Predicting shoot biomass and nitrogen concentration of rice by canopy reflectance data and first derivative analyses

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Introduction

For site-specific nitrogen (N) fertilizer topdressing rate prescription, an in-situ, fast and nondestructive method for crop biomass and N status determination is indispensable. The objectives of this study were (i) to select the maximum slopes of reflectance region from 400-1050 nm and (ii) to estimate rice shoot biomass and N concentration by stepwise multiple linear regression (SMLR) using reflectance data at the selected maximum slope positions.

Materials and Methods

Two experiments were conducted in the Experimental Station, Seoul National University in year 2004 with variable N applied rates at tillering, panicle initiation stage (PIS) and rice varieties. Canopy reflectance, shoot dry weight (SDW), and shoot N concentration (SN) were measured on July 03 and July 09 were used for model calibration and validation to predict SDW and SN using the first derivative (Zhao et al., 2005) and stepwise multiple regression analyses.

Results and Discussion

The results revealed that the maximum slopes of reflectance located at 540, 585, 631, 658, and 673 nm in the visible region, 726, 745, and 778 nm in the red edge region and 957 and 981 nm in the near infrared region (Fig. 1). The importance of the selected waveband reflectance has been discussed by Thenkabail et al. (2000) The stepwise linear multiple regression models to predict SDW and SN using selected reflectance were as follows·

$SDW = 260.7 + 18.69R_{957} - 8.66R_{778} - 638.26R_{763} + 927.14R_{631} - 384.48R_{585}$ (R^2=0.75)

$SN = 25.0 - 16.1R_{585} + 13.4R_{540} + 26.0R_{673} - 121.4R_{631} + 70.9R_{658}$ (R^2=0.74)

In general, the stepwise multiple linear regression (SMLR) model using reflectance variables at the ten selected positions of the maximum slopes of reflectance produced higher and more consistent R^2, root mean square error in prediction (RMSEP) and relative error in prediction (REP) in calibration and validation sets than the model using all of 445 waveband reflectance data (Table 1). The R^2 and REP derived from regression between measured and calculated values in independent validation set by the calibrated model equations were 0.66 and 13 5% for SDW and 0.73 and 8 5%. for SN, promising its application for SDW and SN prediction in rice production

Key references

Zhao, D., Reddy, K. R., Kakani V. J., & Reddy V. R. (2005). European Journal of Agronomy, 22, 391-403.

Thenkabail, P. S., Smith, R. B., & Pauw, E. D. (2000). Remote Sensing of Environment, 71, 158-182.

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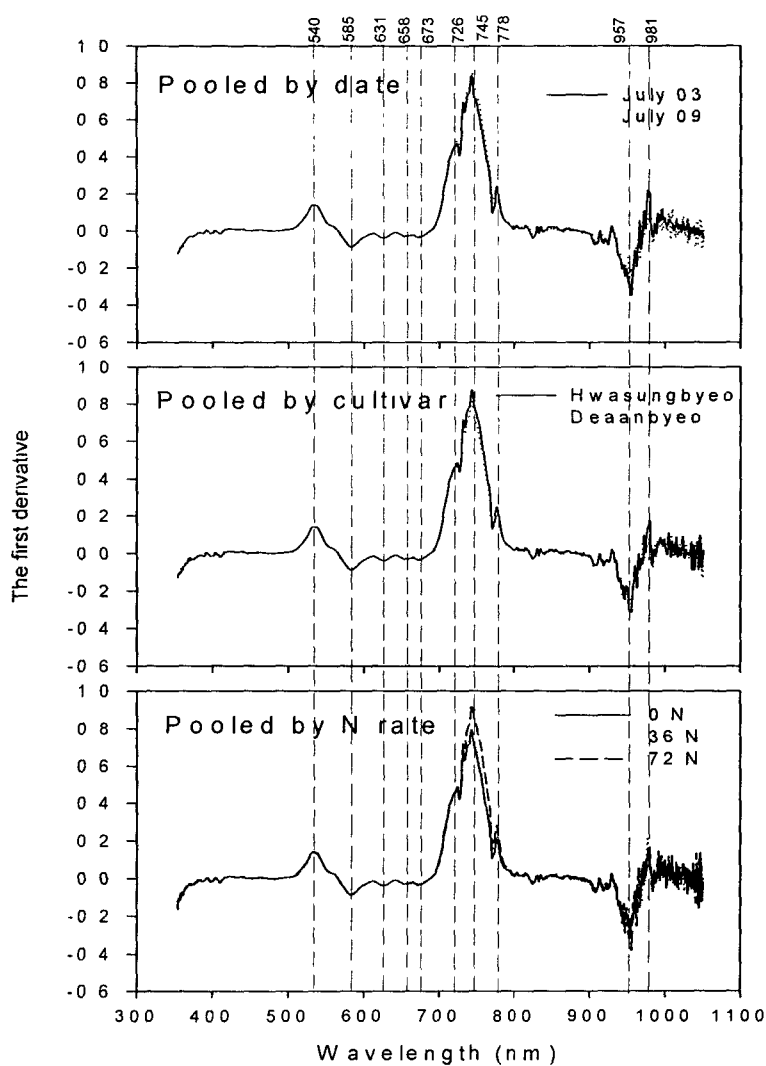
Fig. 1. The first derivative mean by measuring date, cultivar and N rate (kg ha^{-1}) applied at tillering stage (13 DAT). Numbers on the top of the graph were critical wavelength (nm) selected by derivative analysis.

Table 1. Description of calibrated and validated stepwise multiple linear regression models to predict agronomic variables

Crop variables	Model using 10 selected reflectances			Model using 445 reflectances		
	R^{2a}	RMSEP	REP	R^2	RMSEP	REP
Calibration						
Shoot dry weight	0.75	31.4	13.1	0.87	22.6	9.5
Shoot N concentration	0.74	2.18	9.0	0.64	2.59	10.6
Validation						
Shoot dry weight	0.66	32.8	13.5	0.51	41.8	17.2
Shoot N concentration	0.73	2.10	8.5	0.56	2.69	10.9