Optimizing Topdressing Fertilization Through Ground Sensing Measurements in Rice

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Introduction

In rice several methods have been developed to rule N fertilization at panicle initiation stage (PI). Optical properties of leaf pigments, and particularly chlorophyll, are promising measure to be used as plant N status indicators (Muñoz-Huerta *et al*., 2013). Therefore vegetation indices (VI) are calculated on the basis of specific waveband combinations (Bajwa *et al*., 2010). The most used are SPAD, NDVI (Normalized Difference Vegetation Index) and NDRE (Normalized Difference Red Edge).
The purpose of this study was to evaluate the best indicator to provide practical information about the N rate to be applied at PI to maximize crop production, and to build a statistical model to provide PI N rate = f(VI).

Methods

The study was carried out during 2014-2015 cropping seasons in an experimental area of the Rice Research Centre of Ente Nazionale Risi, located in Castello d'Agogna (PV), Italy.
The experiment compared four N rates (0-60-100-140-200 kg N ha^{-1}) as sum of pre-sowing and tillering stage application (PRE+TILL) combined with four N rates at PI stage (0-30-60-100 kg N ha^{-1}).
The treatments were laid out in a split plot design, with PRE+TILL supply in the main plots and the nitrogen rate at PI stage in the subplots. Cultivar Centauro, a round grain variety, was used.
Some vegetation indices (SPAD, NDVI and NDRE) were detected at PI stage. SPAD was determined using SPAD -502-Soil Plant Analysis Development (Konica Minolta, Japan). GreenSeeker (Trimble ©, Sunnyvale, California, USA) and Rapid Scan (Rapid Scan CS-45, Holland Scientific, USA) handheld optical sensors were used to determine NDVI. As the second sensor incorporates three optical measurement channels, it was used to determine NDRE as well. Biomass was also detected and N concentration determined at PI. Grain yield (normalized to a moisture content of 14%) was determined at harvest.
General Linear Model was used to build a model explaining yield as a function of N fertilization at pre-sowing+tillering stage (PRE+TILL), fertilization at panicle initiation stage (PI) and their squares as covariate, block and year as simple effects and PRE+TILL*PI, PRE+TILL*year and PI*year as interactions.
Then, yield was predicted from VI values and nitrogen rates supplied at panicle initiation stage, using General Linear Model again. This model included PI nitrogen supply, VI and their squares as covariate, block and year as simple effects and PI*VI, year*VI and years*PI as interactions. Then, from this model, a calibration curve for VRA fertilizer spreader was derived.

Results

Maximum grain yield (11.0 Mg ha^{-1}) was achieved when 160 kg N ha^{-1} were applied (Figure 1). Further increase in N level did not increase or reduced crop production. The higher grain yield values were recorded with the higher nitrogen supply at PI stage. The application of the statistical model showed that grain yield is influenced by basal N fertilization as well as PI N supply. Moreover, interaction between pre-sowing and tillering stages fertilization and PI N supply was significant. So, deficient supplies provided during initial stages can be compensated with N topdressing fertilization at PI. This study confirmed previous results reported in Manzoor *et al*. (2006) and Lee *et al*. (2009).

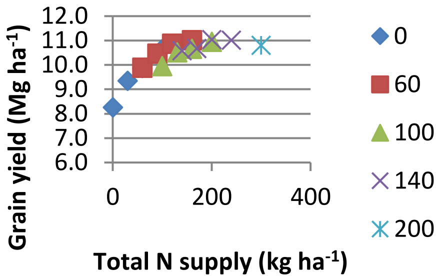

Figure 1: Grain yield response curve at increasing levels of N additions.

The capability of the VI to predict yield is reported in Table 2.

Table 2: Capability of VI of predicting yield

VI	PI	PI²	VI	VI²	PI*VI	YEAR*VI	YEAR*PI	BLOCK	YEAR	R²
SPAD	0.000	0.010	0.002	0.021	0.000	n. s.	n. s.	0.039	n. s.	0.639
GS NDVI	0.000	0.000	0.000	0.009	0.000	0.000	n. s.	n. s.	0.000	0.740
RS NDVI	0.000	0.003	0.044	n. s.	0.000	n. s.	n. s.	0.013	n. s.	0.692
NDRE	0.000	0.001	0.000	0.000	0.000	n. s.	n. s.	n. s.	n. s.	0.769

All VI and their interaction with N supply at PI stage were significant on predicting crop yield. Topdressing N fertilization at PI stage can hence compensate low VI values. Maximum R^2 value was achieved by NDRE. An example of calibration curve for VRA fertilizer spreader was then derived from the statistical model maximizing grain production at each NDRE value. Results are reported in Fig. 2.

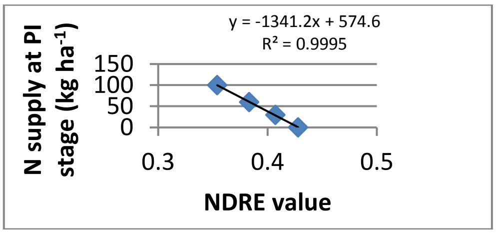

Figure 2: Calibration curve obtained for NDRE

Conclusions

Nitrogen supply at PI stage is effective on rice yield. Its calibration is important to avoid N imbalances. This study demonstrates that NDRE is the best crop N status indicator. As NDRE is not influenced by seasonal effect and soil variability, this VI can be used to determine Centauro variety calibration curve. To made negligible the influence of soil variability and weather recorded for the others VI, Sufficiency Indices (SI) could be calculated.
The determined calibration curve will allow a site specific rice N fertilization management accounting for soil and spatial variability, avoiding consequent negative environmental impacts.

References

Bajwa, S. G. *et al.* 2010. Canopy reflectance response to plant nitrogen accumulation in rice. Precision Agric. 11: 488-506.
Lee, J *et al.* 2009. Assessment of N topdressing rate at panicle initiation stage with chlorophyll meter-based diagnosis in rice. J. Crop Sci. Biotech. 12(4): 195-200.
Manzoor, Z. *et al.* 2006. Appropriate time of nitrogen application to fine rice, Oryza sativa. J. Agric. Res. 44(4): 261-267
Muños-Huerta, R. F. *et al.* 2013. A review of methods for sensing nitrogen status in plants: advantages, disadvantages and recent advances. Sensors 13: 10823-1084.