

Agronomic Studies with Mulberry in Cuba

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Introduction

Mulberry (*Morus alba*) is a shrub that has traditionally been used for feeding the silkworm. It belongs to order of Urticales, to the Moraceae family and to the genus *Morus*, with more than 30 species and 300 varieties. It comes from China and other species originate in other temperate countries, and despite this, they can be considered "cosmopolitan" for their capacity of adaptation to different climates and altitudes. In Cuba, according to Paretas et al. (1997), it was planted in the 1940s for sericulture purposes and extended well in various regions.

The foliage has a high nutritional value, since it contains high levels of protein and digestibility. Mulberry does not tolerate bad drained or compacted soils, and it requires fertilisation since it extracts large quantities of soil nutrients (it can use up to 50% of the fertilisers applied). Nevertheless, it has been shown that responds well to organic fertilisers, and yields of up to 50ton/ha of edible fresh forage have been obtained when goat manure applications.

Benavides, Lachaux and Fuentes (1994) evaluated the effects of applying goat manure in the soil and the cutting frequency on biomass quality and yield in the humid tropic of Costa Rica. Three levels of goat manure (240, 360 and 480 kg of N/ha/year), two

controls (no fertilisation and 480 kg de N/ha/year of NH_4NO_3), and three cutting frequencies (60, 90 and 120 days) were used. The largest total dry matter production was with the cutting frequency of 120 days, although there was no difference in edible biomass between 90 and 120 days. Manure levels proportionally increased total and edible biomass yield, and the highest level of manure application (equivalent to 480 kg of N/ha/year) significantly exceeded both controls.

In the dry tropic of Guatemala, Rodríguez, Arias and Quiñones (1994) found that biomass production increased with shorter cutting frequencies (6, 9 and 12 weeks) and higher fertiliser doses (40 and 80 kg de N/ha/year as urea). There was a positive interaction between both factors.

There remain a lot of factors to be studied in this plant, and even more in Cuba, due to the need to find new forages of higher nutritional value than the conventional ones. The studies should be directed towards the different production systems and ecological conditions.

The objective of this paper is to present the results of the various agronomic studies carried out in Cuba with *Morus alba*.

Methodology

Experiment 1.

At the Indio Hatuey Grass and Forage Experimental Station (EPPF Indio Hatuey, 22°48'7" north y 81°2' west, at 19m above sea level), an experiment was conducted in a plantation of the variety "Tigreada" with a complete random design. Two cutting heights (50 and 100cm) and three cutting frequencies (45, 60 and 90 days) were used. Each treatment was represented by 20 plants

randomly distributed in the field. They were planted at a spacing of 1m between lines and 0.40m between plants. They were not irrigated and poultry manure was applied twice at the rate of 150kg N/ha/year during the rainy season.

In one year 8, 6 and 4 cuts were given at the frequencies of 45, 60 and 90d, respectively. In the 20 plants for each treatment total biomass and its components (leaf, woody stem and young stem) were determined, and the edible biomass calculated. Total biomass yield per ha was calculated from the mean dry weight of individual plants and a density of 25,000 plants/ha.

For data processing descriptive statistics and analysis of variance were used.

Experiments 2 and 3.

At the Centro Politécnico “Villena Revolución”, with typical red ferralitic soils, two experiments were conducted to study cutting height and frequency on biomass yield and on quality during the dry period of October 1998 to April 1999. The two experiments were set in a 1.5ha area, using a random block design with 4 repetitions.

The experimental plot was composed by 10 plants, with 8 plants used as net plot. In total there were 32 plants per treatment. Total biomass and the three fractions were determined in each plant, and a plot sample was taken for N and fibre analysis. Cutting heights and frequencies were 20, 30 and 40cm, and 45, 60 and 90 days, respectively.

In experiment 2, the cutting frequency was 90d and cutting height 30cm.

Experiment 4.

This study was carried out at Indio Hatuey Station in a well drained red ferralitic soil. There were 4 treatments:

- A) Mulberry
- B) Mulberry + 50 kg of N
- C) Mulberry + Dolicho (*Lablab purpureus*)
- D) Mulberry + Canavalia (*Canavalia. ensiformis*)

A random block design with four repetitions was used. Plot size was 10 x 10m. The Tigreada variety was planted in September 1998, at 1 x 0.4m spacing with 40cm stakes. The two legumes were planted next between mulberry lines. These legumes were harvested when pods turned from green to yellow (06/01/99 for dolicho and 05/04/99 for canavalia). Nitrogen fertiliser was applied 60d after planting.

Two manual weedings were given and mulberry was first harvest at one year of age. Parameters measured were total biomass yield (TDMY), edible biomass (EDMY), height, branch number, legume grain yield and legume plant yield.

The Duncan (1955) test was used to interpret the results.

Results and Discussion

Experiment 1.

The analysis of total biomass yield showed highly significant differences ($P < 0.01$) among cutting frequencies. Cutting height and the interaction height x frequency were non-significant.

Table 1. Effect of cutting height and frequency on biomass yield (g DM/plant/year).

Variable	Treatment						
	Height (cm)		SE±	Frequency (days)			SE ±
	50	100		45	60	90	
Total biomass	650	670	44	537 ^b	514 ^b	1,031 ^a	62 ^{***}
Edible biomass	533	453	85	456 ^b	378 ^b	645 ^a	120 [*]
Edible biomass %	82	68		85	74	63	

^{a,b} Significantly different horizontally P<0.05; ^{*} P< 0.05; ^{***} P< 0.001

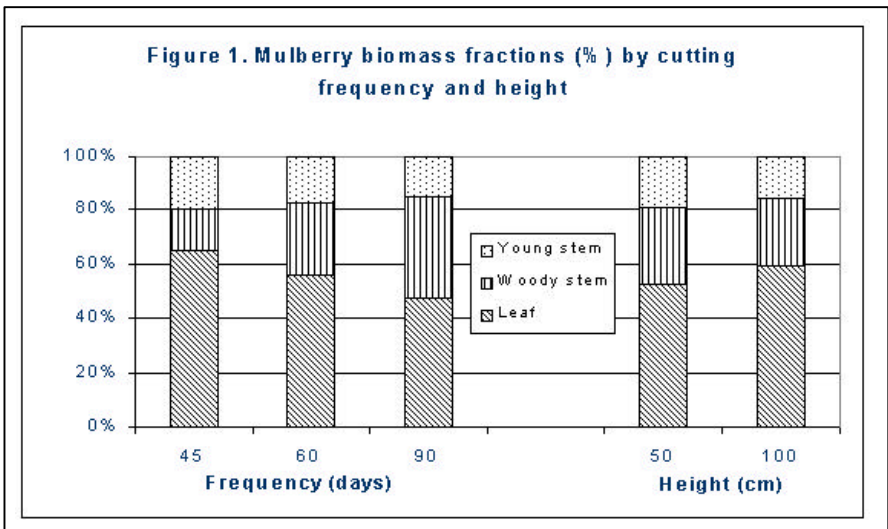
The 90d frequency gave the highest yield (1,031g DM/plant/year). This result allows inferring that 25 ton of DM can be produced from ha per year (with 25,000 plants/ha). Edible biomass production showed similar results. At the 90d frequency 645g of edible DM were produced pr plant, equivalent to 16 ton/ha/year or 63% of total biomass. The 45 and 60d frequencies yielded less edible biomass despite the higher edible fractions in the total DM yield.

These results are similar to those obtained in the humid tropic of Costa Rica by Benavides, Lachaux and Fuentes (1994) and in the dry tropic of Guatemala by Rodriguez, Arias and Quiñones (1994).

The analysis of the biomass proportions (Figure 1) more clearly shows the influence of cutting frequency. On the contrary cutting height has no effect. Percentages of leaf and young stems go down at cutting intervals increase, but the woody stem fraction goes up.

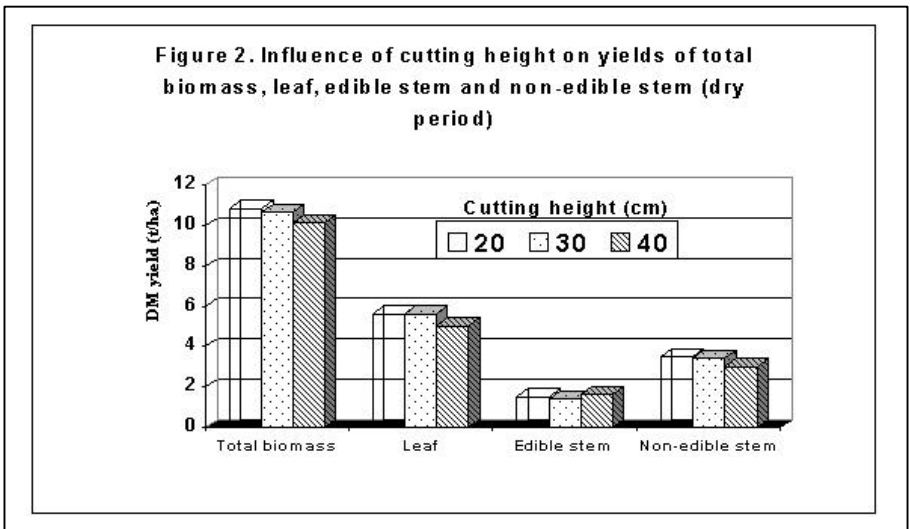
These results are closely linked to the growth process, by which sclerenchymatous tissues increase proportionally to age.

Cutting height did not have an effect on fraction proportions.



Experiment 2.

Cutting height did not have an effect on total and fractional biomass yields during the dry period of 1998-99 (Figure 2). Nevertheless, according to studies from other countries



(Benavides, 1986), cutting height has not shown a clear tendency on its effect on biomass yield.

It should be noted that among plant fractions, leaf gave the highest yield with approximately 55% of total biomass. Adding the young stem fraction of 12%, it can be inferred that over 60% of total biomass is edible. This means that over 7 t of DM/ha were obtained during the dry period, result superior to those of other conventional forages obtained in this experimental conditions.

Table 2. Effect of cutting height on protein and crude fibre of total biomass and fractions.

Variables	Crude Protein (%)			Crude Fibre (%)		
	Height (cm)			Height (cm)		
	20	30	40	20	30	40
Total biomass	16.1	16.0	14.7	29.6	27.9	23.8
Leaf	21.0	21.6	21.6	16.1	17.8	15.1
Edible stem	8.7	8.6	8.9	41.8	38.8	39.3
Non-edible stem	5.4	4.9	5.3	47.3	44.1	50.7

There were no differences in protein and fibre due to cutting height (Table 2). Protein obviously higher and fibre lower in leaf and edible stems.

Experiment 3.

There were significant differences ($P < 0.05$) on the effects of cutting frequency on total and fractional biomass yields (Table 3). All yields increased with cutting interval, the largest values were at 90d.

Table 4 indicates that the percentage of leaf and edible biomass decreased as cutting interval increased, whereas woody stem showed the reverse effect.

Table 3. Effect of cutting frequency on total and fractional biomass production (t de MS/ha) during the dry period 1998-99.

Variables	Cutting frequency (days)				
	45	60	75	90	SE
Non-edible stem	0.06 ^c	0.38 ^c	1.15 ^b	3.38 ^a	0.263 [*]
Edible stem	0.33 ^b	0.41 ^b	0.82 ^a	0.83 ^a	0.087 [*]
Leaf	2.70 ^c	2.60 ^c	3.79 ^b	5.24 ^a	0,261 [*]
Total biomass	3.09 ^c	3.39 ^c	5.76 ^b	9.45 ^a	0.493 [*]

^{a, b, c} Significantly differ horizontally $P < 0.05$; ^{*} $P < 0,05$;

Table 4. Effect of cutting frequency on the percentages of biomass components.

Variables	Cutting frequency (days)			
	45	60	75	90
Leaf	87.4	76.7	65.8	55.4
Edible stem	10,6	12.1	14.2	8.8
Non-edible stem	2.0	11.2	20.0	35.8
Edible biomass	98.0	88.8	80.0	64.2

The results obtained in this experiment with the 90d cutting frequency are similar to those obtained in experiment 2, showing the great potential of mulberry to produce biomass during the dry period.

There were significant differences ($P < 0.05$) in protein content of various fractions with cutting frequency (Table 5). Protein decreased with longer cutting intervals, indicating greater lignification and more fibre (Table 6). This tendency was not observed in the edible stems, although at 90d the protein content was the smallest.

Considering that DM production reaches 9.5 t/ha during the dry period, with 15.6% crude protein, it is possible to produce 1.5t of crude protein/ha, which is equivalent to the yield of transgenic

soybean in one year (Preston, 1999). This means that mulberry can produce three times more protein than transgenic soybean in a year.

Table 5. Effect of cutting frequency on protein content.

Variables	Cutting frequency (days)				
	45	60	75	90	ES
Total biomass	24.1 ^a	16.0 ^b	14.7 ^c	15.6 ^{bc}	8.38 [*]
Leaf	27.0 ^a	24.4 ^b	23.6 ^b	21.4 ^c	0.36 [*]
Edible stem	11.5 ^a	10.8 ^a	11.2 ^a	8.9 ^b	0.42 [*]
Non-edible stem	-	11.8 ^a	9.2 ^b	7.6 ^c	0.04 [*]

^{a,b,c} Significantly differ horizontally; ^{*} P<0,05

Table 6. Effect of cutting frequency on crude fibre percentage.

Variables	Cutting frequency (days)				
	45	60	75	90	SE
Total biomass	26.5	25.2	25.0	30.0	1.29 ^{NS}
Leaf	14.0 ^b	12.4 ^a	15.5	15.1	0.47 [*]
Edible stem	41.2	39.7	38.6	40.6	1.25 ^{NS}
Non-edible stem	40.5	40.0	37.2	44.0	0.70 ^{NS}

Experiment 4

Table 7 shows total and edible production, there were no significant differences among treatments A, B and C, although B had the largest total yield (9.8 t/ha). The lowest production of edible (2.5 t/ha) and total biomass (5.3 t/ha) occurred with canavalia (D), which was significantly (P<0.01) lower than the other treatments. This could be due to the very aggressive growth of canavalia, which covered mulberry branches intercepting light. Cover crops if not managed adequately can become weeds,

shading the main crop and competing with water and nutrients (López and Hernández, 1997). This can be resolved with various management practices like pruning, spatial orientation, etc.

Table 7. Effect of intercalated legumes on mulberry yield

	EDMY	TDMY
Mulberry alone	3.4 ^a	8.5 ^a
Mulberry + 50 kg of N	3.8 ^a	9.8 ^a
Mulberry + Dolicho	3.5 ^a	9.4 ^a
Mulberry + Canavalia	2.5 ^b	5.3 ^b
SE ±	1.8 ^{***}	3.30 ^{***}

EDMY = Edible dry matter yield

TDMY = Total dry matter yield

^{a,b} Significantly different vertically; ^{***} P<0.001

Plant height and branch number are presented in Table 8, without any differences due to treatments.

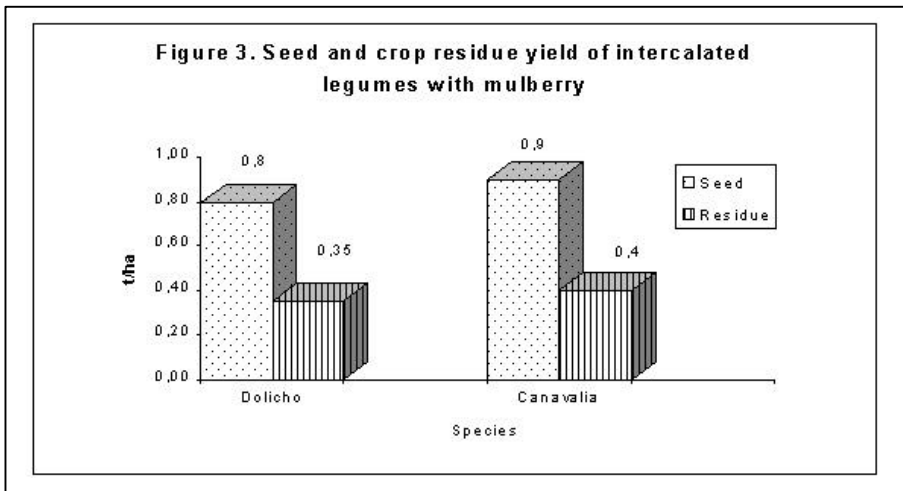
Table 8. Effect of intercalated legumes on height and branch number at first cut.

	Height (cm)	Branch number
Mulberry alone	3.75	3.1
Mulberry + 50 kg of N	2.70	2.8
Mulberry + Dolicho	3.10	2.9
Mulberry + Canavalia	2.77	2.9
SE ±	0.16 ^{NS}	0.11 ^{NS}

^{NS} Non-significant

The results in dry matter production during the establishment period coincide with those of Martín *et al.* (1998) for this same variety.

Intercalated legumes (Figure 3) produced additional grains: 0.87 t/ha for dolicho and 0.92 t/ha for canavalia, plus crop residues, which can help in maintaining soil fertility through nutrient recycling.



This trial shows that it is possible to substitute certain quantities of nutrients that mulberry requires by inter-sowing short-cycle herbaceous legumes. Although there were no significant differences among treatments A, B and C, treatments B and C had 1.3 and 0.9 t/ha more biomass yield compared to A. In addition, treatment C additionally had 870 kg/ha of legume grain and 350 kg of crop residue. These later were incorporated to the soil, but could be used as feed. All this indicates that studies should continue to determine more accurately the effects of intercalating short-cycle legumes on the biological, economic and ecological sustainability of mulberry under cut-and-carry systems.

Final Considerations

As part of the research programme being carried out in Cuba with *Morus alba*, the four agronomic experiments concluded up to now were included in this article. From these the following was observed:

- In experiments 1 and 2 it was determined that cutting heights (20, 30, 40, 50 and 100 cm) did not significantly influence dry matter production (total and fractional) neither protein nor crude fibre contents.
- Cutting frequencies in experiments 1 and 3 (45, 60, 75 y 90d) significantly affected total and fractional biomass yield and protein and fibre contents. In both trials, the 90d frequency gave the best results.
- Intercalated legumes can contribute to improving biologic, economic and ecological sustainability of mulberry.
- Yield and quality results of these mulberry studies, in particular during the dry period, demonstrate the potential of this plant for Cuban conditions. This justifies further agronomic studies along the same lines and in related matters necessary to introduce mulberry to livestock farms in the country.

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