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Evaluation of corn hybrids for silage grown in different locations

[*Avaliação de híbridos de milho para silagem cultivados em diferentes locais*]

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ABSTRACT

The aim of this study was to evaluate the yield, morphometric and chemical characteristics, and the digestibility of various corn hybrids cultivated in different locations for silage production. Four corn hybrids were grown: P2866H, P3456H, P30R50VYH and P4285YHR, in four locations, defined as farm A; B; C and D. The hybrid P4285YHR presented the highest plant and ear insertion heights (2.72m, 1.52m respectively), with a minimum registered height of 2.63 m and 1.42 m, for plant and ear insertion height, and for that reason it presented the highest yield of fresh biomass (78,089kg ha^{-1}). The TND values showed trend very close to that observed in the DISMS of the whole-plant, with hybrid P3456H presenting the highest estimated value (68.74%), and the hybrid P4285YHR the lowest among them (65.25%). In general, lower fibrous carbohydrates and lignin content, higher fibrous carbohydrates content, together with satisfactory grains participation in the plant structure led to a greater dry matter digestibility. Hybrids with lower plant heights do not necessarily have lower dry biomass yields, but hybrids of greater height and with high stem and leaf participation tend to have a higher aFDN content and less dry matter digestibility.

Keywords: growth altitude, fibrous carbohydrates, dry matter digestibility (DMS), vegetative fraction, varieties

RESUMO

O objetivo deste estudo foi avaliar o desempenho produtivo e as características morfométricas e químicas, além da digestibilidade de diferentes híbridos de milho cultivados em diferentes locais para produção de silagem. Foram cultivados quatro híbridos de milho: P2866H, P3456H, P30R50VYH e P4285YHR, em quatro locais, definidos como propriedades A; B; C e D. O híbrido P4285YHR apresentou as maiores alturas de planta e de inserção de espiga (2,72m, 1,52m, respectivamente), com altura mínima registrada, nos diferentes locais, de 2,63m e 1,42m, para altura de planta e inserção de espiga, e, por isso, apresentou o maior rendimento de biomassa fresca (78.089kg ha^{-1}). Os valores calculados de NDT mostraram tendência muito próxima àquela observada na DISMS da planta inteira, tendo o híbrido P3456H apresentado o maior valor estimado (68,74%), e o híbrido P4285YHR o menor entre eles (65,25%). Em geral, menores concentrações de carboidratos fibrosos e lignina, maior teor de carboidratos fibrosos, juntamente com satisfatória participação de grãos na estrutura da planta, conduzem a uma maior digestibilidade da matéria seca. Híbridos com menores alturas de planta não necessariamente apresentam menores rendimentos de biomassa seca, mas híbridos de maior altura e com alta participação de colmo e folhas tendem a apresentar maior teor de aFDN e menor digestibilidade da matéria seca.

Palavras-chave: altitude de plantio, carboidratos fibrosos, digestibilidade da matéria seca (DMS), fração vegetativa, variedades

INTRODUCTION

The demand for corn hybrids with ability for grain production causes breeding companies to turn their attention to the development of increasingly better hybrids for this purpose, generating a shortage of hybrids with specific qualities for silage production (Horst *et al*., 2020a). Due to the constant increase in demand for silage hybrids and also the requirement for higher quality materials, they make more information about those existing indispensables. That is why comparative research

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between hybrids is fundamental for the advancement of genetic improvement programs and is essential for technical recommendations given mainly to farmers (Horst *et al*., 2020b). This type of study may encourage breeding companies to do more to find genetically superior materials than are available.

Among the characteristics of importance for a silage hybrid, these stand out: high participation of grains in the plant, high dry matter and fibrous portion digestibility (Horst *et al*., 2020b). Daniel *et al*. (2019) corroborates stating that the quality of the fibrous portion and the starch content are the main limitations for the corn silage quality, and these characteristics may suffer interference from the environment (Krämer-Schmid *et al*., 2016). The technological standard adopted by farmers and environmental conditions are extremely variable, undergoing intense changes within the same region, or from one crop season to another, influencing the productive and qualitative hybrids behavior (Ferraretto and Shaver, 2015; Tres *et al*., 2014).

Some factors, such as soil type and fertility, water availability, luminosity, fertilization, density and management, are particular to each farm, varying within the same region, favoring different productive results from the same hybrid, for example (Tres *et al*., 2014). Therefore, it's fundamental to find hybrids adapted to the soil and climatic conditions to the location where it will be grown (Paziani *et al*., 2009). Thus, our objective was to evaluate the yield, morphometric and chemical characteristics, and the digestibility of various corn hybrids grown in different locations for silage production.

MATERIAL AND METHODS

The experiment was carried out in Guarapuava, Paraná, Brazil. The climate of the region is Cfb (subtropical humid mesothermal), with no dry season, with cool summers and moderate winter according to the Köppen classification, average annual rainfall of 1,944 mm, minimum and maximus average annual temperature of 12.7 and 23.5ºC, respectively and relative humidity of 77.9%.

Four corn hybrids (*Zea mays* L.) were used: P2866H, P3456H, P30R50VYH and P4285YHR (Pioneer®), in four locations, defined as A; B; C and D. Farm A is located at latitude 25°31'932" S, longitude 51°33'437" W and at an altitude of 1,080 m. Farm B is located at latitude 25°13'219" S, longitude 52°22'066" W and at an altitude of 1,184 m. Farm C is located at latitude 25°07'705" S, longitude 51°41'983" W and with 1,079 m. Farm D is located at latitude 25°34'075" S, longitude 51°38'380" W and with 1,207 m. Thus, the experiment was conducted in a randomized block design, in a 4 × 4 factorial scheme, and three repetitions each (blocks).

The sowing was in no-tillage system in succession with a forage mixture of black oats (*Avena strigosa*) and ryegrass (*Lolium multiflorum*). The experiment was implemented in plots of 15 lines with 25 linear meters each, and for each of the evaluations, the useful area used was 10 planting lines with 15 linear meters. On farm A, sowing took place on October 14, 2017, with 0.8 m line spacing, basic fertilization with a mixture of MAP fertilizers at a dose of 330 kg ha^{-1}, KCl at a dose of 200 kg ha^{-1} and Surfurgan at a dose of 100 kg ha^{-1}, and urea in coverage at a dose of 605 kg ha^{-1}. In farm B, sowing took place on October 13, 2017, with 0.47 m line spacing, basic fertilization with N-P_2O_5-K_2O fertilizer (08-30-20) at a dose of 400 kg ha^{-1}, and urea in coverage at a dose of 400 kg ha^{-1}. On farm C, sowing took place on October 19, 2017, with 0.45 m line spacing, basic fertilization with N-P_2O_5-K_2O fertilizer (09-24-24) at a dose of 350 kg ha^{-1}, and urea in coverage at a dose of 400 kg ha^{-1}. On farm D, sowing took place on October 13, 2017, with 0.80 m line spacing, basic fertilization with fertilizer N-P_2O_5-K_2O (09-24-24) at a dose of 400 kg ha^{-1}, and urea in coverage at a dose of 400 kg ha^{-1}.

When the plants reached the hard-grain stage (R5), they were harvested at 20 cm from the ground. All plants contained in the useful area of each plot were weighed to determine the production of fresh and dry biomass (kg ha^{-1}). Plant heights and ear insertion were measured, and the number of green and yellow leaves per plant was counted. From the plants harvested in the useful area of each plot, a sub-sample of 20 homogeneous plants were immediately sent to the laboratory, where the centesimal composition of plant anatomical structures was determined by manual segmentation of components: stem, green leaves, yellow leaves, husk and corn cob, grains, as well as the dry matter contents of the whole-plant, vegetative fraction and its components.

Corresponds to the vegetative fraction, the plant without grains, which were removed manually and carefully during anatomical segmentation.

The samples of whole-plant, vegetative fraction and structural components were weighed and pre-dried in a forced air oven at 55 ℃ until constant weight was obtained. After drying, these were weighed again to determine the dry matter content (Silva and Queiroz, 2009). Only the whole-plants and vegetative fraction were sequentially ground in a Willey mill, with a 1 mm mesh sieve.

In the pre-dried samples, the total dry matter (DM) was determined in an oven at 105 ℃, crude protein (CP) by micro Kjeldahl method and ash by incineration at 550 ℃ for 4 hours, according to AOAC (Official…, 1995). The neutral detergent fiber content (aNDF) was also determined using thermostable α-amylase (Termamyl 120L), and lignin, according to Van Soest *et al*. (1991), and the content of acid detergent fiber (ADF) according to Goering and Van Soest (1970). Hemicellulose (HEM) contents were obtained by difference between NDF and ADF, as well as cellulose (CEL) contents were obtained from the difference between ADF and lignin. The contents of total digestible nutrients (TDN) were obtained by an equation suggested by Bolsen (1996). The content of non-fibrous carbohydrates (NFC) was obtained by the equation: $NFC = 100 - (aNDF + CP + ash + EE)$, and the ether extract (EE) content was standardized at 3%, according to NRC (Nutrient…, 2001).

The dry matter digestibility (DMD) in 24 and 48 hours was estimated by the *in-situ* technique using nylon bags measuring 12×8cm and with pores of 40 to 60μm, containing 5g of sample ground to 1mm, for later incubation in the rumen (Nocek, 1988). Before incubation, the bags were immersed in water and inserted into the rumen at different times to be retrieve as a group. After removal, the bags were rinsed under running water under moderate handling until the water appeared to be clean. A blank bag was inserted at each time for correction. For this purpose, two steers of 36 months-old, average live weight of 650kg, with permanent ruminal fistula were used, previously fed with corn silage *ad libitum*.

The data were submitted to Shapiro-Wilk and Bartlett tests, in order to verify the assumptions of normality and homogeneity of variance, respectively. Once these assumptions were met, the F test was applied at 5% probability through variance analysis (ANOVA; Supplement 1) and then the Tukey test to compare means at 5% significance through the SAS program (1993).

RESULTS AND DISCUSSION

Although there was no statistical difference for phenological cycle, in days, until the harvesting moment in R5 stage, it's important to highlight that there was a numerical difference of 23 days between the average of hybrids P2866H and P4285YHR (149 and 172 days, respectively). The latter showed a difference of three days among locations of the earlier and later harvest, while the others were 11 days of difference (Table 1). Knowing the cycle of each hybrid is essential to outline strategies better adapted to the systems of each farm, enabling the determination of the best time for sowing and harvesting, and foreseeing the realization of crop treatments and possible climatic risks ((Baum *et al*., 2019; Hetta *et al*., 2012). These differences on cycles of the same hybrid are already documented when grown in different locations (Pinto *et al*., 2010).

The hybrid P4285YHR presented the highest plant and ear insertion heights in relation to the others (2.72m, 1.52m respectively), with a minimum height recorded among locations of 2.63m and 1.42 m, for height plant and ear insertion. These minimum values are higher than the average of other hybrids tested. In all locations, the four hybrids had sufficient height necessary to be classified as medium size, between 2.20 and 2.80m (Pinto *et al*., 2010). Pinto *et al*. (2010) also stated that shorter cycle hybrids tend to obtain shorter plant heights, but our data went against what was reported by the authors. We believe that the cycle until flowering has more interference on this variable than the complete physiological cycle.

Supplement 1. Summary of variance analysis (ANOVA)

	Mean square					Probability		
	Hybrid (H)	Location(L)	Block	H×L	Error	Hybrid	Block	H×L
Degrees of freedom	3	3	2	8	16	-	-	-
Cycle	0.1	2.81	0.1	0.5	0.4	0.432	0.332	0.225
Plant height	0.1	0.1	0.1	0.1	0.1	<0.001	<0.001	<0.001
Ear height	0.1	0.1	0.1	0.1	0.1	<0.001	<0.001	<0.001
Number of yellow leaves	4.0	6.9	0.8	5.8	0.3	<0.001	<0.001	<0.001
Fresh biomass	14879^2	15676^2	8248^2	9689^2	5036^2	<0.001	<0.001	0.004
Dry biomass	4137^2	3497^2	2988^2	3087^2	2587^2	0.075	0.165	0.230
Dry matter								
Plant	110.6	39.6	0.1	35.9	4.8	<0.001	<0.001	<0.001
Vegetative fraction	40.5	23.8	30.9	5.1	3.9	<0.001	0.002	<0.001
Stem	92.8	6.9	1.4	5.0	2.5	<0.001	0.062	0.086
Green leaves	98.2	229.3	191.6	224.8	72.9	0.279	<0.001	0.001
Yellow leaves	17.4	28.6	0.6	43.3	4.2	0.001	0.001	<0.001
Husk and corn cob	60.7	129.5	1.8	23.0	5.7	<0.001	<0.001	0.002
Grain	35.7	71.8	10.5	41.1	11.8	0.045	0.002	0.006
Centesimal composition								
Stem	83.9	56.0	4.1	5.8	4.7	<0.001	<0.001	0.318
Green leaves	67.5	28.1	0.4	24.5	3.5	<0.001	<0.001	<0.001
Yellow leaves	6.1	32.3	4.3	15.9	2.4	0.080	<0.001	<0.001
Husk and corn cob	47.4	5.9	0.1	6.0	2.0	<0.001	0.051	0.015
Grain	468.9	60.3	13.4	28.5	15.2	<0.001	0.018	0.106
Ash	1.5	0.7	0.1	0.4	0.1	<0.001	0.019	0.042
Crude protein	0.3	3.5	0.2	0.4	0.3	0.398	<0.001	0.295
aNDF	346.9	71.3	0.5	17.8	10.0	<0.001	<0.001	0.124
Hemicellulose	140.9	51.0	7.2	16.9	9.38	<0.001	<0.001	0.118
ADF	47.0	9.8	4.24	8.7	12.5	0.022	0.511	0.687
Cellulose	21.6	12.2	3.99	9.0	9.9	0.112	0.314	0.516
Lignin	5.0	3.0	0.1	0.7	0.9	0.005	0.041	0.635
NFC	356.7	43.9	0.5	22.8	12.0	<0.001	0.024	0.100
TDN	23.0	4.8	2.0	4.3	6.1	0.020	0.511	0.686
ISDMD-24h								
Whole plant	41.5	3.2	111.2	15.4	13.2	0.040	0.865	0.353
Vegetative fraction	26.4	16.3	197.2	14.6	5.2	0.006	0.043	0.081
ISDMD-48h								
Whole plant	197.2	31.7	30.7	15.1	18.6	<0.001	0.189	0.597
Vegetative fraction	7.4	82.0	149.3	5.6	11.3	0.586	0.001	0.845

Table 1. Cycle, morphometric characteristics and biomass yield of four corn hybrids grown for silage in different locations. Average, minimum and maximum values obtained among locations

Average (Min - Max)	P2866H	P3456H	P30R50VYH	P4285YHR
Cycle, days	149 (146 - 157)	153 (146 - 157)	154 (146 - 157)	172 (171 - 174)
Plant height, m	2.57 b (2.48 - 1.61)	2.48 c (2.37 - 2.58)	2.51 c (2.39 - 2.68)	2.72 a (2.63 - 2.87)
Ear height, m	1.31 c (1.18 - 1.41)	1.31 c (1.19 - 1.42)	1.42 b (1.19 - 1.61)	1.52 a (1.42 - 1.68)
Number of yellow leaves	4.3 a (3.0 - 6.7)	3.4 b (3.0 - 4.3)	3.0 b (2.0 - 4.7)	3.3 b (2.0 - 5.3)
Fresh biomass, kg ha^{-1}	68,023 b (59,589 - 80,620)	68,880 b (61,826 - 73,894)	70,526 b (63,934 - 78,708)	78,089 a (71,688 - 80,978)
Dry biomass, kg ha^{-1}	27,586 (25,038 - 29,205)	26,362 (24,733 - 28,572)	24,710 (22,450 - 26,973)	26,539 (24,973 - 28,722)

[a-c] Different letters differ by Tukey test at 5%.

The hybrid P4285YHR has a higher fresh biomass yield (78,089 kg ha^{-1}) compared to the others, which did not differ between them (68,023; 68,880; and 70,526kg ha^{-1} for the hybrids P2866H, P3456H, P30R50VYH, respectively). Despite presenting an average of 68 t of fresh biomass per hectare, the hybrid P2866H had a yield of 59 t in one location and 80 t in another, and this variability is considered unfavorable, precisely due to the difficulty of predictability. Rosa *et al*. (2004) found that higher hybrids with higher ear insertion had higher potential for fresh biomass yield. It's salutary to say that while higher hybrids tend to have higher biomass yield, smaller hybrids have a higher proportion between grains and vegetative fraction, favoring the quality of silage (Horst *et al*., 2020a). In addition, smaller plants have better support, reducing stem breakage under conditions of denser populations.

Oliveira *et al*. (2003) evaluated 22 hybrids in six cultivation locations, and obtained differences in dry biomass yield, reporting an interaction between genotype and environment that provides discrepancies in results of the same hybrid among locations. This behavior was not noticed in the present study, neither for hybrids nor for locations (P>0.05).

The hybrid P2866H had the highest number of yellow leaves compared to hybrids P3456H, P30R50VYH and P4285YHR (4.3, 3.4, 3.0, and 3.3, respectively), again having the greatest variation between minimum and maximum values among them. The smaller number of yellow leaves found in the hybrids P3456H, P30R50H and P4285YHR can be considered an indication of good stay-green (Neumann *et al*., 2018), which can result in a larger harvest window due to greater hydration during the reproductive phase and/or grain fill. The early yellowing of leaves can also be linked to leaf diseases and considering that there are more resistant hybrids than others in the natural control of these diseases (Malinovsky *et al*., 2014), it's possible that the hybrid P2866H is less tolerant to them than others evaluated. This difference can be better observed in one of these locations where there was only one application of fungicide (6.7 yellow leaves for this hybrid).

The hybrid P2866H presented the highest dry matter content of plant at harvest time in hard grain stage, with 40.95% (Table 2), followed by the hybrid P3456H with 38.38%, and then by the hybrids P30R50VYH and P4285YHR with the lowest dry matter content of plant (35.06 and 34.12%, respectively). Again, it's possible to observe the high variation among locations for the hybrid P2866H (10.53 percentage points). On the other hand, the hybrid P30R50VYH showed variation of only 1.91 percentage points among locations where the most moisture and the least moisture was harvested (34.20 and 36.11% DM). This stability demonstrated by this hybrid is considered positive because it allows greater predictability of the chosen harvest time. In one of these locations, the hybrid P2866H was harvested with 46.08% DM, which raised the hybrid average to 40.95%, which according to criteria proposed by Arriola *et al*. (2012), exceeds what is considered ideal to obtain adequate fermentation of silage (30-40%). This result was already expected, given that shorter cycle hybrids advance their reproductive stages with water loss more rapidly (Horst *et al*., 2020a).

Like the whole-plant, the lowest DM contents of vegetative fraction, stem, green and yellow leaves, husk and corn cob were observed in hybrid P30R50VYH (24.70%; 16.86%; 26.04%; 57.75%; and 36.52%, respectively). On the other hand, even though there was no significant difference (P> 0.05) for dry matter of grain, this same hybrid obtained the highest values, with an average of 67.23% and a maximum value of 71.71%. In farm B, we observed the lowest levels of DM in whole-plant for all hybrids, and we believe that this may be related to the use of *Pyraclostrobin* based fungicide in this area. According to Haerr *et al*. (2016), this class of fungicide has stood out for its greening effect, reducing lignification and promoting increased levels of leaf chlorophyll.

High stalk participation in centesimal composition of plant may reduce the ruminal utilization of corn silage due to the characteristics of structural carbohydrate composition of this fraction (Hetta *et al*., 2012). The hybrid P4285YHR was the one with the highest participation of this component (P <0.05). The leaves are the component of the vegetative fraction with the greatest digestibility due to the higher concentration of sugars and digestible fiber (Horst *et al*., 2020b), and the hybrid P4285YHR was the one that had the greatest participation of this component in its centesimal composition. This result explains the high biomass yield of this hybrid seen previously. There was no difference for yellow leaves among hybrids, but in one of locations (farm D), the hybrids P2866H, P3456H and P30R50VYH had the maximum values of yellow leaves and minimum of green leaves in the centesimal composition of plant. In that area there was only one application of fungicide. The presence of leaf diseases generates competition for nutrients between fungi and plant itself, causing it to activate some defense mechanisms to try to control the development of the fungus, such as lignification and leaf fall (Haerr *et al*., 2016), and this can reduce the dry matter and fiber digestibility of plant (Weinberg and Chen, 2013; Der Bedrosian *et al*., 2012).

Table 2. Dry matter content of plant fractions and centesimal composition of four corn hybrids grown for silage in different locations. Average, minimum and maximum values obtained among locations

Average (Min - Max)	P2866H	P3456H	P30R50VYH	P4285YHR
Dry matter, % AF				
Plant	40.95a (35.55-46.08)	38.38b (34.74-40.33)	35.06c (34.20-36.11)	34.12c (31.12-39.99)
Vegetative fraction	28.25ab (25.25-32.86)	29.93a (24.70-32.78)	24.70c (21.36-28.06)	26.88b (24.91-29.04)
Stem	22.70a (21.27-25.24)	19.78b (18.62-20.53)	16.86c (16.63-17.43)	22.60a (20.07-23.77)
Green leaves	28.15b (25.62-31.96)	30.73a (29.52-32.80)	26.04b (22.73-30.35)	28.22b (22.51-35.08)
Yellow leaves	55.77b (36.56-77.60)	64.31a (58.14-69.04)	57.75b (28.38-72.46)	62.29a (41.52-76.94)
Husk and corn cob	41.86a (35.95-50.29)	40.47ab (39.70-41.11)	36.52c (30.78-40.72)	38.02b (34.71-41.46)
Grain	63.49 (55.30-69.81)	66.73 (63.31-68.63)	67.23 (63.07-71.71)	63.82 (61.10-65.90)
Centesimal composition, % whole-plant				
Stem	17.88b (14.30-19.50)	15.60b (13.50-18.40)	17.17b (15.80-18.70)	22.20a (20.50-24.90)
Green leaves	11.51b (7.10-15.80)	12.07b (10.80-13.60)	11.93b (9.00-13.80)	16.71a (11.70-19.70)
Yellow leaves	4.51 (1.80-9.10)	4.36 (2.60-7.10)	3.00 (1.20-6.60)	3.09 (1.10-5.90)
Husk and corn cob	12.23c (9.70-14.10)	13.33bc (12.80-14.30)	14.54b (13.00-16.50)	16.92a (16.00-17.80)
Grain	53.87a (48.80-58.00)	54.64a (50.90-59.30)	53.36a (52.60-53.70)	41.08b (37.10-45.70)

[a-c] Different letters differ by Tukey test at 5%.

In addition to considering the quality of vegetative fraction as essential to obtain silage with good digestibility, it's also unanimous among many authors that the greater participation of grains in the plant, the better the results regarding caloric density and corn silage digestibility tend to be (Horst *et al*., 2020a; Ferraretto *et al*., 2018; Khan *et al*., 2015). In three of the hybrids evaluated here, we obtained participation of grain in the plant above 50%, and this can be considered satisfactory in comparison to other similar studies (Neumann *et al*., 2017; Kruse *et al*., 2008). If we extrapolate these values for grain production corrected by moisture (13%), we can infer that the hybrids P2866H, P3456H, P30R50VYH and P4285YHR had a yield of 285; 275; 252; and 208 corn bags per hectare.

The ash content of hybrid P2866H (2.33%; Table 3) was significantly lower ($P < 0.05$) compared to hybrids P30R50VYH and P4285YHR (3.10 and 3.04%, respectively). The crude protein concentration did not differ among hybrids, varying from 6.33% in the hybrid P4285YHR to 6.68% in the hybrids P2866H and P30R50VYH, values close to those described by Horst *et al*. (2020b) for three other distinct hybrids grown in locations close to the present study. Also without noticing any difference, these authors demonstrated that there is a higher concentration of CP in the leaves compared to other fractions and, therefore, without major differences between hybrids in the participation of this component, hardly any difference in the crude protein will be observed.

Table 3. Nutritional value of four corn hybrids grown for silage and harvested in hard-grain stage, in different locations

Parameter, % of MS	P2866H	P3456H	P30R50VYH	P4285YHR	S.E.M.
Ash	2.33b	2.67ab	3.10a	3.04a	0.32
Crude protein	6.68	6.53	6.68	6.33	0.37
aNDF	56.46b	52.88b	57.70b	66.15a	0.88
Hemicellulose	28.04b	25.61b	28.95b	33.88a	0.87
ADF	28.43b	27.27b	28.75b	32.27a	0.93
Cellulose	23.18b	22.27b	23.54b	25.76a	0.88
Lignin	5.24b	5.01b	5.21b	6.51a	0.49
NFC	31.53ab	34.92a	29.52b	24.49c	0.93
TDN	67.94ab	68.74a	67.71ab	65.25b	0.78
ISDMD-24h					
Whole plant	37.03a	38.10a	36.11ab	34.00b	0.95
Vegetative fraction	26.61b	29.37a	25.69b	28.28a	1.03
ISDMD-48h					
Whole plant	55.13b	57.98a	55.28b	47.84c	0.75
Vegetative fraction	39.65	39.46	39.06	38.54	0.91

[a-c] Different letters differ by Tukey test at 5%.

aNDF: Neutral detergent fiber; ADF: acid detergent fiber; NFC: non-fibrous carbohydrate; TDN: Total digestible nutrient; ISDMD-24h: I*n situ* dry matter digestibility on 24 hours of ruminal incubation; ISDMD-48h: I*n situ* dry matter digestibility on 48 hours of ruminal incubation; S.E.M.: Standard error of mean

The hybrid P4285YHR had the highest (P <0.05) contents of all components related to the plant cell wall, with an average of 66.15%; 33.88%; 32.27%; 25.76%; and 6.51% for aNDF, hemicellulose, ADF, cellulose and lignin, respectively. For this reason, this hybrid had the lowest NFC content (24.49%). The other three hybrids evaluated did not differ for cell wall components, while hybrids P3456H and P2866H had higher levels of NFC (34.92 and 31.53%, respectively). We believe that the higher content of fiber components found in the hybrid P4285YHR is directly related to the higher plant height presented by this hybrid, because the elongation of stem increases its participation, and this fraction has a great influence on fiber concentration in the plant (Horst *et al*., 2020b) and silage.

The aNDF is composed of cell wall structures, consisting of cellulose, hemicellulose and lignin, and is directly related to the capacity of ingestion by ruminants, as it promotes physical occupation of ruminal space (Neumann *et al*., 2017). While the ADF intermediates the digestion potential of fibrous fraction (Van Soest, 1994), as it's composed of cellulose, which has intermediate digestibility, and lignin, which is indigestible. Therefore, low levels of aNDF and ADF are preferable when choosing hybrids for silage production. The values of aNDF and ADF in this study are close to those described by Ferraretto and Shaver (2015) and Ferreira *et al*. (2011).

It's possible that a greater number of yellow leaves on a corn plant leads to a higher lignin content (Hetta *et al*., 2012). However, we observed that these two variables were unrelated in our study, and that it may be an intrinsic characteristic of each hybrid to deposit more or less lignin in its cell structure according to situations occurring in each environment (water stress, leaf diseases, fertilization level, soil characteristics, e.g.).

In general, dry matter digestibility is reduced due to lignification and increased cell wall thickness (Hetta *et al*., 2012). Differences in cell wall digestibility of corn plants have already been described experimentally *in vitro* (Deaville and Givens, 2001) and *in vivo* (Jensen *et al*., 2005). The hybrid P4285YHR, which had the highest lignin content, had the lowest whole-plant ISDMD (P <0.05), either in 24 or 48 hours (34.00 and 47.84%, respectively). We note, however, that this result was not repeated for vegetative fraction ISDMD, where there is the highest lignin concentration (Horst *et al*., 2020b), suggesting that the lower participation of grains of this hybrid has had greater interference in this result. According to Krämer-Schmid *et al.* (2016), lignin may have a low correlation with dry matter digestibility, and its three-dimensional arrangement may influence this characteristic more than its own participation in the plant.

The hybrid P3456H had whole-plant ISDMD-24h statistically similar to hybrids P2866H and P30R50VYH, but had vegetative fraction ISDMD-24h higher than them (29.37%). As the vegetative fraction has a longer time in the rumen, its real changes in digestibility of the intake are highlighted in longer incubation times, and we confirm this by noting that the hybrid P3456H had the largest whole-plant ISDMD-48h (57,98 %; $P < 0.05$).

The calculated TDN values showed a trend very close to that observed in the ISDMD of the whole-plant, with the hybrid P3456H presenting the highest estimated value (68.74%), and the hybrid P4285YHR the lowest among them (65.25%).

CONCLUSION

We noticed that lower fibrous carbohydrates and lignin content, higher fibrous carbohydrates content, together with satisfactory grains participation in the plant structure led to a greater dry matter digestibility. Hybrids with lower plant heights do not necessarily have lower dry biomass yields, but hybrids of greater height and with high stem and leaf participation tend to have a higher aFDN content and less dry matter digestibility.

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