Assessment in grazing of plant materials of *Tithonia diversifolia* (Hemsl.) collected in Cuba

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In order to assess highlighted materials of *Tithonia diversifolia* an experiment was conducted for two years under dry conditions and simulated grazing. The materials were collected in the center-west of Cuba. A random block design with factorial arrangement and four repetitions was applied. The factors were: A) plant materials (3, 5, 10, 13, 16, 17, 23, 24 and25) and B) plantation distance (0, 75, 1.0 and 1.5 m). The grazing was conducted with dry cows and instantaneous stocking rate of 38 LAU/ha/d, with occupation time from one to two days, and that of resting from 35 to 70 d for the rainy and dry season, respectively. The leaf weight per plant was measured in DM grams; the weight of 100 leaves in GM g, the leaf yield in 5 m in DM kilograms and the percent of animals eating. There was interaction for the factors under study during the dry season. During that, the plant material 17 had the lowest weight of leaf per plant ($P < 0.01$) for any of the plantation distances. The highest value was achieved by the material 3 at 0.75 m. The leaf yield in 5 m ($P < 0.001$) was better in plant material 3, planted at 0.75 m between furrows and did not differ from the collection 17, and the highest in the materials 5, 23 and 24. There was no interaction between the factors under study in the rainy season. The distance between furrows at 1.50 m reached the highest yield ($P < 0.001$). The weight of 100 leaves GM and that of the leaf in 5 m had better performance ($P < 0.001$) in collections 3, 23 and 3, 10 and 23, respectively. The animals did not surpass 20 % of the grazing time ($P < 0.01$) for the materials 24 and 17, while the rest surpassed this value. The materials 10, 13 and 23 highlighted, with values next to 30 %. The increase of the distance between furrows ($P < 0.01$) increased the amount of animals eating. It is concluded that plant material 17 should not be used as grazing plant. Material 3 should be the one used for this purpose during the whole year and, in the rainy season, the materials 10 and 23, as well as the 24 in the dry one. The materials 5, 10, 13, 23, 24 and 25 reached an intermediate performance. The increase of the distance between furrows (0.75 vs 1.50 m) favored the amount of animals eating. The results show the possibility of having materials of tithonia collected in Cuba, for its grazing for bovines. At the same time, they suggest the use of other shrubs in silvopastoral systems.

Key words: *assessment, plantation distance, grazing, tithonia*.

Tithonia diversifolia (golden button) has been traditionally used in cattle feeding. However, it is hardly used in direct grazing (Rúa 2011). Interesting experiences applied by Colombian producers are known but no technical articles on this topic are available.

The study of germoplasm is of great importance during the assessment process. Undergoing the tithonia plant material to the animal grazing makes possible conducting more integral studies that allow recommending the use of new plant materials for animal feeding.

In this sense, there is lack of knowledge about the animal performance with the grazing of *Tithonia diversifolia*.

The objective of this study was to assess highlighted materials of *Tithonia diversifolia* in simulated grazing.

Materials and Methods

Treatment and design. A random block design with factorial arrangement and four repetitions was used. The factors were: A) plant materials (3, 5, 10, 13, 16, 17, 23, 24 and 25) and B) plantation distance (0.75; 1.0 and 1.5 m). The studies lasted two years.

Experimental procedure. The study was conducted on a red ferralic soil, of rapid drying, clayish and deep over limestone, equivalent to the ferralic cambisol subtype (Hernández *et al*. 2005), with ploughing and two harrowings. The species was planted in furrows during the rainy season. The dimensions of the plots were of 6 x 6 m, belonging to the Pastures and Forages Department of the Institute of Animal Science of Cuba. This facility is located in the western part of the country, at 22º 53 of north latitude and 82º 02' of west longitude, at 80 m of altitude. Materials collected in the center-west part of the island were used (Ruiz *et al*. 2010). The grazing was conducted with dry cows of the cattle unit "Genético 3" of this institution. The instantaneous stocking rate was of 38 LAU/ha/d, with occupation time of 1 and 2 d. For the rainy and dry season, respectively, 35 and 70 d of resting were established. The weight of leaf per plant was measured in g DM, weight of 100 leaves in g GM, leaf yield in 5 m kg DM and percent of animals eating. Analysis of variance was conducted and the Duncan's test (1955) was used when necessary.

Results and Discussion

There was interaction between the factors during the dry season for the means under study (table 1 and 2). Table 1 shows, for the leaf weight per plant, that the plant material 17 reached the lowest values for any distance. The highest value was obtained by the material 3 at 0.75 m of plantation distance. It was followed by the materials 3, 16 and 23 at 1 m. Apart from the 23 and 24 at 1.5 m of plantation distance.

In respect to the leaf yield in 5 m (table 2), the plant material 17 had the lowest values for any of the

Table 1. Effect of the plantation distance and plant material on the leaf weight per plant during the dry season [1], g DM

Plant material	Distances, m			SE ± and Sign
	1	1.5	0.75	
3	2.74^{de}	1.49^{abcd}	4.89^{f}	0.42**
25	1.99^{bcde}	2.00^{bcde}	1.48^{abcd}	
16	2.24^{cde}	1.74^{abcde}	1.79^{bcde}	
23	2.82^{de}	3.00^{e}	2.24^{cde}	
13	1.94^{bcde}	1.20^{abc}	1.49^{abcd}	
17	1.53^{abcd}	0.38^{a}	0.67^{ab}	
24	1.51^{abcd}	2.43^{cde}	1.63^{abcde}	
5	1.50^{abcd}	1.50^{abcd}	1.50^{abcd}	
10	1.88^{bcde}	1.81^{bcde}	1.92^{bcde}	

^{abcdefeg}Different superscripts differ at P < 0.05 (Duncan,1955). ** P < 0.01.
[1]Mean per rotation

Table 2. Effect of the plantation distance and plant material on the leaf yield in 5 m during the dry season [1] kg DM.

Plant material	Distances, m			SE ± and Sign
	1	1.5	0.75	
3	0.290^{ef}	0.240^{def}	0.510^{g}	0.048***
25	0.110^{abcd}	0.090^{abcd}	0.050^{abc}	
16	0.100^{abcd}	0.070^{abc}	0.030^{ab}	
23	0.210^{cde}	0.300^{ef}	0.140^{abcde}	
13	0.180^{bcde}	0.060^{abc}	0.050^{abc}	
17	0.030^{ab}	0.008^{a}	0.002^{a}	
24	0.120^{abcd}	0.390^{fg}	0.070^{abc}	
5	0.170^{bcde}	0.230^{de}	0.110^{abcd}	
10	0.200^{cde}	0.290^{ef}	0.160^{abcde}	

^{abcdefeg}Different superscripts differ at P < 0.05 (Duncan,1955). ** P < 0.01.
[1]Mean per rotation

distances. The plant material 3 had higher values when planted at 0.75 m between furrows and did not differ from collection 24 planted at 1.50 m. This, at the same time, did not show differences in respect to the material 10, at same distance. It was followed by plant material 3, planted at 1.00 m, and the 23 at 1.50 m. The rest of the treatments had an intermediate performance.

The performance proved during the dry season in respect to the interactions could be influenced by the differential growth of the materials assessed, stated by Ruiz *et al*. (2010), when studying a larger number of these plant materials.

The weight measurement of 100 leaves did not have interaction, and only showed significance for the plant material factor (table 3). It showed the lowest values for the collection 17. The highest ones were in the materials 5, 23 and 24. The intermediate group was formed by the materials 3, 10, 16 and 25. The rest had intermediate values between groups.

There was no interaction between the factors under study in the rainy season. The table 4 showed the performance of the plantation distance. This reached higher yield when the furrows were planted at 1.50 m.

In table 5, when analyzing the leaf weight per dry plant, proved that the materials assessed were grouped in three. The collection of lowest value was 17. Those with the higher indicators were 3, 10 and 23. There was an intermediate group formed by 13, 16, 24 and 25. The measurement related with the weight of 100 leaves GM had a similar performance of that of the previous one. Its grouping was as followed: material 17 had lower weight and 3 and 23 had the highest. The intermidiate group was formed by 5, 10 and 13. The rest of the collections had intermediate values between the formed groups. In respect to the leaf weight in 5 m, the collections with lower values were 16, 17 and 25. Those with higher value were 3, 10 and 23. The intermediate group was formed by the collections 13 and 24.

In respect to the percent of animals eating the materials under assessment (figure 1), the collections 24 and 17 did not surpass 20 % of the grazing time (P < 0.01), while the rest surpassed this value. The

Table 3. Performance of tithonia plant materials on the weight of 100 leaves during the dry season [1], g GM

Plant materials	Weight of 100 leaves, g GM
3	125.18[b]
25	122.57[b]
16	129.85[b]
23	167.40[c]
13	114.88[ab]
17	89.37[a]
24	170.25[c]
5	168.71[c]
10	126.15[b]
SE±	9.87***

[abc]Means with different superscripts differ at P < 0.05 (Duncan,1955).
** P < 0.001. [1] Mean per rotation

Table 4. Effect of the plantation distance on indicators of biomass production during the rainy season[1]

Indicators	Distances, m			SE±
	1	1.5	0.75	
Weight of the leaf per plant, g DM	9.50	9.42	8.81	0.33
Weight of 100 leaves, g GM	479.44	471.22	434.77	16.15
LOeaf yield in 5 m, kg/DM/furrow	0.39[a]	0.51[b]	0.36[a]	0.03***

[ab] Means with different superscripts differ at P < 0.05 (Duncan1955). *** P < 0.05
[1] Mean per rotation

Table 5. Performance of tithonia plant materials on indicators of biomass production during the rainy season1

Plant material	Weight of the leaf per plant, g DM	Weight of 100 leaves, g GM	Leaf yield in 5m, kg DM/ furrow
3	12.98[d]	607.14[f]	0.71[de]
25	7.94[b]	434.04[cd]	0.16[ab]
16	6.58[b]	362.50[bc]	0.15[ab]
23	12.91[d]	650.00[f]	0.68[de]
13	8.02[b]	468.08[de]	0.24[bc]
17	4.33[a]	251.51[a]	0.03[a]
24	6.49[b]	343.75[b]	0.34[c]
5	10.20[c]	512.00[de]	0.65[d]
10	13.75[d]	527.27[e]	0.82[e]
EE±	0.57***	27.98***	0.05***

[abcdef] Means with different superscripts differ at P < 0.05 (Duncan,1955). ***P < 0.001
[1] Mean per rotation

collections 23, 10 and 13 standed out with values close to 30 %. The results found by Castillo and Ruiz (2005) in leucaena should be considered. They inform values in grazing that ranged between 17 and 20 %. These results indicate the possibility of the materials under study for their grazing, except the collection 17.

When assessing the best space between rows to favor the grazing of these materials (figure 2), it was observed that as the separation between furrows increased (P < 0.01), the amount of animals eating also augmented. The previous statement is important for generating an exploitation technology for this species.

When conducting an integral analysis of the results related with the indicators of biomass production, the

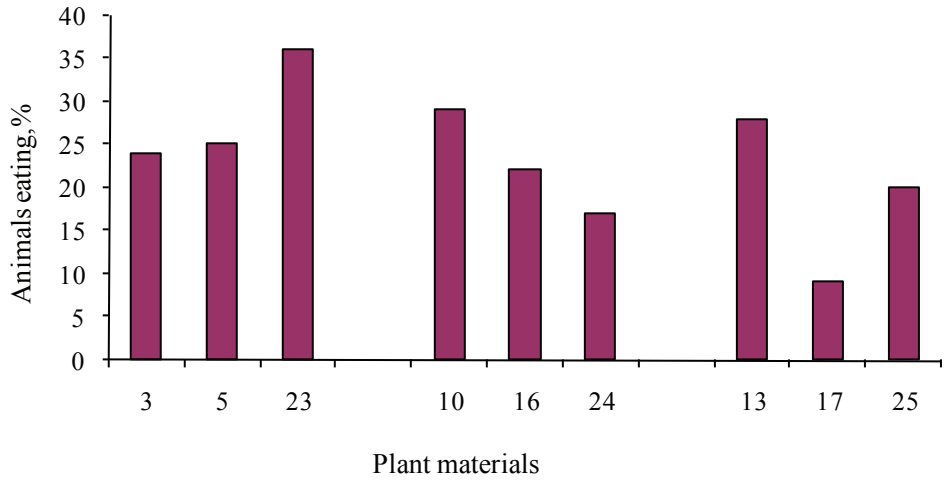

Figure 1. Animal performance at grazing with different plant materials of tithonia[1].
[1] Mean per rotation

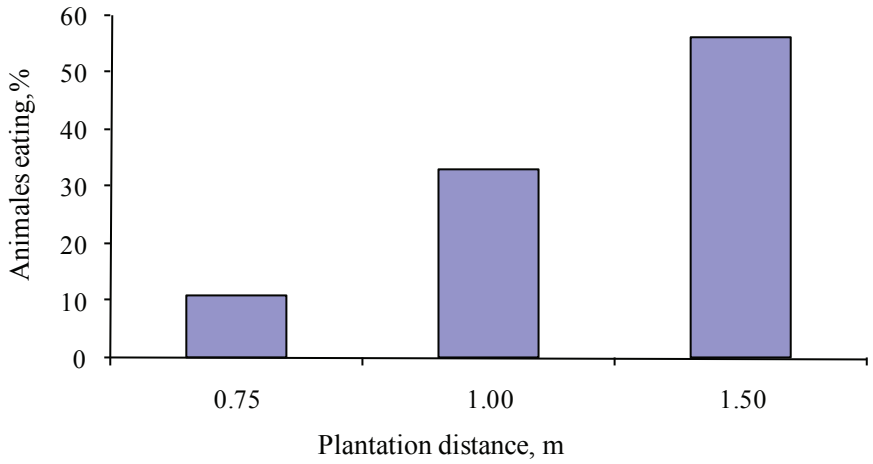

Figure 1. Animal performance with different distances of tithonia plantation[1].
[1] Mean per rotation

material 17 had the worst performance, while in the two seasons, the 3 was the best. In the rainy season, the materials 10 and 23 were also the best, as well as the 24 in the dry season. The materials 5, 10, 13, 23, 24 and 25 achieved an intermediate performance. The percent of animals eating the different materials should be added. This ratifies the few possibilities of material 17 for its use in grazing systems, as well as the best acceptance of 10, 13 and 23, followed by the collections 3 and 5. As the plantation distance increased, the number of animals eating augmented.

The literature states that this plant is mainly used as cut and transported forage (Mahecha and Rosales 2005, Murgueitio 2005 and Zapata and Silva 2010). Besides, it is indicated that, in spite of the observations about the use of *Tithonia diversifolia* in animal feeding mainly by farmers, few studies have been conducted worldwide in this field (CIPAV 2009). However, tithonia materials collected in Cuba to be grazed by cattle, especially dairy cows, are informed in this study.

It is concluded that plant material 17 should not be used as grazing plant. The material 3 may be used for these purposes during the whole year. The material 10 and 23 may be used in the rainy season and the 24 in the dry one. The materials 5, 10, 13, 23, 24 and 25 achieved an intermediate performance. The increase of the distance between furrows (0.75 vs 1.50 m) favors the amount of animals eating. All this indicates the possibility of having tithonia materials collected in Cuba for cattle grazing. This suggests the possibility of using other shrubs in silvopastoral systems.

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