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Evaluation of corn cultivars harvested at two cutting heights for ensilage

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ABSTRACT - The objective of this study was to evaluate the agronomic characteristics, bromatological-chemical composition and digestibility of 11 corn cultivars (*Zea mays*) harvested at two cutting heights. Cultivars D 766, D 657, D 1000, P 3021, P 3041, C 805, C 333, AG 5011, FO 01, CO 9621 and BR 205 were evaluated when they were harvested 5 cm above ground (low) and 5 cm below the insertion of the first ear (high). The experiment was designed as random blocks, with three replicates, arranged in an 11 × 2 factorial scheme. Cultivars presented similar productions of forage dry matter and grains. Percentages of stalk, leaf, straw, cob and kernel fractions were different among cultivars, as well as dry matter content of the whole plant at harvest. Considering the whole plant, only the contents of gross energy, nitrogen in neutral detergent fiber, and *in vitro* neutral and acid detergent fiber digestibility did not differ among cultivars. Increase on the cutting height improved forage quality due to the reduction of stalk and leaf fractions and contents of cell wall constituents.

Key Words: digestibility, neutral detergent fiber, plant fractions, productivity, plant fractions, water soluble carbohydrates

Avaliação de cultivares de milho colhido em duas alturas de corte para ensilagem

RESUMO - Objetivou-se neste estudo avaliar as características agronômicas, a composição químico-bromatológica e a digestibilidade de 11 cultivares de milho (*Zea mays*) colhido em duas alturas de corte. As cultivares D 766, D 657, D 1000, P 3021, P 3041, C 805, C 333, AG 5011, FO 01, CO 9621 e BR 205 foram avaliadas quando colhidas 5 cm acima do solo (baixa) e 5 cm abaixo da inserção da primeira espiga (alta). O experimento foi delineado como blocos casualizados, com três repetições, arranjados em esquema fatorial 11 × 2. Os cultivares apresentaram produções semelhantes de matéria seca de forragem e de grãos. As porcentagens das frações colmo, folha, palha, sabugo e grão diferiram entre os cultivares, assim como os teores de matéria seca da planta inteira no momento da colheita. Considerando a planta inteira, apenas os teores de energia bruta, nitrogênio da fração fibra em detergente neutro e a digestibilidade *in vitro* da fibra em detergente neutro e detergente ácido não diferiram entre os cultivares. O aumento da altura de corte melhorou a qualidade da forragem, devido à redução das frações colmo e folha e dos teores dos constituintes da parede celular.

Palavras-chave: carboidratos solúveis, digestibilidade, fibra em detergente neutro, frações da planta, poder tampão, produtividade

Introduction

In order to produce high quality whole-plant corn silage, several technical recommendations should be observed, such as the proper of maturity stage and characteristics of plant components at harvest, which result in increased nutritional value and reduced production costs (Ferreira, 1990).

According to Demarquilly (1994), the optimum stage for harvesting the whole-plant corn, described in literature, is at the maximum dry matter (DM) yield per hectare, which occurs when the corn kernel is at the dent stage (33 to 35% dry matter).

However, in order to evaluate the DM production of the corn plant, agronomical conditions, such as planting density, cutting height and DM content of the whole corn plant components, should be considered. By considering this, Wu and Roth (2005) gathered data from 11 studies utilizing corn silage harvested at two cutting heights, high and low. The authors observed that cutting height of 50 cm above ground, when compared to the common cutting height utilized (17 cm above ground), increased crude protein (CP) and net energy percentage, in addition to neutral detergent fiber (NDF) digestibility, therefore enhancing yield of the dairy cow milk per ton of silage.

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According to Hunter et al. (1991), the importance of kernels, as the main factor responsible for the whole-plant corn silage quality is questionable, inasmuch as there is genotypic variation in fiber quality of the plant, expressed in terms of DM intake and forage digestibility. These values do not depend on the proportion of grains in the whole corn plant DM, indicating that the forage portion significantly contributes to the overall silage quality. This confirms that the quality of the forage produced may determine several advantages regarding to intake, particularly for efficiency of nutrient use, which is intensified by the higher silage digestibility.

Moreover, variations on harvest conditions may influence the fermentation pattern during the ensiling process, causing losses in the roughage nutritional value, which besides reducing animal performance, may promote economic losses as well.

Accordingly, the objective of this work was to evaluate the agronomic characteristics, the chemical-bromathological composition and the digestibility of corn cultivars harvested in two cutting heights, as well as their respective whole-plant silages.

Material and Methods

This study was conducted in the experimental area of the Fazenda de Ensino, Pesquisa e Produção da Faculdade de Ciências Agrárias e Veterinária (FCAV) – UNESP, Jaboticabal campus (21°15' 22"S and 48º18' 58"W), at an average altitude of 595 m.

Eleven corn cultivars (D 766, D 657, D 1000, P 3021, P 3041, C 805, C 333, AG 5011, FO 01, CO 9621 and BR 205) were harvested when, by visual evaluation, the milk-line of the central ear kernels was at approximately 2/3 of the kernel. At that time, harvesting was done at two cutting heights: low (5 cm above ground) and high (5 cm below insertion of the first ear).

The experiment was designed as randomized blocks (three blocks), in an 11 × 2 factorial arrangement (11 cultivars and two cutting heights). However, because cutting height does not interfere in the chemical characteristics of the straw, cob and kernel fractions, and because height of the first ear was determined only in low cut plants, these variables were analyzed according to the randomized block design with two replicates per block and 11 corn cultivars, irrespective to the cutting heights.

The climate in the experimetnal area is classified as Cwa climate, according to the Köppen climate classification, which can be described as subtropical with a well defined dry season during winter (April to September), and a rainy season during summer (October to March). The average annual precipitation was 1,400 mm, and the mean annual temperature is 22ºC. The soil is classified as typical eutroferric Red Latosol (Andreoli & Centurion, 1999), with a 0 to 20 cm layer of argillaceous texture.

Soil was conventionally prepared with deep moldboard plowing (30 cm), followed by two harrow plowings immediately before sowing, and plots were composed by six 5 m long rows at 0.9 m row spacing, totalizing an area of 27 m^2. Ten seeds per meter, two by two, spaced by 20 cm in a row, were hand sown over fertilized furrows, with the aid of a jab planter. After emergence, the number of plants was reduced to five plants per linear meter, by manual thinning, in order to obtain a final population of 55,000 plants per hectare.

Fertilization was carried out in two periods. At sowing, before planting, the fertilizer was placed in furrows, with a row planter regulated for 90 cm row spacing. At this time, 300 kg per hectare of the formula 4:30:16+Zn (3%) were utilized, totaling 12 kg of N, 90 kg of P_2O_5, 48 kg of K_2O and 9 kg of Zn per hectare. For the second fertilization, about 25 days after emergence of the corn plants, 150 kg urea per hectare (67.5 kg N per hectare) was used. Then, 15 days after emergence, the presence of fall armyworms was controlled with 1.5 kg Sevin 850 PM per hectare.

Percentages of crude protein (CP), ether extract (EE), ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), nitrogen in acid detergent fiber (N-ADF) and cellulose were determined in whole corn plant, plant components (stalk, leaf, straw, cob and kernel) and silage samples whereas nitrogen in neutral detergent fiber (N-NDF) was determined only in whole corn plant samples, according to Silva (1998). Cellulose was determined by lignin oxidation with potassium permanganate, whereas lignin was considered as the difference between ADF and cellulose concentrations. Hemicellulose, in turn, was determined as the difference between NDF and ADF concentrations.

Antifoam agent was not used for the NDF and ADF determinations neither was sodium sulfite used for the NDF determination. All samples containing starch, namely whole corn plants and kernels, it was added 0.2 ml amylase PA. Cellulose values presented in this study refer to cellulose plus insoluble minerals, once that inasmuch as residues from cellulose determination were not ashed.

Nitrogen (N) was determined by using the semimicro-kjeldahl method, phosphorus (P) by colorimetry with vanadate-molibdate solution, potassium (K) by flame photometry, calcium (Ca) and magnesium (Mg) by atomic absorption spectrophotometry, and sulfur (S) by the turbidimetric barium sulfate method.

Gross energy (GE) was determined in whole corn plant samples, with a semi-automatic Parr calorimetric bomb, model 1281.

Dry matter, CP, NDF and ADF *in vitro* digestibility (IVDMD, IVCPD, IVNDFD and IVADFD, respectively) in silage samples were determined through a digestibility assay in an Ankom® Ruminal Fermenter ("Daisy-II Fermenter"). For these analyses, 0.25 g of sample was weighed in F57 digestion bags, previously washed in acetone, then they were dried in air forced oven at 65°C and weighed. Bags for obtainment of residues for CP determination, however, received approximately 0.4 g of sample. After being sealed, bags were put into the digestion container (25 bags each) with 1,600 ml pre-heated (39°C) buffer, which was composed of a 5:1 mixture of a solution A (10 g/L KH_2PO_4; 0.5 g/L $MgSO_4.7H_2O$; 0.5 g/L NaCl; 0.1 g/L $CaCl_2$ and 0.5 g/L urea-degree reactive) and a solution B (15 g/L Na_2CO_3 and 1.0 g/L $Na_2S.9H_2O$). After that, 400 mL of ruminal fluid inoculum was added into each recipient.

The ruminal fluid inoculum was obtained from a rumen cannulated Holstein steer that was adapted for 15 days in feedlot, receiving about 25 kg corn silage, 2 kg concentrate and water *ad libitum*. During the ruminal fluid collection period, the steer received the same diet.

For the *in vitro* DM digestibility determination, samples were incubated for 48 hours, followed by 8 g pepsin and 40 mL HCl 6N addition for another 24 hours under heating. Pepsin and HCl were added only in samples of kernel and leaf fraction. For *in vitro* NDF and ADF digestibility determination, only the bags with whole corn plant samples were taken to the Ankom® fiber analyzer equipment, after being dried and weighed. The *in vitro* CP digestibility coefficient was obtained after CP determination from whole corn plant samples residues present in the bags incubated for 48 hours, after being dried in forced air oven at 65°C. In order to calculate the *in vitro* true DM digestibility coefficient, the indigestible DM was considered as only the NDF residue obtained from the determination of the *in vitro* NDF digestibility coefficient.

Results were submitted to analysis of variance and means were compared by the Tukey test at 5% probability. Statistical analyses were performed in the SAS (1999) program, and all variables were tested for normality of residues. Blocks were used for local control.

Results and Discussion

There were no differences (P>0.05) in forage DM production, grain DM per hectare production and grain production between the different cultivars (Table 1). The

Table 1 - Dry matter production of the whole corn plant harvested at high and low cutting heights

	Dry matter production (t/ha)		Kernels dry matter production	1st ear (cm)
	Low cutting height	High cutting heigh		
Cultivar				
Dina 766	14.24a	10.21a	4.89a	76.73cd
Dina 657	15.16a	11.35a	4.16a	100.53ab
Dina 1000	14.39a	10.18a	4.05a	80.67bcd
P 3021	15.01a	10.07a	4.48a	81.87bcd
P 3041	16.84a	10.05a	5.07a	93.00abc
C 805	14.09a	11.88a	5.08a	69.20d
C 333	15.30a	10.41a	4.60a	71.20cd
AG 5011	14.12a	10.26a	3.87a	75.60cd
FO 01	13.40a	10.45a	3.44a	113.07a
Dina co 9621	14.96a	11.89a	4.63a	101.53ab
BR 205	14.09a	13.50a	4.23a	82.60bcd
Cutting height				
High	14.69a	-	-	-
Low	-	10.93b	-	-
			Significance level	
Cultivar	0.6410	0.6410	0.0300	0.0001
Cutting height	0.0001	0.0001	-	-
Cultivar × cutting height	0.2507	0.2507	-	-
Coefficient of variation (%)	13.34	13.34	19.22	9.22

Means, in a column, followed by the same letters do not differ (P>0.05) by Tukey test.

first ear insertion height was higher (P<0.05) in cultivars Dina 657 (100.53 cm), FO 01 (113.07 cm) and Dina Co 9621 (101.53 cm), compared with cultivars C 805, C 333 and AG 5011. These results are in agreement with Beleze et al. (2003), who reported an average height of first ear insertion of 122.0 cm, for minimal and maximal observed heights of 100. 0 cm and 134.0 cm. When evaluating silages of the simple forage corn hybrid P-30S40, Neumann et al. (2007) observed mean heights of the first ear of 142 cm. However, kernel DM production (KDMP) was greater (P<0.05) in the high cutting height (Table 2), probably because harvest was realized at an earlier stage of development, when the low cutting height was desired, therefore, there was no time for sufficient DM accumulation in the kernels (Afuakwa & Crookston, 1984; Hunter et al., 1991; Beleze et al., 2003).

Considering the forage DM production per hectare, there was no interaction between cultivars and cutting height (P=0.2507). Regarded to that, in addition to the fact that mean production of each cultivar harvested at the two cutting heights do not have any practical meaning, and considering that DM production is a very important variable in corn evaluation for silage production, it was chosen to present the results of high and low cutting height groups separately. However, the numerical difference (1.64 t/ha) between cultivar C805, which had the greatest production (5.08 t/ha), and cultivar FO 01, which had the lowest production (3.44 t/ha), is very high and should be considered. Besides, the analysis of variance indicated that kernel production should differ among cultivars, at 3% probability, which was not detected by the Tukey test (P>0.05) (Table 3).

During the final third of the experimental period, rain scarcity could have affected grain filling, resulting in reduced average kernel production (4.41 t DM/ha), mostly when the good forage DM production of plants harvested at low cutting height (14.69 t/ha) (Table 1) is considered. Beleze et al. (2003) reported a mean kernel production of approximately 7.0 t/ha for corn hybrids P32R21; P30R07; P304; P30F33 and P30F80, higher than the results presented in this study. In the same way, Mello et al. (2005) also reported kernel production values of about 8.71 t/ha, when evaluating six corn hybrids for silage production.

Higher kernel production (6.27 t DM/ha) with lower forage DM production per hectare (13.63 t) was reported by Henrique et al. (1994) and Pereira et al. (1993). It should be mentioned that, for a constant total forage DM production per hectare, the effects of increasing cutting height on silage quality improvement will be smaller when kernel production per hectare is lower.

Cutting height, in turn, significantly affected forage DM production per hectare (P<0.05) (Table 1), which was reduced in 25.60% when mean cutting height increased from five to about 80 cm. Similarly, Lauer (1998) observed a 15% reduction of forage production per area, when cutting

Table 2 - Component fractions percentage of the whole corn plant harvested at high and low cutting heights

	Leaf	Stalk	Cob	Straw	Kernel	Ear
	% DM of the plant					
Cultivar						
Dina 766	11.39e	19.02c	12.64bcd	16.87bcde	40.08a	69.59a
Dina 657	14.07abc	21.84bc	11.84cde	20.30abc	31.96bcd	64.10bcd
Dina 1000	13.82abc	22.54abc	12.01cde	18.17bcde	33.46abcd	63.64bcd
P 3021	12.01cde	21.45bc	12.05cde	18.01bcde	36.50abc	66.55abc
P 3041	11.42e	21.98bc	13.33bc	14.64e	38.62ab	66.60abc
C 805	10.68e	20.67bc	14.10b	15.02de	39.53a	68.65ab
C 333	11.65de	20.63bc	11.99cde	19.17abcd	36.58abc	67.73abc
AG 5011	13.55abcd	21.25bc	16.48a	16.39cde	32.33bcd	65.20abc
FO 01	14.87a	26.35a	8.09f	20.98ab	29.72d	58.78d
Dina co 9621	14.12ab	23.35ab	11.04de	16.72cde	34.77abcd	62.53cd
BR 205	12.47bcde	23.18ab	10.22e	23.24a	30.89cd	64.35abc
Cutting height						
Low	13.69a	28.09a	10.69b	16.65b	30.89b	58.22b
High	11.77b	15.95b	13.63a	19.63a	39.01a	72.27a
	Significance level					
Cultivar	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cutting height	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cultivar × Cutting height	0.7835	0.0823	0.4710	0.5878	0.8630	0.1844
Coefficient of variation (%)	8.44	9.36	8.08	11.75	9.76	4.18

Means, in a column, followed by the same letters do not differ (P>0.05) by Tukey test.

Table 3 - Bromathological composition of whole corn plants harvested in two cutting heights

	Buffering capacity (mEq/100g DM)	Water soluble carbohidrates	Dry matter	Ash	Ether extract	Crude protein	Gross energy (Mcal/kg DM)
		% in DM					
Cultivar							
Dina 766	16.16ab	12.22ab	31.85ab	3.11ab	2.50a	8.52ab	4.15a
Dina 657	17.32ab	14.30ab	31.53ab	2.93b	1.98abc	8.21abc	4.18a
Dina 1000	17.38ab	16.12a	28.17b	3.21ab	2.26abc	8.17abc	4.14a
P 3021	14.45b	14.46a	32.01ab	2.68b	2.25abc	7.57c	4.17a
P 3041	17.45ab	13.01ab	31.45ab	3.30ab	2.30abc	7.77bc	4.19a
C 805	14.48b	14.21ab	34.16a	2.74b	2.23abc	7.52c	4.14a
C 333	14.60b	10.12b	33.88a	3.10ab	2.49ab	8.29abc	4.16a
AG 5011	18.25a	14.00ab	29.34b	3.93a	2.03abc	9.04a	4.18a
FO 01	19.24a	13.59ab	29.41b	3.31ab	1.81bc	8.97a	4.18a
Dina co 9621	16.75ab	13.89ab	31.39ab	3.27ab	2.08abc	8.81a	4.19a
BR 205	17.27ab	13.25ab	31.21ab	3.09ab	1.68c	7.83bc	4.13a
Cutting height							
Low	17.79a	14.34a	29.58b	3.45a	2.10a	8.16a	4.16a
High	15.55b	12.74b	33.04a	2.85b	2.19a	8.33a	4.17a
Variation source			Significance level				
Cultivar	0.0001	0.0060	0.0001	0.0126	0.0034	0.0001	0.2529
Cutting height	0.0001	0.0055	0.0001	0.0001	0.2645	0.1381	0.5141
Cultivar × height	0.0939	0.4993	0.9350	0.1521	0.3044	0.8722	0.1044
Coefficient of variation (%)	10.34	15.69	6.42	15.96	16.39	5.63	1.01

Means, in a column, followed by the same letters do not differ (P>0.05) by Tukey test.

height was increased from 15 to 45 cm, corresponding to an 865 kg DM/ha decrease per 15 cm of increase in cutting height. In the present study, this value corresponded to 752 kg DM, for the same difference in cutting height.

Generally, cultivars FO 01, Dina 657, Dina 1000, had greater proportion of leaves and stalks, and lower proportion of cobs and kernels participating in the DM of the whole plant, resulting in ears smaller than those of cultivars Dina 766 e C 805, P 3021, P 3041, C 333, BR 205, which had lower percentage of leaves and stalks, and greater percentage of kernels and ears. This result can be explained by the forage characteristic of the former cultivars, in which, as reported by Penati (1995), the extremely early cycle probably was the cause of the greater kernel percentage observed. Similarly, Zopollatto et al. (2009) evaluated the morphological composition of six corn cultivars (CO 32; AG 5011; P 3041; DKB-333B; AG 1051 and Z 8550) and observed a mean proportion of leaf and stalk of 23% and 25%, respectively, about 85 days after sowing.

The percentage of kernels is the main cause of high DM productivity of the whole corn plant per area, high nutritive value for ruminants, and adequate DM percentage that produces adequate fermentation pattern and reduces effluent losses during the ensiling process. Therefore, kernel percentage has been the most utilized criteria for choosing corn cultivars for silage production (Hunter, 1991; Penati, 1995).

Cultivars Dina 766, Dina 657, Dina 1000, P 3041, FO 01, AG 5011, Dina co 9621 and BR 205 had greater buffering capacity (P<0.05), than cultivars P 3021, C 805 e C 333 (Table 3). Moreover, the mean values observed in the low cutting height group are very similar to those reported by McDonald et al. (1991) for corn crops, 17 mEq HCl/100g DM; and by Lavezzo et al. (1997) for corn harvested at the kernel milk stage, which was 17.25 mEq HCl/100g DM.

The buffering capacity of whole corn plants harvested at the high cutting height was significantly reduced (P<0.05), when compared to plants harvested at the low cutting height. Cultivars P 3021, C 805 and C 333 had the lowest buffering capacity (P<0.05), compared to cultivars AG 5011 and FO 01. Cutting height also altered the level of water soluble carbohydrates, which was significantly reduced (P<0.05) in plants harvested at the high cutting height. However, plants cut lower had a mean water soluble carbohydrates level, in DM basis, close to 14.5%, which was reported by McDonald et al. (1991) for a corn crop that produced well preserved silage. Water soluble carbohydrates levels differ among cultivars (P<0.05), however.

For DM levels, cultivars AG 5011, Dina 1000 and FO 01 showed values lower than cultivars C 805 and C 333. Cutting height also affected the plant DM content. So, the greater percentage of ears and the lower percentage of the vegetative fraction (leaf and stalk) were causes of the higher DM levels of plants harvested at the high cutting height.

Ash, ether extract (EE) and crude protein (CP), determined in whole corn plant samples, differed among cultivars (P<0.05) (Table 3). Cultivars AG 5011, FO 01 and Dina CO 9621, recommended for silage production, had higher CP levels, compared to cultivars C 805 and P 3021. There was no difference among cultivars for gross energy level (GE) (P>0.05). Cutting height did not alter the EE, CP and GE content of the plants (P>0.05).

Cultivars Dina 657 and FO 01 had higher (P<0.05) NDF levels, compared with cultivars Dina 766, P 3021 and P 3041 (Table 4). Similar behavior was observed in hemicellulose level, except for cultivar P 3041, which did not differ from cultivar FO 01. High cutting height produced lower mean values of NDF and hemicellulose than low cutting height (P<0.05) did, which could have been caused by the reduction of the vegetative fraction and increase in kernel production in the whole plant DM.

Table 4 - Bromathological composition, in % of dry matter, of the whole corn plant cell wall in two cutting heights

	Neutral detergent fiber (NDF)	Acid detergent fiber (ADF)		Cellulose	
		Low	High	Low	High
Cultivar					
Dina 766	51.16c	30.54abA	22.55cB	26.16abA	20.58abB
Dina 657	58.29ab	30.54abA	23.76abcB	25.77abcA	21.90aB
Dina 1000	54.66abc	30.08abcA	24.26abcB	25.02bcdA	21.39aB
P 3021	51.48c	28.95bcA	23.05bcB	24.18bcdeA	20.29abB
P 3041	51.54c	27.32cdeA	22.69cB	22.41cdeA	18.18bB
C 805	51.75bc	27.93bcdA	24.51abcB	23.22bcdeA	20.74abA
C 333	53.89bc	25.87deA	25.48abcA	22.14deA	20.69abA
AG 5011	55.21abc	27.19cdeA	26.28aA	23.59bcdeA	21.46aA
FO 01	61.09a	32.64aA	25.79abB	28.24aA	21.57aB
Dina co 9621	55.07abc	24.93eA	26.24aA	21.74eA	22.18aA
BR 205					
Cutting height	54.75abc	28.98bcA	25.24abcB	25.87abA	21.35abB
Low	57.68a	-	-	-	-
High	51.21b	-	-	-	-
Variation source		Significance level			
Cultivar	0.0001	0.0001		0.0001	
Cutting height	0.0001	0.0001		0.0001	
Cultivar × Height	0.1108	0.0001		0.0001	
Coefficient of variation (%)	6.14	3.54		4.50	

	Lignin		Hemicellulose	N-NDF	N-ADF
	Low	High			
Cultivar					
Dina 766	4.37abcA	1.97cB	24.62c	0.375a	0.107ab
Dina 657	4.77abA	1.86cB	31.14ab	0.405a	0.093ab
Dina 1000	5.06aA	2.87bcB	27.48abc	0.433a	0.112a
P 3021	4.77abA	2.75bcB	25.48bc	0.361a	0.091ab
P 3041	4.91aA	4.51aA	26.54abc	0.384a	0.093ab
C 805	4.71abcA	3.77abA	25.52bc	0.345a	0.093ab
C 333	3.73abcA	4.79aA	28.22abc	0.383a	0.082ab
AG 5011	3.61abcA	4.81aA	28.47abc	0.400a	0.095ab
FO 01	4.41abcA	4.22abA	31.88a	0.423a	0.080ab
Dina co 9621	3.18bcA	4.07abA	29.49abc	0.402a	0.074b
BR 205	3.11cA	3.89abA	27.64abc	0.381a	0.085ab
Cutting height					
Low	-	-	29.05a	0.426a	0.101a
High	-	-	26.68b	0.354b	0.082b
Variation source			Significance level		
Cultivar	0.0001		0.0038	0.2464	0.0420
Cutting height	0.0001		0.0041	0.0001	0.0002
Cultivar × height	0.0001		0.6473	0.1328	0.3152
Coefficient of variation (%)	13.22		11.37	14.10	20.62

Means followed by the same capital letters (line) and lower case letters (column) do not differ (P>0.05) by the Tukey test.

Table 5 - Digestibility coefficients of the whole corn plants harvested at high and low cutting heights

	True *in vitro* DM digestibility	*In vitro* DM digestibility	*In vitro* NDF digestibility	*In vitro* ADF digestibility	*In vitro* CP digestibility
	%				
Cultivar					
Dina 766	71.21a	63.85a	44.32a	44.12a	64.09a
Dina 657	67.06ab	60.75ab	43.28a	36.02a	60.32ab
Dina 1000	69.00ab	62.82ab	43.53a	40.78a	60.90ab
P 3021	68.05ab	61.92ab	38.32a	36.79a	61.20ab
P 3041	70.17a	63.91a	41.74a	33.67a	60.58ab
C 805	71.10a	63.98a	43.89a	41.52a	59.95ab
C 333	66.39ab	59.38ab	37.56a	29.32a	52.13b
AG 5011	70.00ab	61.51ab	45.74a	39.82a	62.53ab
FO 01	61.39b	56.67b	36.49a	28.00a	60.45ab
Dina co 9621	65.47ab	59.84ab	37.32a	27.62a	57.62ab
BR 205	69.84ab	64.03a	45.10a	41.38a	60.49ab
Cutting height					
Low	66.17b	60.37b	41.35a	34.50a	60.46a
High	70.13a	63.02a	41.80a	38.05a	59.58a
Variation source			Significance level		
Cultivar	0.0146	0.0031	0.1517	0.0378	0.0646
Cutting height	0.0008	0.0016	0.7913	0.1459	0.5117
Cultivar × Cutting height	0.6882	0.6688	0.5664	0.5817	0.5134
Coefficiente of variation (%)	6.54	5.19	16.33	26.88	8.95

Means, in a column, followed by the same letters do not differ (P>0.05) by Tukey test.

Cell wall associated to nitrogen was evaluated by N concentration in NDF (N-NDF) and ADF (N-ADF) fractions. There was no difference (P>0.05) in N-NDF level among cultivars, however, N-ADF in cultivar Dina 1000 was higher than in cultivar Dina co 9621, which showed the lowest N-ADF value (P<0.05). But, mean N-ADF and N-NDF were higher in plants harvested at low cutting height, reflecting the difference observed in NDF and ADF levels. There was a significant interaction between cultivar and cutting heights, regarding to ADF, cellulose and lignin values (P<0.05).

Cutting height did not influence the *in vitro* NDF, ADF and CP digestibility coefficients (Table 5). On the other hand, *in vitro* dry matter digestibility and *in vivo* dry matter digestibility coefficients of plants harvested at high cutting height were higher than (P<0.05) those of plants harvested at low cutting height, confirming that variability of plant components affects the final forage digestibility. Analyzing silages from 33 corn hybrids for two consecutive years, Allen (1990) observed that the amplitude of *in vitro* DM (74 to 80%) and fiber (41 to 46%) digestibility coefficients varied very little, compared to amplitudes of ADF levels (38 to 53%) and kernel percentage in DM (22 a 53%). The author concluded that, besides the high variation in kernel percentage in DM, dry matter digestibility remained stable, indicating that other plant components also play an important role on the ensiled forage quality.

Conclusions

Increasing cutting height improves corn silage quality because of the reduction of stalk and leaf fractions, and because of the reduction of cell wall constituents. Cultivars Dina 766 and C 805 represent a good option for corn silage production inasmuch as they present kernel and fibrous (stalk, leaf, cob and ear) fractions of better quality. Values of the fibrous fraction, in percentage of the whole plant, together with higher total DM digestibility, result in higher quality of the ensiled material for these two cultivars.

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