AGP58 CROP CANOPY REFLECTANCE SENSOR USE FOR NITROGEN FERTILISATION IN SUGARCANE FIELDS

By

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Abstract

Nitrogen (N) use efficiency of sugarcane is low (± 30%) and there is difficulty in estimating N needs by the sugarcane crop within local conditions. To aid in decision-making for location-specific nitrogen application, crop canopy reflectance sensors were examined for N management in sugarcane. Experiments in commercial fields in the region of Ribeirão Preto, São Paulo State, Brazil, were conducted in order to evaluate different N rates, nitrogen uptake, chlorophyll amount, leaf N concentration, and yield and their relationships with canopy sensor measurements. The sensors studied were CropCircle ACS-210 and N-Sensor ALS. High correlation of canopy sensors were observed with yield, biomass and nitrogen uptake ($R^2 > 0.6$), showing that this may be a valuable tool to identify and quantify the variability of crop vegetative vigour in sugarcane fields.

Introduction

Although extensively studied, nitrogen (N) management remains a challenge for growers, especially spatially variable management, which requires the use of variable rate technologies. Recently this challenge has been associated with variable rate application on-the-go based on crop reflectance sensors. In sugarcane, there are few crop canopy reflectance sensor studies; however, canopy sensors have been studied in sugarcane by the Precision Agriculture Lab., University of São Paulo, Brazil, since 2007 and results of the technology for sugarcane are promising (Portz *et al*., 2012; Amaral *et al*., 2012).

Materials and Methods

We studied two canopy sensors, CropCircle and N-Sensor. These sensors have different operational and measurement concepts, but in our studies the goal for both was to validate N variable rate application. However, it was first necessary to test sensor relationships with plant parameters and their capability in identifying sugarcane N nutrition, which was the main objective of this paper. Due to the differences, they will be treated separately in this paper and called the American and European canopy sensors.

The American canopy sensor used was the CropCircle ACS-210 (Holland Scientific, Lincoln, NE, USA) which emits modulated light and captures its reflectance in the visible

(590 nm) and near infrared (880 nm) wavelengths, calculating a NDVI (normalised difference vegetation index). It works in nadir view (perpendicular to the soil) with a footprint around 0.5 m, measuring one row at a time. Experiments with this sensor were conducted in plots with N rates (0, 50, 100, 150 and 200 kg/ha of N) in different growth conditions (soil and season).

The European sensor was the N-Sensor™ ALS, (Yara International ASA, Duelmen, Germany), mounted behind the cabin of a high clearance vehicle. The sensor uses an optimised vegetation index based on near infrared (NIR) (760 nm and the slope of reflectance between the red and the NIR named REIP - Red Edge Inflection Point - at 730 nm) (Reusch, 2005). The system measures two oblique ellipses (left and right) of approximately 3.0 m each. Experiments were conducted on eight commercial fields and the sensor readings (three per field) were compared to the crop parameters (sampled data), specific calibration functions were derived, and the capacity of the sensor measurements to predict the actual crop biomass and N-uptake was defined.

Results and discussion

The American canopy sensor proved to be an efficient tool to identify N sugarcane nutrition. This sensor was able to differentiate N rates when sugarcane responded to the N applied. In addition, the American canopy sensor NDVI had a high correlation to sugarcane yield, with readings done approximately nine months before harvesting (Figure 1), when plant stalk height was approximately 0.5 m. Moreover, the sensor was more reliable in identifying sugarcane yield then chlorophyll and leaf N concentration (Table 1). This sensor allows the user to identify the sugarcane N needs during the growing season as well as N sugarcane response and thus N variable rate application can be performed with this information.

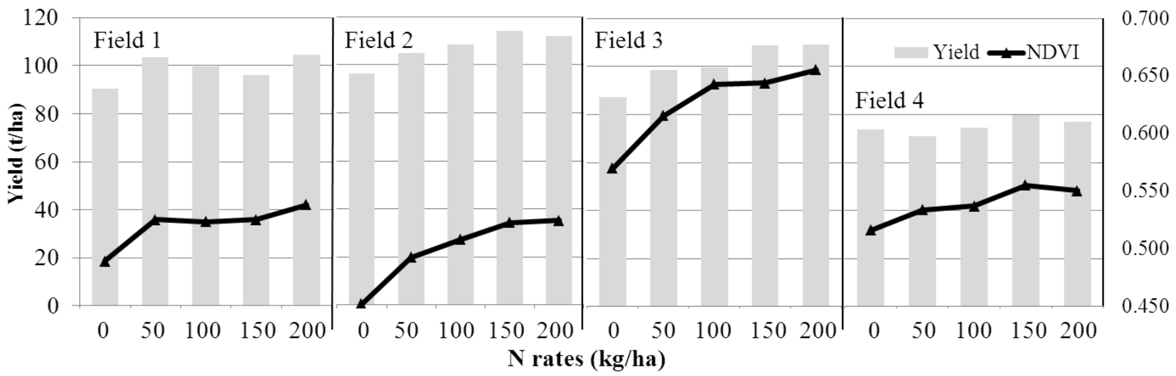

Fig. 1 – Yield and American canopy sensor (CropCircle) readings (NDVI) obtained with treatments (N rates) in four plot experiments

One way to establish variable rate application is based on N uptake required for cane production (estimation based on sensor readings). Another way to direct N application is based on fertiliser distribution models that are established to apply more N in areas that yield more biomass (higher sensor values), assuming that in those areas all other production factors are at satisfactory levels, which can increase the potential N response.

Table 1 – Correlation coefficients for linear relationships between sugarcane yield and the American canopy sensor (CropCircle) NDVI, chlorophyll amount and the leaf N content in four fields.

Field	NDVI	Chlorophyll	Leaf N
1	0.763**	0.338^{ns}	0.203^{ns}
2	0.648**	0.406^{ns}	0.296^{ns}
3	0.623**	0.465*	-
4	0.628**	-0.025^{ns}	-0.456*

* and **, significant at the 0.05 and 0.01 level, respectively; ^{ns} not significant at the 0.05 level

Using the European canopy sensor it was possible to determine accurate relationships of crop biomass and nitrogen uptake during the initial crop growing period, correlating field samples to the predicted sensor values for the same variables (Figure 2). Sugarcane biomass and nitrogen uptake were detected by the sensor and the relationship between sensor predicted and measured values were close to the 1:1 line for the entire data set taken from 0.2 to 0.6 m stalk height. This data set can be used as a database to implement real time variable rate application of nitrogen fertiliser based on the sensor readings over commercial sugarcane fields based on distribution models.

As both sensors demonstrated a good response to sugarcane, more studies should be conducted in order to improve the efficiency of nitrogen variable rate applications guided by canopy sensors.

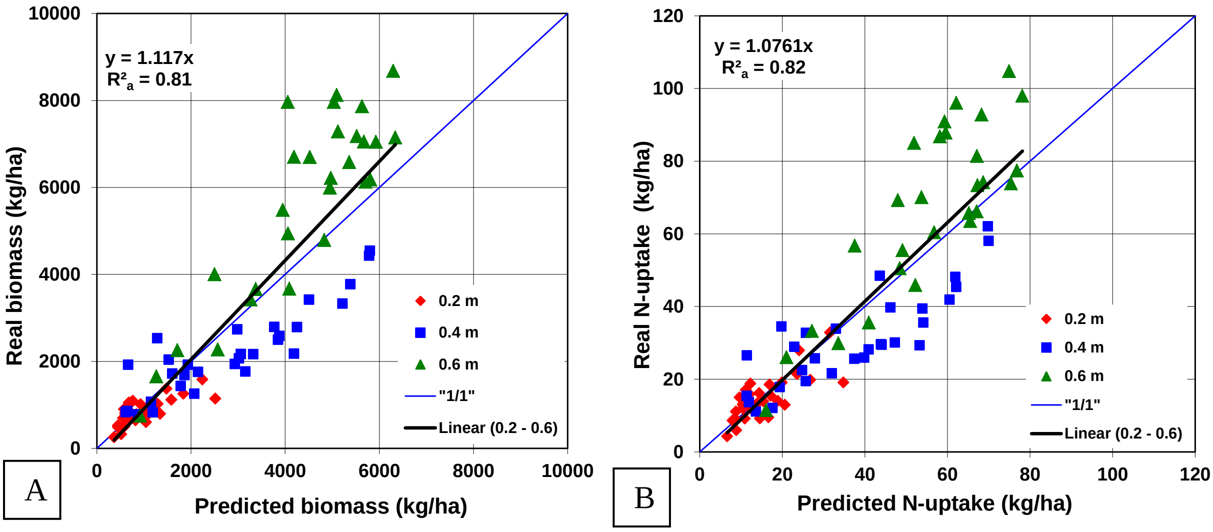

Fig. 2 – European canopy sensor (N-Sensor) predictions for biomass (A) and nitrogen uptake (B) against sampled values obtained at different growth stages (0.2, 0.4 and 0.6 m plant stalk height)

Conclusions

The American canopy sensor was an efficient tool to identify the N nutrition, sugarcane yield and sugarcane N response, which might allow for N variable rate application in sugarcane. The European canopy sensor had a high correlation between readings and sugarcane biomass and nitrogen uptake, showing potential for use of this sensor to manage variable rate application of nitrogen on sugarcane.

More studies involving nitrogen variable rate application guided by canopy sensors should be conducted in order to prove the efficiency of this approach.

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