Potential for using low-cost spectral sensors to predict yield in small-scale rice fields in northwest Cambodia

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Introduction

Smart technology is playing a vital role in making crop management decisions (Awan et al., 2018). However, advanced high throughput technologies may be a significant adoption challenge for small-scale rice growers in Cambodia due to cost and accessibility. Hence, developing algorithm to predict yield in-season using cost-effective technologies is a better intervention to support Cambodian rice growers.

GreenSeeker-NDVI and Canopeo are potentially emerging affordable tools that can produce a working algorithm to support small-scale rice growers. Thus, we hypothesized that low-cost sensors can predict yield in small-sale rice fields. Therefore, the objective of the study is to calibrate a working algorithm for predicting yield in small-scale rice fields in northwest Cambodia.

Materials and Methods

Spectra data were collected from different field experiments at Battambang and Banteay Meanchey Provinces in 2018 Cambodian wet season. GreenSeeker-NDVI and Canopeo were scanned 70 cm above crop canopy in transect at varying growth stages simulteneously. A total number of 720 sample size of individual spectral data was collected. Data were analysed using simple linear regression (SLR) model to determine a better predictor of rice yield between both spectral sensors. While multiple linear regression (MLR) was used to develop a model to rice predict yield at harvest using the spectral indices as well as easy to measure climatic variables; cumulative rainfall, average temperature including insect and disease counts.

Data were split into 80:20 % for training and testing of the model respectively. Model accuracy was evaluated using the coefficient of determination (r^2), Lin's concordance correlation coefficient (LCCC) and root mean square error (RMSE).

Results and Discussion

The result indicates that NDVI had a higher coefficient of determination ($r^2 = 0.36$) in predicting yield at panicle differentiation (PD) stage in the early wet season and r^2 of 0.4 at grain filling (GF) stage in the main wet season than Canopeo index (CI) using SLR model. When data was pooled across locations, NDVI explained 30 % of the variability in yield at GF stage than CI. This explains that each spectral index showed limited capability in estimating yield which could be attributed to environmental heterogeneity in rice ecosystems with soil increasing saturation effects or higher concentration of plant pigments at visible wavelength (Ali et al., 2014).

Alternatively, the MLR model indicates that combination of cumulative rainfall, insect counts and CI explained 66 % of variation in yield at PD stage. The results of the validation model indicate the model performs reasonably well ($r^2 = 0.53$, LCCC = 0.7 and RMSE= 0.46) at PD stage than GF stage (Figure 1). Thus, model performance was improved by integrating environmental variables with spectral sensors indicating the usefulness of environmental variables to develop a robust model for yield prediction.

Conclusions

The MLR model clearly showed the potential for using spectral sensors in combination with environmental variables to predict yield in small-scale rice fields. More spectra data collection are underway on the rice fields with varying conditions to validate model robustness.

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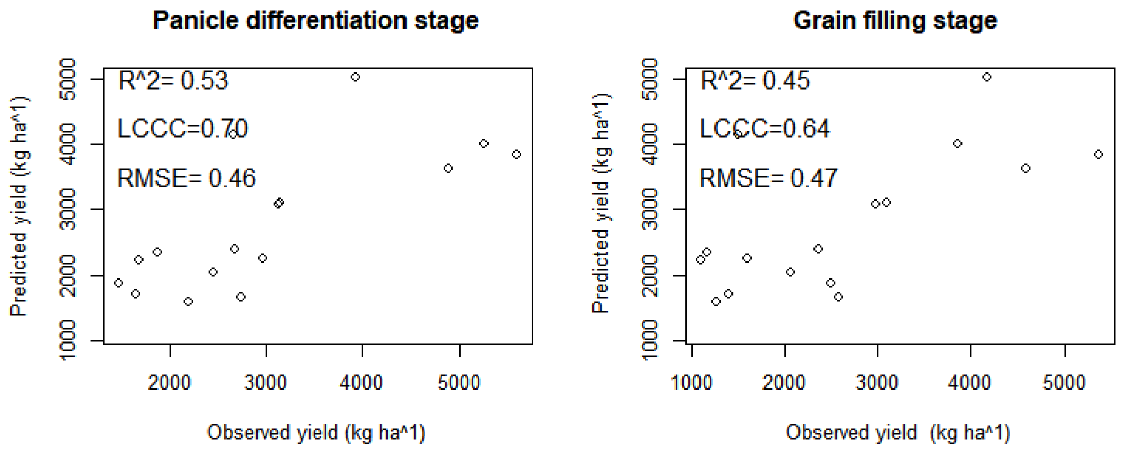

Figure 1. Cross-validation between observed yield and predicted yield across both locations in 2018 planting season

Keywords: Spectral indices, Rice paddy, Yield prediction.

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