CROP BREEDING AND APPLIED BIOTECHNOLOGY

*CULTIVAR RELEASE*

# UENF N01, UENF N02 and UENF N03: popcorn cultivars with elevated nitrogen-use effectiveness

Crop Breeding and Applied Biotechnology
23(3): e44642333, 2023
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332023v23n3c26

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**Abstract:** *The hybrids UENF N01, N02 and N03 have enhanced nitrogen-use efficiency, particularly in terms of N responsiveness, which makes them ideal for low-input cultivation. Even under abiotic stress, popping expansion is not reduced, indicating these hybrids for growth in the N and NW of Rio de Janeiro State.*

**Keywords:** *Diallel analysis, abiotic stress, nitrogen-use effectiveness*

## INTRODUCTION

The increase in agricultural production over the last four decades has entailed an eight-fold increase in nitrogen (N)-use, whereas on the other hand, agricultural N fertilization jeopardizes ecosystem diversity and functioning (Kaur et al. 2017, Khan et al. 2022).

In the soil-plant system, the dynamics of the nutrient required in the highest amounts by plants, nitrogen, are complex (Xu et al. 2012, Moro et al. 2013, Iqbal et al. 2020). Numerous transformations and losses affect the N balance, e.g., ammonia volatilization ($NH_3$), nitrous oxide ($N_2O$) launching, nitrate ($NO_3^-$) percolation (Mahmud et al. 2021) and low N-use efficiency of the genotypes (Fageria and Baligar 2014, Gao et al. 2014). The effectiveness of processes of nitrogen utilization and waste (Fageria and Baligar 2014, Gao et al. 2014) in the soil-plant complex has economic and ecosystem implications, particularly if nitrogen oxides are released inside of atmosphere. Special attention has been paid, e.g., to $N_2O$, for contributing to the greenhouse effect and ozone layer depletion (Chien et al. 2009, Khan et al. 2022). Therefore, the technologies upgrades that enhance nitrogen utilization effectiveness can assist restrict losses, atmospheric disturbance with $N_2O$ and $NH_3$ dissipate (Chien et al. 2009).

In this context, planting nitrogen-use effectiveness hybrids is a promising possibility to assure production stability with less negative effects on income costs and for the ambience. According to Kant et al. (2011), obtaining specific information about genotypes with high nitrogen-use efficiency (NUE) would

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**Received:** 11 February 2023
**Accepted:** 14 June 2023
**Published:** 10 August 2023

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benefit the environment and economy, whereas a 1% raise in the nitrogen-use efficiency of plantations would save US$ 1.1 billion annually. For this reason, several public and private institutions are investing in research to identify genotypes and genes that may be used to yet more optimize NUE (Iqbal et al. 2020, Khan et al. 2022).

In particular for popcorn, that spawns an annual turnover of approximately 1 billion dollars in the United States, until nowadays every improved seeds used in our country need to be imported, which has motivated investigation at the State University of Northern Rio de Janeiro (UENF). Hybrids are being advanced with resistance or tolerance to: biotic stresses (Ribeiro et al. 2016, Schwantes et al. 2018, Amaral Junior et al. 2019, Schmitt et al. 2019, Santos et al. 2020, Kurosawa et al. 2021, Almeida et al. 2021, Santos Junior et al. 2022); abiotic stresses, especially the dry period (Santos et al. 2021, Lima et al. 2021, Leite et al. 2022, Viana et al. 2022, Kamphorst et al. 2022); low N availability (Santos et al. 2020, Khan et al. 2020, Khan et al. 2022); and low P availability (Gerhardt et al. 2017, Gerhardt et al. 2019, Santos et al. 2022). Furthermore, genome-wide selection in a recurrent intrapopulation selection program has been used to accelerate the breeding of upper segregating generations (Mafra et al. 2019, Mafra et al. 2021, Schwantes et al. 2020a, Schwantes et al. 2020b).

The objective of this study was to provide hybrids acclimated to Brazilian weather, as regional alternatives for cultivation in the Brazilian agriculture. Outcome, three popcorn hybrids, named UENF N01, UENF N02 and UENF N03, with improvement N-use effectiveness, recommended for planting in the N and NW regions of Rio de Janeiro State, are presented here.

## BREEDING METHOD

The Genotypes UENF N01, UENF N02 and UENF N03 were derived, respectively, from crosses of the lines P7 x L77, P6 x L77 and L59 x P7. In turn, lines P6 and P7 were originated from the hybrid Zaeli, line L59 from the population 'Beija-flor: UFV' and line L77 from the population ´Viçosa` (Table 1), and all of them are conserved at the Active Germplasm Bank of the UENF popcorn breeding program. Prior to registering of these Genotypes by the MAPA (Ministry of Agriculture, Livestock and Food Supply), both hybrids and the parents passed by a sequence of assessments, according to the rules and Minimum Requirements for determining the VCU (Value for Cultivation and Use) for specialty corn such as popcorn, with a purpose to including them in the National Cultivar Registry (MAPA 2020).

The hybrids were selected for NUE, and these findings were comprised in the MAPA hybrid archive. The experiments to test these genotypes for NUE were as follows: initially, the *per se* performance of 29 $S_7$ lineages of the UENF Popcorn Breeding Program was assessed in a randomized block design through three repetitions, at two locations with different levels of N availability: Campos dos Goytacazes and Itaocara, which represent the N and NW regions of the State of Rio de Janeiro, respectively (Santos et al. 2017). Three inefficient and non-responsive (INR) lines, three effective and responsive (ER) lines and four intermediate lines were selected for NUE and N responsiveness. These lines were crossed, resulting in 45 cross combinations and their corresponding reciprocals (Santos et al. 2020).

To assess NUE, 90 hybrids were assessed simultaneously with the ten parents in a 10 x 10 triple lattice design, in which every trial unit comprised of one 4.20-m-long row, and the rows were set aside 0.60 m separately and plants 0.25 m apart. The experiments tested two N availability levels – one low and the other optimal – at two locations (Santos et al. 2020).

In the trial with best N availability, fertilizer application at planting, calculated according on soil chemical analysis, consisted of 32 kg $ha^{-1}$ of N at establishing and 128 kg $ha^{-1}$ of N as side dressing. In the trials with minimal N availability, establishing fertilization was analogous to that of the prior trial and side dressing consisted of thirty percent of the amount enforced in the conditions with optimum N rates (38.4 kg $ha^{-1}$).

***Table 1.*** Description of $S_7$ lines crossed in a diallel mating design to establish hybrids for enhanced nitrogen-use efficiency

| Parents | Classification for Nitrogen-use efficiency |
|---|---|
| L54 | Intermediate |
| L59 | Intermediate |
| L61 | Inefficient and unresponsive |
| L75 | Inefficient and unresponsive |
| L76 | Intermediate |
| L77 | Intermediate |
| L80 | Inefficient and unresponsive |
| P2 | Effective and responsive |
| P6 | Effective and responsive |
| P7 | Effective and responsive |

The evaluation sites were the Experimental Field of the Antônio Sarlo State School of Agronomy in Campos dos Goytacazes (lat 21° 42' 48" S, long 41° 20' 38" W, alt 14 m asl) in the North and the Experimental Field of Itaocara (lat 1° 38' 50" S, long 42° 03' 46" W, alt 58 m asl) in Northwest of the State of Rio de Janeiro. At both locations, the weather is humid tropical (Aw), according to Köppen's specification, and the soil is a Latossolo Vermelho-Amarelo (Oxisol).

The other cultural practices were applied as advised for the crop. Supplemental irrigation was provided in the experiments whenever needed to avoid water stress. For the NUE studies, the plants were selected for mean yield of both environments, and morphological and agronomic characters were also determined, being them: popping expansion (PE), female flowering, male to female flowering interval, chlorophyll content, plant height, ear height, prolificacy, ear length, ear diameter, 100-grain weight and grain yield (GY). The means for cultivars and controls, as well as estimates of trial means for every place/agricultural year and combined means, were statistically analyzed. Experimental precision was assessed by estimating selective accuracy.

## PERFORMANCE

The hybrids UENF N01, UENF N02 and UENF N03 were assessed according on agronomic and morphological characters, as recommended by SNPC (National Plant Variety Protection) for registration by MAPA. Experimental precision was assessed by estimating selective accuracy, which appraises the quality of data and procedures underlying the prediction of genetic values (Pimentel et al. 2014). Significant accuracy values were found for all evaluated traits, mainly for GY (100%) and PE (94%), which indicates high accuracy in the recognition and possibility of achievement in the selection of N-use effectiveness plants use for the main economic traits of popcorn.

The cultivar UENF N01 has yellow kernel, an average plant height of 2.20 m and average ear height of 1.20 m. PE was 31.26 mL $g^{-1}$ and GY was 5,298.26 kg $ha^{-1}$. The cultivar UENF N02 is a yellow-kernel hybrid with a average plant height of 2.11 m and average ear height of 1.12 m. PE was 33.63 mL $g^{-1}$ and GY 4689.47 kg $ha^{-1}$. The cultivar UENF N03 is also a yellow-kernel hybrid with a average plant height of 2.14 m and a average ear height of 1.06 m. The PE was 30.00 mL $g^{-1}$ and GY was 4,280.25 kg $ha^{-1}$.

## MAINTENANCE AND SUPPLY OF BASIC SEEDS

The hybrids UENF N01, UENF N02 and UENF N03 were cataloged by the MAPA, as no. 39245, 39246 and 39247, respectively. The UENF, in partnership with Rio Norte Sementes, a seed company, headquartered in Campos dos Goytacazes-RJ, are in charge of the production and sale of hybrid seeds.

## ACKNOWLEDGMENTS

The authors are indebted to the Foundation Carlos Chagas Filho for Research Support of the State of Rio de Janeiro (FAPERJ) and the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) – Finance Code 001.

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