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Hydroponic forage of corn and millet grown on different organic substrates

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Abstract

The objective of this study was to evaluate the production and nutritive value of the hydroponic forage of corn and pearl millet grown in different organic substrates. It was carried out in a completely randomized design in 2 x 3 factorial scheme with four replications. The grasses used were corn and pearl millet and sugarcane bagasse, chopped elephant grass and chopped Brachiaria grass as substrates. The harvest was carried out 15 days after sowing, with seed density of 2 kg/m², irrigated with water and commercial nutrient solution. The productive parameters and chemical composition of the hydroponic forage were evaluated. The use of sugarcane bagasse substrate resulted in a greater production of total dry mass for corn among the other treatments, which reflected in better efficiency in the production parameters. As for substrates composed of chopped grass, lower values of neutral detergent fiber were identified in both corn and pearl millet. The substrates and grass species affect the evaluated parameters, in which the use of sugarcane bagasse resulted in greater total production of dry mass using corn. The substrates based on chopped grass reflected in biomass with reduced fiber content, high levels of digestible nutrients, in addition to high protein content.

Keywords: Sustainable production; Hydroponic forage; Hydroponic millet; Hydroponic corn.

1. Introduction

In production systems where pasture represents the primary source of food for the animals, their performance can be affected, with reflects on the meat and milk yield resulting from climatic seasonality, which results in low forage production in some periods of the year.

Thus, the search for strategies that aim to minimize the seasonality effects on forage and its consequences on animals becomes essential for clean and profitable production. In this sense, there is a frequency of studies in the academy with the purpose of promoting the development of new technologies, as sustainable alternatives, which serve to supplement the diets of the ruminants and to avoid reductions in productivity in adverse times. Amidst this, hydroponics has stood out as one of the viable alternatives, as it is a soilless cultivation technique that consists of producing food in a short period, from 10 to 15 days, with the capture of solar energy and assimilation of minerals contained in the nutrient solution (FAO, 2001). This technology has been widely disseminated around the world and adapted to the production of forage to serve as food for animals.

Among the plant species used in animal diets, corn and pearl millet draw attention because they are grasses with a fast cycle and offer dry matter in quantity and good nutritional value. However, these plant species produce less dry mass in places where severe climate and prolonged drought impair their cultivation (Martins, et al., 2018). Thus, its use in hydroponics is a feasible roughage option, with a high protein content to be supplied to the animal, as it does not depend on soil fertility and rainfall for its production.

The rise in the production of the dry mass of hydroponic forage (HF) is influenced by residues from agroindustry and crops, and also by chopped grasses (grass), as they have the potential for use as substrates in the hydroponics technique. These substrates provide substantial increases in the levels of fiber and nutrients required by the HF set (substrate + root + aerial part) and also allow the satisfactory development of the roots. The availability of the data on the quality of hydroponic forages cultivated on different substrates is still scarce. From this perspective, the scientific work that aims to promote this information is relevant, as high-quality HF will allow producers to maintain and expand the productivity of their herds, making them more stable, regardless of seasonal climatic variations.

The objective of this work was to evaluate the production and nutritive value of the hydroponic forage of corn and pearl millet produced in different organic substrates.

2. Material and methodos

The experiment was carried out from April to July 2020 by setting beds in a greenhouse located in the State University of Sudoeste da Bahia (UESB), *campus* Juvino Oliveira, within the geographic coordinates 15º38’46” S latitude, 40º15’24” W longitude at 28m above sea level in the municipality of Itapetinga, Bahia.

It was carried out in a completely randomized design, in a 2x3 factorial scheme, using two species of grass: *Zea mays* (corn) and *Pennisetum glaucum* (pearl millet); and three organic substrates: *Saccharum* sp. (sugarcane bagasse - SB), *Pennisetum purpureum* (elephant grass - EG) and *Brachiaria decumbens* (brachiaria grass - BG), with four replications, totaling 24 experimental units.

The experimental units (EU) had an area of 0.49 m² (0.85 m x 0.58 m) and spacing of 0.3 m between them, built on 150-micron polyethylene canvas. The substrates were placed on the canvas with a layer of 2 cm, and then sowing was carried out using 2 kg of m² seeds, then covered by another 2-cm layer of substrate, which corresponded to 1.2 kg of each substrate per experimental unit, with density (kg/m³) of 513.7 (SB), 510.0 (EG) and 339.2 (BG).

Before sowing, the seeds were disinfected using a commercial solution of sodium hypochlorite at 2%, for 10 minutes, with subsequent washing. Finally, they underwent dormancy breaking through soaking in water, for 24 hours and 12 hours for corn and pearl millet, respectively, according to Roversi (2004).

The corn and millet seeds were purchased from the local trade, while the SB substrate was obtained by the manual process of juice extraction and the EG and BG were collected in the university's area. Subsequently, the substrates were chopped in an ensiling machine and air-dried. Before starting the experiment, samples of substrates and seeds were collected for characterization, whose results are shown in Table 1.

Table 1. Chemical-bromatological characterization of corn and millet seeds and organic substrates used in the experiment for the production of hydroponic forage.

Item	Corn	Millet	SB	EG	BG
pH	---	---	3.52	6.80	8.0
Cond. (µS/cm)	---	---	1,880	2,940	4.896
DM (%)	87.69	88.19	31.88	34.28	30.04
	% in DM				
MM	2.56	4.88	2.04	8.50	9.20
OM	98.44	95.12	97.95	91.49	90.73
CP	9.67	15.94	2.38	4.41	6.69
NDF	9.79	20.40	63.44	72.12	70.83
ADF	4.01	7.14	43.75	53.85	48.50
LIG	1.32	1.48	7.69	11.37	9.46
TDNe	79.70	75.28	57.33	53.71	54.25

SB= sugar cane bagasse. EG= elephant grass. BG= brachiaria grass. pH= hydrogen ion potential; Cond= electrical conductivity; DM= dry matter. MM= mineral matter. OM= organic matter. CP= crude protein. NDF= neutral detergent fiber. ADF= acid detergent fiber. LIG=lignin. TDNe= estimated total digestible nutrients.

For irrigation, the open system was adopted, without reusing the applied solution. Using a conventional watering can, irrigation was carried out using water ($5L/m^2.day^{-1}$, split into four times a day) during the first three days after sowing.

When germination started (three days after planting), irrigation was carried out using $1L/m^2$ of water, executed at 8 a.m. and 10 a.m., and fertigation with $4L/m^2$, which was performed in the afternoon at three times, namely, 12:00, 2:00 p.m., and 4:00 p.m. Fertirrigation was done for 10 days and was suspended one day before harvesting, when the forage was irrigated only with water (2L), to remove salts and avoid waterlogging of the substrate at harvesting.

A commercial nutrient solution recommended for forage production (SaladaShop® – complete kit) was used. The solutions were prepared daily, following the manufacturer's recommendation, and stored in a plastic container. Before irrigation, temperature and electrical conductivity were monitored employing a TDS & IC meter (B-MAX®), and pH was measured using a portable pH-meter (ATC - 009), which showed mean values of 23ºC, 1180µS/ cm and 5.7, respectively.

Harvest was done on day 15th after planting, where samples of the complete forage (aerial part + substrate + roots + non-germinated seeds), aerial part, and base (substrate + roots + non-germinated seeds) were collected. Before that, height measurements were taken at two representative points of each experimental unit, with the aid of a graduated ruler from the distance between the upper limit of the leaves and the base formed by the substrate, expressed in centimeters.

The different parts of the forage were detached, weighed, and stored in identified paper bags and taken to an oven at 65°C for 72 hours for drying, and eventually weighed again to determine the dry mass. Height (HEIGHT), aerial part fresh mass production (APFMP), base fresh mass production (BFMP), total fresh mass production (TFMP), aerial part dry mass production (APDMP), production of base dry mass (BDMP), total dry mass production (TDMP), ash (AC), organic matter (OM), crude protein (CP) and neutral detergent fiber corrected for ash and protein (NDFap), according to Detmann (2012). The estimate of total digestible nutrients was obtained through the equation proposed by Cappelle et al. (2001), where: NDT = 83.79 - 0.4171 NDF.

Evaluations of water use efficiency (WUE) and conversion efficiency (CE) were also carried out based on the production process. For WUE the variable was determined based on the following equation: WUE = DMY/WUE. Where: WUE= Water use efficiency (kg DM/m^3); DMY= Total dry matter yield (kg DM/m^2) and TWU= Total water use during the production process (m^3). The TWU = 0.078 m^3 includes the process of seed washing, dormancy breaking, substrate preparation, irrigation, and fertigation.

For the CE analysis of the production process, the relationship between the HF total dry mass production and the amount of seeds and substrates expressed based on dry matter, was defined. CE=TDMP/(SE+SB). Where: CE= Conversion efficiency; TDMP= Total dry mass production (kg/m^2); SE= seed (kg/m^2) and SB= substrate (kg/m^2).

The results were submitted to analysis of variance using the SAS OnDemand for Academics statistical program. The interactions, when significant, unfolded according to the factors involved, and the treatment means were compared by the test of Tukey at 5% probability.

3. Results and discussion

The interaction between species and substrates for plant height, fresh mass production of the aerial part and base, and total fresh mass production were significant ($p<0.05$) (Table 2).

Table 2. Plant height (HEIGHT), aerial part fresh mass production (APFMP), base fresh mass production (BFMP), total fresh mass production (TFMP) of hydroponics green forage of corn and millet grown in different organic substrates.

Grass	Substrates			Mean	CV[1] (%)
	SB	EG	BG		
		HEIGHT (cm)			
Corn	22.05bA	33.30aA	34.72aA	30.02	
Millet	20.40aA	16.37aB	19.70aB	18.82	11.16
Mean	21.22	24.83	27.21		
		APFMP (kg/m^2)			
Corn	2.92cB	4.41bB	4.90aB	4.08	

Millet	4.45cA	4.74bA	5.21aA	4.80	2.42
Mean	3.68	4,57	5.05		
		BFMP (kg/m²)			
Corn	20.92aA	14.07bA	13.15bA	16.05	
Millet	11.58aB	11.13aB	11.49aB	11.40	5.18
Mean	16.25	12.60	12.32		
		TFMP (kg/m²)			
Corn	23.84aA	18.48aA	18.06aA	20.13	
Millet	16.03aB	15.87aB	16.70aB	16.20	3.97
Mean	19.94	17.18	17.38		

SB= sugar cane bagasse; EG= Elephant grass; BG= brachiaria grass; [1]Coeficient of variation in percentage. Means followed by the same upper case letter in the column and lower case letter in the row are not different from each other by the test of Tukey ($P<0.05$).

Plant height infers the adaptation degree that HF has achieved during the growth phase. The study reveals that the height of the pearl millet plant did not differ between the assessed substrates, indicating an average of 18.82 cm. For corn, a difference between the substrates was observed as the one that was grown in the SB-treatment had a lower average height, which is associated with the effect of the low pH value of the substrate, affecting plant development, due to lower availability of nutrients caused by the low pH.

On the other hand, in the grass species, corn reached a high height compared to millet, in the EG and BG substrate treatments. The smallest height values identified in the millet HF may be associated with the difference in grain size. Because it has smaller grains, the amount used for millet was greater than for corn, which probably increased population density and, consequently, competition for light, water, and nutrients, therefore reducing plant growth.

The highest production of fresh mass from the aerial part resulted from the use of SB substrate, while the lowest was identified by the use of SB, regardless of the grass used.

In relation to the plant cultivation using the soil, nutrients are better used by the plants because of their pH range. Maximum availability is within the range of 6 to 6.5, with a further decrease. Nitrogen (N) significantly favors the plant in soil with a pH above 5.5, whereas phosphorus (P) stands out with a pH of 6 to 6.5 and potassium (K) above 5.5 (Cardoso & Andreote, 2016).

The nutrient absorption range in the soil, in comparison with the substrates of hydroponic cultivation, indicates that, although the pH of the SB is 8.0, a value related to the reduction of the main nutrients responsible for the development of the plant, it is likely that the SB has retained a greater amount of nutrients, generating a greater production of the aerial part. Nutrients such as nitrogen, phosphorus, and potassium are directly related to plant growth (Malavolta, et al., 1986), and their deficiency can lead to a reduction in the height and leaf area.

When observing the effect of the species factor, in all substrates, the production of the fresh mass of the aerial part in corn HF (4.08 kg/m²) was lower than the pearl millet HF (4.90 kg/m²), and this result may be associated with the smaller number of seeds, as they are larger than those of millet.

In relation to the APFMP, the substrates did not influence the production of pearl Millet HF, indicating an average of 11.40 kg/m². Conversely, the substrates influenced the HF corn production, in which the SB in the corn HF reflected higher production (20.92 kg/m²). For species purposes, the corn HF was higher, probably because it produced more roots and because the number of seeds was lower than that of millet, and, for this reason, there was less competition between plants, promoting growth and development of the roots.

The base fraction directly influenced the production of total fresh mass, with the highest values in corn HF, a treatment that achieved the highest value for base production. Those found in this work ranged between 15.87 and 23.84 kg MF/m², which exceed the fresh mass results found by Muller et al. (2005). These authors, when comparing the production of the fresh mass of corn HF with that of millet in elephant grass substrate, identified means of 19.54 and 11.60 kg MF/m², respectively.

Regarding the interaction between species and the assessed substrates on the aerial part dry matter production, base dry matter production, and total dry matter production (Table 3), a significant effect ($p<0.05$) was observed. In the production of aerial part dry mass, millet stood out, as the substrates assessed in this experiment did not have a negative effect on its productivity. These signaled an average of 0.47 kg/m² resulting from the greater number of seeds at sowing, which possibly generated a greater quantity of seedlings and a high yield for this fraction.

Table 3. Aerial part dry matter production (APDMP), base dry matter production (BDMP), and total dry matter production (TDMP) of hydroponic green forage of corn and pearl millet grown in different organic substrates.

Grass	Substrate			Mean	CV[1] (%)
	SB	EG	BG		
		APDMP (kg/m²)			
Corn	0.23bB	0.20bB	0.31aB	0.25	
Millet	0.44aA	0.50aA	0.47aA	0.47	16.93
Mean	0.33	0.35	0.39		
		BDMP (kg/m²)			
Corn	2.78aA	2.01bA	1.77bA	2.18	
Millet	1.62aB	1.59aB	1.78aA	1.43	10.37
Mean	2.20	1.45	1.77		
		TDMP (kg/m²)			
Corn	3.01aA	2.21bA	2.08bA	2.43	
Millet	2.06aB	2.09aB	2.25aA	2.21	9.89
Mean	2.53	1.80	2.41		

SB= sugar cane bagasse; EG= Elephant grass; BG= brachiaria grass; [1]Coeficient of variation in percentage. Means followed by the same upper case letter in the column and lower case letter in the row are not different from each other by the test of Tukey ($P<0.05$).

Conversely, in corn HF, the BG substrate surpassed the SB and EG substrates (mean of 0.21 kg/m²), showing an average production of 0.31 kg/m². It also provided a 32% increase in aerial part production and greater retention of nutrients in this substrate, which reflected in the high efficiency of use by the plants and increases in the aerial part.

The dry matter production of the pearl millet base was not influenced by the substrates and had an average production equivalent to 1.43 $kg.m^{-2}$. On the other hand, in the corn crop, production was significantly higher in the SB substrate treatment.

At the beginning of the experiment, the values of the base fraction (substrate + seeds) in kg DM/m² were: millet + SB= 2.14; millet + EG= 2.17 and millet + BG= 2.12. Corn + SB= 2.14; corn + CE= 2.16; corn + BG= 2.11. These values, when higher than those at the end of the cycle, indicate a positive balance for the production of the base fraction, while lower values indicate a negative balance.

Based on this difference, it can be inferred that, for the base fraction, only corn cultivation in SB-treatment showed a positive result in dry mass production, with an increase of 5.8%, which may be related to the growth of roots.

The values of the total dry mass production had similar behavior to the results of the base dry matter production, being strongly influenced by this fraction as the corn grown in the SB-treatment indicated higher dry mass production (3.01 kg/m²). Although the millet grown in the BG substrate exposed a negative balance in the base fraction, it became positive in the total production, due to the production of areal part dry mass, which was adequate to promote the values in this crop, with an increase of 5.7%.

Apart from the corn in the SB treatment and pearl millet in the BG, a negative balance is identified in the values found in this experiment, that is, the amount of dry matter used at the beginning exceeded that at the end of the 15-day cycle. This fact is normal in HF production, as the seeds or grains consume their reserve for plant development, reducing the dry matter content contained in them. However, it is expected that the production of roots and aerial part is sufficient to circumvent this decrease.

In general, the literature shows contrasting values of HF total dry matter production, which vary depending on the grass, substrate, density, and harvest age. In the analysis of the corn grown with HF at the sowing density of 2.5 kg/m², in SB-substrate treatment and a standard nutrient solution, Piccolo et al. (2013) found a total dry matter production of 4.02 kg/m². On the other hand, with the application of the same sowing density in the cultivation of corn with the CE substrate, Campêlo et al. (2007) reached the value of 3.9 kg/m². Otherwise, Paula et al. (2011) found a dry matter production equal to 2.10 kg/m², in the experiment using a harvest age of 21 days for the cultivation of corn in SB substrate.

The water used in the experimental period was the pattern for the six forms of cultivation, so the differences between the values of WUE represent the increase in productivity (kg DM/m^2) of the HF. This is confirmed by the significant interaction ($p<0.05$) for this variable (Table 4), where a better water use efficiency was found in corn HF with SB, a treatment that resulted in higher production of total fresh and dry mass.

Table 4. Water use efficiency (WUE) and conversion efficiency (CE) of hydroponics green forage of corn and pearl millet grown in different organic substrates.

Grass	Substrate			Mean	CV[1] (%)
	SB	EG	BG		
		WUE (kg/m^3)			
Corn	38.69aA	28.39bA	26.78bA	31.29	
Millet	26.48aB	26.77aA	29.07aA	27.44	9.80
Mean	32.58	27.58	27.93		
		CE (kg/kg)			
Corn	1.37aA	0.99bA	0.96bA	1.10	
Millet	0.93aB	0.93aA	1.03aA	0.96	9.75
Mean	1.15	0.96	0.99		

SB= sugar cane bagasse; EG= Elephant grass; BG= Brachiaria grass; [1]Coeficient of variation in percentage. Means followed by the same upper case letter in the columns and the same lower-case letter in the row are not different from each other by the test of Tukey ($P<0.05$).

In the determination of the conversion efficiency of the assessed treatments, a significant interaction between species and substrate was observed, in which the highest value of the conversion efficiency was from the cultivation of corn HF in SB substrate. It can be seen in Table 4, the conversion values less than one, which shows that the cultivation system was not efficient in terms of productivity, demonstrating a negative balance in the amount of dry matter at the beginning of the process and post-harvest when the germination process losses were offset by root and/or aerial part production.

According to Magalhães & Durães (2002), the digestion of reserve substances present in the seeds occurs in the germination process, and these substances are used for the development of the seedling in its initial stage. This normally leads to a loss of dry matter, however, this loss is expected to be compensated with the aerial part production and HF root content, as it was developed in this work when corn grown with SB and millet with BG were used.

The species and substrates evaluated in this experiment ($P<0.05$) showed a significant interaction between the variables dry matter content, neutral detergent fiber corrected for ash and protein, crude protein, and total digestible nutrients, which are shown in Table 5.

Table 5. Content of dry matter (DM), neutral detergent fiber correct for ash and protein (NDFap), crude protein (CP), and total estimated digestible nutrients (TDNe) of complete hydroponic green forage of corn and pearl millet grown in different organic substrates.

Grass	Substrate			Mean	CV[1] (%)
	SB	EG	BG		
			DM (%)		
Corn	12.65aA	13.11aA	12.60aB	12.78	
Millet	13.55aA	12.80bB	14.78aA	12.22	9.98
Mean	13.69	10.71	13.69		
			NDFap (%DM)		
Corn	60.03aB	54.93bB	47.19cB	54.05	
Millet	68.16aA	57.84cA	64.24bA	63.41	2.18
Mean	64.09	56.38	55.71		
			CP (%DM)		
Corn	12.08bB	12.43bB	16.88aB	13.80	
Millet	19.88bA	21.97aA	17.88cA	19.87	3.52
Mean	15.92	17.20	17.38		
			TDNe (%DM)		
Corn	58.75cA	60.88bA	64.11aA	61.25	
Millet	55.36cB	59.60aB	56.99bB	57.34	0.90
Mean	57.05	60.27	60.55		

SB= sugar cane bagasse; EG= Elephant grass; BG= Brachiaria grass; [1]Coeficient of variation in percentage. Means followed by the same upper case letter in the columns and the same lower-case letter in the row are not different from each other by the test of Tukey ($P<0.05$).

The contents of dry matter contents found in this work were less than 15%, taking into account that millet cultivated in substrates BG (14.78%) and SB (13.55%) and corn cultivated in substrate EG (13 .11%) signaled higher averages. It is common for young plants to have water and nutrients in their constitution and lower dry matter content. Those aspects reduce the production of dry matter when compared to plants in an advanced stage of maturity.

However, in HF cultivation, the dry matter contents can be increased as the harvest age is increased, if the availability of nutrients is sufficient for its development. If this age is increased and the availability of nutrients is not incremented, there may be a reduction in dry matter content, because, as the physiological age advances, plants intensify their nutritional requirements (FAO, 2001). The lack of nutrients affects and delays the development of plants, and, as a consequence, the growth rate (Pimentel et al., 2016) and tillering are reduced and early senescence may occur (Malavolta et al. 1986), with a lower accumulation of dry matter.

The cell wall is composed of cellulose, hemicellulose, lignin, pectin, and other components, which define the fibrous content of materials for feeding ruminants (Paciullo, 2002). When comparing the results of the NDFap content in the different experimental treatments, it was found that the SB substrate treatments allowed higher values, is associated with a greater proportion of the base part, composed of higher fiber contents than those of the aerial part.

Due to its outstanding production in the aerial part, the HF of millet achieved higher values corresponding to the fibrous content than those of the corn HF. Lower NDFp values than those found in this study were expected, as the harvest age was 15 days, however, because the analysis consisted of complete forage, the fiber content in the substrate added to plant development resulted in high values.

Regarding the crude protein content of the grasses in the different substrates, it can be seen that t, despite showing fiber values that exceed those of corn, millet achieved higher protein content, particularly in CE substrate, which obtained a significant increase compared to the other substrates. Plants grown in CE substrate showed lower dry matter content, which could have collaborated to increase the protein concentration.

In the evaluation of corn, it was found that the BG substrate contributed to the highest crude protein content (16.88%), while SB and CE were equivalent and showed a mean of 12.25%. The lower levels of crude protein in the HF of corn are related to the lower protein content of the seeds and the lower proportion of the aerial part when compared to pearl millet. Thus, the increase in the aerial part production directly influences the abundant amount of leaves and protein content for this fraction.

Although the variation in the percentage of crude protein in the forage was influenced by the protein content of the seeds and production of the aerial part, the values exceeded 7% in all treatments, indicating that HF has a good supply of protein for ruminants which is 6 to 7% higher than critical levels in DM. One of the outstanding characteristics in the production of HF is its protein content, as plants in the initial development stage have growth related to the increase in leaf surface, where the highest levels of nitrogen are concentrated (Muller et al., 2005).

Regarding the energy aspects that emerge as the main limiting factor in animal nutrition (Medeiros et al., 2015), the corn HF exceeded that of millet, with estimated TDNe values ranging from 58.75% to 64.11%. Among the assessed substrates, CE and BG were responsible for the high levels of TDNe, 59.60% for millet and 64.11% for corn.

Because it is a measure estimated from the equation that used the NDFp values, it was expected that the treatments with lower fiber values would indicate higher TDNe values, and this result would be higher in corn cultivation, as its seeds contained greater content for this variable.

The values of organic matter and ash can be seen in Table 6. The statistical analysis did not show any significance for the interaction of species and substrates ($P>0.05$), however, when observing the isolated effect of each factor, the treatments differ from each other. ($P<0.05$), so it is possible to identify that the organic matter of corn exceeded that of millet, as well as the substrate SB exceeded the other substrates, which implies lower levels of inorganic matter (ash) for these treatments.

Table 6. Ash content (AC) and organic matter (OM) of complete hydroponic green forage of corn and pearl millet grown in different organic substrates.

	Species		Substrate				P value		
Item	Millet	Corn	SB	EG	BG	CV[1]	S	Sb	S x Sb
OM	92.54	93.25	95.59A	91.30B	91.80B	0.79	0.027	0.001	0.439
AC	7.47	6.74	4.41B	8.69A	8.19[a]	10.34	0.027	0.001	0.439

SB= sugar cane bagasse; EG= Elephant grass; BG= Brachiara grass; [1]CV= Coefficient of variation; S = Species; Sb= substrate; S x Sb = interaction between the Factors; P>0.05 not significant by the F test.

The ash content allows us to know the concentration of minerals in the HF, as it showed a higher mean in millet (7.47%) than in corn (6.74). Regarding the CE and BG substrates, these were not divergent, showing means of 8.69% and 8.19%, higher than the SB (4.41%).

Based on these results, it can be inferred that the higher ash values were probably influenced by the bromatological characteristics of the seeds and substrates (Table 1), resulting in higher values for pearl millet and chopped-grass substrates. Furthermore, another factor that explains the superiority of ash contents with the use of millet would be the efficient use of the nutrient solution by the species, which ensured better grass adaptation and aerial part dry mass yield.

4. Conclusions

The use of the sugarcane bagasse substrate in the production of HF from corn was superior with higher production of total dry mass, with a positive effect on the efficiency parameters.

Chopped grass-based substrates have a higher nutritional value, regardless of the species of grass used for the production of HF.

5. Acknowledgement

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