CIAT / JL. Urrea

Urochloa grass and biofortified maize rotation improve zinc uptake: A promising strategy to fostering human health

Madyan Vanessa Prado-Murcia; Daniel Mauricio Villegas; Mike Bastidas; José Luis Urrea-Benítez; Jacobo Arango.

International Center for Tropical Agriculture, Tropical Forages Program, Colombia.

Contact: m.prado@cgiar.org

Introduction

- Hidden hunger, or micronutrient deficiencies, occurs when the quality of food fails to meet human nutritional needs. One-third of the world's population suffers from micronutrient deficiencies (FAO et al., 2022). The consequences include physical and mental underdevelopment, weakened immune systems, especially in children, pregnant women, and the elderly (ENSIN, 2015).
- Pastures of the *Urochloa* genus, were identified by Subbarao et al., (2009), with the potential to reduce nitrification through root exudation of compounds. This process is known as Biological Nitrification Inhibition (BNI), that promotes nutrient recycling, primarily nitrogen (N), which is stored in the soil in stable forms and becomes accessible to plants.
- A study from Karwat et al. (2017) in Colombian Eastern Plains showed that the *Urochloa*-maize rotation improves maize productivity parameters. Following studies conducted in Palmira (Colombia) have discovered that that in addition, biofortified maize crop increase their potential for zinc micronutrient absorption, thereby improving the grain's nutritional quality.

Objective

To evaluate the residual effect of *Urochloa* genotypes with contrasting BNI capacity on the maize yield and Zn uptake in the grain of biofortified white maize (SGBIOH2).

Methodology

Study conducted at the Palmira Campus of the Alliance Bioversity & CIAT, Colombia. Altitude: 1001 m.a.s.l.; Avg. Temperature: 23.4°C; Precipitation: 1,051 mm/year. Soil order: Mollisol, pH: 7.5, texture: silt loam.

First Phase (2016), Final phase (2019-2023), experimental design in RCBD, 3 repetitions.

Figure 1. Experimental design. T=Treatment. Uh=*Urochloa humidicola*; Ub=*Urochloa brizantha*. *T11.Conventional Maize (Maize planting history spanning over 10 years)*

Results

Pastures with high BNI potential showed a 22.4% increase in grain Zn absorption, averaging 31.8 mg kg^{-1}, compared to control treatments without BNI at 24.7 mg kg^{-1}, showing significant differences (Figure 2).

Treatment with the highest Zn concentration in grain was Uh72 with 33.53 mg kg^{-1} (Table 1). The bare soil and continuous maize control treatments without BNI had Zn concentrations of 24.28 mg kg^{-1} and 25.24 mg kg^{-1}, respectively, which were 27.6% and 24.7% lower than Uh72.

Biofortified maize reached a maximum accumulation of 43.85 mg kg^{-1}, promoted by the BNI effect of the pastures, representing a 36% increase compared to the value reported in the factsheet (32 mg kg^{-1}) and a 75% increase compared to the baseline Zn content in conventional maize (25 mg kg^{-1}) (Andersson, et al., 2017).

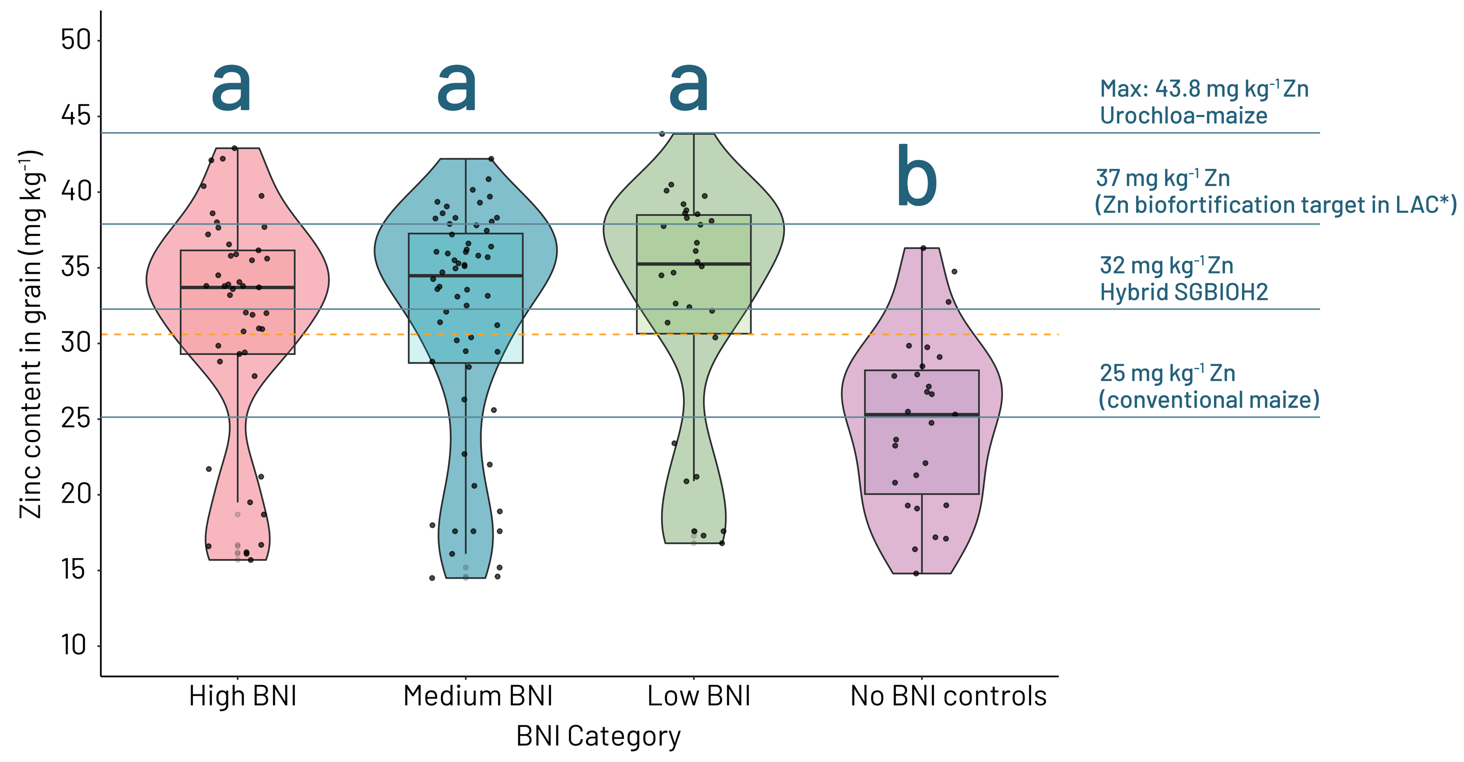


Figure 2. Zn content in plants by BNI categories. n =160. Different letters indicate statistical differences according to the TukeyHSD test (α = 0.05). * LAC=Latin America and the Caribbean.

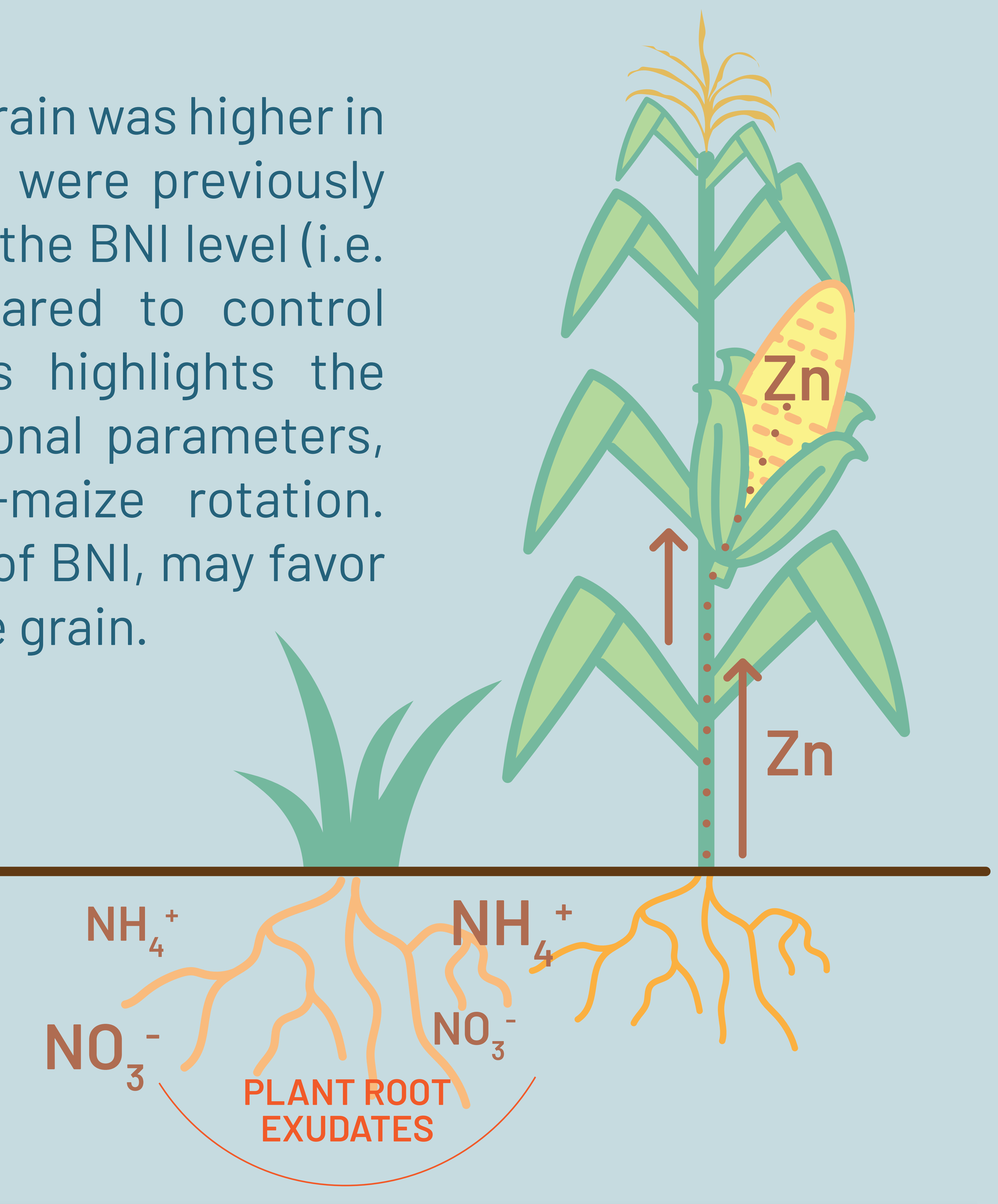
Table 1. List of *Urochloa* genotypes with average Zn levels over five sowing cycles

Treatments	Zn in grain (mg kg^{1})	Nitrification rates (mg N-NO_3-/kg)*
Uh 675	31.83 (9.1)ab	5.15 (1.7)a
Uh 91	31.53 (7.2)ab	5.37 (1.3)ab
CIAT 16888	30.81 (6.8)ab	5.65 (1.6)ab
Cv. Marandu	32.78 (7.5)ab	5.98 (1.2)abc
Cv. Mulato II	31.30 (6.7)ab	6.00 (1.6)abc
Uh 1149	30.51 (8.7)b	6.15 (1.8)bc
CIAT 679	31.71 (8.4)ab	6.24 (1.5)bcd
**Uh 72	33.53 (8.4)a	6.62 (1.9)cde
CIAT 26146	31.63 (7.9)ab	7.13 (1.0)de
Fallow	24.28 (5.3)c	7.58 (2.3)e
Continuous maize	25.24 (6.1)c	-

Values in brackets represent the standard deviation of the mean, n = 15. Different letters indicate statistical differences according to the TukeyHSD test (α = 0.05).
*Nitrification rates in *Urochloa* plots in the last year (2018) before planting biofortified maize.
**Uh Uh72, the treatment exhibiting the highest concentration of zinc.

Conclusions

The accumulation of Zn in the grain was higher in soils where Urochloa pastures were previously planted, planted, regardless of the BNI level (i.e. high, medium, or low) compared to control treatments without BNI. This highlights the potential for improving nutritional parameters, especially Zn, in the grass-maize rotation. Adequate N supply, as a result of BNI, may favor the accumulation of Zn in maize grain.



References

Andersson M, et al. (2017). Progress update: Crop development of biofortified staple food crops under HarvestPlus. African Journal of Food, Agriculture, Nutrition and Development, 17(02):11905-11935. https://doi.org/10.18697/ajfand.78.harvestplus05

ENSIN – Encuesta nacional de la situación nutricional 2015; https://bit.ly/45ItXKO

FAO, IFAD, UNICEF, WFP, & WHO. (2022). The State of Food Security and Nutrition in the World 2022. FAO. doi.org/10.4060/cc0639en

Acknowledgments

This work was carried out as part of the CGIAR Initiative on Livestock and Climate. We would like to thank all the donors who globally support our work through their contributions to the CGIAR System. The authors also acknowledge the Japan International Research Center for Agricultural Sciences (JIRCAS). The opinions expressed in this document cannot be taken as official opinions of these organizations.

Special Thanks to Jairo Antonio Arcos Jaramillo, Miguel Angel Acosta Chinchilla, the Nutritional Quality Laboratory of the Alliance, and Semillas Guerrero SAS, for their contributions to this research.

Alliance Bioversity & CIAT

CGIAR INITIATIVE ON Livestock and Climate

JIRCAS

Poster prepared for:
Tropentag 2023
September 20-22, 2023
Berlin (Germany)