A Review on Predicting Outbreak of Tungro Disease in Rice Fields Based on Epidemiological and Biophysical Factors

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***Abstract*—This paper reviews on tungro disease predictive technique in rice fields. The success of a monitoring system can be measured by its ability to provide early detection of pests for prevention of a serious outbreak of rice tungro. This paper also discusses on spectral reflectance data of epidemiological and biophysical factors that are related to tungro outbreak and also propose using these data along with an algorithm to predict probability of tungro disease occurrence. This information then could be used in agricultural decision support system for taking actions according to the level of threats that have been predicted.**

***Index Terms*—Tungro, rice disease, spectral reflectance data, prediction, decision support system.**

I. Introduction

Diseases become one of the most important causes of quality reduction in agricultural products [1]. Plant diseases can cause catastrophes through destroying large areas of agricultural fields. Controlling plant pathogens are difficult due to their changing populations according to time, space, and genotype, also, their evolution leaded to resistance. To reduce the losses, identification of cause, problem and remedies should be defined clearly [2]. Most of rice diseases occur in Asia and those diseases are related to climatic situation [3]. The timely detection and applying effective actions is a challenging aspect of disease control [4].

II. Tungro

The most important rice virus disease is tungro that transmit through green leafhopper. Southeast Asia is one of those regions which tungro is prevalent [5] and is one of the most damaging and destructive diseases of rice in this area. Outbreaks of the disease can affect thousands of hectares and at the early crop growth stage; losses can be as high as 100%. The damage depends on the variety, plant stage, the virus particles, and the environmental conditions. Absence of symptoms at early growth stage of the disease development is one of limitation in the way of tungro management [6]. Many farmers in South and Southeast Asia describe rice tungro disease as a cancer disease because of the severe damage it causes and the difficulty of controlling it [7] and [8]. The most serious tungro infestation occurred in 1982 in Kedah and Perlis when more than 20,300 ha of rice fields were affected by tungro and yield loss was about 34,000 tonne (US$10 million). Occurrence of tungro in paddy fields depends on epidemiological variables that can affect the probability of its occurrence in the field [9]. The concept of integrated pest management (IPM) was adopted for rice in Malaysia and the pest surveillance and forecasting system became a crucial component [10].

Elements that contribute to epidemiology of tungro are: irrigation, continuous asynchronous farming systems, weather condition, variety and fertilizers that play important role in predicting early tungro infection in the field (Table II) [7]. Leafhopper is one of the main insects of rice and is able to transmit rice tungro [11]. Using pesticides to control vector will not be effective and the operations threatens operator’s health [12]. Through identification of infected areas, selective spraying is possible with the use of detection methods that will provide an on-time protection as a key in protection methods and will limit applying fungicides to reduce environmental effects [13].

Sometimes when symptoms are detected, it is often too late or beyond the action level [10]. A major problem is that tungro symptoms can be mistaken with lack of nutrients or other rice diseases. Asynchronous planting can cause the tungro outbreak, because it will let vector to continue feeding, transmit the virus, lay eggs, and multiply. Using inappropriate varieties, applying high amount of fertilizers that contain nitrogen and high temperature are among those factors that will accelerate occurrence of tungro [9]. Leafhoppers population and the temperature are the main elements in determining plant-hopper population. Warnings in beginning stages and monitoring of plant-hopper during the cropping can be used in agricultural decision support system.

Early warning about tungro, allow management actions to be taken such as the adjustment of planting times or using of resistant varieties [14]. Epidemiology of disease and its role in development of disease stages and reproduction of disease agent, determined as the fundamental of recent plant disease prediction approaches through applying Bayesian decision theory and information technology [15]. The success of a monitoring system can be measured by its ability to provide an early detection of pests thus preventing a serious outbreak [10].

III. Plant Biophysical Parameters

Recent development in materials and optics have bring about applying smaller and accurate imaging spectrometers which will enable assessing of biophysical properties based

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on the spectral absorbing and scattering characteristics of the land surface [16]. In the case of disease detection, sometimes when symptoms were detected, it is often too late or beyond the action level. The success of a monitoring system can be measured by its ability to provide early detection of pests and to prevent a serious outbreak [10]. In some cases previous studies had attempted to use remote sensing measurements of vegetation, precipitation, and temperature to find out when and in which places conditions would be favourable outbreak of insects.

Also, biophysical parameters such as leaf greenness, leaf area index, plant height, leaf nitrogen content, leaf chlorophyll content, and associated factors (soil moisture) can be obtained through airborne and infield hyper-spectral remote sensing [17]. The 350 nm to 1,050 nm range spectrum determined as optimum range for estimation of agricultural biophysical information [18]. Physiological parameters such as chlorophyll and the carotenoid contents changed with more heavy infestation of cotton with spider mite [19]. One of the potential benefits of hyper-spectral remote sensing in Malaysia is the valuable data it produces for early detection of physiological changes in oil palm that will directly affect the cost for treatment and consequently the yield and decision making will be faster and more accurate [20]. Then it can be expanded to rice fields that will increase the productivity and supporting the disease management system.

IV. Epidemiological Factors

The probability of plant diseases occurrence depends on both environmental and epidemiological factors, so, diseases usually shows a patchy distribution in the farm [21]. Among the main epidemiological elements contribute to the rice disease are as follows:

A. *Insects*

Remote sensing can be used in the case of pests management in agriculture as a technique for observation of pests itself, detection of the effects of insects on plants and also the environmental factors that influence insects behavior [22]. Spectral bands across the visible and infrared regions are useful for monitoring differences in the conditions of rice infested with plant-hopper and leaf-folder [23]. Also, hyper-spectral remote sensing is useful to detect aphid damages in wheat [24]. Other example of using hyper-spectral imaging mentioned as using near-ground hyper-spectral Pushbroom Imaging Spectrometer showed that it is enough in the case of leaf-scale wheat aphides identification [25]. Combination of Geographical Positioning System (GPS) and video imagery leaded to entering longitude-latitude coordinates from GPS to Geographical Information System (GIS) and consequently mapping of white-fly invasion in the cotton field [26]. There is a possibility of forecasting outbreak of tungro disease with high accuracy based on precise information of vector activity and pathogen in the field [27]. The increase in tungro incidences came before the population increase of Nitrogen (N). It was revealed that increasing migratory activities of the first generation of leaf-hopper adults can be considered as an element of leaf-hopper population increase in the field [28]. Insect-damaged crops had been discriminated through hyper-spectral imaging [29]-[31].

Results showed that remote sensing is able to detect root oxygen stress through analyzing chlorophyll-fluorescence in rice [32]. The nitrogen in rice estimated in a non-destructive way through using canopy spectral reflectance in the range of visible and near infra-red spectroscopy mixed with LS-SVM regression [33]. Hyper-spectral reflectance and hyper-spectral characteristic was able to quantitatively determine the nitrogen nutritional status in rice [34].

B. *Variety*

Variety of rice has been determined as another contributor in tungro occurrence, because some varieties are resistant to tungro [7]. Space-borne hyper-spectral imaging has been used for the development of a crop-specific spectral library and automatic identification and classification of cultivars [35], [36]. Also, crop reflectance beside spectral library had successfully resulted 86.5% and 88.8% spectral variability by hyper-spectral reflectance data at canopy [37].

V. Proposed Predictive Approach

Through reviewing previous works in the case of Lyme disease, and rice-land anopheline populations they concluded that remote sensing and GIS technologies can provide scientists with a new perspective with which to study the factors influencing the patterns of vector-borne diseases at a variety of landscape scales [38]. Reflectance measurements of rice canopy growth stages obtained through remote sensing and GIS can be used to determine the probability of paddy fields became the anopheline host two months before the increase of larva populations, with a 90% accuracy [11], [39], [40]. The best results for identifying diseases were obtained with hyper-spectral information in the visible and near-infrared spectrum [41], for example to detect bacterial leaf blight, rice panicle blast and fungus (bipolarize oryzaein) in rice [42]-[44], stem rot disease in oil palm [45], severity of yellow rust [46], healthy and infected rice plants affected by leave folder [47] and [48], rice brown spots (fungal disease) [31], [49], [50]. It can be said that most plant diseases can be detected and discriminated through applying hyper-spectral remote sensing and showed high ability of this technology in the field of plant disease identification and detection. Further approaches for using hyper-spectral data in the case of predicting tungro disease in rice could be through applying field-spectrometer along with hyperion instrument on the Earth Observing-1 (EO-1) satellite of NASA (records visible light and other reflected electromagnetic energy ranging from 0.4 to 2.5 mm in 220 channels) and spectral bands across the visible and infrared regions for monitoring epidemiological factors. Smoothing reflectance data through calculating first derivative reflectance and applying correlation analyses between the spectral data and disease index should be performed. As a result, sensitive spectral ranges will be selected according to the correlation coefficient for the relationships between the estimated and measured disease index, coefficient of determination, error and correct recognition ratio. The spectral library, which contains reference spectra, will be built using spectral module of Environment for Visualizing Images (ENVI) image processing software. Back propagation neural network model is a full-connected neural network including input layer, hidden layer, and output layer to build a predictive model for disease and training and testing with the MATLAB software. A dynamic simulation model for the risk of disease based on systems analysis is needed to calculate a daily infection risk based on epidemiological factors and infection of host tissue causing the disease. Disease transmitter and dispersal will be calculated as functions of epidemiological and biophysical factors, while the main factors affecting the infection rate are some of those factors.

VI. Conclusion

Through using lots of spectral channels that are available through applying new technology, spectroscopic techniques could be applied in image processing especially in the field of precision agriculture. Combining hyper-spectral remote sensing data and predictive models had been attended in recent years. Developing predictive models in the case of tungro disease in rice could be an important step for food security and less application of chemicals in rice fields. Developing cost-effective predictive algorithm is able to increase the accuracy performance for the very high computational needs of remote sensing applications. Future works will be the development of a method for the prediction of the rice disease.

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