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Production and nutritional quality of sweet sorghum forage in monoculture and intercropped with corn and beans

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Abstract

In order to evaluate the productivity and green forage quality of *Sorghum bicolor* (L.) Moench cv. Corpoica JJT-18 in monoculture and intercropped with corn and beans, a trial was conducted in the Caribbean region of Colombia, in which five treatments were evaluated consisting in sowing *S. bicolor* cv. Corpoica JJT-18 in monoculture and intercropped with *Zea mays* L. and *Vigna unguiculata* (L.) Walp. A completely randomized design was used with three repetitions. The green forage yield of *S. bicolor* in monoculture (77,92 t ha^{-1}) was significantly higher than that of corn (61,04 t ha^{-1}), and no significant increases were observed because of intercropping. On the other hand, the total green forage productivity in the intercropped systems was 84,58; 86,67 and 82,92 t ha^{-1} in sorghum/beans, sorghum/corn and sorghum/corn/beans, respectively. The bromatological analyses indicated that the green forage produced by sweet sorghum showed a nutritional quality similar to corn in the CP, NDF and ADF content, and higher in soluble solids. On the contrary, *in situ* degradability and dry matter content were higher in the green forage of corn. It is concluded that *S. bicolor* is a viable alternative for substituting corn in green forage production systems, for animal supplementation in the Colombian Caribbean.

Keywords: animal feeding, drought, productivity

Introduction

In Colombia, and especially in the Caribbean region, the forage generated by pastures is the main feed source for cattle and the most practical end economical one. Nevertheless, the systems in the Caribbean region face serious limitations, due to the variations that occur in rainfall throughout the year; which are manifested in a rainy season followed by a dry season, the latter with an approximate duration of five months.

This rainfall pattern causes limitations in cattle husbandry, mainly in the availability and nutritional quality of pastures in the dry season, which can decrease between 30 and 60 % (Mejía *et al.,* 2013). Hence that, to prevent losses during the critical periods, the establishment of forage plants with high biomass and dry matter production, adapted to the edaphoclimatic conditions of the region and whose conservation would allow to stabilize beef and milk production, is required.

In that sense, *Zea mays* L. (corn) is the forage material that has been most utilized as strategy for minimizing the effects of drought on animal husbandry (Castro-Rincón *et al*., 2017), mainly like forage preserved as silage. This plant has high energy value and high biomass yield, with averages that vary between 34 and 54 t ha^{-1} (Asangla and Gohaim, 2016); however, its protein contribution to the rumen system is limited, for which it is necessary to have other sowing alternatives that reduce production costs and improve the competitiveness of the productive system. The Colombian Corporation of Agricultural Research (Agrosavia) has released *Sorghum bicolor* (L.) Moench cv. Corpoica JJT-18 (Bernal *et al*., 2014) for cattle raisers, as an option for green forage production with conservation purposes, with which the animals can be supplemented in the dry season.

S. bicolor cv. Corpoica JJT-18 generates between 40 and 56 t ha^{-1} of green forage in the first cutting (88-100 days after planting); it is possible, sometimes, to utilize the regrowth and perform a second cutting, thus producing in total up to 80 t ha^{-1} in the two cuttings. Likewise, its stems show high content of soluble solids (13-16 %), which makes this material a good choice for animal supplementation (Bernal *et al*., 2014). In addition, it shows high capacity of adaptation to different soil types and to short periods of water deficit (Getachew *et al*., 2016).

Due to its high production, it is considered that sweet sorghum could substitute corn in cattle feeding systems. Thus, the objective of this research was to evaluate the production and nutritional quality of sweet sorghum sown in monoculture and intercropped with corn and beans.

Materials and Methods

Location. The study was conducted in the Caribbean region of Colombia, in the facilities of the Agrosavia Research Center of Turipaná, located in the Cereté municipality (Córdoba department), at the geographic coordinates 8º 58′ North latitude and 75º 47′ West longitude, and at a height of 15 m.a.s.l. Its annual average temperature and annual rainfall are 28 ºC and 1 200 mm, respectively; while the relative humidity varies between 85 and 90 %.

Plant material. The commercial sorghum cultivar Corpoica JJT-18; a variety of cowpea [*Vigna unguiculata* (L.) Walp] (Araméndiz–Tatis *et al.*, 2017), of creeping growth habit; and the commercial corn hybrid 30F35, from the Pioneer® store (Acosemillas, 2019), were used.

Treatments and experimental design. Five treatments were evaluated: T1: sorghum in monoculture, T2: corn in monoculture, as well as the intercropping treatments T3: sorghum/beans, T4: sorghum/corn and T5: sorghum/corn/beans; the corn in monoculture was used as control. The experimental unit was made up by plots of six 5-m long rows, separated by 0,80 m. The total area of each plot was 24 m^2, and for sampling the four central rows of each plot were taken. A complete randomized block experimental design was used, with five treatments and three repetitions.

Sowing and agronomic management. The sowing of monoculture and intercropped sorghum was carried out at a distance of 0,80 m between rows and 0,10 m between plants, for a population density of 125 000 plants ha^{-1}; while in the monoculture and intercropped corn the distance was 0,80 m between rows and 0,20 m between plants, for a population density of 62 500 plants ha^{-1}.

In the intercropping treatments, the species were simultaneously sown; in the case of sorghum/beans, the latter was planted at 0,10 m from the sorghum row, with a separation of 0,30 m between plants. In sorghum/corn, the corn was planted at 0,20 m from the sorghum row; while in sorghum/corn/beans, the corn was sown at 0,20 m from the sorghum rows, and the corn was planted within the corn row, at 0,30 m between plants. For weed control a glyphosate-based non selective herbicide was applied, in dose of 4,0 L ha.

The soil analysis of the site showed neutral pH, with low contents of organic matter, phosphorus and microelements. According to the results of this analysis (table 1), a corn-aimed full fertilization was calculated.

Table 1. Results of the soil chemical analysis.

Indicator	Value	Method
pH	6,4	NTC 5264 de 2008
EC, ds m^{-1}	0,2	NTC 5596
OM, %	2,2	Walkley & Black
P, mg kg^{-1}	15,4	NTC 5350
S, mg kg^{-1}	4	Turbidimetric (monobasic calcium phosphate)
Ca, $Cmol^{+}$ kg^{-1}	10	NTC 5349
Mg, $Cmol^{+}$ kg^{-1}	7,3	
K, $Cmol^{+}$ kg^{-1}	0,4	
Na, $Cmol^{+}$ kg^{-1}	0,1	
CEC, $Cmol^{+}$ kg^{-1}	17,8	Sum of cations
B, mg kg^{-1}	0,2	Turbidimetric (monobasic calcium phosphate)
Cu, mg kg^{-1}	6,0	NTC 5526
F, mg kg^{-1}	86,4	
Mn, mg kg^{-1}	0,5	
Zn, mg kg^{-1}	1,2	

The total fertilization dose was 156,6 kg ha^{-1} N (source urea, diammonium phosphate and Vicor®)[1]; 46,0 kg ha^{-1} P_2O_5 (DAP source); 60 kg ha^{-1} K_2O (KCl source) and microelements (Vicor source). Such total dose was fragmented into three applications: the first one at pre-sowing, with 100 % DAP, 100 % Vicor and 50 % KCl; the second application was made 15 days after the crop emerged, with 50 % urea and the remaining 50 %, KCL; and the third application was carried out 25 days after the crop emerged, with the remaining 50 % urea.

Green forage harvest. In the case of the treatments that contained corn in monoculture, the harvest season was defined when the grain was in a doughy state, which occurred 75 days after sowing (das). For the ones that contained sorghum in monoculture or intercropped with beans, the harvest was carried out when the sorghum grain was found in blister state (watery grain), which happened 90 das. In the intercropping treatments with corn, for the harvest the development status of the corn grain (75 das) was used as indicator. The development status of beans at the moment of harvest corresponded to the stage of pod formation for the intercropping with corn, and to the state of grain filling for the case of intercropping with sorghum.

The green forage harvest was carried out manually. The plants of the four central rows of each plot were cut; the ones corresponding to each species were separated and the green forage weight of each species was individually recorded. For that purpose an OHAUS scale, model CS 5000, was used (Pine Brook, NJ, USA).

Evaluated variables

Final plant population. Ten days after harvest, the total number of sorghum, corn and bean plants were counted in each of the treatments. This variable was expressed in number of plants per hectare.

Plant overturning. To determine this variable in each plot, 10 days after harvest, the number of blown down or overturned sorghum plants at the root neck and stem level was counted. The overturning percentage was calculated as the percentage of overturned plants with regards to the total number of final plants in each plot.

Plant height. Height was determined in five corn and sorghum plants per plot, by measuring from the root neck to the first branching of the spike; this variable was expressed in centimeters. The evaluation was made five days before the harvest.

Green weight of the ear. This variable was determined only in the treatments that contained corn in monoculture and as part of the intercropping. For such purpose, samples of 10 ears were taken with wicker basket in each plot, and their green weight was recorded.

Green forage production. The total weight of the green forage produced per plot was recorded. In the intercropping treatments, total green forage production was calculated by adding the green forage production of the species included in each treatment.

Content of soluble solids (degrees Brix). Samples of the green forage from each plot were taken, which were ground in an electrical mill to collect the juice. In this juice the content of soluble solids was determined, with the aid of a digital refractometer (Trademark ATAGO, Model PAL-1, Tokyo, Japan).

Nutritional composition of the ensiled forage. A 1 000-g sample of the green forage mixture produced per each treatment was taken. This forage was packed and airtight sealed in plastic bags for micro-silos, and it was preserved for a period of 30 days to favor fermentation. From the silage obtained in each treatment, a 300-g sample was weighed. The samples were taken to the animal nutrition laboratory of the Turipaná Research Center of Agrosavia, where the following determinations were made: dry matter content (DM), by drying in oven at 60 ºC during 48 h; crude protein content (CP), through the Kjeldahl method (AOAC, 2016); as well as the neutral detergent fiber (NDF) and acid detergent fiber (ADF), according to the method proposed by Van Soest and Robertson (1987). In addition, the *in situ* dry matter degradability (ISDMD) was determined, following the rumen digestion technique, for which samples of ground forage were incubated in nylon bags in the rumen of fistulated animals (Orskov *et al.*, 1980).

Statistical analysis. The data were subject to normality and variance homogeneity tests through the Shapiro–Wilk and Levene's methods, respectively, which indicated the fulfillment of the

[1] Vicor®: granulated fertilizer of edaphic application, formulated as a source of microelements. http://www.ghcia.com.co/plm/source/productos/3610_23_152.htm

assumptions for the variables. A variance analysis (ANOVA) was carried out on all the response variables, and in the cases in which differences were detected at a significance level of 0,05, mean separation tests were carried out using Tukey's HSD test. Tests of orthogonal contrasts were made to compare sets of treatments. The statistical package SAS version 9.4 was used.

Results and Discussion

Final plant population. As a product of the intraspecific and interspecific competition which is established among plants from the same species in monoculture systems and among plants from different species in the intercropping system, a part of the initially established population does not survive during the growth process. In this experiment significant population losses were observed, in the monoculture as well as the intercropped systems (table 2).

In the monoculture with sorghum and corn, reductions of 14,0 and 12,7 %, respectively, were observed in the initially established plant population. With the intercropping, the losses in the population of sweet sorghum were 22,7; 28,0 and 29,7 % in the sorghum/beans, sorghum/corn and sorghum/corn/beans systems, respectively; while in the case of corn the losses were 8,7 and 13,3 % for sorghum/corn and sorghum/corn/beans, respectively.

These results showed that *S. bicolor* is a species sensitive to the competition that is established in intercropped systems, which results in a significant loss of plants during crop growth; this indicates a possible disadvantage of sweet sorghum in the competition for the available resources, especially water, light and nutrients.

Green forage production. The analyses of total green forage (TGF) production indicated significant differences ($p < 0,05$) among the treatments (table 3). The TGF production of the corn in monoculture was lower than that of sorghum in monoculture and sorghum/corn, sorghum beans and sorghum/corn/beans. There were no statistical differences in the TGF production between the sorghum in monoculture and intercropping. The TGF production was 27,7 % higher in the monoculture of sweet sorghum, with regards to the corn in monoculture; and equally 38,5; 41,9 and 35,8 % higher than that of corn in the sorghum/beans, sorghum/corn and sorghum/corn/beans, respectively.

The results of this study coincide with the ones obtained by Islam *et al.* (2018), who evaluated different arrangements of sorghum intercropping for grain (millet) and cowpea, and obtained higher yield of both species in monoculture than in the different intercropping systems.

The productivity of *S. bicolor* in this trial coincides with the report by Nava-Berumena *et al.* (2017), who evaluated the forage yield and quality of three varieties of this species and obtained 75,9 t ha^{-1} under adequate environmental conditions. This is of high interest for animal husbandry in the Caribbean region of Colombia, because sowing

Table 2. Initial and final plant population per treatment.

Treatment	Initial population	Final population		
		Corn	Sorghum	Beans
Corn in monoculture	62 500	54 583,3	-	-
Sorghum in monoculture	125 000	-	107 500,0^{a}	-
Sorghum/beans	125 000 41 666	-	96 666,7^{ab}	26 250,0^{a}
Sorghum/corn	125 000 62 500	57 083,3	90 000,0^{b}	-
Sorghum/corn/beans	125 000 62 500 41 666	54 166,7	87 916,7^{b}	28 750,0^{a}
Mean		55 277,8	95 520,8	27 500,0
VC, %		6,5	5,51	31,7
SD		3 596,39	5 270,46	8 705,20
Significance		NS	*	NS

Different letters in the same column indicate statistical differences, according to Tukey's test ($p \leq 0,05$).

Table 3. Green forage production (t ha-1) per treatment.

Treatment	Sorghum	Corn	Beans	Total (TGF)
Corn in monoculture	-	61,0[a]	-	61,0[b]
Sorghum in monoculture	77,9[a]	-	-	77,9[a]
Sorghum/beans	83,3[a]	-	1,3[a]	84,6[a]
Sorghum/corn	47,3[b]	39,3[b]	-	86,7[a]
Sorghum/corn/beans	36,8[b]	41,4[b]	4,7[a]	82,9[a]
Mean	61,4	47,3	3,0	78,6
VC, %	15,2	6,8	39,7	7,4
SD	9,30	3,22	1,19	5,86
Significance	**	**	NS	**

Different letters in the same column indicate statistical differences, according to Tukey's test p ≤0,05.
TGF: Total green forage production

sweet sorghum could represent significant increases in forage production with regards to the modal systems that are based on sowing corn hybrids, where commercial productions are reported which vary between 15 and 50 t ha-1 (Mejía *et al.,* 2013).

Likewise, the analysis of orthogonal contrasts among treatment groups indicated that the different intercropping possibilities of sweet sorghum with corn and beans did not contribute significantly to increase the total green forage production in the system, because sweet sorghum in monoculture has the capacity to produce a high quantity of green forage, which is not surpassed by that of the intercropping systems (table 4).

On the contrary, in the case of corn the contrast tests indicated that the TGF production, in the inter-

Table 4. Contrasts for the comparison of the forage production of sweet sorghum in monoculture and intercropped in the Caribbean region of Colombia.

Contrast	Sum of squares	Square of the mean	F-value	Pr > F
Corn in monoculture *vs*. sorghum in monoculture	427,1	427,1	12,5	0,0077**
Corn in monoculture *vs*. intercropped corn	1 128,1	1128,1	32,9	0,0004**
Corn in monoculture *vs*. double intercropping	985,0	985,0	28,7	0,0007**
Corn in monoculture *vs*. triple intercropping	717,8	717,8	20,9	0,0018**
Sorghum in monoculture *vs*. in intercropping	104,2	104,2	3,0	0,1194 NS
Sorghum in monoculture *vs*. double intercropping	118,8	118,8	3,5	0,0997 NS
Sorghum in monoculture *vs*. triple intercropping	37,5	37,5	1,1	0,3262 NS
Sorghum in double intercropping *vs*. triple intercropping	14,7	14,7	0,4	0,5314 NS
Corn in double intercropping *vs*. triple intercropping	21,1	21,1	0,6	0,4554 NS
Error	274,3	34,3		
Total	1 626,7			
Mean	78,6			
R^2	0,8			
VC, %	7,4			
SD	5,85			
Significance	**			

R^2: determination coefficient, VC: variation coefficient, SD: standard deviation of the mean. **Highly significant (p < 0,01); *significant (p < 0,05); NS: not significant (p > 0,05).

cropping sorghum/corn and sorghum/corn/beans, was significantly higher than the production of corn in monoculture. The increases were, as average, of 41,9 and 35,8 % (for sorghum/corn and sorghum/corn/beans, respectively), with regards to the species in monoculture. Such results indicate that in the systems where this species is used as forage, the intercropping systems with sorghum and beans could be an alternative to increase production.

Similar results were reported by Getachew *et al.* (2016), who indicated that sorghum has the possibility of replacing corn in forage production systems, especially in areas where water availability is limited, because their yields are comparable; however, these authors state that the quality of corn silage is higher due to its higher metabolizable energy content.

Corn and sorghum productivity was observed to decrease, because of the competition that is established in the associated systems, in which the reduction is higher as the intercropping system becomes more complex. In this sense, in the sorghum/corn intercropping the individual sorghum production was reduced in 39,2 % and the corn production, in 35,5 %, compared with both species in monoculture; while in the sorghum/corn/beans intercropping, the sorghum yield was reduced in 52,7 % and the corn yield, in 32,2 %, unlike the sorghum/beans intercropping in which the sorghum productivity was maintained.

According to Islam *et al.* (2018), the sorghum yield can even increase in the intercropping system with legumes, due to the contribution made by the latter to the system, given their capacity to fix atmospheric nitrogen. In literature it is frequent to find systems that combine cereals for forage production, because of the complementarity in the growth habits of the species, and the biological and economic advantages that result from the association (Eskandari *et al.*, 2009). In the case of sorghum for forage, the mixed and intercropped systems with soybean, beans and peanut, of which substantial increases in biomass production are reported, are frequent (Iqbal *et al.*, 2019).

The bromatological analyses indicated that sweet sorghum Corpoica JJT-18 shows nutritional quality similar to that of corn regarding crude protein, neutral detergent fiber and acid detergent fiber, and higher in the content of soluble solids (degrees Brix). On the contrary, the *in situ* degradability and the dry matter content were significantly higher in the corn forage (table 5).

In this study lower DM values than 25 % were recorded, indicating high moisture contents in the forage. Such results can be explained by the storage structure used (micro-silos of plastic bags), which does not generate effluents and causes the preserved material to maintain the moisture of the harvest moment. The DM content was statistically higher ($p < 0,05$) in the silage from corn in monoculture, which can be related to the higher development status shown by the corn plants at the moment of harvest (doughy state), compared with that of the sorghum and bean plants.

On the other hand, the CP contents of the green forage may be considered low, but sufficient to guarantee the nitrogen availability for an effective microbial fermentation in the rumen

Table 5. Nutritional quality of green forage from sweet sorghum in monoculture and intercropped, in the Caribbean region of Colombia (%).

Treatment	DM	CP	NDF	ADF	ISDMD	Degrees Brix
Corn in monoculture	25,0^{a}	6,8^{a}	51,9	27,3^{b}	71,2^{a}	3,4^{c}
Sorghum in monoculture	16,0^{b}	6,7^{a}	58,5	36,0^{ab}	56,2^{b}	9,0^{a}
Sorghum-beans	18,8^{b}	4,3^{c}	64,9	40,3^{a}	54,2^{b}	7,0^{ab}
Sorghum-corn	20,0^{b}	7,0^{a}	56,5	34,2^{ab}	60,4^{ab}	6,8^{ab}
Sorghum-corn-beans	18,9^{b}	5,3^{b}	62,6	39,8^{a}	55,9^{b}	6,6^{b}
Mean	20,1	6,5	57,1	33,9	61,2	6,6
VC, %	5,1	2,5	8,6	6,6	4,0	12,7
SD	1,02	0,15	4,90	2,23	2,47	0,83
Significance	**	**	NS	*	**	**

Different letters in the same column indicate statistical differences among the treatments according to Tukey's test ($p\leq 0,05$).

of cattle (García-Ferrera *et al.*, 2015). These results differ from the ones reported by Castillo-Jiménez *et al.* (2009), who when evaluating the corn/Vigna association recorded a concentration of 11,3 % CP, value that exceeds the ones in this study. Likewise, they are lower than the CP values found by Contreras-Govea *et al.* (2008), who when evaluating corn silages in intercropping with *Mucuna pruriens* (L.) DC.*, Lablab purpureus* (L.) Sweet and *Phaseolus coccineus* L. reported CP concentrations of 8,2; 7,8 and 7,1 %, respectively.

In turn, little contribution was observed of beans to the total protein content of the TGF in the sorghum/beans and sorghum/corn/beans intercropping. This could have occurred due to the fact that, at the moment of harvest, the bean plants were at the beginning of pod formation; and, additionally, they showed low individual biomass production (1,28 and 4,69 t ha^{-1}, respectively). In this regard, different authors emphasize the contribution of cowpea in the green forage production and crude protein content in the intercropped systems with sorghum (Iqbal *et al.*, 2015; Basaran *et al.*, 2017).

Regarding the green forage fiber, a higher NDF and ADF content was found in the treatments that included sorghum in the intercropping systems, due to the fibrous incorporation of sweet sorghum to the forage. This could mean a limitation in intake by the animals, because forage density increases and thus intake is reduced (Castillo-Jiménez *et al.*, 2009). Sorghum and corn are species that show a remarkable quantity of structural compounds, such as cellulose, hemicellulose and lignin, which is shown in the fiber contents. For such reason, in species of this kind and in many grasses, it is advisable to perform the forage harvest in pre-flowering and until a little later after the spike emergence, in order to prevent affecting digestibility (Nava-Berumena *et al.*, 2017).

The forage from the corn in monoculture showed the lowest acid detergent fiber values, which is important because this fraction is closely related to the digestibility and energy contribution of the forages. In that sense, Ribeiro and Pereira (2010) state that the forages with ADF values over 40 % are less consumed and contribute less energy to the animals; while those with concentrations closer to 30 % show higher intake and energy contribution.

The highest values of *in situ* dry matter degradability were recorded in the green forage of the corn in monoculture and the sorghum/corn intercropping. These results indicate that the ISDMD of the green forage of sweet sorghum Corpoica JJT-18 is lower than that of corn, with low contribution of beans in the improvement of ISDMD. The ISDMD expresses the proportion of digestible compounds contained in forage, with regards to the total feed ingested by the animal. A digestibility of 65 % in forage indicates good nutritional value, and allows adequate intake of the energy required by most animals (Pirela, 2005). In this trial, ISDMD values higher than 65 % were reached only with the corn in monoculture (71,23 %); while the intercropping with sorghum significantly reduced digestibility. This indicates the need to consider intercropping, preferably with legumes that show higher growth status, and the use of higher densities than the ones in this essay.

The highest content of soluble solids was found in the green forage of sweet sorghum in monoculture, and also in the sorghum/corn and sorghum/beans intercropping. This is due to the fact that the cv. Corpoica JJT-18 is from a breeding program in which, originally, materials were sought for the production of carbureting alcohol, and whose objective was to increase the sugar levels in the stem (Bernal *et al.*, 2006). Finally the release of such cultivar for forage production was decided, because of its productive traits and the possibility of improving the energy contribution of the species in animal supplementation (Bernal *et al.*, 2014).

Green weight of the ear. One of the questionings of green forage producers in the Caribbean region of Colombia, regarding the intercropping of corn with other species, is that it reduces the green weight of the ear, which is an important component of forage quality in this species. In the treatments that included corn there were no reductions in the green weight of the ear, indicating that the intercropping of corn with sorghum and beans does not compromise the size and weight of this important forage component.

Indeed, the average weight of the ear of corn in monoculture was statistically similar (table 6) to that of the ear in the treatments with sorghum and beans (sorghum/corn and sorghum/corn/beans). These results differ from the report by Pérez-López *et al.* (2013), who when evaluating at several ages the accumulation and distribution of corn biomass in association with beans, found that the ear weight was substantially reduced. From the point of view of forage production, the complementarity of the species in the intercropped systems, so that competition decreases and the energy contribution of the

Table 6. Green weight of the corn ear, corn and sorghum height, and overturning of the sweet sorghum plants.

Treatment	Ear green weight, g	Corn height, cm	Sorghum height, cm	Ear height, cm	Plant overturning, %
Monoculture corn	307,5[a]	256,6[a]	-	135,6[a]	-
Monoculture sorghum	-	-	359,0[ab]	-	40,5[a]
Sorghum/beans	-	-	366,6[a]	-	28,8[a]
Sorghum/corn	244,7[a]	247,6[a]	345,6[ab]	133,3[a]	16,76[a]
Sorghum/corn/beans	240,1[a]	251,3[a]	313,3[b]	142,6[a]	23,8[a]
Mean	264,1	251,8	346,1	137,2	27,5
VC	11,0	4,34	4,79	8,6	22,2
SD	29,06	10,92	16,58	11,79	0,98
Significance	NS	NS	*	NS	NS

Different letters in the same column indicate statistical differences among treatments, according to Tukey's test ($p \leq 0,05$).

corn ears to the green forage can be guaranteed, is important.

Plant height. The plant height was determined before the harvest, in sorghum and corn, in the arrangements where these species were present. The treatments did not affect the final height of the corn plants, but they did affect sorghum. In this case, the final plant height was higher in the treatments of sorghum in monoculture and in the sorghum/beans and sorghum/corn intercropping. On the contrary, in the sorghum/corn/beans intercropping, the final height of the sorghum plants was lower than the other treatments in the trial; this indicates that the competition degree in this last treatment caused reductions in the sorghum height.

The intercropping between the cereals and legumes causes increase in the height of the former, as a product of better complementarity between the species (Eskandari *et al.*, 2009). This indicator is highly important in the forage production systems in the Caribbean region of Colombia, due to the strong winds that occur at some times of the year, overturning and production losses.

Plant overturning. The intercropping of sorghum with other species intends not only to increase green forage production, but also improve its nutritional quality and reduce plant height. In this sense, according to the results, the association or intercropping of sorghum with other species allowed heights that reduced the risk of overturning.

Conclusions

It is concluded that sweet sorghum Corpoica JJT-18 is a viable alternative for the production of green forage aimed at animal supplementation in the Caribbean region of Colombia, because it shows high productions and a forage quality similar to that of corn in monoculture systems. The different studied intercropping alternatives allowed to increase the green forage production per surface unit and increase its quality.

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