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# Root Exudates as Pathway for Nitrogen Transfer from a Tropical Leguminous Tree

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## 1. Introduction

N<sub>2</sub>-fixing plants may contribute N to associated plants, and thus compensate for the use of chemical fertilisers in agricultural systems.

In the tropics, the N<sub>2</sub>-fixing plant in the association is usually a woody species, and leaf litter or prunings are considered as the main pathway of N release to the system.

Recent research in other natural and man-made ecosystems has provided evidence on the role of below-ground processes in N transfer. Possible mechanisms include root and nodule decomposition (Sierra et al. 2002; Nygren et al. 2000), root exudates (Paynel et al. 2001; Sierra et al. 2007), and common mycorrhizal networks (He et al. 2003). These pathways still remain relatively poorly understood.

We studied (i) the extent of root exudation on a tropical leguminous tree *Gliricidia sepium*, and (ii) transfer of N via exudates from the tree to a fodder grass *Dichanthium aristatum* in a glasshouse experiment.

## 2. Material & Methods

**Study site:** a glasshouse study at the Antillean research centre of INRA, Guadeloupe, Lesser Antilles

**Plant material:** N<sub>2</sub>-fixing tree *Gliricidia sepium*, and C4 fodder grass *Dichanthium aristatum* (N receiver).

**Soil:** Vertisol with 80% of clay, collected from a *G. sepium* – *D. aristatum* agroforestry plot and sieved for removing plant roots

**Methodology:** Hydroponics cultivation and leaf feeding of <sup>15</sup>N

Trees established from cuttings were transferred to hydroponic tanks, and 30 mg of <sup>15</sup>N was applied on tree leaves in the form of 99% <sup>15</sup>N-enriched KNO<sub>3</sub>.

During the following 10 weeks, water solution in tanks was changed weekly and used for irrigation of grass grown in separate pots. The root exudates of 3 trees were collected solely for analysis of <sup>15</sup>N.

Half of the grass pots were treated biweekly with fungicide *Iprodione* to reduce arbuscular mycorrhizal colonisation and to study the role of mycorrhizal fungi in nutrient uptake.

Grass shoots were sampled for <sup>15</sup>N analysis immediately before, and 4, 7 and 10 weeks after the initiation of irrigation with exudates. At the end of the experiment, tree and grass were harvested and analysed for N & <sup>15</sup>N content by compartments. Mycorrhizal colonisation was determined from plant roots using the method described in McGonigle et al. (1990).

Upper photo: *Gliricidia sepium* in hydroponic tanks

Lower photo: Pots of *Dichanthium aristatum*

Photos by J. Sierra



## 3. Results & Discussion

During the 10-week experiment, trees exuded 1.3% (0.23 mg) of the foliarly-fed <sup>15</sup>N. Exudation of N equalled 1.7% (38 mg) of the total N in tree at the end of the experiment (fig. A).

The average amount of daily exuded N was similar to that measured in *G. sepium* by Sierra et al. (2007), but exudation as percentage of total N in tree was only half of what they observed.

Of the total <sup>15</sup>N in grass at the end of the experiment, 1% originated from the exudates added in grass pots in irrigation water. Grass absorbed only 6% of the total <sup>15</sup>N in exudates. The results suggest a significant immobilisation of N by soil microorganisms.

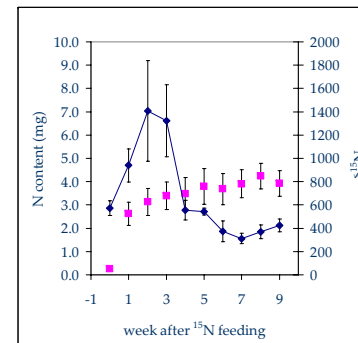
Grass total and root <sup>δ</sup><sup>15</sup>N correlated with <sup>δ</sup><sup>15</sup>N of exudates ( $P = 0.066$  to  $0.034$ ; fig. C). <sup>15</sup>N content of grass did not correlate with <sup>15</sup>N content of exudates. This lack of correlation was probably due to the immobilisation of N and thus the small amounts of <sup>15</sup>N transferred. As the <sup>15</sup>N enrichment of exudates was high, the effect of even small transfer showed in <sup>δ</sup><sup>15</sup>N of grass.

Fungicide application did not reduce mycorrhizal colonisation within-root. However, fungicide-treated grass had

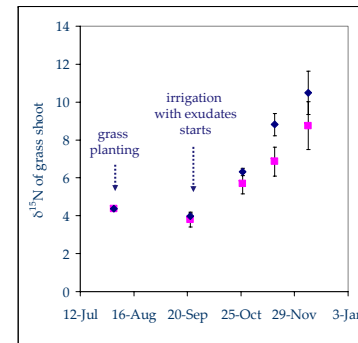
- lower N and <sup>15</sup>N concentration
- higher total and root weight
- higher shoot <sup>15</sup>N enrichment

The results imply a reduction in external mycorrhizal mycelia, which are more vulnerable than mycorrhizal organs inside plant roots. Non-fungicide treated grass seemed to benefit clearly from the mycorrhizal association in terms of N yield, but had to invest photosynthetic products for maintaining the symbiosis. Additional N in exudates was more readily available for the fungicide-treated grass than N in soil.

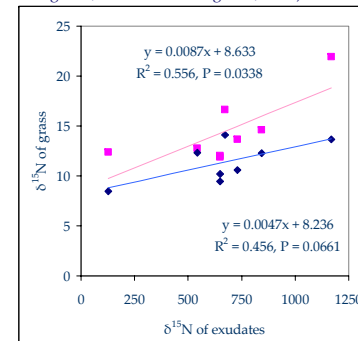
Trees suffered visibly from defoliation. On average, only 32% of the leaf-fed <sup>15</sup>N was recovered from trees at the end of the experiment. Tree compartments were unevenly enriched with <sup>15</sup>N, enrichment being highest in leaves and smallest in exudates.



A. N content (♦) and <sup>δ</sup><sup>15</sup>N (■) in exudates (n = 3)



B. Development of <sup>δ</sup><sup>15</sup>N in grass (♦ = with fungicide, ■ = without fungicide; n = 4)



C. Correlation between <sup>δ</sup><sup>15</sup>N in exudates and in grass (■ = grass root, ♦ = grass total; n = 8)

## 4. Conclusions

In this experimental setup root exudates did not contribute substantially to <sup>15</sup>N content in grass, indicating negligible transfer of N in general. Possible explanations for these results include

(i) Low levels of root exudation due to tree suffrance.

(ii) Immobilisation of <sup>15</sup>N by soil micro-organisms, as exudates were applied on soil surface in irrigation water. In natural systems, root exudates are released in rhizosphere where they can be readily absorbed by associated plants. Therefore N immobilisation by soil biological activity is likely smaller, and more N from exudation is available for plant uptake.

The extremely high level of immobilisation observed in this study suggests, however, that the role of exudation in interplant N transfer may be curtailed by competition with soil microorganisms. The substantial below-ground N transfer observed in several studies probably results largely from other, more direct transfer mechanisms, such as mycorrhizal networks.

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