Phenotyping of *Brachiaria humidicola* hybrids for its BNI potential, biomass production, forage quality and \( \text{N}_2\text{O} \) Emissions

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CIAT: Three breeding programs in Tropical Grasses

Interspecific - *Brachiaria decumbens* / *brizantha* / *ruziziensis*  
1990

Robust, tolerant to low fertility.

**Characteristics to be improved:** Spittlebug resistance, persistence, seed production and abiotic stress.

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*Brachiaria humidicola*  
2010

Robust, tolerant to low fertility, tolerant to waterlogging and high BNI.

**Characteristics to be improved:** Nutritional quality, spittlebug resistance, seed production, abiotic stress.

*Panicum maximum*  
2016

High quality and biomass production. Double purpose forage and high BNI.

**Characteristics to be improved:** Abiotic stress.

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Dr. Valheria Castiblanco

Building a sustainable future
Brachiaria humidicola program: Recurrent Selection

CIAT (Sexual) → CIAT 26149 (Apomictic) cv “Tupí”

Sexuals (14 genotypes) × Apomictic ACC (21 genotypes)

Bh08 population

Sexuals → Apomictic

First synthetic population of tetraploid sexuals in B. humidicola CIAT’s hybrid breeding for Recurrent Selection

High biological nitrification inhibition and biomass
- [BNI, CIAT-16888 (Subbarao et al. 2009)]
- Cv. “Antioqueña” (ICA 2017)

High waterlogging tolerance
- CIAT-6570, CIAT-6013, CIAT-6133 and CIAT-679 (Cardoso et al. 2013, 2014)

Spittlebug tolerance
- CIAT-6133 [previously identified as B. dictyoneura (Fig. & De Not.) Stapf]
- “Llanero” cultivar (ICA 1987)
Why Inhibit Nitrification?

Nitrification is one of the major causes of nitrogen loss from agricultural systems (up to 70% of the N fertilizer applied is lost to the environment)

Direct annual economic loss

$81 Billions

U.S. Dollars*

*Based on a world annual N fertilizer production of 150 million Mg, US$ 0.50 kg⁻¹ urea. Source: Galloway et al., 2008.

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Apomictic hybrids of *B. humidicola* (Bh) BH08 population

Year 2012:

Evaluation of 118 hybrids of *B. humidicola* (Bh) for their growth and nutritive value and their potential ability to inhibit nitrification in soil under greenhouse conditions.

**Objective:**

To identify contrasting hybrids with different levels of BNI and the selection of a set of 12 contrasting hybrids for subsequent field evaluations.

(Pre-breeding, methodology development and potential hybrid identification)
Soil nitrification rate for 118 apomictic *B. humidicola* hybrids

- High BNI 1149 (low nitrification rate)
- 1250 (high nitrification rate)
Twelve contrasting *Bh* hybrids BH08 selected for field evaluation

<table>
<thead>
<tr>
<th>Bh08 hybrid</th>
<th>Controls</th>
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<tr>
<td>1149</td>
<td><em>B. humidicola</em> CIAT 26159 (high BNI)</td>
</tr>
<tr>
<td>450</td>
<td><em>B. humidicola</em> CIAT 16888 (high BNI)</td>
</tr>
<tr>
<td>1250</td>
<td><em>B. humidicola</em> CIAT 679 (high BNI)</td>
</tr>
<tr>
<td>0700</td>
<td><em>B. humidicola</em> CIAT 26146 (parental)</td>
</tr>
<tr>
<td>696</td>
<td><em>B. humidicola</em> CIAT 26149 (parental)</td>
</tr>
<tr>
<td>1155</td>
<td><em>Brachiaria</em> hybrid cv. Mulato II CIAT 36087 (low-inter. BNI)</td>
</tr>
<tr>
<td>422</td>
<td><em>Panicum maximum</em> CIAT 16028 (intermediate BNI)</td>
</tr>
<tr>
<td>0680</td>
<td>Bare soil: negative control (no plants)</td>
</tr>
<tr>
<td>0675</td>
<td></td>
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<td>1248</td>
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<td>1243</td>
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<td>0022</td>
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Field evaluation 2014-2018

**Study location:** Agrosavia-La Libertad Research Center ("Llanos" region of Colombia)

- **Altitude:** 336 m.a.s.l.
- **Annual mean temperature:** 26 °C
- **Annual mean rainfall:** 2,933 mm
- **Soil order:** Oxisol

**Soil chemical analysis (20 cm depth) of field site**

- **pH:** 4.91
- **OM:** 30.34 g/kg
- **P:** 14.37 mg/kg
- **Al:** 1.30 cmol/kg
- **Ca:** 1.10 cmol/kg
- **Mg:** 0.38 cmol/kg
- **K:** 0.11 cmol/kg
- **CEC:** 2.89 cmol/kg
- **Al-saturation:** 44.95%
Field trial

Experimental design: RCB, 3 replications
Experimental unit: 4x4 m plot
(60 experimental units in total)
Planting density: 10,000 plants/ha
(16 plants/plot)
Planting date: August 29, 2013
Fertilizers mixture rates (Kg/ha):
100 N (urea), 25 P (DAP), 50 K (KCl), 50.5 Ca, 14.2 Mg, 10 S, 0.44 B, 0.09 Cu and 2.6 Zn.
Measurements from field evaluation 2014-2017

Forage yield
- Biomass production

Forage quality parameters:
- Crude protein (CP)
- In vitro dry matter digestibility (IVDMD)
- Neutral and Acid detergent fiber (NDF, ADF)

Wet season

Dry season

NIRS Foss 6800
Soil nitrification rates measured during the rainy season

5 g of rhizosperic soil

Basal N

$\text{NH}_4^+$
27 mM

$\text{NH}_4^+$ and $\text{NO}_3^-$ quantification

Incubation at 25°C

11 15 19 27 days

$\text{NH}_4^+$ and $\text{NO}_3^-$ quantification

Nitrification rate (mg N-NO$_3$ kg soil$^{-1}$ day$^{-1}$)

High nitrification rate $\sim$ Low BNI capacity!
Measurement of N\textsubscript{2}O emission in the field using a portable FTIR Gas analyzer

Timeline (in days)

Daily measurements (per chamber)

- Soil moisture
- Soil temperature
- Nitrous oxide

2 chambers per each plot (6 chambers per genotype)

- Soil sampling each every 2 days to measure mineral nitrogen

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Comparison of *Bh* hybrids in the field evaluation from 2014 to 2017

Bh 1149 is a promising hybrid:
Low BNI + High yield + High nutrition quality

3D visualization of a principal component analysis based on forage yield (Axis 1), nutrition quality-crude protein (Axis 2), nitrification rates (Axis 3)  
A. Hierarchical Cluster using PCA;  
B. Representation comparing hybrids vs control genotypes
N$_2$O emissions from *Brachiaria* hybrids BH08 are lower than bare soil control

**A** N$_2$O emissions from bare soil

**B** Bar plot showing cumulative N$_2$O emissions. Asterisk indicates significant difference according to Dunn test p<0.05

N$_2$O emissions from *Brachiaria* hybrids BH08 (450, 675, 680, 700 and 1149) and controls Bh 679 cv. Tully (high BNI) and Bare Soil in the rainy season of 2018. **A.** N$_2$O emissions from *Brachiaria* hybrids BH08 during 11 days after fertilization. **B.** Bar plot showing cumulative N$_2$O emissions. Asterisk indicates significant difference according to Dunn test p<0.05.
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REFERENCES: Galloway JN; Townsend AR; Erisman JW; Bekunda M; Cai Z; Freney JR; Martinelli LA; Seitzinger SP; Sutton MA. Transformation of the Nitrogen Cycle: Recent Trends, Questions, and Potential Solutions. Science 320:889-892. DOI: 10.1126/science.1136674

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