Agronomic performance of maize hybrids for forage production in the 2019/2020 harvest

Dionatas Alex Garcia[1], José Luiz de Andrade Rezende Pereira[2], Tássio Rezende Garcia[3], Vítor Marinello Souza[4], Luciano Luiz Pereira Júnior[5]

[1] Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais (IFSULDEMINAS) – *Campus* Inconfidentes. Graduando em Engenharia Agronômica. dionatas.garcia10@gmail.com.

[2] IFSULDEMINAS – *Campus* Inconfidentes. Professor. joseluiz.pereira@ifsuldeminas.edu.br.

[3] IFSULDEMINAS – *Campus* Inconfidentes. Graduando em Engenharia Agronômica. rezendegarcia@bol.com.br.

[4] IFSULDEMINAS – *Campus* Inconfidentes. Cursando Técnico em Agropecuária. marinellosv@outlook.com.

[5] IFSULDEMINAS – *Campus* Inconfidentes. Graduando em Engenharia Agronômica. luciano115junior@gmail.com.

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Abstract

Maize has great economic prominence in national and international agribusiness, being used for various purposes such as grain use and in the form of bulky (silage). This study aimed to evaluate the agronomic characteristics of twelve maize hybrids for silage production in Inconfidentes-MG. Twelve hybrids were used: 20A78PW, 2B512PW, 2B533PW, 2B688PW, 30F53LEPTERA, AG8740-PRO3, DKB345-PRO3, DKB363-PRO3, LG3055-PRO3, LG6036-PRO3, MAXIMUS-VIP3, and MG652PW. The treatments were implanted in a randomized block design (CBD) containing three repetitions. The experimental plots consisted of four lines of five meters in length and 0.8 m spacing between rows, with the two central lines as useful areas. The parameters evaluated were green matter productivity, dry matter productivity, plant height, ear height, average stalk thickness, cutting window, flowering, and cycle. The hybrids 20A78PW; 2B533PW; DKB345-PRO3, and DKB363-PRO3 presented the highest cut-off window values in relation to the others. LG3055-PRO3 hybrid presented the smallest cut-off window. The hybrids 30F53LEPTERA, AG8740, DKB345-PRO3, LG6036-PRO3, and MG652PW presented the highest plant height values. No statistical difference was observed between the hybrids for the variables: green matter productivity, ear height, and stalk thickness. Hybrids AG8740, DKB345-PRO3, LG6036-PRO3, and MG652PW obtained the highest dry matter productivity values. Hybrids 20A78PW, 2B533PW, DKB345-PRO3, and DKB363-PRO3 presented the lowest male and female flowering time. Hybrid DKB345-PRO3 stood out, showing great potential to be recommended and cultivated by silage producers.

Keywords: Dry matter. *Zea mays* L. Silage. Bulky. Blooming/Flowering.

Introduction

Maize crop has great economic prominence in national and international agribusiness, being used for various purposes, mainly for human consumption of grains and for concentrated in animal diets and in the form of bulky (silage). High crop yields can be related to the physiological characteristics of the plants used for the processing of silage, because studies propose that the final quality of the product is directly more correlated with qualitative characteristics of the vegetative elements of the plant than to the grain itself (MENDES *et al*., 2008; PEREIRA *et al*., 2011).

The silage process aims at the conservation of forages, which, in turn, has been increasingly adopted as a strategy for the dry season, lack of food for animals, and improvement in the use of the production chain. Silage represents a participation of more than 70 % in dairy farms, thus making it a strong parameter for the maize market at the national level (VIEIRA; ANTUNES, 2018). Maize (*Zea mays* L.) is one of the cultivated species of great genetic diversity both in nutritional quality and productivity, thus presenting a bulky of high nutritional value and highly significant mainly for ruminant feeding, aiming at the highest productive potential of the animal (MARCONDES *et al*., 2012).

Moraes *et al*. (2013) pointed out the existence of a wide variety of maize hybrids for silage production, being the species *Zea mays* L. one of the most cultivated for this purpose, in addition to providing a considerable diversity in variables such as green matter, stalk thickness, among others that will influence the nutritional aspect of the final silage product.

Zopollatto *et al*. (2009) expressed that maize has several different compounds, the vegetative fraction consisting of structuring carbohydrates and the graniferous fraction with endosperm starch. Thus, we verify that, from bloom to the stage of flour grain, the culture undergoes an important transformation, taking into account the quantitative aspect, with the concentration of dry matter, and the qualitative aspect, with the quick change in the percentage of nutritional compounds, that is, the forage part of the plants.

Oliveira *et al*. (2007) exposed in their work that factors such as cycle, type, dry matter productivity, as examples, are highlighted in the choice of hybrids for cultivation, as they influence the quantity and nutritional value of silage. They also emphasize there is a wide variety of maize cultivars when considering dry matter productivity and its quality.

The maize crop presents great variability to define its complete cycle since environmental conditions and genotype diversification interfere with its development; thus, the number of days from its sowing to harvest or the occurrence of the inflorescence is taken as a basis (MACHADO *et al*., 2017).

Oliveira *et al*. (2005) cited that competition trials of maize hybrids are extremely important for the evaluation of the agronomic performance of new genetically improved hybrid cultivars launched on the market, being rated under different environmental conditions. Therefore, the producer's choice of a hybrid cultivar that is more suitable for their local conditions will be obtained based on data resulting from agronomic characterization testings (SANTOS *et al*., 2002). Lupatini *et al*. (2004) emphasized that the best performances of the hybrid cultivars intended for silage production occur when all local conditions are adequate for plant development.

Jaremtchuk *et al*. (2005) reinforced that cultivars with higher productivity and adapted to the environmental conditions of the cultivation location should be used for choosing maize hybrid for silage for ab economically feasible production, with emphasis on quality.

Thus, it is relevant that research generates information, evaluating the performance of hybrid maize cultivars available on the market, subsidizing recommendations of cultivars for whole plant silage for various occasions and regions. Neumann *et al*. (2018) also cited the strong interaction between the genotype and the environment on the performance of maize cultivars intended for silage production.

Given the information exposed, this study aimed to evaluate the agronomic performance of twelve maize hybrids for silage production in Inconfidentes-MG in the 2019/2020 harvest.

Material and methods

The experiment was conducted in the field in the municipality of Inconfidentes-MG, in the experimental area of the farm that belongs to the Federal Institute of Education, Science, and Technology of Southern Minas Gerais, Inconfidentes Campus.

The municipality is located at 869 m above sea level, 22º18'47" South latitude, and 46º19'54.9" West longitude (FAO, 1985). The climate of the region is temperate, i.e., mesothermic, of dry winter (Cwb). It has a mean annual temperature of 19.3 ºC and a mean annual rainfall of 1.411 mm (FAO, 1985). The area has an eutrophic yellow-red latosol (DOS SANTOS *et al*., 2018) being cultivated annually with corn.

Twelve hybrids were used (20A78PW, 2B512PW, 2B533PW, 2B688PW, 30F53LEPTERA, AG8740, DKB345-PRO3, DKB363-PRO3, LG3055-PRO3, LG6036-PRO3, MAXIMUS, and MG652PW) with characteristics for silage production.

The experiment was installed on November 22, 2019, the recommended planting season in the region. The soil was prepared in a conventional manner. A ploughing was carried out at 30 cm depth and then two gratings for deburring and levelling.

The treatments were installed using a randomized block design (RBD) containing 3 repetitions. The experimental plots consisted of 4 lines of 5 meters in length and 0.8 m spacing between rows, with the 2 central lines as useful areas.

The parameters evaluated were green matter productivity (PMV) in t ha^{-1}, dry matter productivity (PMS) in t ha^{-1}, plant height (AP) in meters, ear height (AE) in meters, average stalk thickness (EC) in centimeters, cut-off window (JC) in days, male (FM) and female (FF) bloowing in days and cycle (CC) in days.

The evaluation of these parameters was determined due to their extreme relationship both in the qualitative and quantitative aspect of the final product, which is whole plant silage. The genotype and environment interaction also have a strong influence on them.

The variable green matter was determined from the plants of the 2 centerlines of each useful area in which they were cut, tied in bundles for weight distribution, weighed on a digital hand-held scale, and then had its productivity calculated in t ha^{-1}.

To obtain the dry matter, the plants of the useful areas were cut and chopped, after the ears presented ½ line of milk. Then, a sample of 300 g was removed, dehydrated with the aid of a forced air circulation oven at 56 ºC for 72 h, and, after this period, the samples were removed from the oven and weighed on a precision scale. From the percentage of dry matter of the hybrid obtained through the difference of green and dry weight, the productivity in t ha^{-1} of this variable was determined.

We determined the plant height by measuring the average height in meters of 10 plants randomly chosen in the useful area, this measurement was carried out from the ground level to the insertion point of the flag leaf (last leaf of the plant).

The ear height was obtained by the mean height of 10 plants randomly chosen in the useful area, measured in meters, from the ground level to the insertion point of the main ear.

To determine the average stalk thickness, measurements were performed in centimeters with the aid of a caliper. Three points were measured in the plant and an average was obtained, one point 20 cm above the ground level, another in the insertion of the main ear and another in the insertion of the flag leaf, and the final value for evaluation purposes was the average of ten plants randomly chosen within the useful area.

The window for pruning was determined when the plants could be cut, in which they presented ½ of the milk line and ending this period when they reached ¾ of the milk line.

To evaluate the blooming, we used the methodology of Clovis *et al*. (2015) and Ciappina (2019), measuring the number of days from sowing until 50 % of the plants in the plot had presented anthers releasing pollen, in the case of male flowering (hanging) and the issuance of the style-stigma in female flowering (embossing). The flowering interval that deals with the difference in days of hanging and embossing were also calculated.

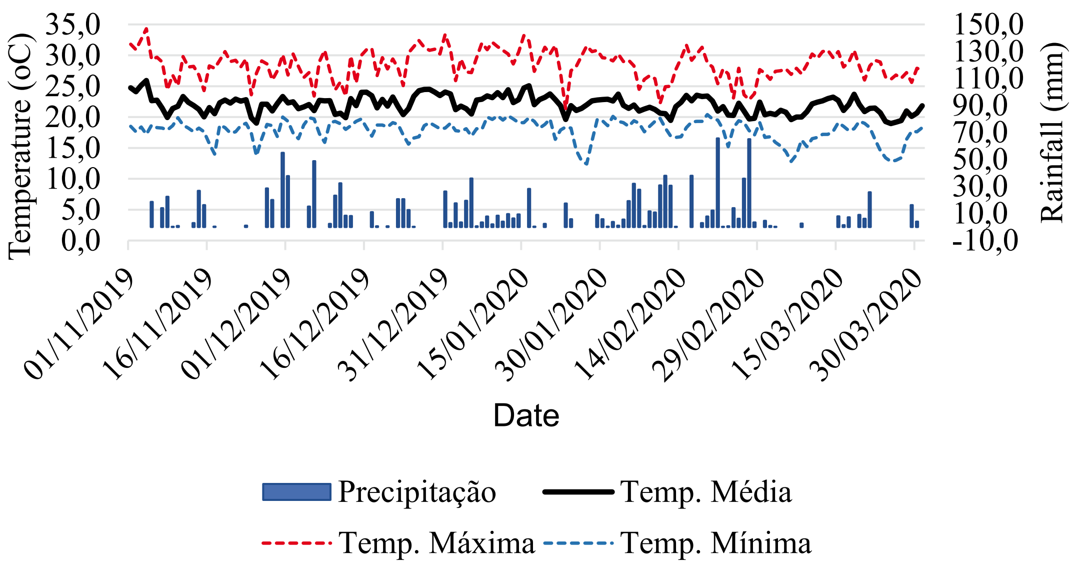
To achieve the cycle of each hybrid, we determined from the time of sowing until the plants presented their cut-off point, in which corn was in ½ of the milk line. The evaluations of the milk line were performed weekly after male and female flowering. Later, with the hybrids presenting almost half of the milk line, we started evaluation daily to realize the ideal moment of the cut and not incur possible analytical errors.

The data were analyzed using the SISVAR software (FERREIRA, 2011) and the variables were compared by the Scott-Knott test (1974), at 5 % probability.

Results and discussion

The genotype and environment interaction is extremely important, thus we can observe in Figure 1 the data of the maximum, minimum, and average temperatures and precipitation during the experiment. The data were collected at a weather station (Vantage Pro2 - Davis®) installed at the farm that belongs to the IFSULDEMINAS - Campus Inconfidentes in a location with Latitude: 22º 18' 37.47" S, Longitude: 46º 19' 56.31" O and Altitude: 914.0 m. The equipment stores hourly data, which were integrated to obtain the total daily precipitation and the daily average for the temperatures.

Figure 1 – Temperature and precipitation during the experiment from November/2019 to March/2020 in Inconfidentes/MG.



Source: Barbosa (2020).

The average results for green matter productivity (PMV), dry matter productivity (PMS), plant height (AP), ear height (AE), stalk thickness (EC), and cut-off window (JC) are set forth in Table 1.

Table 1 – Agronomic performance values of 12 maize hybrids for silage evaluated in Inconfidentes/MG in the 2019/2020 harvest.

Hybrids	*PMV (t ha-1)	*PMS (t ha-1)	*AP (m)	*AE (m)	*EC (cm)	*JC (days)
20A78PW	61.15 a	17.54 b	2.37 b	1.22 a	1.71 a	18 a
2B512PW	56.07 a	18.08 b	2.32 b	1.26 a	1.72 a	14 b
2B533PW	66.58 a	18.20 b	2.35 b	1.27 a	1.82 a	15 a
2B688PW	56.96 a	19.47 b	2.29 b	1.22 a	1.86 a	12 c
30F53LEPTERA	61.48 a	15.77 b	2.57 a	1.44 a	1.74 a	13 b
AG8740-PRO3	63.76 a	24.12 a	2.45 a	1.31 a	1.70 a	10 c
DKB345-PRO3	59.96 a	23.63 a	2.48 a	1.29 a	1.74 a	16 a
DKB363-PRO3	51.86 a	20.67 b	2.40 b	1.27 a	1.68 a	16 a
LG3055-PRO3	52.61 a	19.59 b	2.26 b	1.35 a	1.75 a	7 d
LG6036-PRO3	62.68 a	24.38 a	2.50 a	1.24 a	1.88 a	11 c
MAXIMUS	49.23 a	18.86 b	2.20 b	1.24 a	1.73 a	13 b
MG652PW	70.86 a	22.74 a	2.50 a	1.33 a	1.87 a	12 c
CV (%)	11.52	16.00	5.22	5.07	6.79	12.75

*Means followed by distinct letters in the columns differ from each other by the Scott-Knott test (1974) ($P < 0.05$).

Source: Prepared by the authors (2020).

The analysis of the variable PMV showed no significant difference ($P < 0.05$) between the hybrids. On the other hand, Paziani *et al*. (2009) emphasized in their research that the productivity of green matter is one of the first parameters sought by producers to choose a particular cultivar, because they are concerned with the sizing of the silos where they will store the raw food, in addition to diluting the costs of crop implementation due to increased productivity. However, PMV is influenced by the harvesting time, so it is recommended to observe the PMS better since it is also where the nutrients that the animals will use are found.

For the variable PMS, there was a statistical difference, at which hybrids AG8740-PRO3, DKB345-PRO3, LG6036-PRO3, and MG652PW presented the highest values. This variable is extremely important in the choice of a hybrid because it contains essential nutrients and the energy that animals need for meat or milk production. Lupatini *et al*. (2004) emphasized that the cultivars recommended for silage should be adapted in the planting region, seeking an optimal performance of PMS with good grain participation, which consequently will result in high food quality and productivity.

There was a statistical difference in AP between hybrids, with 30F53LEPTERA, AG8740-PRO3, DKB345-PRO3, LG6036-PRO3, and MG652PW being the largest. This variable is influenced by the genotype and the place where the hybrid is sown (genotype x environment interaction). Bedding is related to this variable, however, in this experiment, it did not occur.

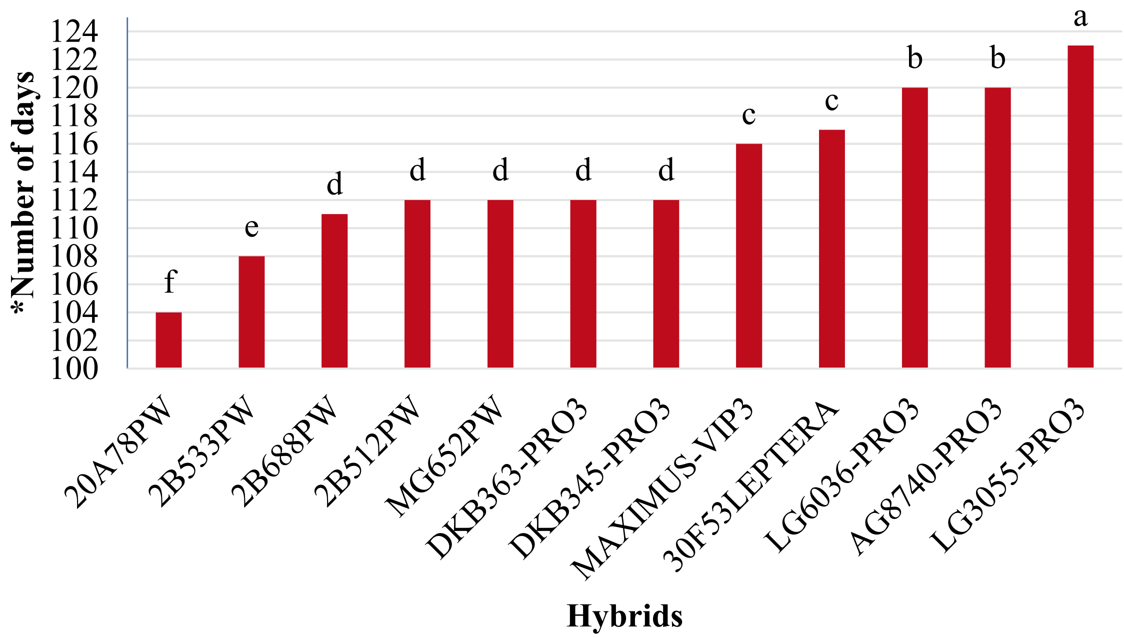
For variables AE and EC, there was no statistical difference between the hybrids. These parameters are also related to the genotype and environment interaction.

The analysis of the variable JC showed a significant difference ($P < 0.05$), and the hybrids that showed higher cut-off window values in relation to the others were: 20A78PW; 2B533PW; DKB345-PRO3, and DKB363-PRO3. The smallest cut-off window was presented by the LG3055-PRO3 hybrid. This variable is very important because it helps silage producers to better plan their crops within an ideal period, aiming at the excellence of the final product results, thus hybrids with larger cut-off windows will be the most suitable for silage production.

In this way, to choose the hybrids, we recommend those with the highest dry matter productivity. Another important factor is the cutting window that should be as spaced as possible.

The results obtained from the culture cycle (CC), counted in days, can be seen in Figure 2.

Figure 2 - Culture cycle values of 12 maize hybrids for silage evaluated in Inconfidentes/MG in the 2019/2020 harvest.



*Means followed by distinct letters in the columns differ from each other by the Scott-Knott test (1974) ($P < 0.05$).

CV (%) 1.54.

Source: Prepared by the author (2020).

According to Emater (2016), one of the classifications of the maize cultivars cycle is determined according to the number of days from sowing to the time of harvest. Based on this statement, in the case of maize for silage, the cycle was established at the moment of cutting.

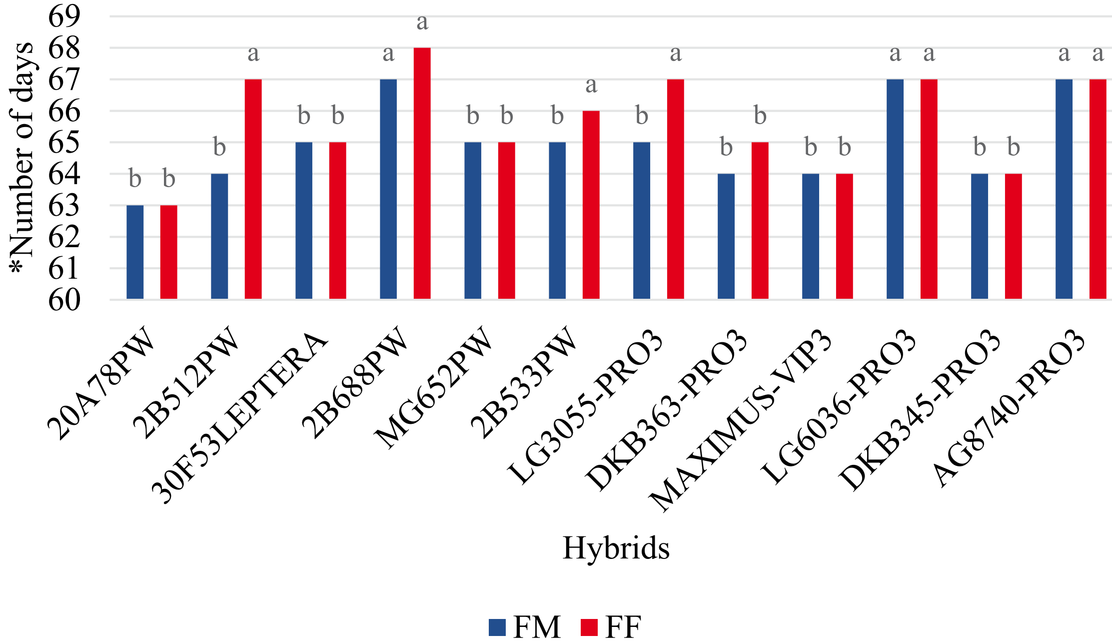
Dekalb (2018) pointed out that the Ministry of Agriculture, Livestock and Supply (Ministério da Agricultura, Pecuária e Abastecimento - MAPA) has been trying to standardize the classification of the maize hybrid cycle in the number of days, but there is still no standard defined for this subject; thus, the division into three groups is suggested: Group I - Super early: up to 110 days; Group II – Normal: between 110 and 145 days and Group III – Late: greater than 145 days.

According to the results presented in Figure 2, the cultivars were classified according to their cycle as Super-early and Normal, the Super-early hybrids being 20A78PW and 2B533PW, and Normal hybrids 2B512PW, 2B688PW, 30F53LEPTERA, AG8740-PRO3,

DKB345-PRO3, DKB363-PRO3, LG3055-PRO3, LG6036-PRO3, MAXIMUS-VIP3, and MG652PW.

Male blooming (FM) and female blooming (FF) can be seen in Figure 3.

Figure 3 – Male and female blooming of 12 maize hybrids for silage evaluated in Inconfidentes/MG in the 2019/2020 harvest.



*Means followed by distinct letters in the columns for the same blooming differ from each other by the Scott-Knott test (1974) (P < 0.05).

FF – CV (%) 2.15.

FM – CV (%) 2.18.

Source: Prepared by the author (2020).

Figure 3 shows that there was no great variation between the flowering intervals of the 12 corn cultivars, highlighting the hybrids 20A78PW, 30F53LEPTERA, MG652PW, MAXIMUS-VIP3, LG6036-PRO3, DKB345-PRO3, and AG8740-PRO3, which had male and female flowering at the same time. However, the other hybrids still remained within the appropriate parameters to evaluate this variable and the period ranged from 1 to 3 days.

The process of pollen release by the tassel of the corn plant can take an average of two to fourteen days since the female plant blooms around two to three days after hanging. Thus, three-day flowering intervals are not considered so long as to affect crop performance (CIAPPINA, 2019).

In his experiment, Ciappina (2019) observed that the flowering interval ranged from zero to three days, considered ideal for production, and a genetic improvement program since longer intervals hinder the process of self-fertilization of plants.

Magalhães *et al*. (2009) highlighted that when blooming, corn is very sensitive, especially if related to lack of water, so there must be no increase in the interval between male and female flowering, as it will affect crop production negatively.

Observing the precocity of the male and female blooming in the hybrids in Figure 3, and highlighting the cut-off window variable in Table 1, we found that the cultivars with higher cut-off window values presented a shorter period for flowering, mainly in the hanging, where the hybrids 20A78PW, 2B533PW, DKB345-PRO3, and DKB363-PRO3 stood out in this evaluation in relation to the others, demonstrating an average of 64 days for both flowering and 16 days of the cut-off window, emphasizing the statement.

Zopollatto *et al*. (2009) evaluated the performance of maize cultivars for silage production in two distinct harvests, finding similar values for the male flowering, with an average of 64 days.

Just as we highlighted the importance of considering the cut-off window variable for better planning of producers, especially for the harvest period, it is also of great relevance to note that flowering has a relationship with the spacing of the cut-off window, thus making it a determinant parameter at the time of choosing the hybrid.

Conclusions

Hybrids 20A78PW; 2B533PW, DKB345-PRO3, and DKB363-PRO3 presented the highest cut-off window values in relation to the others. LG3055-PRO3 hybrid presented the smallest cut-off window.

Hybrids 30F53LEPTERA, AG8740, DKB345-PRO3, LG6036-PRO3, and MG652PW presented the highest plant height values.

No statistical difference was observed between the hybrids for the variables: green matter productivity, ear height, and stalk thickness.

Hybrids AG8740, DKB345-PRO3, LG6036-PRO3, and MG652PW obtained the highest dry matter productivity values.

Hybrids 20A78PW, 2B533PW, DKB345-PRO3, and DKB363-PRO3 presented the lowest male and female flowering time.

In general, hybrid DKB345-PRO3 stood out, showing greater potential to be recommended and cultivated by silage producers in the region of Inconfidentes/MG.

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