UENF MSV2210 and UENF MS2208: Silage and green maize hybrids for Rio de Janeiro State, Brazil

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Abstract: *This study described the main characteristics of the maize cultivars UENF MSV2210 and UENF MS2208. Adapted to the North and Northwestern regions of the state of Rio de Janeiro, they have a high agronomic performance and were developed for both silage and green maize production.*

Keywords: *Zea mays L., topcross, plant breeding.*

INTRODUCTION

Maize (*Zea mays* L.) is a cereal cultivated in almost all agricultural regions of the world and is economically and socially extremely important. It is used in food, feed and fuel production as well as for industrial purposes (Sindmilho and Soja 2005). Worldwide, the USA is the largest maize producer, followed by China and Brazil, with an estimated output of 371.0, 259.1 and 68.5 million tons, respectively (FIESP 2018). According to estimates, the area of maize cultivation in the 2018/2019 growing seasons in Brazil was 17.242 thousand hectares, producing an estimated yield of 5.524 kg ha^{-1}, corresponding to an output of 95.254 thousand tons (CONAB 2019).

According to the Agricultural Census of 2017 in Brazil, around 5 million tons of green maize were produced in that year. The Southeast and Central-West regions accounted for about 3 and 94% of this total production, respectively (IBGE 2018). In the Southeast region, Rio de Janeiro is the state with the lowest number of agricultural production units. Of the 57 vegetables listed by IBGE (2018), green maize is the 15th most produced. According to preliminary data of fodder maize of the Agricultural Census of Brazil in 2018, the largest growing regions (Southeast, South and Central-West) produced 210.535.393 million tons of silage maize (IBGE 2020).

Among the forages, maize is one of the most commonly used in animal feed. Around 70 to 80% of the production is used in animal diets, destined for animal protein production in, e.g., eggs, meat and milk (Alves et al. 2015). According

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to Paziani et al. (2009), maize is the most commonly used crop for silage production because of its high nutritional value associated with high yields. However, to meet the standards, maize cultivars adapted to different environmental conditions must be used.

A major share of the current yield potential of this crop in Brazil is the result of significant advances in breeding programs. Over the years, these have progressively improved agronomic characteristics related to grain yield, disease resistance and adaptability to adverse conditions in the country (Pereira et al. 2019). In the North and Northwest of Rio de Janeiro, maize is an alternative income source for small and medium producers. The application of new scientific technologies to develop improved cultivars adapted to the climate conditions of the North and Northwestern state of Rio de Janeiro would provide an additional relevant increase in roughage production during the annual dry periods, aside from boosting the regional economy by the commercialization of green maize.

Not only in view of both the attractive growth prospects for silage maize on the market and of the complete dependence of Brazilian livestock on this additional forage source, but also because no Brazilian breeding programs have so far focused on forage species, nor are there any specific varieties available to meet the demand, this region-specific research was urgently needed.

The Value for Cultivation and Use (VCU) tests are essential for the registration of new cultivars developed by plant breeding programs. Once registered by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA 2019a), the cultivar is available in the register of the National Register of Cultivars (RNC) and can thus be distributed to farmers. To foster the cultivation of silage and green maize in the North and Northwest of Rio de Janeiro, the State University of Northern Rio de Janeiro has been developing research in the area of maize breeding, with a view to the registration and release of region-specific cultivars with high agronomic potential.

BREEDING METHOD

Eight genotypes of the maize collection of the State University of Northern Rio de Janeiro were selected (UENF-2205, UENF-2198, UENF-2207, UENF-2208, UENF-2209, UENF-2210, UENF-2202, UENF-2191), all of the heterotic group "dent", from which the topcross hybrids were derived. Each genotype was crossed with a single tester, Piranão 12. The topcross hybrids were developed on an isolated field of the Experimental Station of Ilha Barra do Pomba- RJ. The topcross hybrids were selected based on the fresh matter yield, after four years of testing (Crevelari et al. 2017, Crevelari et al. 2018).

Of each genotype, five seeds per meter were planted in one 20.0-m row (plant spacing 0.20 m, row spacing 1.0 m), with a total of 100 plants per row. During flowering, the plants used as female parents were detasseled before the ears released the style/stigma, to avoid undesirable crosses. In this way, the style/stigma received pollen only from the tester. Harvest was performed 120 days after sowing. The Value for Cultivation and Use (VCU) of the hybrids was tested during the main and second growing seasons, simultaneously at three locations: Antônio Sarlo State College of Agriculture, Campos dos Goytacazes, - RJ; Campus Cambuci of the Federal Institute of northern Rio de Janeiro (IFF-RJ) and at the Experimental Station of Ilha Barra do Pomba in Itaocara – RJ, in 2017/2018 and 2018/2018, i.e., in a total of six environments.

These three environments were located, respectively, at lat 21° 24' 48" S, long 41° 44' 48" W, alt 14 m asl, with a mean rainfall of 108.6 mm and mean temperature of 27.27 °C; the second at lat 21° 34' 31" S, long 41° 54' 40" W, alt 35 m asl, mean rainfall of 120.0 mm and mean temperature of 23 °C; and the third at lat 21° 40' 09" S, long 42° 04' 34" W, alt 60 m asl, mean rainfall of 183.25 mm and mean temperature of 25.32 °C, respectively (INMET 2017).

The experiment was arranged in a randomized complete block design with three replications, with 11 treatments each, eight topcross hybrids (UENF-2205, UENF-2198, UENF-2207, UENF-2208, UENF-2209, UENF-2210, UENF- 2202 and UENF-2191) and three controls (AG 1051, BM 3061 and UENF 506-11). The experimental units consisted of one 8.0-m row (plant spacing 0.20 m, row spacing 1.0 m), resulting in a stand of 40 plants per plot. Cultural treatments were applied as recommended for the crop (Fancelli and Dourado Neto 2000). The plants were harvested by cutting at 20 cm above the ground, when the grains were in growth stage R4, called dough stage (3/4 milkline) for silage maize. At the milky grain growth stage (R2), another harvest was performed to determine ear yield without straw (EYWS)

The characteristics were evaluated based on the Minimum Requirements for the determination of VCU of maize (*Zea mays*), for the inclusion in the National Register of Cultivars (MAPA 2019b). Combined analysis of variance and Tukey's mean test were performed with software Genes (Cruz 2013).

PERFORMANCE

Significant effects (p < 0.01) for all studied characteristics were observed, which indicated genetic variability between cultivars (Table 1). The experimental precision was concluded to be within normality and the variation coefficient varied from 8.63%, in fresh matter yield (FMY), to 11.54%, in ear yield without straw (EYWS). Mean-based heritability ranged from 94.04% FMY to 94.56% EYWS (Table 1).

Table 1. Summary of the combined analysis of variance applied to two traits assessed in maize cultivars in three counties of the North and Northwest of Rio de Janeiro state, in the growing seasons 2017/2018 and 2018/2018

		Mean squares	
Variation sources	df	EYWS	FMY
Block/Environment	12	8178859.06	56543921.25
Genotype	10	38692014.17**	303782927.84**
Environment	5	77933524.72	155788239.52
Genotype x Environment	50	5719016.92**	41384447.94**
Error	120	2101047.26	18105161.45
Overall mean		12.558	49.270
CV_e		11.54	8.63
$h_{\bar{x}}^2$		94.56	94.04

EYWS - ear yield without straw (kg ha^{-1}); FMY - fresh matter yield (kg ha^{-1}); ** - significant (p < 0.01) by the F test; * - significant (p < 0.05) by the F test.; CV_e: coefficient of experimental variation; $h_{\bar{x}}^2$ - mean genotypic heritability.

The overall EYWS mean of cultivars UENF MSV2210 and UENF MS2208 was superior or equivalent to that of the controls UENF 506-11 and AG 1051 (Table 2). For this characteristic, the coefficient of experimental variation ranged from 8.96 to 13.22% between environments and periods, indicating high experimental accuracy (Table 2).

Interestingly, the overall FMY mean of the cultivars UENF MSV2210 and UENF MS2208 exceeded that of the commercial controls (Table 2). The experimental coefficient of variation ranged from 6.44 to 11.34%, indicating a high experimental precision for the evaluated trait (Table 2).

The agronomic performance of the cultivars UENF MSV2210 and UENF MS2208 was very good in most environments and evaluation periods, making them recommendable for silage and green maize production in the North/Northwestern region of Rio de Janeiro state.

Table 2. Performance of the maize cultivars UENF MSV2210, UENF MS2208 and controls AG 1051 and UENF 506-11 at three locations of the North and Northwestern state of Rio de Janeiro, in the 2017/2018 and 2018/2018 growing seasons

	UENF MSV2210	UENF MS2208	AG 1051	UENF 506-11	CV_e (%)
Environments	**Ear yield without straw** (kg ha^{-1})				
Campos dos Goytacazes 2017/2018	15.583ab	13.290ab	12.725ab	14.908ab	13.22
Itaocara 2017/2018	11.625bcd	10.825cd	14.886abc	12.263abcd	11.47
Cambuci 2017/2018	13.963a	16.707a	15.508a	14.625a	10.94
Campos dos Goytacazes 2018/2018	12.225abc	9.455cd	13.333ab	9.384cd	8.96
Itaocara 2018/2018	11.537bc	10.501c	15.236a	11.105bc	10.04
Cambuci 2018/2018	12.508ab	12.314ab	10.997ab	10.128b	12.90
Overall mean	12.906	12.182	13.780	12.068	11.54
	Fresh matter yield (kg ha^{-1})				
Campos dos Goytacazes 2017/2018	56.573abc	60.520a	46.097bc	53.580abc	9.10
Itaocara 2017/2018	56.992a	57.191a	51.754a	48.925a	6.44
Cambuci 2017/2018	46.138bc	61.417a	44.779bc	44.612bc	8.66
Campos dos Goytacazes 2018/2018	49.308ab	56.229a	49.717ab	44.208b	7.45
Itaocara 2018/2018	48.867abcd	51.667ab	52.492ab	42.891bcd	8.06
Cambuci 2018/2018	54.204ab	58.438a	55.258ab	45.396ab	11.34
Overall mean	52.013	57.577	50.016	46.602	8.63

Means followed by the same letter in the same row do not differ statistically from each other by Tukey's test (p≤0.05).
* Tukey's test was performed based on the 11 treatments evaluated in tests of the value for cultivation and use (VCU).

Table 3. Means of agronomic characteristics of the maize cultivars UENF MSV2210, UENF MS2208, and controls AG 1051 and UENF 506-11 in Value for Cultivation and Use (VCU) tests in three counties of the North and Northwestern state of Rio de Janeiro, in the 2017/2018 and 2018/2018 growing seasons

Traits	UENF MSV2210	UENF MS2208	AG 1051	UENF 506-11
Male flowering	58	61	57	64
Female flowering	61	64	61	64
Plant height (m)	2.79	2.96	2.37	2.25
Ear height (m)	1.74	1.97	1.44	1.56
Mean ear length (cm)	19.04	18.80	19.57	18.66
Mean ear diameter (mm)	47.14	43.38	44.47	44.57
Number of grain rows	12	10	16	12
Grain texture	Dent	Dent	Dent	Semi-dent
Grain color	Medium yellow	Medium yellow	Yellow	Medium yellow
Husk coverage	Compact; tight husk coverage	Compact; tight husk coverage	Compact; tight husk coverage	Compact; tight husk coverage
Disease resistance				
Helminthosporium leaf spot	Moderate	Moderate	Moderate	Moderate
Southern corn rust	Moderate	Moderate	Moderate	Moderate

OTHER TRAITS

Additional characteristics were assessed based on a cultivar inscription form for registration by the National Cultivar Register of the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA 2019b).

The morphological characteristics were assessed at different phenological stages, based on the standard maize descriptors. Those of the two cultivars UENF MSV2210 and UENF MS2208 were generally similar, most likely due to the parent in common.

Both cultivars have the following descriptive characteristics: pointed first leaf tip shape; small angle between leaf blade and stem, measured immediately above the upper ear; straight shape of leaf blade above the upper ear; medium tassel length of the main stem, measured as the distance from the point of origin to the tip of the main stem; medium angle between the main tassel stem and lateral branch, in the lower third of the tassel; absent anthocyanin staining of the stigma and dent grain type, measured in the middle third of the ear.

The cultivars UENF MSV2210 and UENF MS2208 have a super early to early cycle, with male and female flowering between 58 and 64 days after sowing. The plant height is medium to high (2.79 - 2.96 m) and ear height (1.74 - 1.97 m). This is however not a problem, since the lodging risks until harvest time are lower for green and silage than for dry grain maize. For mean ear length and diameter, respective variations of 18.80 - 19.04 cm and 43.38 - 47.14 mm were recorded for UENF MS 2208 and UENF MSV2210 (Table 3). Grain texture and color and husk coverage degree of the evaluated cultivars were classified as dent, medium yellow and tight, respectively (Table 3).

In terms of the main maize diseases, the cultivars UENF MSV2210 and UENF MS2208 were moderately resistant to *Helminthosporium* leaf spot and Southern corn rust. Two evaluations were carried out within a fortnight, assessing from flowering until the point called dough stage, based on the Agroceres (1996) evaluation scale.

SEED PRODUCTION AND DISTRIBUTION

The cultivars UENF MSV2210 and UENF MS2208 were registered by the Ministry of Agriculture, Livestock and Food Supply - MAPA on November 12, 2019, under number 41721 and 41705 respectively. The State University of Northern Rio de Janeiro, together with the seed company Rio Norte Sementes based in Campos dos Goytacazes – RJ, are responsible for the production and trade of hybrid seeds.

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