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A NEW METHOD TO ESTIMATE THE NITROGEN STATUS OF INDIVIDUAL PLANTS IN CANOPIES

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Introduction

Better exploiting the complementarities between plant species in plurispecific canopies is one of the challenges to face in order to reach more sustainable cropping systems. Amongst tools developed for managing monospecific canopies, some of them are invalid for plurispecific canopies. This is the case of the nitrogen nutrition index (NNI) used to quantify the nitrogen (N) nutrition status of a canopy and to identify a N-stress. Based on the critical curve of N dilution (i.e. the minimum plant N concentration required for maximum biomass production; Gastal and Lemaire, 2002), the NNI cannot be estimated for individual plants in canopies due to variations in the critical dilution curve in situations of light competition. Yet, such a tool is necessary to quantify the efficiency of N uptake and use by each component of plurispecific canopies. Lemaire et al. (2005) identified, for lucerne, a proportionality between the quantity of N in the shoot part and leaf area, both at the plant and at the canopy levels. The ratio between both variables was unaffected by plant growth conditions (low vs. high plant density and greenhouse vs. field conditions), suggesting that it could be a stable indicator of plant N status. Our objective was to propose a new indicator for the N status of individual plants whatever they are grown in mono- or pluri-specific canopies. Based on Lemaire et al. (2005), this study analysed whether the ratio between the quantity of N in the shoot plant part and plant leaf area or biomass could provide a relevant indicator of plant N status.

Materials and Methods

Two greenhouse experiments (fully described in Moreau et al., 2008) were conducted on the legume species *Medicago truncatula*. In experiment 1, inoculated A17 genotype and its non-nodulating counterpart (unable to symbiotically fix N₂) were both grown at six nitrate concentrations in the nutrient solution (0, 0.625, 1.25, 2.5, 5 and 10.5 mM). In experiment 2, inoculated A17 was grown with two nutrient solutions contrasted for their nitrate concentration (0.625 and 10.5 mM) and under three light levels in order to mimic situations where plants are differently shaded by neighboring plants. Three light levels (100%, 50% and 30% light levels) were artificially generated using nets. In both experiments, plants were grown individually in 1-L pots with 50 pots per m². At seven consecutive harvest dates in each experiment, plant leaf area and biomass and plant

shoot N were measured. For the last sampling date, NNI was determined at the canopy level using the critical dilution curve of *M. truncatula* (Moreau et al., 2008).

Results and Discussion

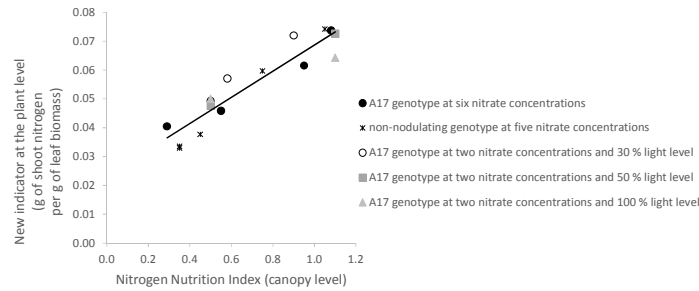


Figure 1. Correlation between a new indicator calculated at the plant level (ratio between plant shoot N and plant leaf biomass) and the N nutrition index (NNI) calculated at the canopy level. Each point is an experimental treatment. When NNI is close to 1, N nutrition is optimal; a lower (resp. higher) value reveals a N-stress (resp. excess). Shoot biomass ranged between 79 and 810 g/m² according to the treatment.

In each experimental treatment, a linear relation was found between the quantity of N in plant shoot and leaf area ($P < 0.001$) or leaf biomass ($P < 0.001$) at the plant level. For each treatment, the slope of the linear regressions was calculated, corresponding to the ratio between the quantity of N in the shoot part and leaf area or biomass. Considering all treatments, the ratios were related to the NNI classically calculated at the canopy level using the critical nitrogen dilution curve (Figure 1). Whatever the ratio was expressed in g of N per g of leaf biomass or in g of N per cm² of leaf, it was positively correlated with NNI ($P < 0.001$ and $P = 0.003$, respectively) but the correlation was better when it was expressed in g of N per g of leaf biomass ($R^2 = 0.87$ vs. 0.46).

Conclusions

This study provides a new tool to quantify plant N status at the plant level. A similar experiment was conducted on three other plant species and the data analysis (in progress) will determine if our findings are applicable to different species.

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