A PRELIMINARY STUDY ON PADDY RICE YIELD PREDICTION BASE ON THE COMBINATION OF SIMPLE CROP MODELING AND SATELLITE REMOTE SENSING IMAGERY

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ABSTRACT: Thailand is one of the world's top rice producers and exporters. However impacts of climate change and natural disaster are widely harmful to its rice production area. We therefore, need an effective tool to support decision maker to make a right decision for rice crop management. Crop model together with remote sensing technology would be leading to achieve a wise decision-making as well as a price guarantee of agricultural products. This research used a simple crop model developed by Pannangpetch, 2007. Which a few numbers of input, including Plant height Biomass Density and Leaf Area Index (LAI) which are less constrains its applications than the others. We combined simple crop model with satellite data and ground observation to estimate the rice yield. The study site is located in Suphan-buri province which is one of the largest rice crop plantation fields in Thailand. This research, preliminary found that there is a good correlation between SAR backscattering and rice's Leaf Area Index (LAI) which is one of the input parameter of our simple crop model. Then we use Radarsat-2 Quad-Pol time series data to observe the rice phenology. These data integrated with LAI, and weather data from field router, are input parameters to the crop model to estimate the rice yield

1. INTRODUCTION

Rice is one of the staple crops for a large part of the world's population, especially in Subtropical and Tropical regions. In these areas, it is difficult to acquire optical remote sensing data in rice growing regions due to the heavy cloud cover and rainfall (Yun Shoa et al, 2001).With the cloud penetrating property of microwave, Synthetic Aperture Radar (SAR) is able to acquire cloud-free images in all weather and is capable of night-time operation. It was applied widely in many researches, especially in agricultural studies.

Since the Earth observation satellite such as ERS-1/2 of the European Space Agency and RADARSAT of Canada has been launched into orbit, the C-Band was widely studied (Chakraborty et al., 2005; Le Toan et al., 1997). Korosu el al.,(1995) indicated that multi-temporal Radarsat data could be used to show the differentiating in growth stages of rice by Backscattering coefficient (σ^0) factor. Meanwhile, Aschbacher J et al. (1995) evaluated the ERS-1 satellite data to monitor and map the paddy field in Thailand.

Analysis of rice plantation areas from multi-temporal Radarsat data was based on the backscattering coefficient values of rice and other land cover. The backscattering coefficient was changed between - 15 dB to -8 dB. Maximum likelihood classification was used to classify area of rice from Radarsat data by reducing the speckle noise. Thuy Le Toan et al. (1997) analyzed data from the measurement of rice plantation in two sites at Samarang, Indonesia. The study in Akita Prefectural College of Agriculture (APCA) in Japan found that height and day after sowing were related. However, different parameters such as density, sowing rate, a limited amount of water, fertilizers, and other uncertainty of relationship were found to depend on skill of farmers.

M. Chakraborty et al. (1997) and Yun Shao et al. (2001) focused on the use of muti-temporal Radarsat data to study growth stage of rice by different methods. Y. Inoue (2002) presented a different wave range and polarized to show the backscattering coefficient in C-Band wave range. This was associated with biological characteristics such as leaf area index and height of the canopy. Alexandre Bouvet et al. (2009) has developed a Time series of ASAR Dual Polarization data and has used the ratio of HH/VV to provide statistical classification between pixels of rice and non-rice. Fan Wu (2011) used Radarsat-2 quad-Polarization image for monitoring the cultivation of rice in southern China. The result showed that when a satellite image ground data as well as HH, HV, VH, VV, HH/VV, HV/HH, HV/VV, entropy (PE), Polarization phase difference (PPD) was analyzed, the differentiation of land cover (rice, banana forest, forest, and river) by HH/VV data was the most obvious. HH can be divided into forest areas and rivers as well.

Shen ShuangHe et al.(2009) and YANG Shen-bin et al. (2009) put forward a practical scheme for mapping rice yield estimation based on ENVISAT ASAR data and ORYZA 2000 rice crop model. Cloud model and SCE-UA algorithm was used to correct the data before processing. This study found that multi-temporal and multi-polarization were appropriate tools for mapping rice yield which resulted in mapping accuracy of 84.36%. In addition leaf area index (LAI) was related to productivity.

2. STUDY AREA AND DATA SET

2.1. Test Site and Description

The study area was situated at Muang district Supan-Buri province in the Central of Thailand (100.08°N, 14.47°E) , consisting of approximately 25 x 25 km^2 of the sampling sites area. Rice is one of the major crops in this area. They are mostly rice fields with various species. The rice life cycle is around 109 to 120 days and two rice crops were grown annually. Sowing or transplanting starts in November to February and rice were harvested in late of April to early of May. The second cropping starts in one month or a half after the first harvest and will be harvested again in the late of August to early of September before flooding. Cultivation depends on skill behavior and allocation of water in the irrigation area.

2.2 SAR Data

RADARSAT-2 fine quad-polarization images were used to cover an area of approximately 25 x 25 square kilometers and were revisited 24 days. RADARSAT-2 FQ22 with a tilt angle of the camera 41 degrees was used at the Near range up to 42.4 degrees at far range. Nominal spatial resolution was 5.2 meters at slant range and 7.6 meters at Azimuth resolution with pixel resolution of 4.7 meters x 5.5 meters. A number of images used in the analysis of all 6 images were shown in Table 1. The ground survey was conducted in the area every 2 weeks correlating with satellite orbiting record or before and after 1-2 days.

Table 1

Detail of the RADARSAT-2 Fine Quad polarization data used in the study area

Data set	Beam	Incidence angle (deg.)	Date of acquisition (2011)
1	FQ22	41-42.4	February 23
2	FQ22	41-42.4	March 19
3	FQ22	41-42.4	May 06
4	FQ22	41-42.4	May 30
5	FQ22	41-42.4	June 23
6	FQ22	41-42.4	July 17

3. METHODOLOGY

3.1 Experiment

The study was planned to collect the ground survey. The sampling plot was seven plots and combined with satellites data in the study area. Parameters were consisting of leaf area index and height of rice. Figure 2 showed correlation of time between height and leaf area index. In the reproductive phase, rice was rising rapidly in contrast to that in the ripening phase which showed a slightly increase. The height of the rice grain was related to the stage after the sow. The leaf area index was relative to height and after sowing the rice (Figure 3).

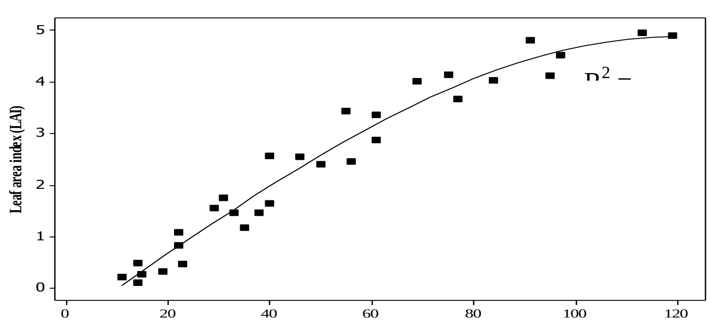
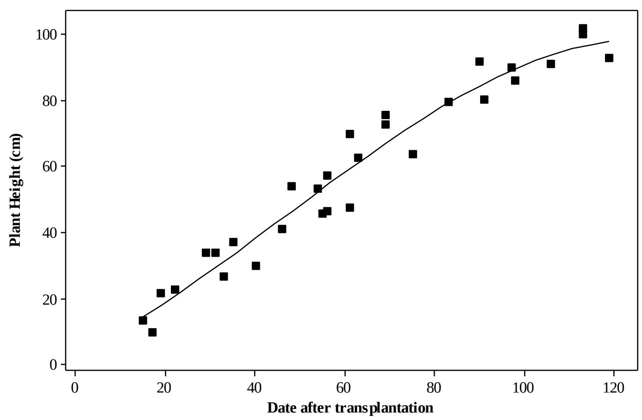


Figure 2 Relationship of rice crop leaf area index (LAI) with rice age after transplantation.

3.2. Backscattering coefficients of growth

Backscattering coefficients Quad Polarization and the growth of rice in the information stage were determined. RADARSAT-2 data in the form of the Digital number was converted to data in the form of Backscattering. A study by Fan Wu et al. (2010) has pointed out that the sum of HH polarization was the highest among all of the 4 polarization. LAI values were related to the HH polarization (Figure 4) and were increase compared to the ratio of HH / VV (Figure 5).



$R^2 = 0.9536$

Figure 3 Relationship of rice crop height with rice age after transplantation.

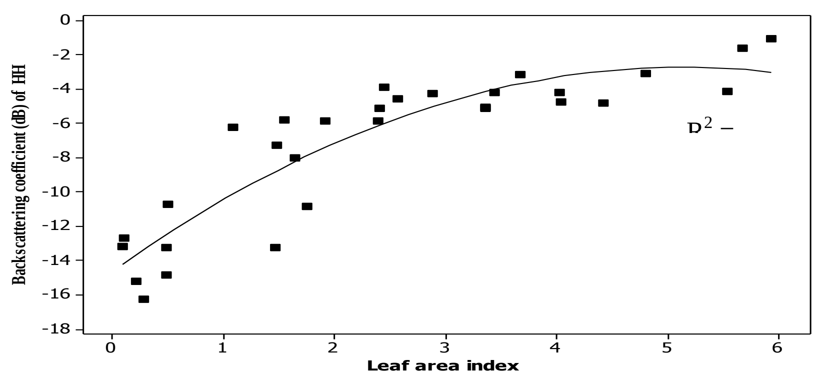


Figure 4 Backscattering coefficient (HH) as a function of leaf area index (LAI)

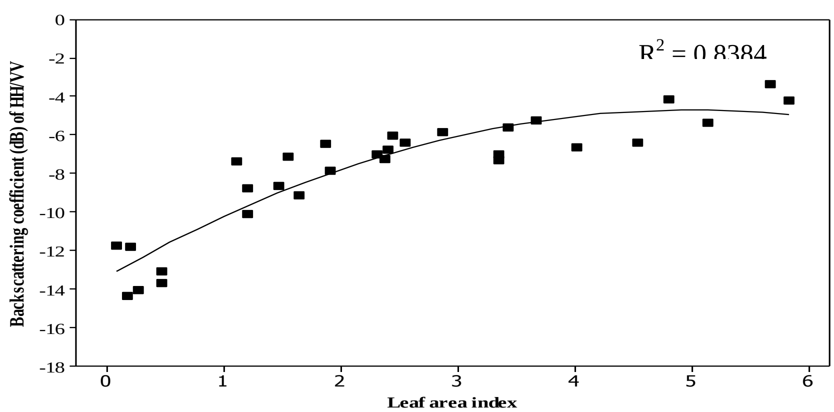


Figure 5 Backscattering coefficient (HH/VV) as a function of leaf area index (LAI)

4. RICE FIELD MAPPING AND RICE PRODUCTION

4.1. Classification of multi-date SAR data

RADARSAT-2 Quad polarization data was classified using simple classification method of the Polarization of the data layer. It was able to differentiate between two types of crops and non-rice crops. Analysis procedures were as follows

1. Information from satellite radar system was analysed by using NEST ESA SAR Toolbox. The distortion of the noise of data was then reduced with a 5 x 5 pixel Lee filter (Alexandre Bouvet, Thuy Le Toan, 2011) and the image was then created by Multilook the azimuth look at 5 and range look at 4. All data was geographically corrected by using SRTM-3 Version 4 and geocoding and radiometric calibration.

2. Backscattering coefficients was analyzed by using satellite and ground survey combineromd to land use mapping. This was used to distinguish the difference of rice and non-rice growing area of HH, HV, VH, VV polarization, and Pauli decomposition (HH/VV, HV+VH and HH+VV).

3. Classification of rice and non-rice crops by false color combination showed that HH/VV (even-bounce) could separate water, urban and rice plantation in each of the rice stage better than other polarization. In addition, it was also differentiating Early sown, Normal sown, and Late sown (Figure 6).

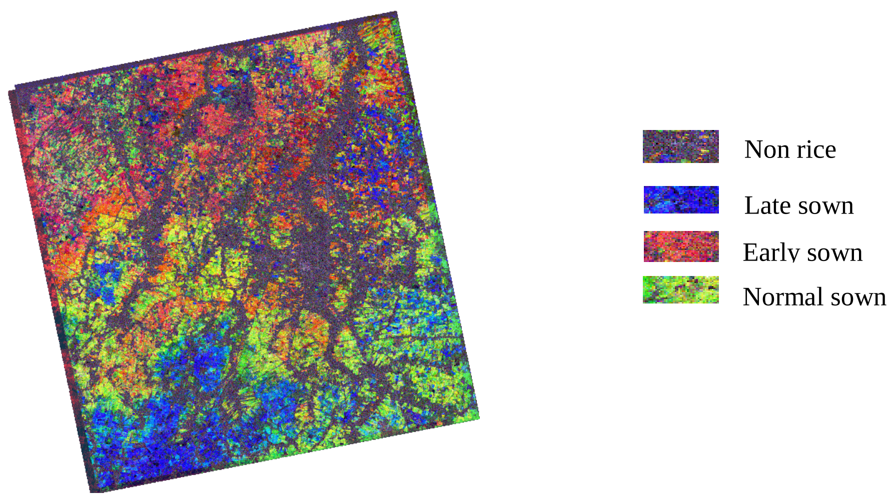


Figure 6 A visualization of satellite RADARSAT-2, through rice and non-rice area classification by using False color images, HH/VV, of the February 23 (Red), 19 March (Green), and May 6 (Blue)

The results of the processing Simple model showed rice yield per rai of each plot. This was evaluated with the areas classified by satellites, leading to the estimating rice production and the planning decisions as well as the further resources management.

5. CONCLUSION

A preliminary study using data from satellite, RADARSAT-2 Quad polarization together with simple model for monitoring rice areas and classification of rice and non-rice areas found that HH/VV polarization ratio can be used to differentiate between water urban and stages of rice. A simple crop model can also be used to estimate the rice yield. However the accuracy of the output from this simple model was needed to be analyzed in the next step.

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