

Plantation distance, frequency and cutting height on the biomass production of *Tithonia diversifolia* collection 10 during the year

T.E. Ruiz, G. Febles and H. Díaz

Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba
Email: teruizv@ica.co.cu

Two experiments were conducted, for two years each, to study the effect of combining plantation distance, frequency and cutting height on the annual biomass production of *Tithonia diversifolia* collection 10. A random block design in factorial arrangement with four repetitions was applied in each experiment to analyze the following factors: plantation distance (0.5 and 1.0 m) and cutting height (5, 10 and 15 cm) (experiment 1 A); cutting frequency (40, 60 and 80 d) and cutting height (5, 10 and 15 cm) (experiment 2 A). There was interaction for the factors under study. During the rainy season, there was higher yield ($P < 0.001$) in the experiment 1 with the lowest plantation distance (5.0 – 5.5 t/ha DM) and there was no effects in respect to the cutting height. The lowest plantation distance in the dry season had better performance in respect to yield (3.5-4.5 t/ha DM) and there was effect of the cutting height with lower yield (3.5 t/ha DM) at 5 cm ($P < 0.01$). In the experiment 2, the best performance ($P < 0.001$) was at 10-15 cm height and frequency of 80 d during the dry season (0.85-0.90 t/ha DM). The cutting height of 15 cm had ($P < 0.001$) the best yields together with the frequency of 60 d for the rainy season (1.7 t/ha DM). Higher yield was reached at distances of 0.50 m between furrows for both seasons. The plantation should be cut at heights between 10 and 15 cm, with cutting frequency of 60 and 80 d in the rainy and dry season, respectively.

Key words: *plantation distance, cutting frequency, cutting height, biomass production.*

The serious damages of the natural resources and the present economic and social crisis in different countries have increased the interest for a rapid and sustained development of agriculture. This will only be achieved when the production strategies correspond with the rational use of the ecosystem (Iglesia *et al.* 2011). In this context, visualizing the agriculture activity in the agroforestral systems is a valid, necessary and current approach for researching and training cattle rearing in the tropics.

Several studies have demonstrated that, in cattle rearing of tropical America, changing pastures monoculture by mixed vegetation combining in the same space and time grasses, creeping legumes, non-toxic tree legumes, palms, shrubs and trees, increases the photosynthesis, improves the nutrients recycling, recovers the soil biota and fertility and increases biodiversity (Murgueitio *et al.* 2011).

Murgueitio (2005) refers that the cutting and transporting systems, as well as the mixed forage banks, are ideal for preserving the soils with fragile slopes and humid ecosystems, used in farm and dairy production.

Mahecha and Rosales (2005) define *Tithonia diversifolia* as a species with good biomass production capacity and rapid recovery after cut, according to the sowing density, soils and vegetative stage.

The objective of this research was to study the effect of combining plantation distance, frequency and cutting height on the biomass production of *Tithonia diversifolia* collection 10 during the year.

Materials and Methods

Treatments and design. A random block design in factorial arrangement and four repetitions was applied

in each experiment and the factors were: plantation distance (0.5 and 1.0 m) and cutting height (5, 10 and 15 cm) (Experiment 1 A); cutting frequency (40, 60 and 80 d) and cutting height (5, 10 and 15 cm) (Experiment 2 A). The studies lasted two years.

Experimental procedure. The study was conducted on a red ferralic soil of good drainage, clayish and deep over limestone (Hernández *et al.* 1999), equivalent (Duran and Pérez 1994) to the sub-type rodic ferralic cambisol (FAO-UNESCO), with ploughing and two arrowings. The study was carried out in the experimental area of Zaldívar, from the Department of Pastures and Forages of the Institute of Animal Science.

This facility is located in the western part of the country, at 22° 53 north latitude and 82° 02 west longitude, at 80 m altitude. The average temperature of the experimental area is at about between 24.16 °C. The warmest month is June with 26.3 °C, and the coldest are January and February with 20.4 °C and 20.2 °C, respectively. The maximum temperature reaches up to 33 °C in August and the minimum ones up to 5 °C in January. The annual rainfall is of 1300 mm, with the highest values in July (244.6 mm), according to the reports of the Meteorological Station of the Institute of Animal Science of Cuba.

The species was planted in the rainy season, in furrows of 3 m length. Five furrows per plot were established. *Tithonia diversifolia* collection 10 was used.

Sticks taken from the middle part of the stem, with 80 d of age and 50 cm length were used. The furrows had 10 cm depth and were kept mechanically cleaned of weeds. In the experiment 1, the cutting frequencies used were of 60 and 90 d for the rainy and dry season, respectively.

In each cut, the yield of the green part of the plant in leaf and stem (kg DM/plot) was recorded; the yellow and dry leaves were not included. Analysis of variance was conducted and Duncan's test (1955) was applied when necessary.

Results and Discussion

The foliage production of tithonia as cutting plant is well known in Latin American countries (Ríos and Salazar 1995, Ríos 1998, Wanjau, 1998, FAO 1999). At present, there are no references on this respect in Cuba, although the results of this study coincide with those referred in other regions of Latin America.

When analyzing aspects related with the plantation distance, frequency and cutting height, among others, it was observed that there was interaction for the factors under study in both experiments. Partey (2011) reported similar results, when indicating that the cutting height and frequency and their interactions affected significantly the DM production of *T. diversifolia*. The best results were reached when cutting every two months at 50 cm.

Higher yield ($P < 0.001$) was produced in the rainy season with lower plantation distance and there was no effect in respect to the cutting height (figure 1). This performance could have been influenced by the existence of a higher population per m². While during the dry season (figure 2) the lowest plantation distance also presented better performance in respect to the yield and there was effect of the cutting height with lower yield at 5 cm ($P < 0.01$). This could have been influenced by the season, because the plants cut at this height have fewer reserves in the stems for the next regrowth (figure 2). These results coincide with those reached by Ramírez *et al.* (2005) in studies conducted in the center-north part of Yucatan, Mexico, with this plant. These authors studied the sowing distance (0.5 x 1.0 m (20 000 plants ha⁻¹, 0.75 x 1.0 m (13 333 plants ha⁻¹) and 1.0 x 1.0 m (10 000 plants ha⁻¹) and cutting height (25 and 50 cm). They found the highest biomass production with the highest density (5450 kg DM ha⁻¹) and increase of 27 % when the plants were cut at 50 cm. In this sense,

Ríos (2002) reported potential forage production of 31 and 21.2 t/ha in sowing densities of 0.75 m x 0.75 m and 1 m x 0.75 m respectively, without significant differences among them. However, he also reported the possibility of obtaining higher yield per area unit in the density of 0.5 m x 0.75 m, although there might be phytosanitary risks inherent to this cultivation way. In respect to the recovery of the crop after cutting, Ríos (1998) stated that with sowing densities of 0.75 m x 0.75 m, the plants increase 6.2 cm in cuts every 21 d, 19 cm in cuts every 35 d, 44 cm every 49 d and 180 cm every 110 d. Thus, the most proper time for harvesting forage with feeding purposes without damaging the crop is during the pre-flowering stage (cuts every 49-50 d), and a biomass production of 31.5 t/ha is feasible to be obtained.

In the previous study of this series, the combination of frequency and cut height was deepened and the effect of cutting height was analyzed and the best performance ($P < 0.001$) was found between 10-15 cm height and frequency of 80 d during the dry season (figure 3). The diminishing of biomass production with frequency of 40 d and heights of 5 or 10 cm can be noticed in this season. Meanwhile, the cutting height of 15 cm had the best yields ($P < 0.001$) together with the frequency of 60 d for the rainy season (figure 4). It should be pointed out that the frequency of 80 d is too long and the lowest yield is due to the aging of the leaves and a great number of them fall down.

The results of this study reaffirm the reports of Soto *et al.* (2009), who studied the yield of several shrub plants (*Erythrina poeppigiana*, *Gliricidia sepium*, *Tithonia diversifolia* and *Morus alba*) and indicated that the air biomass production was affected by the pruning time. According to their reports, it diminished as the pruning age diminished, and reached, at 26 weeks, higher amount of air and edible biomass. In this sense, Zavala *et al.* (2007) concluded that the cutting frequency (6, 10, 14, 18, 22 and 26 weeks) should be every 18 weeks so the plant is more palatable and more used by the animals. On this respect, Polo (2010) suggests pruning tithonia between 8 and 12 weeks of regrowth, when forage with

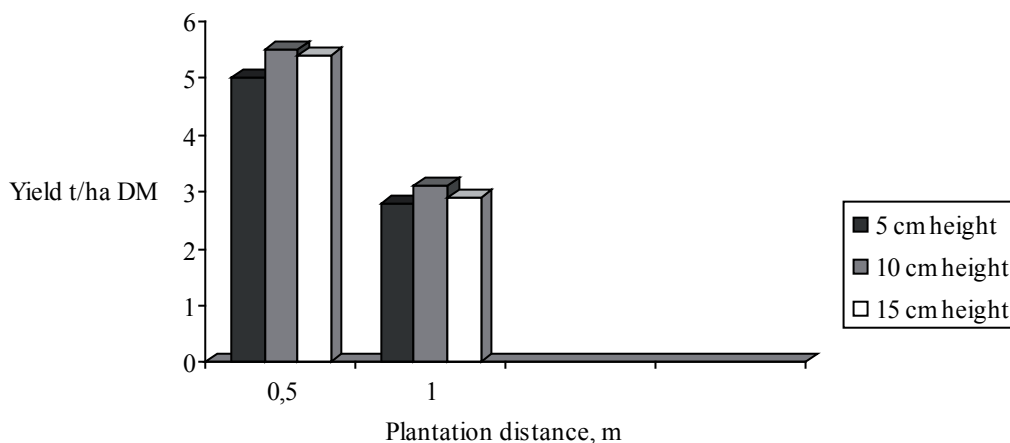


Figure 1. Effect of plantation distance and cutting height on Tithonia yield submitted to a cutting frequency of 60 d in the rainy season.

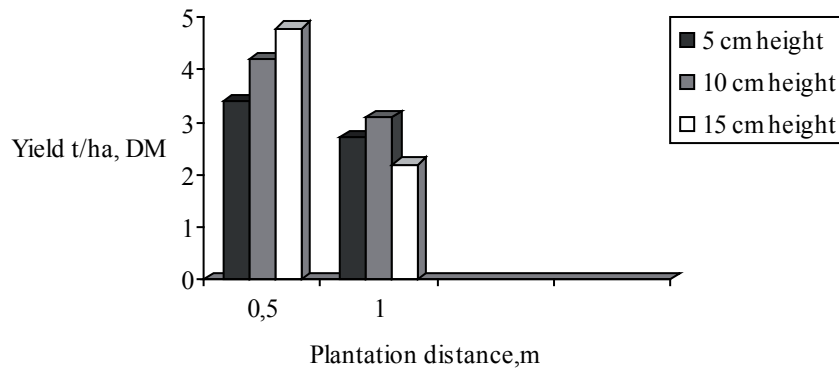


Figure 2. Effect of plantation distance and cutting height on Tithonia yield submitted to a cutting frequency of 90 d in the dry season.

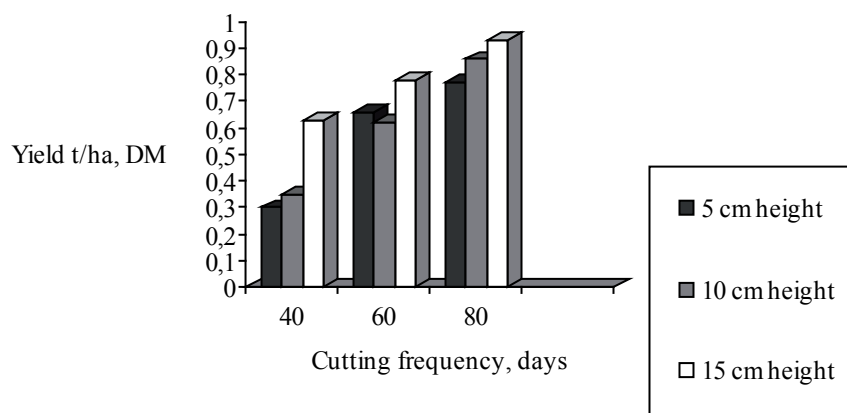


Figure 3. Effect of cutting frequency and height on the yield of Tithonia, dry season.

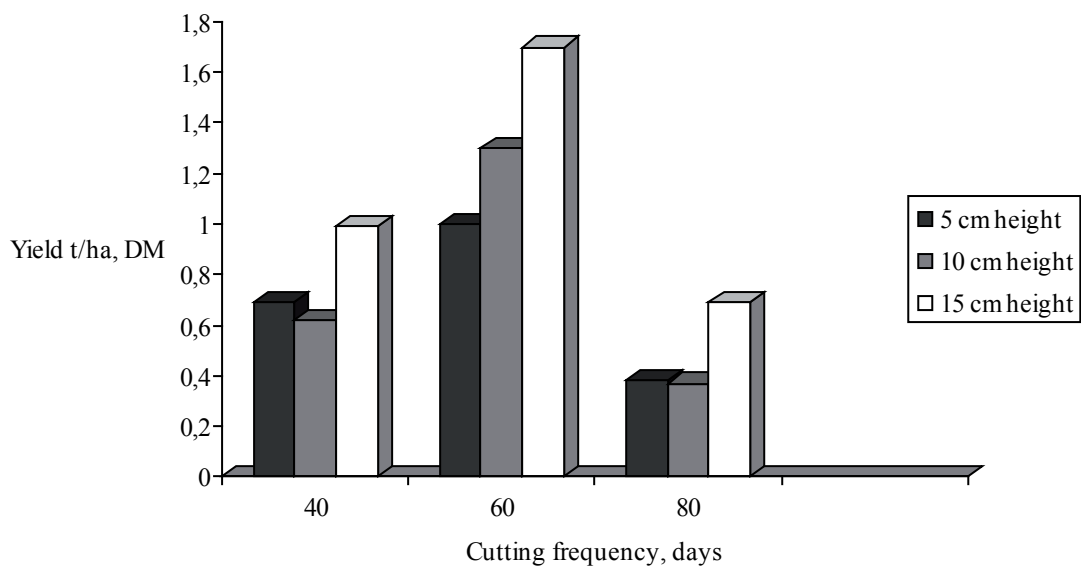


Figure 4. Effect of cutting frequency and height on the yield of Tithonia, rainy season

higher nutrient content and good biomass productivity is achieved whether in the dry or rainy season.

The results of other authors using the blooming degree as physiological indicator of the plant should not be avoided when conducting the cuts. De Souza (2007),

when studying different cutting times (pre-blooming, blooming, and after blooming) in *Tithonia diversifolia* indicated that the lowest yields occur in the pre-blooming stage and the highest, during this stage. In general, there is a tendency to higher production with less space (0.50 x

0.75 m, 0.75 x 0.75 x 0.75 m and 1.0 x 0.75 m). This was also stated by De Oliveira (2007). In reports of CIPAV (2009), harvesting before blooming is recommended, at about every seven weeks, with cut at 10 cm from the soil. Parada (2006) recommends the first cut of tithonia when the plants reach the flower stage (75 %), coinciding with the blooming of the first flower.

It can be concluded that higher yield is reached at distances of 0.50 m between furrows for both seasons. The plantation should be cut at heights between 10 and 15 cm, with a frequency of 60 and 80 d in the rainy and dry season, respectively.

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