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RESEARCH ARTICLE

TRAITS OF IMPORTANCE FOR CORN SILAGE PRODUCTION

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ABSTRACT

The study aimed to identify the phenotypic classes and the relative contribution of traits, which points linear associations and the genetic variation among corn hybrids used for silage production. Was conducted in 2012/2013 crop year, in the city of Campos Borges – RS. The experimental design was a randomized complete blocks, with eight corn hybrids, arranged in six replications. The analysis showed significance at 5% probability tomineral material (MM), total crude protein (PTN), hemicellulose (HEM), lipids (LIP), total carbohydrates (TC) and non-fiber carbohydrates (NFC). However, no significant differences were observed for plant height (PH), ear insertion height (EIH), prolificity (PRO), chlorophyll content (CC), hydrogenic potential (pH), dry mass percentage of silage (DMPS), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LIG), cellulose (CEL), leaf area (AF), green mass yield per hectare (GMY) and dry mass yield per hectare (DMY). The frequency distributions indicate that the traits with more phenotypic classes were the total crude protein and hemicellulose. The cellulose present high relationship with the structural carbohydrates fraction and difficult digest. The cellulose and hemicellulose percentage is inversely proportional to the non-fibrous carbohydrates of corn silage. Neutral detergent fiber, non-fibrous carbohydrates and hemicellulose traits are those that contribute most to discrimination of corn genotypes. The contribution of descriptive, univariate and multivariate analysis demonstrate to be techniques which can be used successfully in the discrimination of corn genotypes and traits of importance for the production of corn silage.

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INTRODUCTION

The Brazil has great aptitude to agribusiness, in this scenario, beef cattle and dairy cattle have featured in national productive chain. On the various panoramas of agricultural production, the southern region has a favorable climate for dairy production, however, the supply of quality food presents seasonally throughout the year. Therefore, the silage is present economically viable because it attends the nutritional demands of the diet, revealing a power supply with high quality and readily available to animals (MITTELMANN *et al*., 2005). The quality of the silage arises from factors linked to cultivation environment and the ensiling process, the soil and climatic characteristics, and management techniques attributed to culture, technological level of the property, and the corn genotype traits used (MOREIRA *et al*., 2001). Thus, the corn hybrids used for silage should have high dry matter production per unit area, nutritional value and digestibility (GOMES *et al*., 2006). The decisive character for the quality of silage production are attributed to fraction of dry matter, crude protein and energy proportion (PAZIANI *et al*., 2009).Researches show that physiological quality of seeds, the initial establishment of plants in the field, the time of seeding the management of fertilization, the arrangement and the plant population, interspecific competition with weeds, can influence the magnitude and quality of cornsilage (ROSA *et al*., 2004).

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The characters of importance in the production of corn silage are largely influenced by the environment, where we emphasize the proportion of digestible dry matter, starch carbohydrates fraction, intrinsic traits of genotype and interaction of genotype x environment (MITTELMANN *et al*., 2005). In this context, it is crucial to understand which traits have greater prominence to the improvement of corn for silage, aiming productivity per unit area, the quality of the product, higher storage time and digestibility (GOMES *et al*., 2004). In conjunction show that the associations among traits of interest, identifying the genetic variation of genotypes involved. Thus, this study aimed to identify the phenotypic classes and the relative contribution of traits, which points linear associations and the genetic variation among corn hybrids used for silage production.

MATERIALS AND METHODS

The study was conducted in 2012/2013 crop year, in the city of Campos Borges - RS, at coordinates: latitude 28 ° 52'31 "S and longitude 53 ° 01'55" O, with an altitude of 439 meters. The soil of the region is classified as Red Latosol (EMBRAPA, 2006), and the climate is characterized by Köppen as humid subtropical *Cfa* (MORENO, 1961). The experimental design was a randomized complete blocks, with eight corn hybrids, arranged in six replications. The genotypes were: HT3248, HS1356, HS1380-2, HS1358, HT7, HSM97, HS1380-1 and HT4, totaling 48 experimental units. The experimental units were composed of four rows with five meters long and spaced 0.5 meters, and a population of 75,000 plants per hectare for all genotypes tested. The seeds were seeded in the first half of October 2012 and proceeded to silage in the first half January 2013.

The plant harvest time for silage consisted when plants revealed in their ears to the milk to flour grain stage. Subsequently the plants were ground in 10 mm to 20 mm particulate, and ensiled in mini-silos of PVC with 3925 cm³. On the basis of mini-silos was added sieved dry sand in order to store the solute resulting from the fermentation of the silage process. Compacted the silage with density 600 kg of green mass per cubic meter (VELHO *et al*., 2007), and subsequently mini-silos were tightly sealed and stored for 820 days. We used fertilizer base of 250 kg ha^{-1} NPK formulation (10-20-20), coverage was applied 90 kg ha^{-1} of nitrogen in amide form, in the vegetative stages V4 and V6 (FANCELLI e DOURADO NETO, 2000). The weed management, insect pests were carried out preventively, in order to reduce external interference to the results of the experiment. The traits were measured in the useful area of each experimental unit, which is composed of two main rows, where 0.5 meters from each end were discarded to minimize the effects of surround, the traits measured were: Plant height (PH), measured from the ground level to the last expanded leaf, results in meters (m).

Leaf area (AF), measured the length and width of leaves in five plants per experimental unit, later corrected the values by a factor of 0.75 (MONTGOMERY, 1911), results in cm². Green mass yield per hectare (GMY), obtained by grinding the useful area of the experimental unit and measurement of the ground material mass, then made the ratio between the silage mass and the number of ground plants, adjusting for the final population of plants used, results in kg ha^{-1}. Dry mass yield per hectare (DMY) cut green mass was subjected to drying at 65°C, the results were adjusted for the final population of plants used, results in kg ha^{-1}. Dry mass percentage of silage (DMPS), made up the collect of 100g removed material. Fractions were placed in an oven with temperature of 105°C for 24 hours, after obtained the ratio of the fresh and dry mass, results in percentage. Hydrogenic potential of silage (pH); hemicellulose (HEM); cellulose (CEL); mineral material (MM), were obtained by Silva and Queiroz technique (2006), results in percentage. Neutral detergent fiber (NDF), the samples were subjected to autoclaving with neutral detergent by 110°C for 40 minutes (SENGER *et al*., 2008), results in percentage. Acid detergent fiber (ADF), the residue NDF was autoclaved with acid detergent by 110°C for 40 minutes (SENGER *et al*., 2008), results in percentage. Lignin (LIG), measured by the methodology proposed by Robertson and Van Soest (1981), results in percentage. Total carbohydrates (TC) and non-fiber carbohydrates (NFC) were obtained by methodology Sniffen *et al*. (1992), results in percentage.

Total crude protein (TCP), determined by the methodology proposed by Nogueira and Souza (2005), results in percentage. Lipids (LIP), determined by the technique by Bligh and Dyer (1959), results in a percentage. The data were submitted to variance analysis in order to verify the presuppositions, it carried out the diagnosis of normal errors by the Shapiro-Wilk test (SHAPIRO AND WILK, 1965), and homogeneity of variances by Bartlett (STEEL *et al*., 1997). We conducted a descriptive analysis through the distribution of frequencies with aim to reveal the phenotypic classes of measured traits. Subsequently, it was performed Pearson linear correlationanalysis trend to show the association among traits (CARVALHO *et al*., 2004). There was the relative importance of traits by Singh (1981), and canonical variables analysis in order to identify the genetic variation present among genotypes, analysis were performed using the statistical software Genes (CRUZ, 2013).

RESULTS AND DISCUSSION

The analysis showed significance at 5% probability tomineral material (MM), total crude protein (PTN), hemicellulose (HEM), lipids (LIP), total carbohydrates (TC) and non-fiber carbohydrates (NFC). However, no significant differences were observed for plant height (PH), ear insertion height (EIH), prolificity (PRO), chlorophyll content (CC), hydrogenic potential (pH), dry mass percentage of silage (DMPS), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LIG), cellulose (CEL), leaf area (AF), green mass yield per hectare (GMY) and dry mass yield per hectare (DMY). The frequency analysis has the purpose of organizing a set of observations for easier viewing, while identifies the class formed by observations in each trait (Crespo, 2002). The chlorophyll content (CC) revealed four phenotypic classes with amplitude14.4 to 16.2 mg m^{-2},so that 37.5% of the corn hybrids were included in the class 16.2 mg ha^{-1} (Figure 1 A).Thus, chlorophyll consists of a group of pigments in the plant tissue, and have the ability to transform light energy into chemical energy in the photosynthetic process, is crucial in the transformation of inorganic molecules in organic as assimilated (VOLP *et al*., 2009).

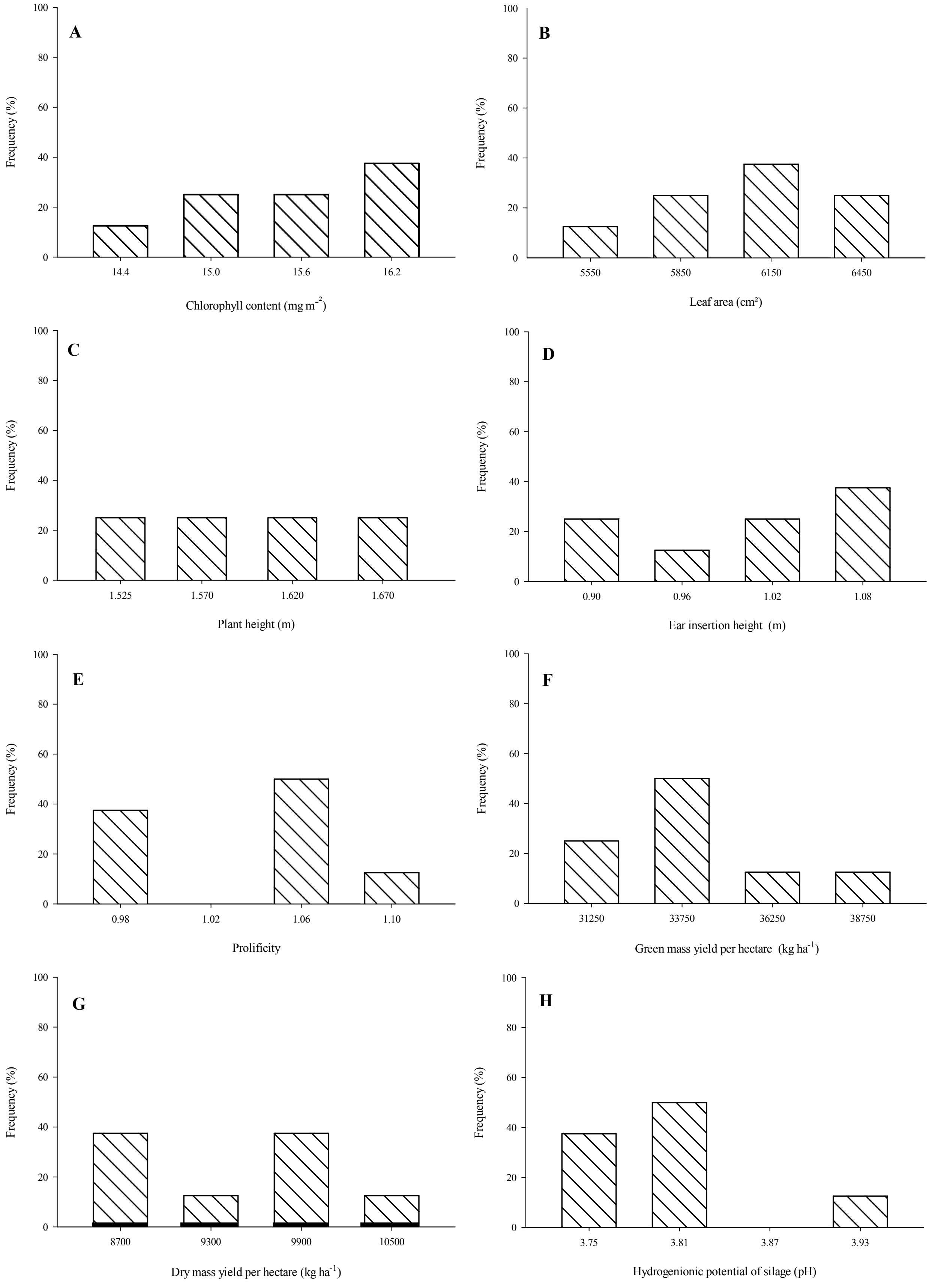

Figure 1. Frequency distribution of phenotypic classes for chlorophyll content (CC), leaf area (LA), plant height (PH), ear insertion height (EIH), prolificity (PRO), green mass yield (GMY), dry mass yield (DMY) and hydrogenic potential (pH)

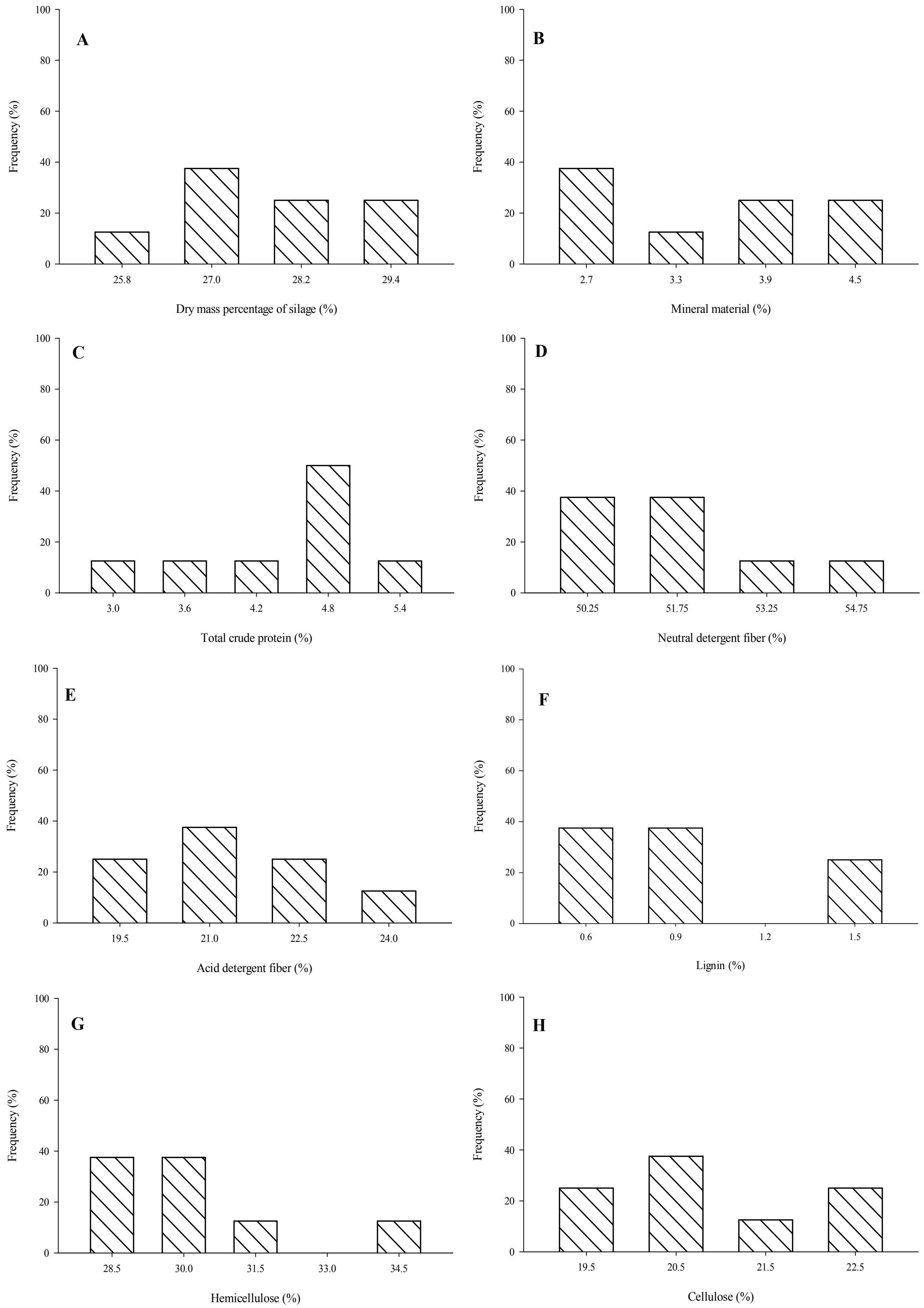

Figure 2. Frequency distribution of phenotypic classes for dry mass percentage of silage (DMPS), mineral material (MM), total crude protein (TCP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LIG), hemicellulose (HEM) and cellulose (CEL)

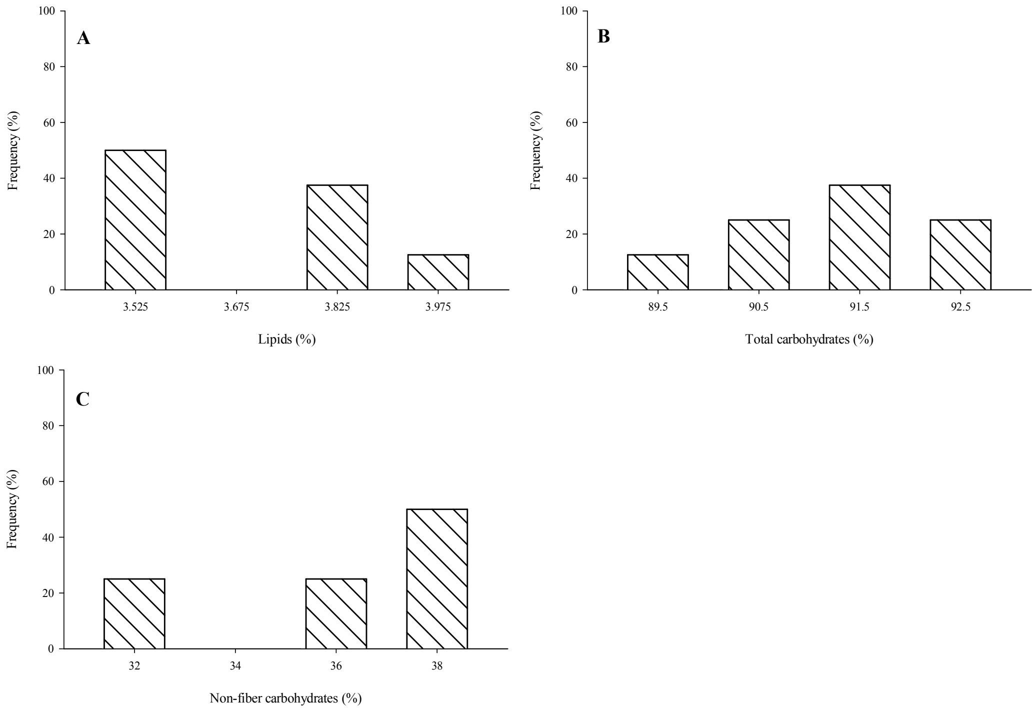

Figure 3. Frequency distribution of phenotypic classes for lipids (LIP), total carbohydrates (TC) a nd non-fiber carbohydrates (NFC)

High chlorophyll levels revealed desirable feature in corn hybrids used for silage, it may be indicative of increased production capacity and the quality of the genotype. The leaf area (AF) showed four phenotypic classes with amplitude 5550-6450 cm^2, and 37.5% of the evaluated corn hybrids include the 6150 cm^2 class (Figure 1-B). The leaf area magnitude of a plant with aptitude for the silage production is intimately related to the green and drymass production per unit area. Research of Cunha (2004) shows a strong positive relationship between leaf area index and dry mass production of Tanzania grass.

The plant height (PH) presented four phenotypic classes, with amplitude comprising 1.52 to 1.67 meters, and the classes were established similarly with 12.5% of tested hybrids (Figure 1-C). The increase in plant height is a factor that increases the unit mass of plant, leaf units, stems per area, that together show the greatest potential for the ensiling process. The ear insertion height (EIH) revealed four phenotypic classes, with amplitude from 0.90 to 1.08 m, so that 37.5% of the hybrids were present in class 1.08m (Figure 1-D). The ear insertion height is related to the balance point of the corn plantsince plants withhigher insertion ear have a greater tendency to lodging, which is not a desirable trait for both the production of silage and for grains. The corn cutting height is a trait that influences the quality of produced silage, where higher and closer to the ear cuts tend to increase the PSof silage, higher proportion of grains with respect to straw, and farther cuts ear reduce the DM. In research, Neumann *et al*. (2007) concluded that the cut corn carried out at 15.2 cm height resulted in an increase of 7.1% in the PS production of silagecompared to cutting at 38.6 cm from the ground.

The prolificacy (PRO) showed three phenotypic classes, varying from 0.98 to 1.10m, and 50% of the hybrids present in the class 1.10 (Figure 1-E), indicating that most of the hybrids used have become more prolific, and are likely to contribute more to PS silage due to the increase of grain and starchy fraction in silage. The ear production by corn hybrids suitable for the silage production is a very important aspect, because they reduce the proportion of slow-digesting fiber, increment protein and starchy fraction and provide a better digestibility of plant (ZAGO, 2002). In this sense, Nússio (1992) defined that the ideal corn plant for the silage production should be composed of 20 to 23% of stem, 12 to 16% leaf and 64 to 65% of ears. The green mass yield per hectare (GMY) revealed four phenotypic classes, with amplitude of 31250-38750 kg ha^{-1}, and 62.5% of the hybrids are in the class 38750 kg ha^{-1} (Figure 1-F). The green mass production, ideal for silage, is an inherent trait in hybrid used, but is strongly influenced by management. Neumann *et al*. (2007) noted an increase in the ensilageGMY production 53744 to 59905 kg ha^{-1} when reduced thecutting height of 38.6 to 15.2 cm.In a similar way, the dry mass yield per hectare (DMY) presented four phenotypic classes, with amplitude 8700-10500 kg ha^{-1}, noting similarly with 37.5% of the hybrids are situated in the classes 8700 and 9900 kg ha^{-1} (Figure 1-G). This result falls short of the potential for dry mass yield of hybrids available in the agricultural scenario. In studies Beleze *et al*. (2003) observed the dry mass yield of 17.24 t ha^{-1}, in simple hybrid. The hydrogenic potential (pH) of the silage is distributed in three phenotypic classes, with amplitude from 3.75 to 3.93 and stands to 3.81 with 50% of the genotypes used (Figure 1-H). Research Vieira *et al*. (2013), with different corn hybrids showed no significant differences in pH between the

Table 1. Pearson's linear correlation estimatives for 19 agronomically important traits in eight single corn hybrids

	PH	EIH	PRO	CC	LA	GMY	DMY	pH	DMPS	MM	TCP	NDF	ADF	LIG	HEM	CEL	LIP	TC	NFC
PH	-	0.78*	0.18	0.58*	0.31*	0.52*	0.47*	0.35*	-0.08	0.14	-0.21	0.49*	0.40*	-0.11	0.32*	0.43*	0.20	-0.03	-0.47*
EIH		-	0.10	0.46*	0.33*	0.46*	0.46*	0.18	-0.003	0.14	0.03	0.24	0.20	-0.10	0.15	0.23	0.21	-0.14	-0.29*
PRO			-	0.06	0.09	-0.12	-0.12	0.04	-0.01	-0.05	-0.07	0.19	-0.02	-0.08	0.30*	0.03	-0.19	0.17	-0.13
CC				-	0.29*	0.58*	0.51*	0.05	-0.19	0.10	-0.05	0.37*	0.32*	0.12	0.22	0.34*	0.11	-0.11	-0.37*
LA					-	-0.03	0.002	0.006	0.10	0.21	-0.26	0.25	0.07	0.01	0.30*	0.08	-0.01	-0.01	-0.23
GMY						-	0.90*	0.07	-0.23	0.14	0.02	0.23	0.12	-0.05	0.22	0.12	0.30*	-0.17	-0.28
DMY							-	0.002	0.21	-0.01	0.04	0.01	-0.001	-0.05	0.02	-0.04	0.17	-0.09	-0.03
pH								-	-0.10	-0.06	0.01	0.20	0.24	0.12	0.05	0.27	0.19	0.01	-0.19
DMPS									-	-0.29*	0.004	-0.47*	-0.27	-0.04	-0.42*	-0.35*	-0.25	0.18	0.54*
MM										-	-0.42*	0.32*	0.17	-0.36*	0.31*	0.19	0.20	-0.55*	-0.51*
TCP											-	-0.35*	-0.17	0.43*	-0.36*	-0.19	0.10	-0.32*	0.21
NDF												-	0.75*	-0.03	0.72*	0.74*	-0.06	-0.24	-0.95*
ADF													-	0.14	0.08	0.96*	-0.01	-0.35*	-0.71*
LIG														-	-0.19	0.05	-0.09	-0.18	0.03
HEM															-	0.10	-0.07	0.003	-0.67*
CEL																-	0.05	-0.21	-0.71*
LIP																	-	-0.12	-0.09
TC																		-	0.47*
NFC																			-

*Pearson's linear correlation coefficient (n = 48) significant at 5% probability.

** PH – plant height; EIH – ear insertion height; PRO – prolificity; CC – chlorophyll contente; LA – leaf area; GMY – green mass yield; DMY – dry mass yield; pH – hydrogenic potential of silage; DMPS – dry mass percentage of silage; MM – mineral material; TCP – total crude protein; NDF – neutral detergent fiber; ADF – acid detergent fiber; LIG – lignin; HEM – hemicellulose; CEL – cellulose; LIP – lipids; TC – total carbohydrates; NFC – non-fiber carbohydrates.

genotypes, however, the average of this trait was 3.86, which is consistent with results obtained in this study. The dry mass percentage of silage(DMPS) revealed four phenotypic classes, varying from 27.0 to 29.4%, and 37.5% of the hybrids are included in the class of 27.0% (Figure 2-A). The ideal amplitude for the dry mass percentage of silage amplitudes 32-35%, and the lower the magnitude of this trait, the greater the need for consumption by animals to meet their food needs. Determination of dry mass silage is fundamental importance, to support the optimal formulation of the diet, being grounded by the proportion of dry mass silage, daily consumption and the animal mass (CARVALHO *et al*., 2016). Regarding mineral material (MM), there is the formation of four phenotypic classes with an amplitude of 2.7 to 4.5%, and 37.5% of the hybrids are contained in class 2.7% (Figure 2-B). The fraction of minerals found in corn silage is composed primarily of nitrogen, potassium, phosphorus, calcium and magnesium (COELHO and FRANÇA, 1995). According to Underwood and Suttle (1999), minerals have structural function, physiological, catalytic and regulatory in animal metabolism. The content of total crude protein (TCP) revealed five phenotypic classes with amplitude from 3.0 to 5.4%, it points out that the most prominent class for this trait and 50% contained hybrids is the class 4.8% of TCP (Figure 2-C). These results are in agreement those obtained by Vilela (1985), which defines the corn silage has from 4 to 7% crude protein. In research on chemical characterization of corn silage in Brazil, Novinski *et al*. (2013) points out that the average TCP content of 7.1%, but the percentage varies depending on the place of cultivation. Similar way, Vieira *et al*. (2013) found TCP average percentage of 7.5% in silage super early corn genotypes. The neutral detergent fiber (NDF) revealed four phenotypic classes with amplitude comprising 50.25 to 54.75%, corresponding to 37.5% of the hybrids contained in classes and 50.25 51.75% (Figure 2-D).

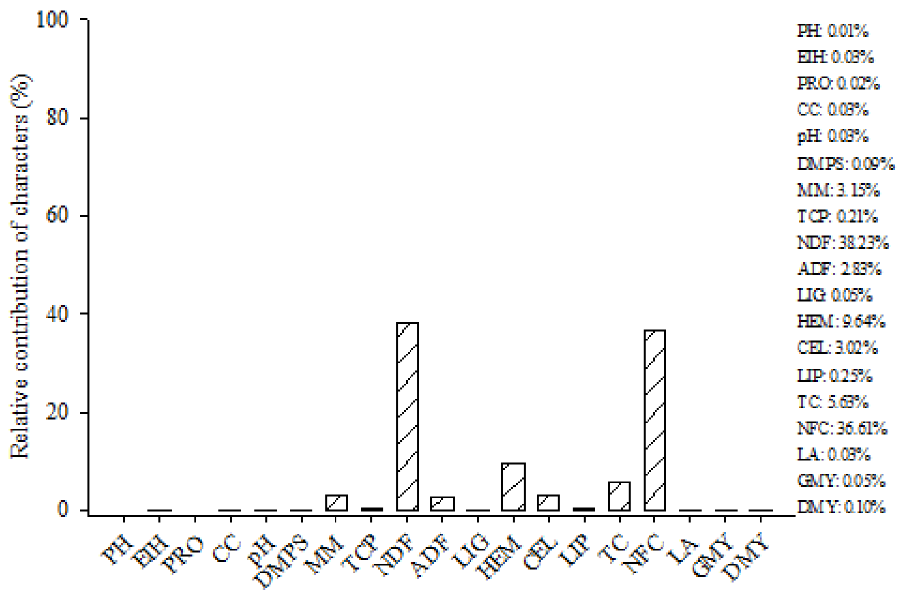

Figure 4. Relative contribution of traits by Singh (1981) method to chlorophyll content (CC), leaf area (LA), plant height (PH), ear insertion height (EIH), prolificity (PRO), green mass yield (GMY), dry mass yield (DMY), hydrogenic potential of silage (pH), dry mass percentage of silage (DMPS), mineral material (MM), total crude protein (TCP), neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin (LIG), hemicellulose (HEM), lipids (LIP), total carbohydrates (TC) and non-fiber carbohydrates (NFC)

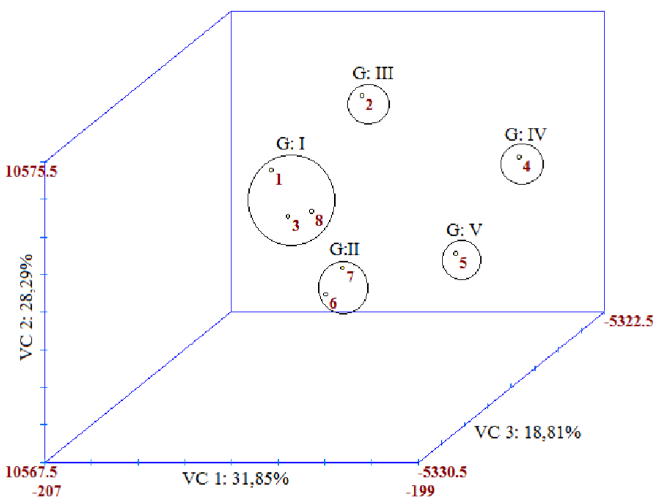

Figure 5. Dispersion of the scores of the first two canonical variables

The voluminous NDF content is closely related to animal feed, that is, the higher the NDF constitution contained in ensiled food, the greater the need for food intake by the animal in order to satisfy their food needs. Research defined as an ideal fiber fraction of 50% NDF (CRUZ, 1998), so the results of this study are consistent with those defined by previous studies. In studies on the NDF bromatologic composition of corn and sorghum silage. Pereira *et al*. (2007) show that the use of 90% of panicle for sorghum and 75% of ear for corn, provided less effective degradation of silage NDF. The acid detergent fiber (ADF) that four phenotypic classes amplitude from 19.5 to 24%, and it is found that 37.5% of the hybrids were included in the class 21.0% (Figure 2-E).

According to Oliveira *et al*. (2010), the low percentage of ADF in the silage is intended, it indicates high quality forage, and better digestibility conditions. The ADF is considered a structural polysaccharide, which comprises the fibers of slow digestion, the increase of this fraction tends to show an increased difficulty in digestibility of silage and lower rate of passage through the digestive system of ruminants(ALVAREZ *et al*., 2006). The lignin (LIG) revealed three phenotypic classes and amplitude of 0.6 to 1.5%, and determines that 37.5% of the genotypes are distributed similarly in classes 0.6 and 0.9% (Figure 2-F). Lignin is a polysaccharide present in the plant cell wall along the cellulose, and hemicellulose present structural function in adult cells (SALMAN, 2010).

Lignin gives greater rigidity to the plant cell wall, but interferes the digestibility of forage through the digestive tract of ruminants. The hemicellulose (HEM) presented four phenotypic classes and amplitude corresponding to 28.5 to 34.5%, where 37.5% of the hybrids are present in classes 28.5 and 30.0% (Figure 2-G). These results are in agreement with those obtained by Silva *et al*. (2005), showed the effects of inoculation with microorganisms in corn and sorghum silage, and showed 30.20% hemicellulose in silage, the results of this study are presented according to those obtained in previous studies. The cellulose (CEL) revealed four phenotypic classes amplitude from 19.5 to 22.5%, with 37.5% of the hybrids contained in the class 20.5% (Figure 2-H). Cellulose is the main component of the plant cell wall and responsible for its rigidity. The results of this study are presented lower those obtained by Silva *et al*. (2005), which obtained 27.45% of cellulose in corn silage. Lipids (LIP) showed the formation of three phenotypic classes and amplitude from 3.52 to 3.97%, and 50% of the hybrids are contained in class 3.52% (Figure 3-A). These results are in agreement with the contents prescribed by Medeiros *et al*. (2015), which point out that levels above 6% lipids may result in negative effects on fiber degradation by rumen, however, despite its limitations, the lipids present nutritional properties, and energy source and essential to the metabolism of ruminants. The total carbohydrates (TC) showed four phenotypic classes and amplitude from 89.5 to 92.5%, highlighting the class with 91.5% with 37.5% of the hybrids (Figure 3-B). The fraction of total carbohydrates is about 80% of dry mass forage, and includes the protein, starchy, fibrous and lipid fractions (VAN SOEST, 1994). The non-fiber carbohydrates (NFC) presented three phenotypic classes amplitude 32 to 38%, and 50% of the hybrids were included in the class with 38% of NFC (Figure 3-C).

This result agrees with the results obtained by Cabral *et al*. (2004), which revealed a percentage of 37.05% of NFC in corn silage. The non-fibrous carbohydrates comprise the starch, sugar, pectin, volatile fatty acidsfractions in food and are characterized by their high energy and high ruminal digestibility (CABRAL *et al*., 2004). The fraction of NFC present in corn silage is made predominantly by starchy fraction (71.3%), and lipid with 28.7% (NRC, 2001). Pearson linear correlation analysis aims to identify the linear trend association among characters, and is expressed by correlation coefficients comprise magnitudes from -1 to 1 with positive or negative sense. These coefficients are classified as null (r=0.00), low or weak (r=0.00 to r=0.30), intermediate or medium (r=0.30 to r=0.60); high or strong (r=0.60 to r=1.00), according to the classification of Carvalho *et al*. (2004). The Pearson linear correlation was performed for the eight corn hybrids and totaled N=48 (Table 1) where the linear associations were held to 19 characters which is: PH, EIH, PRO, CC, LA, GMY, DMY, pH, DMPS, MM, TCP, NDF, ADF, LIG, HEM, CEL, LIP, TC and NFC. Thus 171 associations were obtained, these only 52 were significant by t test at 5% probability. The plant height (PH) showed high positive correlation with the EIH (r=0.78), intermediate and positive with the CC (r=0.58), LA (r=0.31), GMY (r=0.52), DMY (r=0.47), pH (r=0.35), NDF (r=0.49), FDA (r=0.40), HEM (r=0.32), CEL (r=0.43), however, intermediate and negative trend with NFC (r=-0.47).

Thus, plants with increased stature tend to increase leaf area and chlorophyll content, thereby increment photosynthetic efficiency and assimilate accumulation, resulting in higher yield of fresh and dry mass per unit area, increasing the structural fibrous carbohydrates and the reduction of non-fibrous carbohydrates silage. Cancellier *et al*. (2011) and Pazianini *et al*. (2009) show strong positive correlation between PH and EIA, as between the PH and GMY. In corn plants with larger size may have increased the yield of green mass and thus potentiate the silage production (MELO *et al*., 2004). However, taller plants can reveal lodging problems, these problems are eased in corn for silage production, because the plants are less time in the field exposed to weather climate (CANCELLIER *et al*., 2011).

The ear insertion height (EIH) showed intermediate and positive correlation with CC (r=0.46), LA (r=0.33), GMY (r=0.47), DMY (r=0.46), but weak and negative trend with NFC (r = -0.48). Thus, plants with the highest ears tend to increase green and dry mass production, however, may come to reduce the non-fibrous carbohydrates content of silage. Research Cancellier *et al*. (2011) showed a positive correlation between EIH and DMY varieties in open pollinated corn. The prolificity (PRO) and leaf area (LA) had intermediate and positive correlation with the HEM (r=0.30). Thus, it indicates the trend of the most prolific plants and greater leaf area step up the hemicellulose content of the silage. Hemicellulose is associated in the plant with the lignin and structural polysaccharides, older plants tend to increase the hemicellulose fraction proportionally to magnitude of leaf area and stem mass present in the corn plant (JÚNIOR *et al*., 2007). Chlorophyll content (CC) revealed intermediate and positive correlation with GMY (r=0.58), DMY (r=0.51), NDF (r=0.37), ADF (r=0.32), CEL (r=0.34), weak and positive with LA (r=0.29), and intermediate and negative with NFC (r=-0.37). This indicates that plants with higher chlorophyll content increase their photosynthetic capacity and increase the yield of green and dry mass per unit area, but reduce the fraction of non-fibrous carbohydrates. The non-fibrous carbohydrates differ from fibrous carbohydrates due to the presence of pectin, hemicellulose and cellulose (CABRAL *et al*., 2002). The non-fibrous carbohydrates in corn silage are composed of starch, protein and lipid (CABRAL *et al*., 2004). The green mass yield per hectare (GMY) showed strong and positive correlation with the DMY (r=0.90), and low and positive with the LIP (r=0.30). This result shows a positive association between the green and dry mass yield of corn silage, and lipid content of the silage. The dry mass percentage of silage (DMPS) showed intermediate and positive trend with NFC (r=0.54), intermediate and negative with NDF (r=-0.47), HEM (r=-0.46), CEL (r=-0.35), and weak and negative with the MM (r=-0.29). Thus, the increase in dry mass percentage of silage tends to increase the proportion of fibrous and non-fibrous carbohydrates, in addition to the inorganic fraction. The mineral material (MM) showed intermediate and positive correlation with the HEM (r=0.31), and intermediate and negative with TCP (r=-0.42), LIG (r=-0.36), TC (r=-0.55) and CNF (r=-0.51). This indicates that the increase of the mineral fraction tends to reduce the organic fraction of silage, however, increases the hemicellulose. The crude protein (TCP) showed intermediate and positive correlation with the LIG (r=0.43), and intermediate and negative with NDF (r=-0.35), HEM (r=-0.36) and TC (r=-0.32). The high protein concentration results in increased lignin content reduces the neutral detergent fiber, hemicellulose and total carbohydrates of silage corn.

The neutral detergent fiber (NDF) showed strong and positive correlation with FDA (r=0.75), HEM (r=0.72), CEL (r=0.74) and strong and negative with NFC (r=-0.95). The fiber contents in plants are of great importance to the quality of silage (GRALAK *et al*., 2014). The NDF fraction of food is essential for set the amount of food needed to supply the food needs of the animal and the ADF lignin decrease the food digestibility (MORAES *et al*., 2013). The acid detergent fiber (ADF) showed strong and positive correlation with the CEL (r=0.96), strong andnegative with CNF (r=-0.72) and intermediate and negative with TC (r=-0.35). The cellulose percentage in plants is increased with higher ADF (PIRES *et al*., 2010). The hemicellulose (HEM) and cellulose (CEL) showed strong negative correlation with the NFC, r=-0.68 and r=-0.71, respectively. This indicates that plants with higher hemicellulose and cellulose content presentlower magnitude of non-fibrous carbohydrates, because these components are intrinsic to the plant cell wall, being common in the stem, however, non-fibrous carbohydrates are present abundantly in grains (CABRAL *et al*., 2002). The canonical variables analysis is presented as a tool that allows to identify the genetic variations involved among corn hybrids studied, and allows to show the arrangement of genotypes using a three-dimensional plane (MIRANDA *et al*., 2003). In this case, was used for the analysis 19 measured traits, in this way, only three canonical variables were necessary for representing 78.95% of the total genetic variation (Figure 4), where VC1 is 38.23%; VC2: 36.61% and VC3: 9.64%. The canonical variables analysis allow to highlight the formation of five groups to differentiate the eight corn hybrids, as follows: group I formed by HT3248, HS1380-2 and HT4genotypes, group II consists of HSM97 and HS1380-1, group III represented by HS1356hybrid, group IV by HS1358 and groupV by HT7 genotype. The relative contribution traits defined by Singh method (1981) defines that the determining characters in distinguishing corn silage genotypes were neutral detergent fiber, non-fibrous carbohydrates and hemicellulose. However, the plant height and prolificity were the lower contribution to distinguish genotypes.

Conclusion

The frequency distributions indicate that the traits with more phenotypic classes were the total crude protein and hemicellulose. The cellulose present high relationship with the structural carbohydrates fraction and difficult digest. The cellulose and hemicellulose percentage is inversely proportional to the non-fibrous carbohydrates of corn silage.
Neutral detergent fiber, non-fibrous carbohydrates and hemicellulose traits are those that contribute most to discrimination of corn genotypes. The contribution of descriptive, univariate and multivariate analysis demonstrate to be techniques which can be used successfully in the discrimination of corn genotypes and traits of importance for the production of corn silage.

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