NITROGEN NUTRITION OF SUGARCANE WITH FERTILIZERS OR DIAZOTROPHIC BACTERIA

Heitor Cantarella
Agronomic Institute of Campinas (IAC)
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co-PIs: Adriana Parada Dias da Silveira, Cristiano Alberto de Andrade

Nitrogen is required in large quantities for biomass production. Around 23% of the fertilizer N in Brazil is used in sugarcane. Besides being the most expensive plant nutrient, N fertilizers are an important component of the environmental budget of biofuel production. It is estimated that synthesis of N fertilizer accounts for about 25% of all the fossil energy spent in field operations for ethanol production from sugarcane in Brazil. Emission of nitrous oxide, a potent greenhouse gas associated with fertilizer use, also adds to the environmental costs of ethanol.

There are evidences that biological nitrogen fixation (BNF) is responsible for supplying part of the N required by sugarcane plants because several diazotrophic microorganisms have been isolated in that crop. Besides, the amounts of N fertilizer applied to sugarcane in many cases do not replenish the N removed from the fields with the harvest or lost as part of management practices. However, old sugarcane fields generally do not show signs of soil degradation.

The actual contribution of BNF to sugarcane under field conditions is controversial. Some authors have expressed their view that BNF is of little relevance for sugarcane N nutrition. However, it is generally recognized that BNF presents great potential especially in Brazil where many studies have shown promising results.

BNF is affected by plant variety, bacteria species, and plant-bacteria interactions. An inoculant produced with five strains of N_2-fixing diazotrophs was developed by Embrapa but it has not been extensively tested under field conditions. This project has the objective of studying the contribution of BNF to sugarcane production compared with the use of synthetic N fertilizer under different soils, environments, and sugarcane cultivars, evaluating the emission of N_2O from sugarcane fields fertilized with N, and testing an inoculant produced with endophytic bacteria. At the same time new N_2 fixing organisms are being searched for that are adapted to the sugarcane growing conditions of the State of São Paulo.

Figure 1. Greenhouse gases sampling in a sugarcane field. The photo was the cover of the Journal of Environmental Quality 44(2), 2015

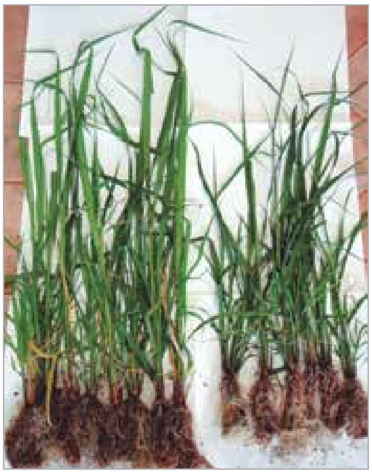

Figure 2. Sugarcane genotype IACSP95-5094 grown in greenhouse for 99 days. Left: plants inoculated with diazotrophic bacteria; Right: control without inoculation. Photo by Silvana A.C.D. Souza

SUMMARY OF RESULTS TO DATE AND PERSPECTIVES

The GHGs emission, especially that of N_2O, measured as a function of nitrogen fertilization were lower than the default value used by IPCC (1% of the fertilizer N emitted as N_2O), which helps to confirm the high sustainability standards of sugarcane production in Brazil. However, the presence of high amounts of sugarcane straw, derived from unburned harvest, associated with the application of vinasse can significantly increase N_2O emissions. Therefore, adequate management practices are needed to maintain GHGs emission low. The use of nitrification inhibitors with N fertilizers allowed a 90% reduction in N_2O emissions.

A large number of endophytic bacteria isolates were obtained in irrigated and rainfed sugarcane fields showing the great variability of microorganisms that can colonize sugarcane. About 80% of the organisms were isolated with nitrogen-free media, indicating that they are capable of fixing N_2 from the atmosphere. In addition, many isolates showed significant indole production, which is associated with phytohormone production that stimulates plant growth. Selected species (*Azospirillum amazonense*, *Gluconacetobacter diazotrophicus*, *Herbaspirillum seropedicae*, *Herbaspirillum rubrisubalbicans* e *Burkholderia tropica*) resulting from long term studies by Embrapa, were inoculated under greenhouse and field conditions to sugarcane varieties. It was clear that the response to inoculation was variety-dependent. Materials such as IACSP-95-5094, IACSP94-2101 and access SES205A of S. spontaneum showed more than 180% and 236% dry matter production of shots and roots in 90 days, whereas some varieties were negatively affected by inoculation.

In field studies comprising 13 site-year of results the inoculation of diazotrophic bacteria failed to increase plant or sugar yields in any experiment. The field studies allowed the conclusions that, at the present stage of knowledge, it is not possible to recommend inoculation of diazotrophic bacteria to increase sugarcane yields or to reduce the use of N fertilizers. However, indirect measurements of BNF using natural abundance techniques (δ 15N) confirmed previous studies indicating that part of the N in the sugarcane plants come from the atmosphere. It is likely that BNF is contributing to sugarcane nutrition through the already existing microbiota. Therefore, new research efforts are needed to understand the complex interactions between sugarcane and diazotrophic bacteria, a promising issue for a sustainable agriculture.

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Heitor Cantarella

Centro de Solos e Recursos Ambientais
Instituto Agronômico de Campinas (IAC)
Av. Barão de Itapura 1481
CEP 13020-940 – Campinas, SP – Brasil

+55-19-2137-0766
cantarella@iac.sp.gov.br