Scientific Paper

Evaluation of three sorghum cultivars [*Sorghum bicolor* (L.) Moench] for animal feeding

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Abstract

The study was conducted in the cooperative of credits and services (CCS) Reytel Jorge of the Jesús Menéndez municipality –Las Tunas province, Cuba–, in order to evaluate, on a Brown soil without carbonates, the productive performance of three sorghum cultivars: CIAP 132-R, CIAP 29 and CIAP 2E-95. A randomized block design was used, with four replicas per treatment in 9-m^2 plots and a distance of 1 m between replicas. The sorghum seeds, with 98 % germination, were from the Central University of Las Villas. Seeding was done at a depth of 4 cm and the distance between furrows was 40 cm. Regarding plant height at 45 and 60 days all the cultivars differed among themselves, and the highest value corresponded to cv. CIAP 29 and the lowest to CIAP 132- R. Cv. CIAP 2E-95 showed the highest dry mass, while CIAP 29 had a moderate one. Likewise, the highest grain yield was obtained with cv. CIAT 2E-95 (14,4 t ha^{-1}), while CIAP 132 -R and CIAP 29 had lower yields, without differences between them. It is concluded that the three cultivars can be used for animal feeding.

Keywords: height, grains, yield

Introduction

Sorghum bicolor (L.) Moench, commonly known as sorghum, is a plant species that originated in Africa, specifically in Sudan and Ethiopia. It is a cereal acknowledged as highly productive, drought resistant; which provides mankind with food, forage, fiber and energy, particularly in the semi-arid regions (Kimber *et al*., 2013). It is a tropical grass of C4 metabolism, which through breeding has been disseminated to temperate regions of the world, and has been established as a crop of high environmental adaptation (Blum, 2004).

A few sorghum cultivars can be utilized to obtain fuel, such as ethanol, and in some places it is used in the production of alcoholic beverages (Bond *et al*., 2015). It is the fifth cereal in the world for its production and surface; it is used as feedstuff for livestock and is considered a corn substitute, although it is usually catalogued as of lower quality.

One of its most outstanding characteristics is dormancy, which allows it to suspend growth until favorable conditions are re-established (Carrasco *et al*., 2011).

If it is compared with other summer crops, this cereal shows lower water need; it is better adapted to dry regions; and contributes good stubble, necessary to develop sustainable agriculture and for the recovery of soil and its fertility (González, 2013).

Sorghum is well developed on alkaline soils, specially sugared cultivars which demand the presence of calcium carbonate, increasing the sucrose content in the stems and leaves. It is better adapted to deep soils, without excess of salts, with good drainage, without hardened layers, of good fertility and pH between 6,2 and 7,8 (Infoagro, 2012).

In Cuba sorghum is adapted to different edaphoclimatic conditions, mainly due to its drought tolerance. In Las Tunas province, this crop is little distributed in the agricultural areas, although its extension and distribution would benefit animal feeding, especially in the dry season when pastures are insufficient. For such reason, the objective of this research was to evaluate, on a Brown soil without carbonates, the productive performance of three sorghum cultivars: CIAP 132-R, CIAP 29 and CIAP 2E-95.

Materials and Methods

The study was conducted in the cooperative of credits and services Reytel Jorge, locality Vedado 3 of the Jesús Menéndez municipality, which is located in the northern area of Las Tunas province.

The prevailing soil in the farm belongs to the Brown type, classified as loose Brown without carbonates (Hernández-Jiménez *et al*., 2015), of loam clayey-sandy texture, which is characterized by a moderate content of organic matter and a pH close to neutrality (table 1).

Table 1. Chemical characteristics of the soil.

Indicator	Value
pH	6,5
Organic matter, %	3,5
Available P, mg 100 g^{-1}	20,0
CEC, $cmol_{(+)}$ kg^{-1}	31,4

A randomized block design was used, with three cultivars that constituted the treatments (CIAP 132-R, CIAP 2E-95 and CIAP 29) and four replicas, in plots 3 m long by 3 m wide and a distance of 1 m between replicas. The planting distance between rows was 60 cm, and the plants of the central rows were evaluated. The planting was carried out between April 21 and September 14, 2015. Sorghum seeds were used, with 98 % germination, from the Central University of Las Villas.

The soil preparation, furrowing, planting and cultivation works were performed according to the orientation in the «Instructivo técnico del cultivo del sorgo» («Technical instructions for sorghum cultivation») (MINAG, 2005). Throughout the crop cycle it was not necessary to apply irrigation because in this period there was high rainfall incidence; no mineral fertilizers or organic matter were used. The harvest was manually done.

To evaluate the yield indicators 40 plants were randomly selected per plot, and the following measurements were carried out:

- Plant height (cm)
- Green and dry mass per plant and yield (t ha^{-1})
- Panicle length (cm)
- Grain mass per panicle (g)
- Number of grains per panicle (g)
- Grain yield (t ha^{-1})

The data obtained from the different measurements were subject to a double classification variance analysis, and the means were compared through Duncan's test for 5 % of error probability, using the statistical package Infostat (1998).

Results and Discussion

Table 2 shows plant height. At 15 and 30 days after germination, there were no significant statistical differences among the cultivars; however, at 45 and 60 days all of them differed among themselves, with the highest value for CIAP 29 and the lowest for CIAP 132-R.

Table 2. Height of the evaluated cultivars.

Cultivar	Plant height (cm)			
	15 days	30 days	45 days	60 days
CIAP 132-R	21,75	90,25	111,00[a]	132,00[a]
CIAP 2E-95	20,13	85,50	155,10[b]	192,00[b]
CIAP 29	18,75	77,75	214,50[c]	243,50[c]
VC (%)	17,16	9,00	8,80	3,82
SE ±	0,86	1,2	1,1	1,5

Means with different superscripts in the same column statistically differ at $p < 0,05$.

The green and dry mass of the sorghum plant in the milky grain stage was significantly lower in cv. CIAP 132-R (table 3). Cvs. CIAP 2E-95 and CIAP 29 did not differ among themselves regarding the green mass, but they did with regards to green mass, and CIAP 2E-95 showed the highest value. The three sorghum cultivars reached high forage yield, which varied between 44,9 and 68,8 t ha^{-1}. In this sense, Peña *et al.* (2007) reported sorghum forage yields between 40 and 50 t ha^{-1}, although in high fertility soils they can be higher, as in the case of Ferralitic red soils (80 t ha^{-1}).

Table 3. Green and dry mass and yield of forage.

Cultivar	Green mass (g/plant)	Dry mass (g/plant)	Yield (t ha^{-1})
CIAP 132-R	314,00[a]	117,00[a]	44,9
CIAP 2E-95	481,25[b]	271,75[c]	68,8
CIAP 29	466,75[b]	190,25[b]	66,8
VC (%)	10,49	12,26	8,45
SE ±	1,1	1,5	0,78

Means with different superscripts in the same column statistically differ at $p < 0,05$.

The leaf surface is highly important, because the interception of the photosynthetically active radiation, necessary for biomass production and the corresponding contribution to yield, depends on its development.

It is important to emphasize the report by different authors about the fact that sorghum is considered a very efficient regarding the environmental conditions; in literature it is stressed that the critical period comprises from the moment in which the panicle surrounded by the leaf sheath emerges, mainly of the flag leaf (stage known as stuffing), to the end of the milky stage in the maturity phase; for which the final yield will depend on the conditions the crop faces in that period and the development it reaches.

In the yield indicators the cv. CIAP 2E-95 showed the highest values, with significant differences with regards to the other cultivars, except in the panicle length in which cultivar CIAP 29 showed the highest value (table 4). According to Villeda (2014) the grain weight also depends on the genetic factor, as well as on the capacity of the plant to store dry matter, because the final mass of the grain depends on the dry matter produced.

The grain yield reached 14,4 t ha^{-1} in cv. CIAP 2E-95 (table 4), which significantly surpassed CIAP 132-R and CIAP 29, and they did not differ between them. Such value in cv. CIAT 2E-95 exceeded the ones obtained by Nápoles *et al.* (2007).

It must be stressed that, in the period in which the study was conducted, the temperature varied between 27,0 and 28,7 ºC; and rainfall in June and July were 174 and 208 mm, respectively. This could have favored the crop growth, which influenced the yield.

Morell-Acosta and Pérez-Matos (2015), when studying vars. CIAP 132-R and CIAP 2E-95 in southern Las Tunas, obtained similar results regarding panicle length and number of grains per panicle; however, the yields were lower in 1,2 and 11,6 t ha^{-1}, respectively, than the ones reached in this study.

On the other hand, Nápoles *et al.* (2007), when conducting studies with the vars. CIAP 2E-95 and CIAP 132-R on eroded soils that had very low values of organic matter, P_2O_5 and K_2O, obtained yields of 3,57 and 3,17 t ha^{-1}, respectively; while Maqueira-López *et al.* (2016), on a petroferric ferruginous nodular Hydromorphic Gley soil, of Los Palacios –Pinar del Río–, reported yields of 3,0 t ha^{-1} in the var. CIAP 132-R.

Villeda (2014) indicated that there is a correlation between the number of grains and the final agricultural yield. This author also makes reference to the positive correlation among the number of inflorescences, spikelets per inflorescence, flowers per spikelet, and the proportion of flowers that produce grain.

Another aspect to be taken into consideration is climate conditions. Sorghum is considered a warm climate plant that responds to high temperatures, and the optimum one for its development is between 29 and 30 ºC; this is due to its morphological characteristics that make it a very efficient crop under such conditions, because it shows good growth of the root system, with low transpiration level with regards to the high capacity of root absorption, and a waxy cover on the stems and leaves (Rangel-Salinas *et al.*, 2013).

The above-mentioned factors influence in one way or the other sorghum yield, hence in the different studies different results have been obtained.

It is concluded that, under the edaphoclimatic conditions of the Jesús Menéndez municipality, the three studied cultivars reached high grain yield, for which they can be used for animal feeding.

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Table 4. Performance of yield indicators.

Cultivar	Panicle length (cm)	Weight of the grains per panicle (g)	No. of grains per panicle (u)	Grain yield (t ha^{-1})
CIAP 132-R	25,25[a]	25,75[a]	1 245,50[a]	3,57[a]
CIAP 2E-95	28,50[b]	101,50[b]	3 382,75[b]	14,4[b]
CIAP 29	32,25[c]	31,75[a]	1 331,75[a]	4,57[a]
VC (%)	4,15	10,8	9,05	11,78
SE±	0,29	1,4	0,96	0,86

Means with different superscripts in the same column statistically differ at $p < 0,05$.

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Received: December 5, 2017
Accepted: May 11, 2018