CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

UENF 506 16: A new maize cultivar alternative for the state of Rio de Janeiro

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Abstract: *This article presents maize hybrid UENF 506 16, focusing on its development through reciprocal recurrent selection and its performance in cultivation and use value tests. UENF 506 16 has shown high prolificacy and environmental stability, making it a reliable, recommended choice for cultivation in the state of Rio de Janeiro.*

Keywords: Zea mays *L., Reciprocal Recurrent Selection, Cultivation and Use Value*

INTRODUCTION

Maize (*Zea mays* L.) is a crop of significant economic and social value that is recognized as one of the most essential crops in global agriculture. Maize is the most widely cultivated cereal worldwide, valued for its versatility, ranging from being used as human and animal food to applications in advanced industries such as biofuel production.

Currently, the production of maize is concentrated in the United States, China, and Brazil, with projected production for the 2023-2024 season reaching 382.7 million tons, 288.8 million tons, and 122 million tons, respectively. In Brazil, maize is second only to soybeans in terms of the planted area and grain production (FIESP 2024, CONAB 2024).

The high yield potential of maize is primarily due to breeding, one of the most effective ways to improve agricultural productivity and grain quality (Hallauer et al. 2010, Cruz et al. 2012). To develop varieties with improved genetic potential for grain yield, the Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF) has maintained an efficient maize breeding program. Since 1996, UENF has successfully implemented strategies and methods to select superior genotypes, resulting in the development and release of hybrids tailored to the Northern and Northwestern regions of Rio de Janeiro.

The latest variety in the program is UENF 506 16. UENF 506 16 underwent the value for cultivation and use (VCU) test, a critical requirement for the registration of new varieties. Once approved and registered by the Brazilian Ministry of Agriculture and Livestock (MAPA) the variety will be included in the National Register of Cultivars (RNC) system. UENF 506 16 will then be available to growers in the Northern and Northwestern regions of Rio de Janeiro, thereby supporting the economic growth of maize production in these areas.

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DEVELOPMENTAL METHOD

The development of UENF 506 16 began in 1996 with the establishment of the UENF Maize Breeding Program. In the mid-1970s, the Universidade Federal de Viçosa (UFV) initiated a full-sib reciprocal recurrent selection program in common maize by using the CIMMYT and Piranão populations. At UFV, these populations underwent five breeding cycles (1st to 5th cycle) as part of the program. As part of an initiative to exchange genetic material between institutions, the populations were transferred to the UENF at the fifth cycle. The UENF program continued the subsequent cycles of full-sib reciprocal recurrent selection, incorporating molecular markers from the ninth cycle (Figure 1).

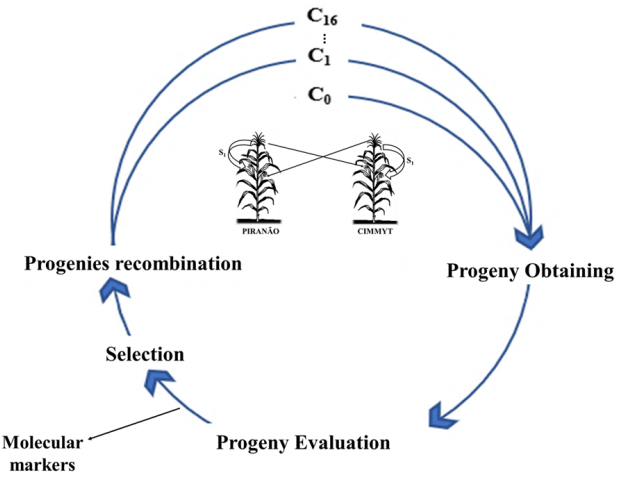

Figure 1. Diagram of the full-sib reciprocal recurrent selection method used to conduct the cycles and obtain UENF 506 16.

Genotypes used to develop UENF 506 16 (16th cycle of reciprocal recurrent selection) originated from the base populations CIMMYT15 and Piranão15. These populations belong to the heterotic groups 'FLINT' and 'DENT,' respectively, and were derived from the UENF Maize Breeding Program. Crosses and self-pollinations to produce the full-sib and S_1 families were carried out in 2016. The CIMMYT and Piranão populations were sown at the Antônio Sarlo State Agricultural School, located in Campos dos Goytacazes in the Northern region of the state of Rio de Janeiro (RJ). The recurrent selection methodology followed was similar to that described by Pereira et al. (2019) for the development of the UENF 506-11 cultivar, with adjustments made to meet the specific requirements of the program.

Full-sib families were evaluated in agronomic trials, leading to the identification and selection of 40 superior S_1 families for molecular genotyping. Based on the molecular analyses, 25 superior families were selected. These families were cultivated at the Antônio Sarlo Agricultural State Technical School in Campos dos Goytacazes (RJ) during the 2018 agricultural year. They were then recombined, completing the 16th cycle and establishing the foundation for a new cycle of reciprocal recurrent selection.

UENF 506 16 underwent additional agronomic evaluation trials in 2019 to determine the optimal population density to maximize grain yield potential. In 2021, VCU trials will be initiated for UENF 506 16, focusing on grain production and ensuring compliance with the minimum requirements established by MAPA for its registration on the RNC.

Hybrid evaluation trials were conducted simultaneously in three locations: 1) Antônio Sarlo Agricultural State Technical School, Campos dos Goytacazes (RJ) (lat 21° 45' 16'' S, long 41° 19' 28'' W, alt 13 m asl), which has an average annual precipitation of 1073 mm and an average annual temperature of 23.6 °C; 2) Federal Institute of Fluminense Advanced Campus Cambuci (RJ) (lat 21° 34' 31'' S, long 41° 54' 40'' W, alt 35 m asl), which has an average annual precipitation of 1200 mm and an average annual temperature of 23 °C; and 3) Experimental Station of Ilha Barra do Pomba in Itaocara (RJ) (lat 21° 40' 09'' S, long 42° 04' 36'' W, alt 60 m asl), which has an average annual precipitation of 1221 mm and an average annual temperature of 23 °C. Trials were conducted during two growing seasons: winter 2021 and summer 2021-2022 (INMET 2021).

Genetic materials assessed for VCU included hybrids from the UENF Maize Breeding Program, namely UENF MSV 2210, UENF MS 2208, UENF 506-11, and UENF 506 16. Additionally, AG 1051, BM 207, LG 6036, and 30F35R were included as commercial checks. Yield trials followed a randomized complete block design with four replications. Each experimental unit consisted of four rows, each 4.0 meters in length. Rows were spaced 0.7 meters apart, with plants spaced 0.2 meters within rows, resulting in 20 plants per row and a total of 80 plants per plot.

Cultural practices across all locations and trials were performed in line with recommended guidelines for maize cultivation (Fancelli and Dourado Neto 2000). During the experimental period, traits were evaluated based on the minimum requirements for determining the VCU of common maize for inclusion on RNC (MAPA 2021). Statistical analyses were conducted by using Genes software (Cruz 2013).

PERFORMANCE

The experimental precision of the trial was assessed by the coefficient of variation (CVe), which ranged from 4.20% for plant height to 15.99% for yield. These values indicate good experimental precision, consistent with the classifications proposed by Scapim et al. (1995) and Fritsche-Neto et al. (2012). Analysis of variance revealed a significant effect for all evaluated traits, with probabilities of $p < 0.01$ and $p < 0.05$ (Table 1).

When comparing UENF 506 16 with AG 1051, one of the most widely used commercial cultivars in the Northern and Northwestern Fluminense regions of Rio de Janeiro, both hybrids showed similar results for plant height and ear height. However, UENF 506 16 excelled in prolificacy, while AG 1051 had a higher average yield than UENF 506 16. The CVe for each environment remained below the minimum requirement set by MAPA, with the highest value recorded at 18.35%. This indicates good experimental precision for both the winter and summer crops (Table 2).

Breeding methods should be considered when comparing the two hybrids. AG 1051 is a double hybrid created by crossing two single hybrids. This type of hybrid typically offers higher productivity but comes with higher production costs due to its more labor-intensive production process, especially when compared to interpopulation hybrids such as UENF 506 16.

On the other hand, UENF 506 16 is an interpopulation hybrid, which, while exhibiting lower average productivity, offers greater stability. This type of hybrid provides an alternative approach to hybrid seed production, combining good genetic potential with more affordable costs. Interpopulation hybrids are developed by crossing two maize populations with a broad genetic base, partially leveraging heterosis. Although they display lower levels of heterosis compared to double hybrids, interpopulation hybrids are notably stable across different years and geographical regions, with less fluctuation in yield. They respond predictably to favorable environmental conditions and maintain consistent production even in less favorable years.

The agronomic performance of UENF 506 16 was highly satisfactory in most environments during the evaluation periods. This makes it a recommended option for grain maize production in the Northern and Northwestern regions of the state of Rio de Janeiro.

Table 1. Summary of the joint analysis of variance for four traits evaluated in maize genotypes for grain yield in Campos dos Goytacazes, Cambuci, and Itaocara, RJ, across two seasons

Sources of variation	df	Mean Squares of traits[1]			
		PH	EH	PROL	GY
Block/E/S	18	0.100	0.019	0.023	797246.9358
Gen. (G)	7	1.833**	1.996**	0.158*	42599242.882**
Season (S)	1	3.922**	0.548*	0.003	16073537.204
Env. (E)	2	0.998*	0.718*	0.412	39880709.416
G × S	7	0.044**	0.026	0.014	3922316.833
G × E	14	0.011	0.012	0.037*	1608835.097
S × E	2	0.036*	0.007	0.172**	39086515.621**
G × S × E	14	0.009	0.011	0.012	3971975.721**
Error	126	0.013	0.010	0.011	1606940.612
Mean		2.69	1.61	1.01	7926.90
CVe(%)		4.20	6.12	10.29	15.99

[1] PH: plant height (m); EH: ear height (m); PROL: prolificacy (ear plant^{-1}); GY: grain yield (kg ha^{-1}). **: Significant ($p < 0.01$) by the F test; *: significant ($p < 0.05$) by the F test.

Table 2. Agronomic performance of UENF 506 16 compared to the control (AG 1051), evaluating plant height, ear height, prolificacy, and grain yield, with Tukey's tests in Campos dos Goytacazes, Cambuci, and Itaocara, RJ, across two seasons

Traits	Environments	Genotypes		
		UENF 506 16	AG1051	CVe (%)
Plant height (m)	Itaocara 1	2.63 a	2.74 a	3.95
	Itaocara 2	2.63 a	2.53 a	2.66
	Cambuci 1	2.74 a	2.83 a	2.14
	Cambuci 2	2.60 a	2.54 a	7.13
	Campos 1	2.55 a	2.64 a	3.86
	Campos 2	2.33 a	2.35 a	4.03
	Mean	2.58	2.60	4.20
Ear height (m)	Itaocara 1	1.60 a	1.68 a	5.65
	Itaocara 2	1.63 a	1.57 a	6.59
	Cambuci 1	1.62 a	1.65 a	3.41
	Cambuci 2	1.57 a	1.55 a	9.40
	Campos 1	1.39 a	1.55 a	5.28
	Campos 2	1.40 a	1.44 a	4.68
	Mean	1.53	1.57	6.12
Prolificacy (ear plant^{-1})	Itaocara 1	1.11 a	0.92 b	7.48
	Itaocara 2	0.88 a	0.78 a	12.65
	Cambuci 1	1.25 a	0.84 b	10.04
	Cambuci 2	1.32 a	0.98 b	12.14
	Campos 1	1.18 a	0.91 b	10.93
	Campos 2	1.22 a	0.87 b	7.79
	Mean	1.16	0.89	10.29
Grain yield (kg ha^{-1})	Itaocara 1	7.033 a	9.701 a	18.35
	Itaocara 2	5.910 a	6.997 a	13.73
	Cambuci 1	7.477 a	8.392 a	16.21
	Cambuci 2	8.938 a	9.569 a	15.40
	Campos 1	5.169 b	9.144 a	18.00
	Campos 2	7.395 a	7.302 a	11.33
	Mean	6.948	8.318	15.99

Means followed by the same letter in the column do not differ from each other by the Tukey's test at 5% probability.

OTHER CHARACTERISTICS

Beyond its grain yield potential, the UENF 506 16 cultivar was assessed for other key agronomic traits as well as for descriptors and disease resistance (Table 3). These evaluations were performed following the minimum requirements for registration on RNC, established by MAPA (MAPA 2021).

For agronomic traits, UENF 506 16 displays medium female and male flowering times of 66 and 64 days, respectively. The plant height averages 2.58 m, with an ear height of 1.53 m. The average ear length is 15.16 cm, and the ear diameter is 4.51 cm.

UENF 506 16 produces semi-dentate textured grains and features compact husks that fully cover the ears. Disease resistance data were collected through three evaluations conducted at 15-day intervals, from flowering to near plant senescence, using the AGROCERES (1996) evaluation scale. Thus, UENF 506 16 was classified as moderately susceptible to Helminthosporium leaf spot (*Exserohilum turcicum*) and Bipolaris leaf spot (*Bipolaris maydis*). For rust caused by *Puccinia polysora*, the cultivar was rated as moderately resistant (Table 3).

For the descriptors, UENF 506 16 has the following characteristics: the shape of the tip of the first leaf is pointed; the angle between the leaf blade and the stem, measured just above the upper ear, is small; the behavior of the leaf blade above the upper ear is medium; the length of the main stem of the tassel, measured between the point of origin and the

apex of the central stem, is medium; the angle between the main stem of the tassel and the lateral branch, measured in the lower third of the tassel, is medium; there is no anthocyanin pigmentation in the stigma; and the grain type, measured in the middle third of the ear, is semi-dentate.

SEED PRODUCTION AND DISTRIBUTION

Cultivar UENF 506 16 was registered with MAPA on April 12, 2024, under registry number 56523, as recorded in the Cultivar 'Web system (MAPA 2024). The UENF, in partnership with the seed company Rio Norte Sementes, based in the city of Campos dos Goytacazes (RJ), is responsible for the production and commercialization of the hybrid seeds.

CONCLUSION

UENF 506 16 has shown exceptional stability, allowing it to be planted in different environments and seasons with minimal variation in grain productivity. The registration of UENF 506 16 ensures greater accessibility and lower seed costs for growers in the state of Rio de Janeiro, particularly in the Northern and Northwestern regions of the state.

Table 3. Average agronomic traits of UENF 506 16 in the VCU test conducted in Campos dos Goytacazes, Cambuci, and Itaocara, RJ, across two evaluation periods

UENF 506 16	
Agronomic traits	
Male flowering (days)	64
Female flowering (days)	66
Plant height (m)	2.58
Ear height (m)	1.53
Average ear length (cm)	15.16
Average ear diameter (cm)	4.51
Number of kernel rows	12
Grain color	Orange-yellow
Grain texture	Semi-dentate
Husk	Compact, covering the ear completely
Disease resistance	
Helminthosporium Leaf Spot (*Exserohilum turcicum*)	Moderately susceptible
Polysora Rust (*Puccinia polysora*)	Moderately resistant
Bipolaris Leaf Spot (*Bipolaris maydis*)	Moderately susceptible

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DATA AVAILABILITY

The datasets generated and/or analyzed in this study are available from the corresponding author upon reasonable request.

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