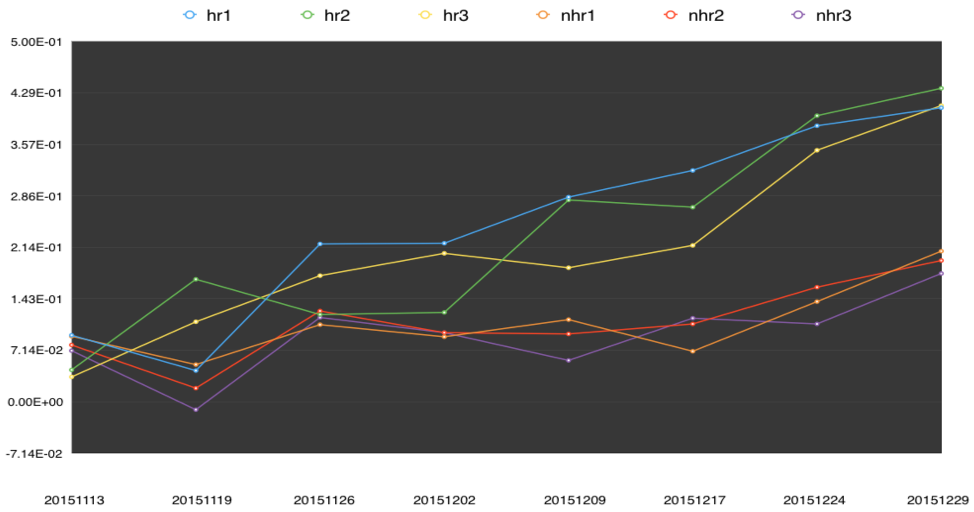

Figure 6 NPCI time series graph of rice crop between BPH and Non-BPH

4 CONCLUSION

BPH is a major rice pest infestation causing grain yield to decrease significantly. In this research, we have proposed an approach to study BPH by consider the spectral vegetation indices based on spectral reflectance of rice crop damaged. The reflectance at wavelengths identified to be sensitive to the BPH damage can be employed to assess BPH damage in rice crop.

From the result of MSI and NPCI is very clear for study effect of BPH in rice crop. The result of MSI shown the time series graph when add BPH, the moisture is increase in 17/12/2015 that mean rice crop has decrease water absorption. Therefore, this research shown the BPH has very effect for water absorption and we can focus on Moisture Stress Index. In addition, the result of NPCI is very well for tack the impact of BPH in rice crop. The NPCI time series graph of rice crop between BPH and non-BPH are clearly differentiated. The valuable of rice crop when add BPH is increased steadily more than area non-BPH, that mean the rice crop in area of hr1, hr2 and hr3 are senescence plants.

The knowledge of the biology index of BPH damage has effect for rice varieties. In this research we can detect beginning epidemic of BPH by study the time series graph. This research can lead to ways to prevent and eliminate the use of rice varieties resistant to BPH effectively and sustainably.

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