

A NON-DESTRUCTIVE METHOD OF ESTIMATING RED TIP DISEASE IN PINEAPPLE

SK Balasundram^{1*}, AK Faizah², G Vadamalai² and MHA Husni³

¹ Department of Agriculture Technology, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

² Department of Plant Protection, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

³ Department of Land Management, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

** Corresponding author (siva@putra.upm.edu.my)*

ABSTRACT

Red Tip disease typically reduces pineapple yields by up to 50%. At present, the causal agent of Red Tip disease is still unconfirmed. Based on disease symptoms and transmission mode within the field, however, Red Tip disease seems to be strongly associated with viral infection. In this work, we assessed the feasibility of using Greenseeker®, an optical sensor, to estimate Red Tip disease severity. This work was performed in a commercial pineapple plantation located in Simpang Renggam, Johor, Peninsular Malaysia. Four 1-ha plots bearing pineapple variety SR36 were demarcated based on crop growth stage. Two plots were used for Disease Severity (DS) and Normalized Difference Vegetation Index (NDVI) recording followed by model calibration, and the other two were used for model validation. A total of eighty corresponding measurements of % DS and NDVI were taken from each observation plot. Results showed a strong correlation between % DS and NDVI. The 7- and 11-month plantings had an r value of -0.83 and -0.88, respectively. The negative correlation infers that NDVI increases when disease severity is low. This is expected since healthy leaves reflect more near-infrared light and less visible light which results in a higher NDVI. The regression of NDVI on % DS for the 7-month planting was explained by: % DS = 181.6 - 185.6*NDVI. Meanwhile, the regression of NDVI on % DS for the 11-month planting was explained by: % DS = 213.2 - 219.8*NDVI. The

linear fit between measured % DS and estimated % DS from the 7-month and 11-month plantings was relatively strong (r value of 0.84 and 0.91, respectively). This infers that NDVI is a reliable predictor of % DS in pineapple. This work suggests that the Greenseeker® is a feasible tool for non-destructive estimation of Red Tip disease in pineapple.

Keywords: Pineapple, Red Tip disease, Greenseeker®

INTRODUCTION

Malaysian pineapple yields have declined by more than 50% over the past 15 years. One of the main causes of pineapple yield decline is disease susceptibility. Several pineapple diseases have been reported in Malaysia, including Red Tip in Gandul variety. Typical symptoms of Red Tip disease include reddening of more than 10% of the total leaves per plant, downward curling, tip dieback, stunting, and early ripening of fruits. The epidemiology of Red Tip disease is still not fully understood. At present, Red Tip-infected plants can only be determined based on visible symptoms, which occur as early as six months after planting.

Early detection of crop stress will help minimize production losses, especially in large scale plantings. Recent advancement in remote sensing technology offers the potential of early detection of crop stress non-destructively. Remote sensing has been shown to be a powerful tool for monitoring of crop growth (Abou-Ismael et al., 2004, Zhang and Qin, 2005). The ability to detect crop diseases via remote sensors lies on the premise that there is a fundamental relationship between the electromagnetic spectrum and the biophysical processes within a crop. Crop stress caused by disease will result in metabolic changes that will eventually lead to changes in the way the crop reflects incident radiant energy.

Greenseeker® is a handheld optical sensor that non-destructively captures reflectance energy from target surfaces within the visible and near infra red regions of the electromagnetic spectrum. These regions are known to provide

information about plant physiological stress (Muhammed, 2005). A non-destructive sensor approach of disease detection will potentially save time previously spent on randomly scouting for potential disease problems, and offers valuable quantitative and near real-time information about crop health.

This work was aimed at assessing the feasibility of using GreenSeeker® to estimate Red Tip disease severity in pineapple.

MATERIALS AND METHODS

Experimental site

This work was carried out in July of 2009 in a commercial pineapple plantation located in Simpang Renggam, Johor (1° 50' 0" North, 103° 19' 0" East), a state located in the south of Peninsular Malaysia.

Plot layout

Four 1-ha plots bearing pineapple variety SR36 (a cross between Gandul and Sarawak) were demarcated based on crop growth stage (i.e. 7- and 11-month after planting). Two plots were used for crop sampling followed by model calibration, and two others were used for model validation. A total of eighty points were geo-referenced using a global positioning device (Trimble Pathfinder Pro XR) using a systematic sampling scheme.

Crop measurements

Each crop sample was measured for Disease Severity (DS) and Normalized Difference Vegetation Index (NDVI). DS was taken as the percentage of leaves showing Red Tip disease symptoms (i.e. leaf reddening, tip dieback and downward curling). NDVI, computed as the ratio of measured intensities in the visible and near infra red bands, was obtained in real-time using GreenSeeker® (Model 505; NTech Industries Inc., California, USA). The

effective distance between the GreenSeeker® and the crop canopy was set at 20 cm.

Each NDVI record from a crop sample was averaged from ten recordings within the same crop sample. A total of eighty corresponding measurements of % DS and NDVI were obtained from each observation plot. In each plot, % DS and NDVI recordings were taken at every five planting beds, where each bed comprised two randomly selected crop samples as recording points.

Data analysis

Correlation and regression analyses were performed using Minitab 14 to determine the relationship between % DS and NDVI.

RESULTS

The correlation between NDVI and % DS was strong. The 7- and 11-month plantings registered r values of -0.83 and -0.88, respectively. The negative correlation infers that NDVI increases when disease severity is low. This is expected since healthy leaves reflect more near infra red light and less visible light which results in a higher NDVI.

The regression of NDVI on % DS for the 7-month planting was explained by the following model: $\% DS = 181.6 - 185.6 * NDVI$ (Figure 1). Meanwhile, the regression of NDVI on % DS for the 11-month planting was explained by the following model: $\% DS = 213.2 - 219.8 * NDVI$ (Figure 2). The linear fit between measured % DS and estimated % DS from the 7-month and 11-month plantings were relatively strong with an R^2 of 0.71 and 0.84, respectively (Figures 3-4).

DISCUSSION

Results clearly show that increased Red Tip disease severity was associated with the increase in visible light reflectance (from 0.4 to 0.7 μm), and decrease in near infra red reflectance (from 0.7 to 1.1 μm). Stressed vegetation reflects more visible light and less near infra red light possibly because of its lower concentration of chlorophyll, which then facilitates expression of other photosynthetic pigments (Chappelle et al., 1984). Stunted pineapple with high Red Tip disease severity typically displays intense reddening and wilting on 25-50% of its leaf surface.

Both regression models give a reasonable estimative ability of Red Tip disease severity. Thus, NDVI is a reliable estimator of Red Tip disease severity in

pineapple. This work has demonstrated the utility of a remote sensing approach for detection and preliminary screening of crop disease.

CONCLUSION

This work suggests that the Greenseeker® is a feasible tool for non-destructive estimation of Red Tip disease in pineapple.

REFERENCES

Abou-Ismaïl, O., Huang, J.F. and Wang, R.C. 2004. Rice yield estimation by integrating remote sensing and rice growth simulation model. *Pedosphere*, 14: 519-526.

Chappelle, E.W., Wood, F.M., McMurtrey, J.E. and Newcomb, W.W. 1984. Laser-induced fluorescence of green plants: 1. A technique for the remote detection of plant stress and species differentiation. *Applied Optics*, 23 (1): 134-138.

Muhammed, H.H. 2005. Hyperspectral crop reflectance data for characterizing and estimating fungal disease severity in wheat. *Biosystems Engineering*, 91 (1): 9-20.

Zhang, M. and Qin, Z. 2004. Spectral analysis of tomato late blight infection for remote sensing of tomato disease stress in California. *IEEE 2004 International Geosciences and Remote Sensing Symposium*, VI. Anchorage, Alaska, USA. Pp. 4091-4094.

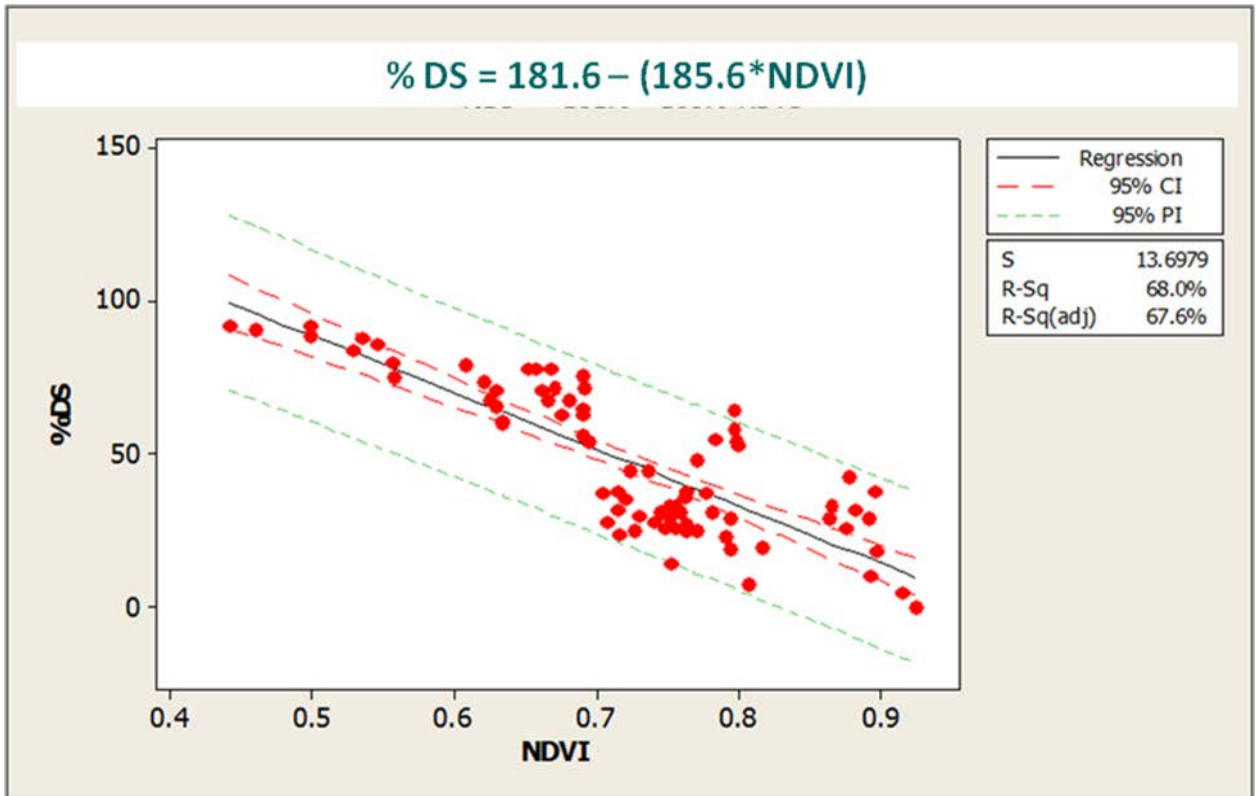


Figure 1: Regression of NDVI on % DS at 7 months after planting

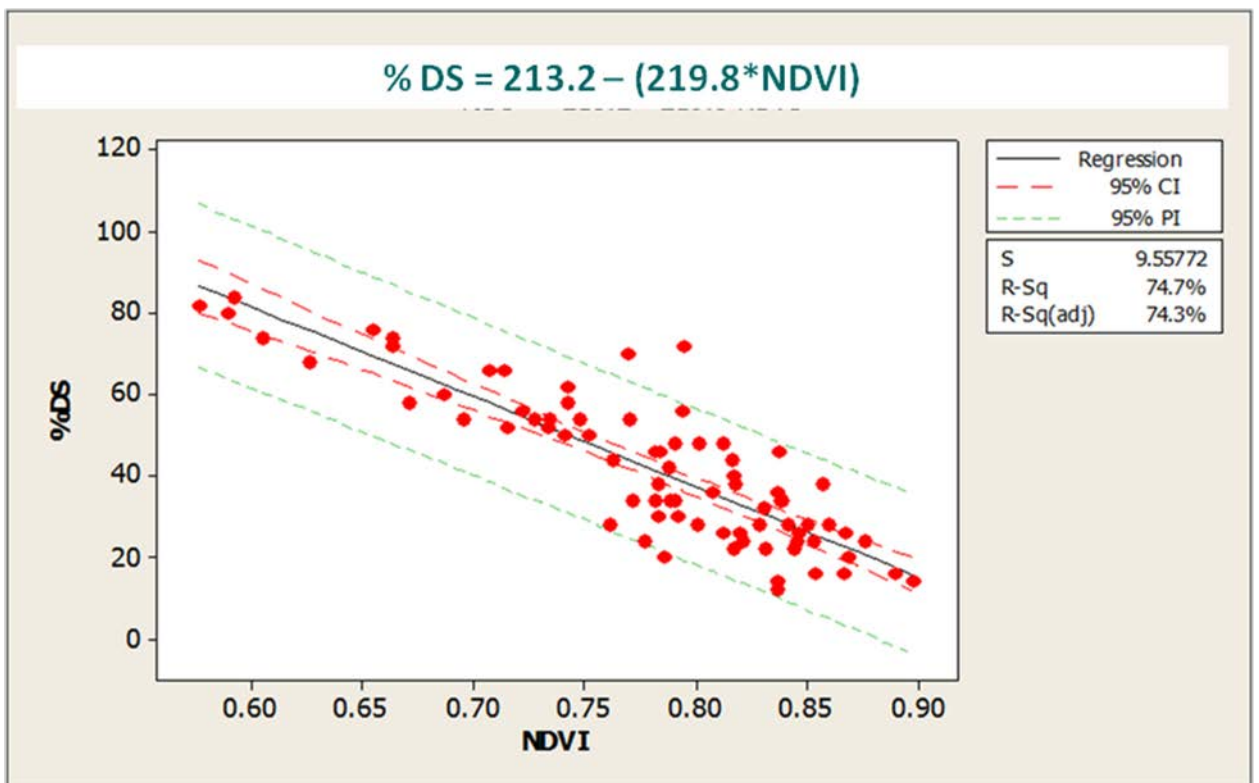


Figure 2: Regression of NDVI on % DS at 11 months after planting

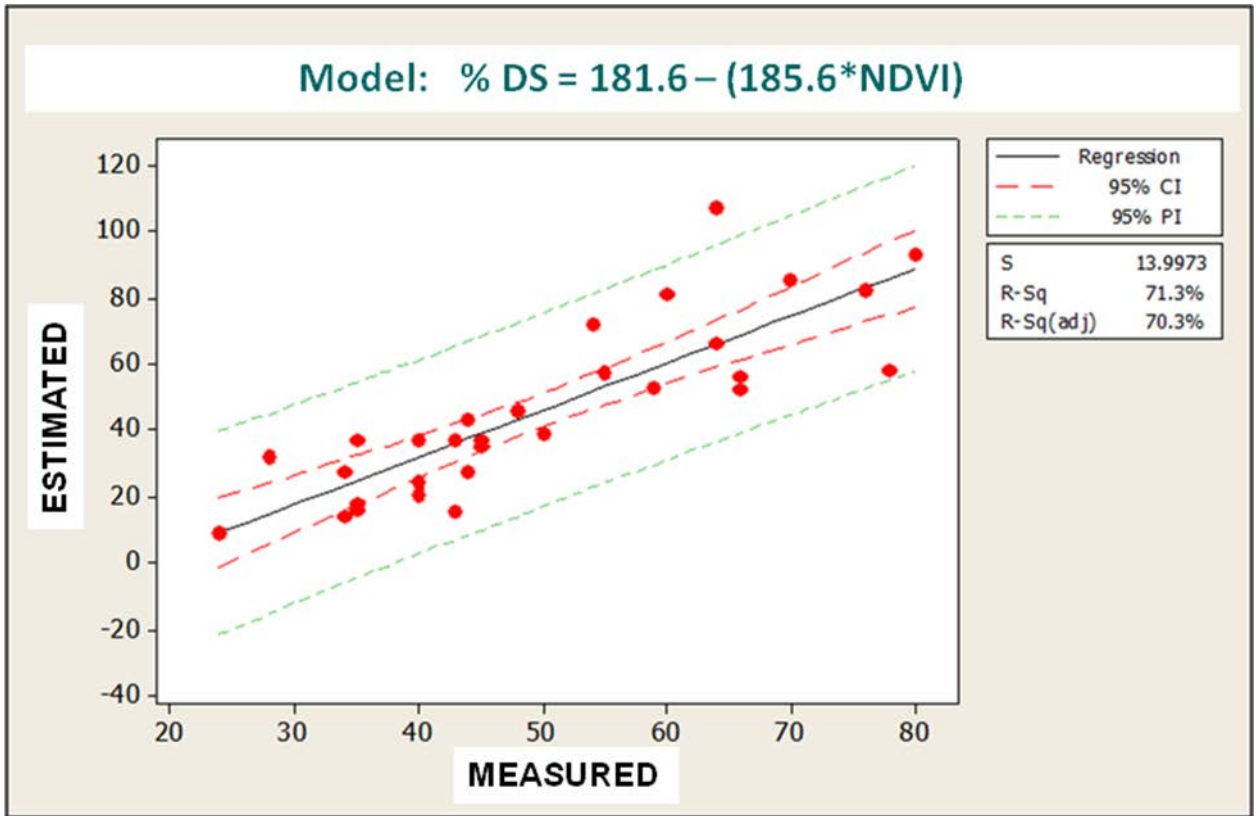


Figure 3: Accuracy of model estimation for 7-month plantings

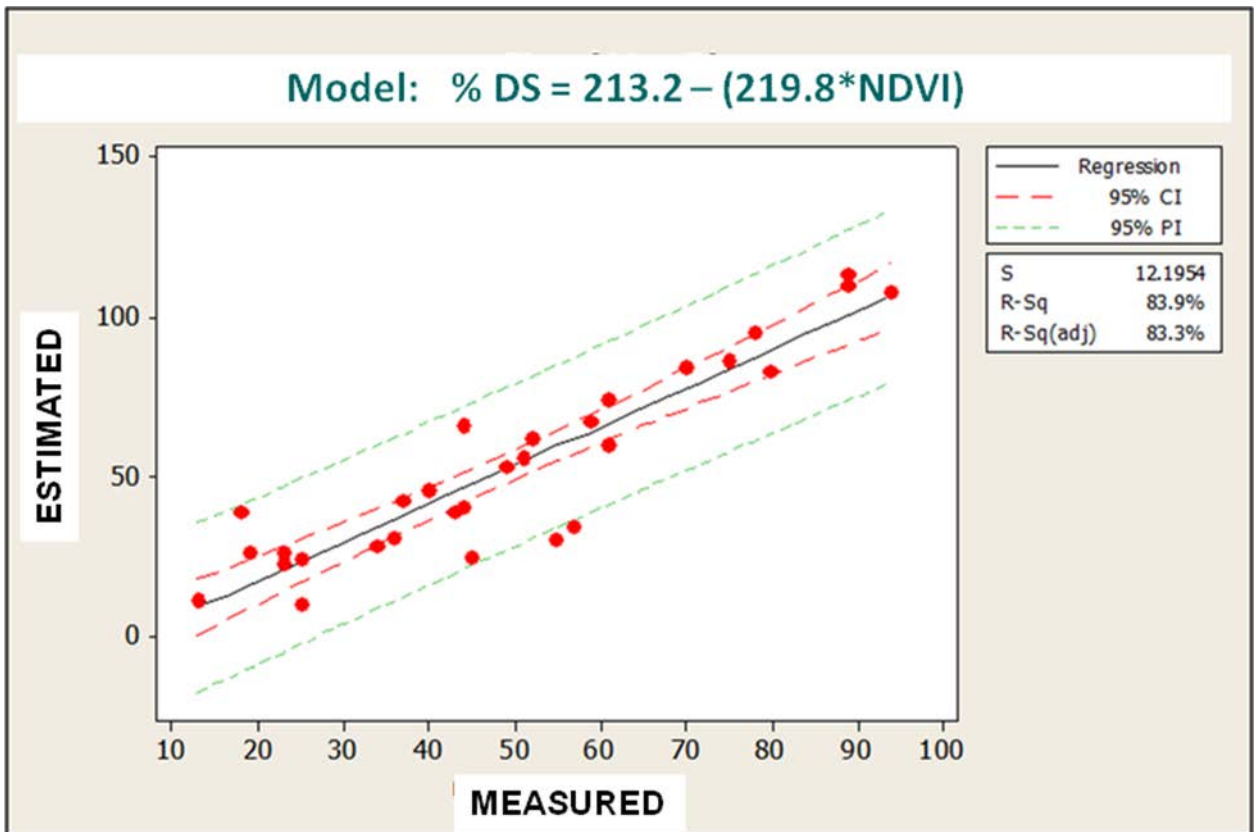


Figure 4: Accuracy of model estimation for 11-month plantings