Application of UAV multi-spectral camera for estimating bananas disease infestations in complex farming in Phitsanulok Province

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ABSTRACT

Phitsanulok Province located in the lower north, Thailand. The famous souvenir of Phitsanulok is dried bananas. The yield from bananas farm is essential as it is used as a raw material for production. The application of Remote Sensing methods to asses crop vigor and yields has had limited applications in Phitsanulok Province due largely to limitations associated with satellite images. The increasing use of Unmanned Aerial Vehicles (UAV) in recent times opens up new possibilities for remotely seeing crop status and yields even on complex smallholder farms.

This study demonstrates the applicability of a vegetation index derived from UAV multi-spectral cameras imagery to assess bananas crop vigor and yields at various stages of crop growth. The study employs a quadcopter flown at 80 m over farm and equipped with 6 bands cameras, RGB, Blue, Green, Red, Red Edge and Near Infrared. The Normalized Difference Vegetation Index (NDVI), Enhance normalized Difference Vegetation Index (ENDVI) and red-edge chlorophyll index (CI_{RE}) were compared. To Estimating bananas vigor and yields, we found that ENDVI and CI_{RE} is better indicator of crop vigor and a better estimator of yields than NDVI.

1. INTRODUCTION

Mali-Aong Banana is a widely grown cash crop in the Phitsanulok. In Bang Krathum District, Phitsanulok Province, there are products that are known as provincial products, famous abroad and have been registered as a type of intellectual property with Geographical Indication (GI) is Bang Krathum dried bananas. The most important raw material for making Bang Krathum dried bananas is bananas. The most suitable banana for making Bang Krathum dried bananas is Kluai Nam Wa Mali Ong (Mali-Aong bananas). Originally, Kluai Nam Wa Mali Ong planted a lot in the small fields at the end or border of the rice farm. After being used to make dried bananas, it has to know that this banana has possessions that are suitable for making dried bananas the most.

"Kluai Nam Wa Mali Ong" is considered an important alternative economic crop in the current situation. In the past few years, it has been affected by drought as well as the impact of deadly disease and banana borer. Make the banana price drop. Phitsanulok Province It is the largest source of dried banana products in Thailand. Farmers have a large demand for banana cultivars for planting. Instead, they pay more attention to the prevention of mortality before planting, and will see the importance when the bananas show symptoms of disease, which is not timely and difficult to fix.

Figure 1 Kluai Nam Wa Mali Ong tree

Banana borer of banana larvae are the larvae of weevils pierce banana stems The scientific name is Odoiporus longicollis (Olivier,1870. It is a beetle of the family Curculionidae. Characteristics of destruction and distribution generally, the adults of the banana larvae have a habit of laying eggs along the sheath of banana leaves in the trunk above the ground until about the middle of the trunk. When hatched from the eggs, the larvae from stage 1 will gradually penetrate and eat into the banana stems gradually to the center of the trunk. The external symptoms that are noticeable by the eye are around the banana plant is a common pore and dead banana.

Figure 2 Banana bore and the damage to banana plants

If destroying in the near term until the chain falls will make the network break in the middle of the beginning or wither, perennial, die throughout the period of Ji Life will live in the area of the trunk and the leaf axils. The species can be found spreading in many areas around the world, including Bhutan, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam.

Once a diseased plant has been found, 'timely removal' is the best way to avoid the formation of a disease center (Picq, 2020). Therefore, timely monitoring of banana disease is important for the disease treatment and crop planting adjustment. Traditional ground surveys to collect crop disease data are expensive and time-consuming(Shi Y Y *et al*, 2018), Remote sensing technology has become a feasible means for crop disease detection and assessment in the past few decades, including for detecting Fusarium head blight, dead bananas and rust infection in wheat (Jin X *et al* 2018, Mahlein A K *et al*, 2019, Huang W J *et al*, 2007) bacterial leaf blight in rice, and grey leaf spot in maize. When plants are infected with diseases, the leaf water, pigment content and internal structure undergo changes, which are reflected in the spectral signature of the plants. Many spectral features of vegetation were found in the red-edge, NIR, Red band that is related to changes in chlorophyll content and leaf area index, and significant changes were observed when bananas were infected with dead bananas. In recent years, various lightweight multispectral sensors that include the blud, green ,red, red-edge nir and visible band (i.e., DJI Phantom 4 multi-spectral camera with RTK) were designed specifically for Unmanned Aerial Vehicle (UAV) platforms for vegetation monitoring. With the rapid development of UAV technology, UAVs have been increasingly used for acquiring imagery to extract phenotypic information of crops rapidly due to their advantages (i.e., high spatial resolution, ease of operation, high flexibility, and acquisition of data on demand). Moreover, scale effects and scaling have become one of the most important research topics in remote sensing. Different spatial resolution images show different landscape characteristics, and data with higher spatial resolution usually get more accurate estimates. However, seeking very high resolution data is unnecessary and unrealistic in the agriculture application at a regional scale as it is expensive and difficult to process. Therefore, it is very important to choose a suitable spatial resolution image for agricultural monitoring.

The objectives of this study were to (i) develop an identification method for the dead zone of banana using UAV-based multispectral imagery, (ii) determine the optimal VI for establishing an optimal identification model, and (iii) assess the effect of different image resolution on the identification accuracy of dead banana from disease to provide a reference for large-scale applications of satellite-based data.

2. METHEOLOGY

2.1 Study Area

The experiments were conducted at Bangkrathum district (Figure3). Bang Krathum District is located in the upper central region and the lower northern region. The condition of the area is generally flat, no mountains and forests. The climate is divided into 3 seasons: summer, from late February to May. In summer the weather is very hot. Influenced by the southeast

monsoon which is a hot wind. In the rainy season starting from May to October and in the next season from October to January which was influenced by northeast monsoon period of extreme cold from China.

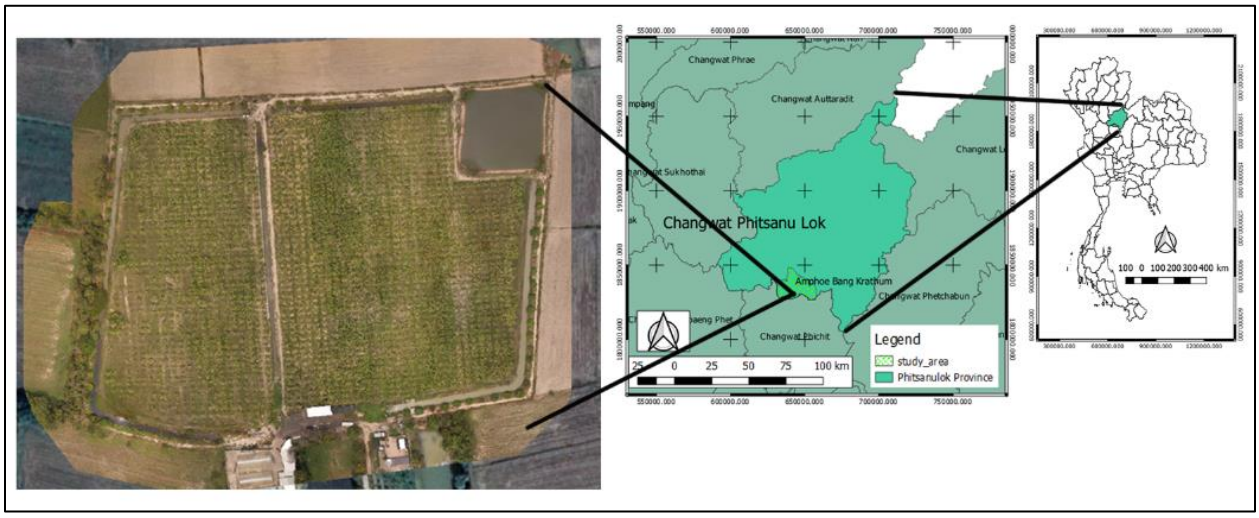

Figure 3 Location of the study area in Amphoe Bang Krathum

2.2 UAV Multi-Spectral Camera and RTK Acquisition

The study area is located at the Banana Society Company. The surveys were done using a DJI Phantom 4 Multi-Spectral Camera with RTK (Figure 4).

This UAV was equipped with a five-band multispectral camera which has five narrow bands: Blue (465–485 nm), green (550–570 nm), red (653–673 nm), red edge (712–722 nm), near-infrared (800–880 nm) and one RGB (visible) band. The flight at the site was conducted between 14:00 p.m.–14:30 p.m. and covered an area of 21 ha. The flight at Hainan site was conducted between 11:00 a.m.–12:00 p.m. on 11 December 2018 and covered an area of 60,500 square meter. The flight plans were developed to ensure greater than 80% cross-track and along-track overlap rates. The multispectral imagery was acquired from a flying height of 100 m above the ground with a ground sample distance of 0.08 m. The multi-spectral imagery is 125 images

Figure 4 Phantom 4 Multi-Spectral Camera with RTK

2.3 Data Analysis

In this study, different VIs were used to identify the infestation status of banana plants. These resolutions were selected because they were similar to those of several mainstream and easily accessible satellite imagery products (i.e., WorldView series with a resolution of 0.5 m, GF-2 with a resolution of 1 m, GF-1 and GF-6 with a resolution of 2 m, RapidEye with a resolution of 5 m, and Sentinel-2 with a resolution of 10 m) for agricultural applications.

2.3.1. Vegetation Indices

Considering the potential pathological characteristics of the Fusarium wilt disease infestations, eight VIs related to pigment absorption and plant growth were selected to characterize the biochemical and biophysical variations caused by individual infestations. The VIs included the Normalized Difference Vegetation Index (NDVI), Enhance normalized Difference Vegetation Index (ENDVI) and red-edge chlorophyll index (CI_{RE})

Table 1 List of vegetation indices developed for remote sensing applications.

Vegetation Index	Equation	Reference
Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{NIR - RED}{NIR + RED}$	Rouse et al., 1974
Enhance normalized Difference Vegetation Index (ENDVI)	$ENDVI = \frac{((NIR + Green) - (2 * Blue))}{((NIR + Green) + (2 * Blue))}$	Gitelson et al. 1996
red-edge chlorophyll index (CI_{RE})	$CIre = \frac{NIR}{(RE - 1)}$	Gitelson et al. 1996

3. RESULE

We analyzed the differences in the VI values between the healthy and diseased samples obtained from the experiment area, and conducted independent t-test analyses for each sample. The results showed that there were significant differences in the values of NDVI, GNDVI and CI_{RE} between the healthy and diseased samples.

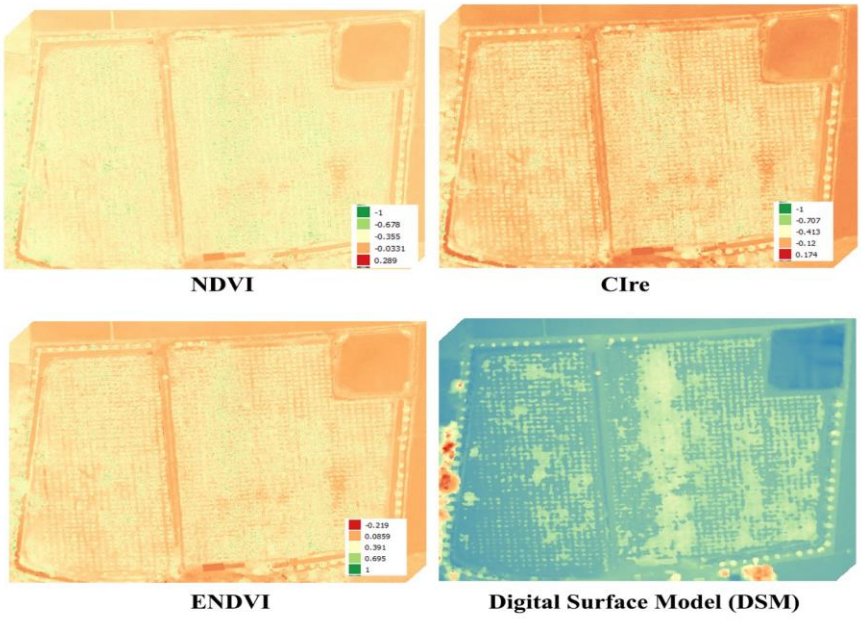

Figure 5 The result of all VI indexs

4.DISCUSSION AND CONCLUSION

The results of this study indicate that the CI_{RE} was the optimal red-edge VI and the NDVI, ENDVI were the optimal non-red-edge VI for developing identification models for banana disease infestations. This is attributed to the fact that as the infection of disease progresses, the chlorophyll content decreases significantly, and the CI_{RE} values are sensitive to small variations in the chlorophyll content.

This study used VIs derived from UAV-based multispectral imagery and BLR to develop an identification method for detecting banana Fusarium wilt. The results showed that disease infestations of banana can be identified with this method.

5. REFERENCE

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