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Genotypes maize for biomass and grains of second season cultivation in Dourados-MS

Genótipos de milho para biomassa e grãos de segunda safra em Dourados-MS

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ABSTRACT

Maize is a versatile crop, which allows from the production of whole plant silage to the harvest of grain maize, but it is necessary to verify the genotypes with these potentials according to the region of cultivation. Thus, the objective of this work was to identify the aptitude of maize for biomass for silage and grain in two years of second season cultivation in Dourados-MS. The experiment was conducted at Embrapa Western Agriculture, Dourados, MS, Brazil under field conditions in the experimental design was in randomized complete block in a 6x2 factorial scheme be six maize genotypes (BRS1010, KWS9606, BRS3046, 1P2224, 1Q2383, CAPO) and two growing years (2021 and 2022) with five replications. The agronomic traits of plant biomass for silage (plant and ear heigh, stem diameter number of leaves, green mass yield plant, leaf, steam more tassel and ear, dry matter yield in the plant and efficiency of land) and maize grain (ear diameter ear length, number of grain rows per ear, number of grains per row in ears, hundred seed weight and grain yield) were evaluated. There was an increase in the values of the traits for whole maize plant in the year 2022 compared to the year 2021. The maize genotypes indicated for biomass for silage were BRS3046, KWS9606 and 1Q2383, as for maize grain, the experimental genotypes that are under development, 1P2224 and 1Q2383, are promising options for the region.

KEYWORDS: Zea mays; Grain yield; forage; joint analysis.

RESUMO

O milho é uma cultura versátil, que permite desde a produção de silagem de planta inteira até a colheita de milho em grãos, porém é necessário verificar os genótipos com esses potenciais de acordo com a região de cultivo. Assim, o objetivo deste trabalho foi identificar a aptidão do milho para biomassa visando a silagem e grão em dois anos de cultivo de segunda safra em Dourados-MS. O experimento foi conduzido na Embrapa Oeste Agropecuária, Dourados, MS, Brasil em condições de campo no delineamento experimental em blocos completos casualizados em esquema fatorial 6x2 sendo seis genótipos de milho (BRS1010, KWS9606, BRS3046, 1P2224, 1Q2383, CAPO) e dois cultivos anos (2021 e 2022) com cinco repetições. Foram avaliadas as características agronômicas de biomassa da planta visando a silagem (altura da planta e da espiga, diâmetro do caule, número de folhas, produtividade de massa verde da planta, folha, colmo mais pendão e espiga, produtividade de matéria seca na planta e eficiência da terra) e milho grão (diâmetro da espiga, comprimento da espiga, número de fileiras de grãos por espiga, número de grãos por fileira na espiga, peso de cem sementes e produtividade de grãos). Houve aumento nos valores das características da planta inteira de milho no ano de 2022 em relação ao ano de 2021. Os genótipos de milho indicados para biomassa visando a silagem foram BRS3046, KWS9606 e 1Q2383, já para milho grão, os genótipos experimentais que estão em desenvolvimento, 1P2224 e 1Q238, são opções promissoras para a região.

PALAVRAS-CHAVE: *Zea mays*; Produtividade de grãos; forragem; análise conjunta.

INTRODUCTION

The maize crop (*Zea mays* L.) is of significant economic importance worldwide, serving as a fundamental staple in both human and animal diets (PAVAN & DUCKETT 2019). In Brazil it is possible to have its cultivation in two seasons, in the summer (first seasons) and autumn-winter (second seasons), and in the 2021/2022 cultivation in the second season there is a higher production of (85,892.4 thousand tons) than in the first season (25,030.4 thousand tons) (CONAB 2023). The second maize crop, also called safrinha maize, has been used in association with forage plants, as grass of the genus *Panicum*, in order to combine the production of grains and forage with the availability of food for the animals, since in this period the availability of food is more scarce, as well as the straw is formed aiming at increment in the no-tillage system (GERLACH et al. 2019).

Silage is a preserved fresh forage with high levels of energy and high yields of green and dry matter, with high nutritional value, being used at any time of the year in animal feed (TAS 2020, ZHAO et al. 2022). Maize silage has become one of the main energy components in ruminant nutrition (KOLAR et al. 2022, PEREIRA et al. 2020), with the use of plant parts (leaves, stem, ear, grain) (SOUZA et al. 2022).

Forage production determines the amount of dry matter available to ruminant animals, and forage quality can influence animal growth and its products (RICHMAN et al. 2015). The characteristics analyzed in the plant in the field for forage yield are strictly related to the type of maize used (CREVELARI et al. 2018, PEREIRA et al. 2018, PEREIRA et al. 2020) and the environmental conditions of cultivation, mainly temperature and precipitation that can modify the physiological processes and the growth of the forage (QUAN et al. 2020, TAS 2020).

Therefore, the information referring to the responses of the productive performance of plant traits for silage and grains, commercial maize and those that are in the development phase in the cultivation in the second crop in the Midwest are restricted (GUIMARÃES et al. 2023). In addition, having information from two years of cultivation in the same place and season becomes necessary to confirm or not whether the evaluated characteristics are maintained over the years in the genotypes, as there may be some alteration due to temperature and precipitation conditions. Thus, the objective of this work was to identify the potential of maize genotypes for silage and grain, in second season conditions in Dourados, Mato Grosso do Sul, and to select them for this dual aptitude (biomass for silage and grain) in two years of cultivation.

MATERIAL AND METHODS

The experiment was carried out at Embrapa Western Agriculture, in Dourados-MS (lat 22°16, long 54°49, alt 408 m asl) Brazil, in the field, in the autumn-winter of 2021 and 2022. The soil was classified as Distroferric Red Latosol, of very clayey texture (SANTOS et al. 2018). The climate in the region, according to the Köppen classification, with hot summers and dry winters (Aw), maximum temperatures observed in the months of December and January and minimum temperatures between May and August, coinciding with excessive rainfall in spring-summer and water deficit in autumn-winter (FIETZ et al. 2017). During the two years of the experiment, temperatures and precipitations were collected and historical series (Figure 1).

The experimental design was in randomized block in a 6x2 factorial scheme be six maize genotypes (three commercial, two from two from Embrapa Maize and Sorghum (BRS1010, BRS3046) and one from KWS Seeds (KWS9606,) and three in the development phase, two from Embrapa Maize and Sorghum (1P2224, 1Q2383) and one from Embrapa Western Agriculture (CAPO)) and two growing years (2021 and 2022) with five replications, in no-tillage system with the predecessor crop soybean. Fertilization was not carried out and weed and disease control according to crop needs. The plots consisted of five rows of 10 m in length (5 m for evaluation at the time of silage and another 5 m for maize grain harvesting). The implantations of the experiments were carried out on March 2, 2021 and February 24, 2022, with a seeder for simultaneous direct planting of maize and grass *Panicum maximum* cv. BRS Zuri (PST4 seeder from the Tatu Marchesan Flex Suprema brand). The plots consisted of five rows of 10 m in length with 50 cm spacing between maize rows and 20 cm between plants.

The traits of maize for silage were evaluated when the plants were at the R4 grain stage, in the farinaceous phase (¾ of the milk line). The plots of the CAPO genotype were harvested 84 days after sowing in 2021, with an accumulation of 80 mm of rain. In the year 2022, the harvest was carried out 92 days after sowing, with an accumulation of 536 mm. The other maize genotypes were harvested 104 days after sowing in the two years of cultivation, with accumulations of 243 mm and 569 mm of rain, respectively. The adopted cut for evaluation was carried out at 0.05 m from the ground with the harvest of a line of 5 m linear plants with planting at 0.5 m spacing between rows, totaling 2.5 m² of area for carrying out the weight of green mass and calculation of green mass yield (GMYP) (kg ha^{-1}) of each maize genotype.

Five plants per treatment were collected to evaluate the means of i) plant height (PH, cm), measured from the base of the last leaves; ii) ear height (EH, cm), measured from the base of the first ear; iii) the number of leaves (NL) per plant; iv) stem diameter (SD, cm), 0.5 m above ground level, determined with a digital caliper; v) green leaf mass yield (GMYL, kg ha^{-1}); vi) green stem plus tassel yield (GMYST, kg ha^{-1});

vii) green ear yield (GMYE, kg ha^{-1}). The percentage of the dry mass of the plant (PDMP) in each genotype was determined with the ratio of green plant weight and plant dry weight multiplied by 100. The dry matter yield in the plant (DMYP, kg ha^{-1}) was obtained with GMYP multiplied by PDMP and divided by 100. Land-use efficiency (Ef, kg ha^{-1} $days^{-1}$) was calculated with the ratio between DMYP and the total number of days from sowing to harvesting. For the dry mass analysis, the plants were chopped and placed in a forced-air circulation oven at 60 °C for 72 hours.

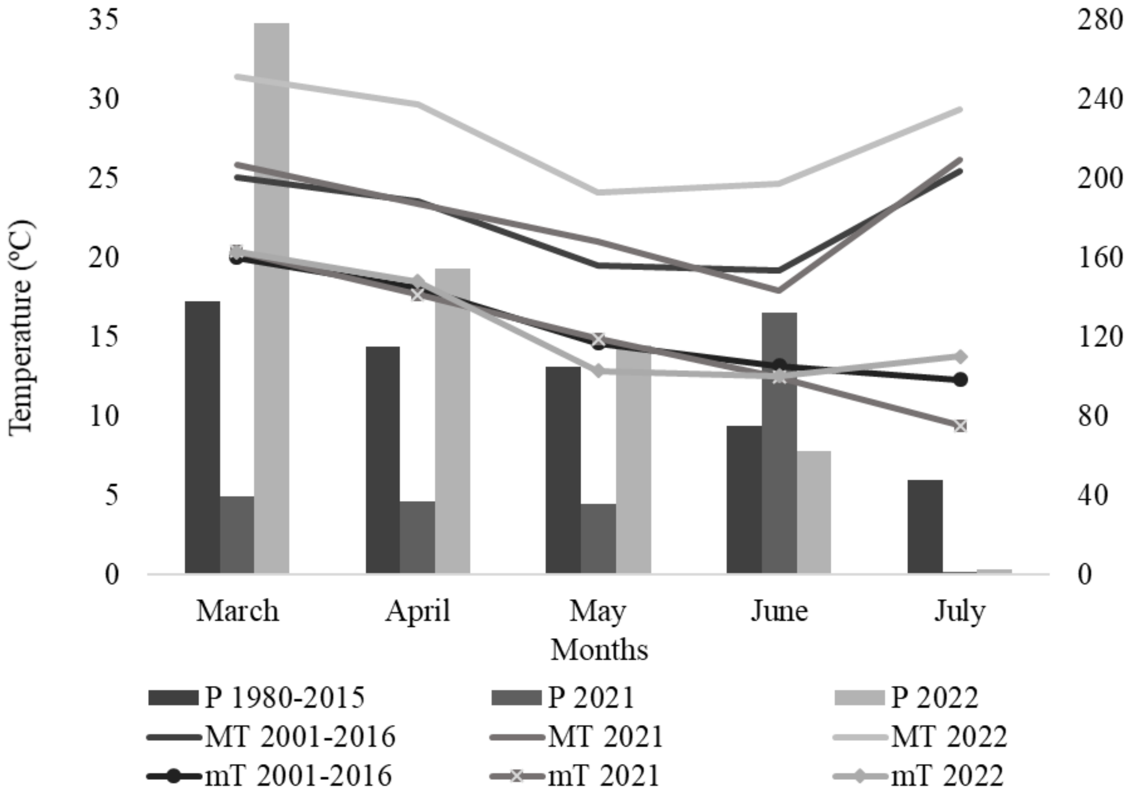

Figure 1. Precipitation (P), maximum (MT °C), and minimum (mT °C) temperatures obtained by the experimental station of Embrapa Western Agriculture during the study (2021 and 2022) and historical series. Dourados-MS, 2021. Source: FIETZ et al. (2017), GUIA CLIMA (2021), GUIA CLIMA (2022).

The traits of the maize grains were evaluated (in the natural drying conditions of the plant) with the 2021 harvest being 126 days after sowing (July 6, 2021) with a total of 245 mm of precipitation. In 2022 the maize grain harvest was 151 days after sowing (July 25, 2022) with a total of 577 mm of precipitation. Five ears per treatment were considered to analyze the means of i) diameter (ED, mm), measured with a digital caliper; ii) length (EL, cm), defined with the help of a graduated ruler; iii) the number of grain rows per ear (NGRE); iv) the number of grains per row in ears (NGE). After the defoliation and removal of the cob, the average hundred seed weight (HSW, g) was evaluated and quantified on a weighing machine in each treatment, and in 10 ears grain yield (GY, kg ha^{-1}) was determined by weighing the grains which was corrected for the humidity of 13%.

The analysis of variance was performed separately for each environment to test homogeneity of residual variances by the relationship between the highest and lowest mean square of the residue (MSR) in all traits, if it is less than seven proce with the joint analysis of variance (GOMES & GARCIA 2002). Subsequently, joint analysis of variance was conducted following the statistical model: $\mathrm{Yijk} = \mu + \mathrm{B/Ajk} + \mathrm{Gi} + \mathrm{Aj} + \mathrm{GAij} + \mathrm{eijk}$, wherein Y ijk is the effect of the genotype i in the year j and block k; µ is the general constant; B/A jk is the effect of the block k within the year j, supposedly independent and normally distributed, with mean zero and constant variance ~ NID (0, σ2 B/A); G i is the random effect of the genotype i (i = 1, 2, ... 6), supposedly independent and normally distributed, with mean zero and constant variance ~ NID (0, σ^2 G); A j is the fixed effect of the year j (j = 1, 2); GA ij is the effect of the interaction of the genotype i with the year j, supposedly independent and normally distributed with mean zero and constant variance ~ NID (0, σ^2 GA); and eijk is the effect of the experimental error of the Y ijk observation, supposedly independent and normally distributed, with mean zero and constant variance ~ NID (0, σ^2). Detected between maize genotypes by the F test at p≤0.05 probability, Tukey Test was performed at p≤0.05 probability using the Genes software version 1190. 2023.10 (CRUZ 2016).

RESULTS AND DISCUSSION

Based on the result of the analysis of variance, it is possible to analyze all the traits together, since the ratio between the largest and smallest mean square of the error is less than seven (GOMES & GARCIA 2002) (Table 1). The maize genotypes differed from each other in all the traits analyzed, that is, they have genetic variability with the possibility of selecting the superior ones (Table 1).

Table 1. Summary of the variation source of the joint analysis of variance (degree of freedom - DF and F test) of eleven trait of maize for silage in two years and six maize genotypes. Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Source of Variation	DF	Traits $^{1/}$										
						GMY						
		PH	EH	SD	NF	P	L	ST	E	PDMP	DMYP	Ef
B/A	8	-	-	-	-	-	-	-	-	-	-	-
Genotypes (G)	5	**	**	**	**	**	**	**	**	*	**	**
Year (A)	1	**	**	*	**	**	**	**	**	**	**	**
G x A	5	**	**	ns	*	**	**	**	**	ns	**	**
$^{2/}$CV (%)		7.7	15.0	10.0	7.0	9.5	18.48	14.1	13.4	7.1	11.1	10.0
$^{3/}$ Highest MSR/Lowest MSR		1.9	3.9	1.4	5.4	1.5	4.0	1.5	5.0	3.4	1.4	1.4

**, *, ns: significant at p≤0.01, significant at p≤0.05, and not significant by the F test. $^{1/}$PH: plant height, EH: ear height, SD: steam diameter, NL: number leaves, GMY: green mass yield, P: plant, L: leaf, ST: steam more tassel, E: ear, PDMP: percentage of dry mass of the plant, DMYP: dry matter yield in the plant. Ef: efficiency of land. $^{2/}$CV: coefficient of variation. $^{3/}$ Highest MSR / Lowest MSR = test of homogeneity of variance according to GOMES & GARCIA (2002).

There was also a difference between the two years of cultivation for all traits, that is, the year factor interferes in the results. Only the traits stem diameter and percentage of plant dry matter were not influenced by the interaction between maize genotypes and years of cultivation, that is, the best genotypes in one year are also in the other year (Table 1). In the other traits, there was a significant interaction between the factors, that is, the performance of the maize genotype was influenced by the year of cultivation, and its ranking may change in the years of cultivation (Table 1).

For the stem diameter characteristic, the maize genotype 1P2224 (20.01 cm) had the highest value in relation to the CAPO (16.95 cm) and KWS9606 (17.56 cm) genotypes, with the year 2022 having the highest diameter with 18.99 cm (Table 2). Plant dry matter content at harvest for silage ranged from 32.16 to 36.10% of dry mass, with genotypes 1P2224 and KWS960 differing from each other (Table 2). These values are close to the recommended 33 to 37% (MAGALHÃES & DURÃES 2006) for ensiling, since it can provide better chopping and compaction and desirable fermentations without loss of nutrients if well managed (DUARTE et al. 2014, NEGRÃO et al. 2016), and the year 2021, on average, was within the recommended range.

Table 2. Means of maize genotypes and years of cultivation for the traits stem diameter (SD) and percentage of dry mass of the plant (PDMP). Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Genotypes	SD (mm)	PDMP (%)
1P2224	20.0 a	36.1 a
1Q2383	18.4 abc	34.3 ab
BRS1010	17.7 abc	35.0 ab
BRS3046	19.5 ab	33.7 ab
CAPO	17.0 c	33.3 ab
KWS9606	17.6 bc	32.2 b
Year		
2021	17.7 b	36.3 a
2022	19.0 a	31.8 b

Means, in the column, followed by the same letter do not differ from each other (p ≤0.05) by Tukey's test

Maize considered to be ensiled can be sustained by its biomass, including larger size, which may reflect in greater production of green and dry forage mass (CREVELARI et al. 2018, PEREIRA et al. 2018).

Thus, on average, the BRS3046, KWS9606 and 1Q2383 maize genotypes had higher values of the biomass traits (Table 3) in relation to the CAPO and BRS1010 genotypes in the two years of evaluation.

Table 3. Means of interactions between maize genotypes and growing years for the traits plant heigh (PH), ear height (EH), number leaves (NF), green mass yield, P: plant (GMYP), leaf (GMYL), steam more tassel (GMYST), ear (GMYE), dry matter yield in the plant (DMYP) and efficiency of land (Ef). Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Genotypes	PH (cm)		EH (cm)		NF	
	2021	2022	2021	2022	2021	2022
1P2224	155.8 Ba	192.2 Aa	68.8 Aab	70.0 Aab	12.6 Aa	12.6 Aa
1Q2383	150.0 Ba	178.6 Aab	65.8 Bab	80.4 Aa	13.2 Aa	11.4 Bab
BRS1010	119.0 Ab	131.4 Ac	51.8 Aabc	54.8 Abc	12.0 Aa	10.8 Bb
BRS3046	135.2 Bab	161.2 Ab	62.8 Aab	69.4 Aab	13.4 Aa	11.4 Bab
CAPO	96.7 Bc	133.0 Ac	35.7 Ac	38.6 Ac	10.0 Ab	10.0 Ab
KWS9606	121.8 Bb	183.4 Aa	51.2 Bbc	86.4 Aa	12.4 Aa	11.4 Aab
Mean	129.8 B	163.3 A	56.0 B	66.6 A	12.3 A	11.3 B
	GMYP (kg ha^{-1})		GMYL (kg ha^{-1})		GMYST (kg ha^{-1})	
1P2224	23924.0 Ba	27680 Ab	3809.0 Aa	4858.6 Ac	10053.1 Aa	10688.3 Ab
1Q2383	22024.0 Bab	37808 Aa	3792.3 Ba	7604.5 Aab	9411.6 Ba	14749.3 Aa
BRS1010	17588.0 Bbc	23616 Abc	2871.3 Aa	3476.4 Ac	7380.6 Bab	9564.8 Ab
BRS3046	20572.0 Babc	42156 Aa	3262.5 Ba	6641.7 Ab	8604.4 Ba	15900.4 Aa
CAPO	16624.0 Bc	22636 Ac	3542.9 Aa	3838.8 Ac	5003.2 Bb	8960.4 Ab
KWS9606	21760.0 Bab	41248 Aa	3437.7 Ba	8340.0 Aa	8754.3 Ba	15199.4 Aa
Mean	20415.3 B	32524 A	3452.6 B	5793.3 A	8201.2 B	12519.5 A
	GMYE (kg ha^{-1})		DMYP (kg ha^{-1})		Ef (kg ha^{-1} days^{-1})	
1P2224	10061.9 Ba	12133.0 Ac	9645.0 Aa	8855.9 Ab	92.7 Aa	85.2 Ab
1Q2383	8820.1 Ba	15454.1 Ab	7938.2 Bab	12184.1 Aa	76.3 Bab	117.2 Aa
BRS1010	7336.1 Ba	9888.3 Ac	6551.9 Abc	7653.8 Ab	63.0 Ab	73.6 Ab
BRS3046	8705.1 Ba	19059.5 Aa	7280.4 Bbc	13386.1 Aa	70.0 Bb	128.7 Aa
CAPO	8077.9 Aa	9836.7 Ac	5854.1 Ac	7087.9 Ab	69.7 Ab	77.0 Ab
KWS9606	9568.0 Ba	17708.6 Aab	7269.6 Bbc	12799.4 Aa	69.9 Bb	123.1 Aa
Mean	8761.5 B	114013.4 A	7423.2 B	10327.9 A	73.6 B	100.8 A

Means followed by the same uppercase in the lines and lowercase in the column do not differ statistically ($p \leq 0.05$) by Tukey's Test.

On average, the plant height, plant green mass, stem and ear productivity traits had high values in the year 2022 in most maize genotypes and only the leaf number trait that on average had a high result in the year 2021, with the exception of genotypes 1P2224 and CAPO. What may have resulted in these differences is that the years of cultivation varied in terms of sowing and harvesting times, and climatic conditions, mainly precipitation, since in 2021, CAPO maize was harvested with an accumulation of 80 mm and other maize genotypes 243 mm, and in the year 2022 the CAPO genotype with 536 mm of rain accumulation, and the others at 569 mm. The maize crop requires an average of 250 to 350 mm of water for forage maize and about 500 to 600 mm for grain production (CRUZ & PEREIRA FILHO 2008), that is, in 2021 the rainfall index that interfered in the results.

Ear height is important to check whether the plants are lodging or not and also to enable mechanized harvesting for more erect plants. In the present study, there was no lodging of the plants, which demonstrates that the genotypes are erect.

The characteristic dry matter productivity gives indications of the potential amount of silage generated by the area, and that this can influence the number of animals that can be fed to generate good performance of these, since the dry matter intake of the food determines the food value being related to the nutritional value (nutrient content) (MEDEIROS & MARINO 2015). Thus, in the 2021 season, the 1P2224 and 1Q2383 genotypes showed high dry matter productivity in the plant, and in the 2022 season, the 1Q2383, BRS3046 and KWS9606 genotypes reached the best potentials for this characteristic. The characteristic land use efficiency, calculated in the period from sowing to harvest, the same maize genotypes of the previous characteristic obtained superior land use, predicting that these had a better use of dry matter.

Regarding the agronomic traits of maize grain, through the result of the analysis of variance, the possibility of carrying out the analysis of the traits together was also verified, since the relationship between the largest and smallest mean square of the error is less than seven (GOMES & GARCIA 2002) (Table 4).

Table 4. Summary of the variation source of the joint analysis of variance (degree of freedom - DF and F test) of six traits of the maize grains in two years and six maize genotypes. Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Source of Variation	GL	Traits [1/]					
		ED	EL	NGRE	NGE	HSW	GY
B/A	8	-	-	-	-	-	-
Genotypes (G)	5	**	**	**	**	**	**
Year (Y)	1	**	**	ns	**	**	ns
G x Y	5	*	*	ns	**	ns	ns
[2/]CV (%)		4.8	12.7	11.4	12.6	11.2	17.9
[3/] Highest MSR / Lowest MSR <		1.3	2.0	1.1	1.1	5.7	3.9

**, *, ns: significant at p≤0.01, significant at p≤0.05 and not significant by the F test. [1/] ED: ear diameter; EL: ear lenght; NGRE: number of grain rows per ear; NGE: number of grains per row in ears; HSW: hundred seed weight, GY: grain yield. [2/]CV: coefficient of variation. [3/] Highest MSR / Lowest MSR = test of homogeneity of variance according to GOMES & GARCIA (2002).

The maize genotypes also had a significant effect for all agronomic traits, that is, they had significant differences between them with the possibility of selecting the best ones (Table 4). The years of cultivation did not interfere for the traits number of grains rows per ear and grain yield; in addition to these traits, the weight of one hundred grains was not influenced by the interaction between the maize genotypes and the years of cultivation studied, that is, the genotypes have, on average, the same performance in the two years (Table 4). In the other traits, there was a significant effect of the genotype and year of cultivation, that is, the best genotypes in one year may not be the same in the other year (Table 4).

The average number of rows of grains and grain yield were similar for the years 2021 and 2022, that is, temperature and precipitation conditions did not interfere (Table 5). However, the mass of one hundred grains obtained higher values in the year 2022, which may be due to greater precipitation in that year than in 2021 (Figure 1).

Table 5. Means of maize genotypes and years of cultivation for the traits number of grain rows per ear (NGRE), hundred seed weight (HSW) and grain yield (GY). Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Genotypes	NGRE	HSW (g)	GY (kg ha^{-1})
1P2224	15.0 ab	19.9 b	2171 ab
1Q2383	16.4 a	22.4 ab	2352 a
BRS1010	12.9 b	23.1 ab	1803bc
BRS3046	15.6 a	20.5 b	1920abc
CAPO	14.2 ab	24.5 a	1689 c
KWS9606	15.8 a	22.3 ab	2118 abc
Year			
2021	14.9 a	20.1 b	1927 a
2022	15.1 a	24.1 a	2091 a

Means, in the column, followed by the same letter do not differ from each other (p ≤ 0.05) by Tukey's Test.

For the characteristic number of rows of grains, the maize genotypes 1Q2383 (16.4), BRS3046 (15.6) and KWS9606 (15.8) had a greater number of grains rows compared to the genotype BRS1010 (12.9 cm) (Table 5). This characteristic may have a direct effect on grain yield in maize (GUIMARÃES et al. 2019).

In the present study, the CAPO genotype had the highest 100-grain mass, with 24.51 g in relation to the genotypes 1P2224 (19.91 g) and BRS3046 (20.54 g) (Table 5). However, the CAPO genotype had lower grain yield than the genotypes 1P2224 (2171 kg ha^{-1}) and 1Q2383 (2352 kg ha^{-1}). This demonstrates that the mass of one hundred grains may have a smaller direct effect on grain yield (GUIMARÃES et al. 2019). Lineages 1P2224 and 1Q2383 are genetic materials developed by Embrapa, have grain production potential for the edaphoclimatic conditions of Dourados-MS and similar regions. However, the grain yield of the present study was lower compared to that of the State of Mato Grosso do Sul and Brazil, which were, respectively, 5669 (kg ha^{-1}) and 5247 (kg ha^{-1}) in the second season of 2021/ 22 (CONAB 2023). Although the averages of the years for grain yield did not have statistical differences, the values in 2022 may be due to the greater accumulation of precipitation (614 mm) compared to 2021 (245 mm), since for grain production the range considered ideal is 500 to 600 mm (CRUZ & PEREIRA FILHO 2008), depending on the type of genotype used.

The maize genotypes had a significant effect with the interaction of the year of cultivation for the traits ear diameter, ear length and number of grains in rows (Table 6), this shows that each genetic material had a different performance each year. Ear diameter is properly related to grain filling and the number of grain rows per ear, and this characteristic is also influenced by plant genetics (GOES et al. 2012). In the year 2022, the BRS1010, KWS9606 and CAPO genotypes obtained higher values compared to the year 2021. On average, the BRS3046 and 1Q2383 genotypes had greater ear diameters.

Table 6. Means of interactions between maize genotypes and growing years for the traits ear diameter (ED), ear lenght (EL) and number of grains per row in ears (NGE). Embrapa Western Agriculture, Dourados-MS, 2021 and 2022.

Genotypes	ED (mm)		EL (cm)		NGE	
	2021	2022	2021	2022	2021	2022
1P2224	42.0 Abc	44.3 Aab	15.2 Aa	15.4 Aa	28.0 Aa	29.4 Aa
1Q2383	45.4 Aab	46.9 Aa	13.6 Babc	15.9 Aa	23.2 Babc	29.8 Aa
BRS1010	39.0 Bcd	44.1 Aab	11.8 Bbcd	15.4 Aa	19.0 Bbc	31.8 Aa
BRS3046	47.8 Aa	46.8 Aa	14.8 Aab	16.7 Aa	24.6 Bab	33.4 Aa
CAPO	37.4 Bd	42.5 Ab	9.8 Ad	9.5 Ab	17.6 Ac	21.6 Ab
KWS9606	40.5 Bcd	44.3 Aab	11.2 Bcd	15.4 Aa	18.0 Bc	27.8 Aa
Mean	42.4 B	44.8 A	12.7 B	14.7 A	21.7 B	29.0 A

Means followed by the same uppercase in the lines and lowercase in the column do not differ statistically ($p < 0.05$) by Tukey's Test.

Ear length is a trait that affects maize productivity, as the greater the ear length, the greater the potential number of grains to be formed per row, and this trait is more affected by the genotype (GOES et al. 2012). In this sense, the average ear length is directly associated with the number of grains per row, since longer ears result in a greater number of grains (VILELA et al. 2012). A reduction in this trait was observed in genotypes 1Q2383, BRS1010, BRS3046 and KWS9606 compared to 1P2224 and CAPO in 2021.

The number of grains per row is considered a characteristic directly linked to the product of economic interest and consequently influences the grain yield (LIMA et al. 2020). Genotypes 1Q2383, BRS1010, BRS3046, KWS9606 and 1P2224 had higher values for this trait in the year 2022. On average, genotypes BRS3046, 1P2224 and 1Q2383 had higher number of grains per row in ears.

The maize genotype BRS1010 genotype CAPO showed lower values for ear diameter, ear length and number of grains per row in ear traits in both years of cultivation. The average increase in the values of ear diameter, ear length and number of grains per row of maize genotypes in the 2022 growing year is noteworthy. Since, in that respective year, there was more precipitation, giving plants greater water availability compared to the year 2021 (Figure 1).

In general, the experimental genotypes 1P2224 and 1Q2383 were the ones that had the best performance for maize silage and maize grain and that the year 2022 that had the highest precipitation was what resulted in better values of the traits analyzed. There are several requirements for maize genotypes to reach high yields, mainly the different edaphoclimatic conditions that were developed, such as fertilization levels and amount of water (SARAIVA et al. 2019). In addition, the distribution of rainfall in the V12 and R1 stages (flowering) of maize are decisive factors in defining the production and yield of the crop, mainly regarding the size and number of ears (BORÉM et al. 2017).

CONCLUSION

In the second season maize conditions in Dourados-MS, there was an increase in the values for the traits for silage maize in the year 2022 in relation to the year 2021.

The maize genotypes indicated in the conditions of Dourados-MS with the characteristics evaluated in the field for silage were BRS3046, KWS9606 and 1Q2383. As for maize grain, the experimental genotypes that are under development, 1P2224 and 1Q238, are on average those indicated for the region.

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