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Evaluation of the vegetative reproduction capacity of mulberry (Morus alba *L.*) *varieties*

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ABSTRACT: In order to evaluate the effect of variety and branch part on the leaf and root sprouting of propagules, five mulberry varieties (tigreada, yu-12, yu-62, murcia and universidad) were studied. The branches were divided into three parts (basal, medial and apical), which originated a total of 15 treatments. The quantity and percentage of sprouted and rooted propagules, number of branches, number of leaves and root weight, were evaluated. Yu-12 and tigreada had the highest sprouting (100 and 98 %, respectively). However, tigreada stood out in rooting (70 % of the total planted cuttings) and the root weight (2,67 g), in which it significantly differed ($p < 0,05$) from the other varieties. In addition, when using the basal and medial parts the highest sprouting percentage was obtained (93 and 90 %, respectively). The interaction of variety and branch part was significant; the best results were obtained in the tigreada variety –basal part–, regarding the number of branches and leaves. Tigreada showed the best morphoagronomic performance during the experimental period; while yu-12, yu-62, universidad and murcia did not respond efficiently to reproduction from propagules. The basal and medial parts were determined in the leaf and root sprouting and in the root weight. To repeat these experiments in nursery, in different months of the year, and to use products that stimulate propagule rooting is recommended.

Key words: propagules, rooting, sprouting

INTRODUCTION

Morus spp. has a wide germplasm, formed by a large diversity of species and varieties which constitute valuable plant genetic resources. In this sense, sericulture has been the main reason for the impressive selection and breeding process of the genus *Morus* (Datta, 2002). Through these methods a great amount of varieties has been created and extended, with excellent capacity of biomass production, nutritional quality and high resistance to the incidence of pests and diseases, which respond to a wide range of climate and soil conditions (García, 2006; Medina *et al*., 2009).

Cappellozza (2002) reported the existence of a collection of 51 accessions in Italy, made up mainly by *Morus nigra* and *Morus alba*. On the other hand, Brazil has three collections from *M. alba*, with a total of 90 varieties on which many agronomic and nutritional studies have been conducted (Almeida and Fonseca, 2002).

Likewise, Benavides (2002) stated that in Central America there are four mulberry varieties: criolla, indonesia, tigreada and acorazonada, which were introduced in the first half of the 20th century, when the silkworm production was attempted to be developed. Such varieties were introduced in Cuba in 1996, with livestock production purposes, and although some studies have been conducted with *M. nigra* (Domínguez *et al*., 2001), the best results have been obtained with the *M. alba* varieties. In this sense, indonesia and acorazonada have had an outstanding agronomic performance with regards to the cubana and tigreada varieties (Martín, 2004).

The introductions of this species in Cuba have not stopped, and at present the germplasm bank of the Pasture and Forage Research Station Indio Hatuey (EEPF-IH) has 21 varieties, from Costa Rica, Brazil, South Korea, China and Spain. The most recent acquisitions are: universidad, universidad mejorada, universidad nueva, yu-12, yu-62 and murcia, of which their agronomic and productive performance under the soil and climate conditions of the country are unknown.

In this sense, it is known that the varieties show different responses regarding efficiency in propagule rooting –used in planting–, selected branch part, prevailing environmental conditions, nutrition of the mother plant and age of the generating tree (Boschini and Rodríguez, 2002).

Taking these antecedents into consideration, a study was conducted in order to evaluate the vegetative reproduction (propagules) capacity in different mulberry varieties.

MATERIALS AND METHODS

Climate and soil. The trial was conducted at the EEPF-IH, located in the Perico municipality –Matanzas province, Cuba–, in the period between September and December, 2012. During this stage, 546,7 mm of rainfall, 81 % of relative humidity and 24,2 ºC of mean temperature, were recorded. The soil is classified as lixiviated Ferralitic Red (Hernández *et al*., 1999).

Design and treatments. A completely randomized block design was used and five varieties were studied: tigreada, yu-12, yu-62, murcia and universidad. The branches were divided into three parts (basal, medial and apical), which originated a total of 15 treatments, four replications and 60 plots.

The varieties used for sowing came from a one-year-old established plantation. They had been recently introduced in Cuba and were sown by botanical seed, except the tigreada variety –that was introduced in 1996 and had been planted by cuttings and exploited for more than 15 years–, which was used as control for its good morphoagronomic performance (Noda *et al*., 2004).

A few months before the experiment, cultural labors were performed in the area where the youngest varieties grow, such as: organic base fertilization with filter cake at a rate of 200 kg N/ha/year, and irrigation and homogenization pruning 10 months after sowing.

Experimental procedure. The beds were prepared and fertilized with filter cake at a rate of 10 kg/m^2. Sowing was done by cuttings. The propagules measured 30-40 cm of length and had more than three good-quality buds, which were separated –according to the branch part– into basal, medial and apical. They were vertically sown, with a planting frame of 20 cm between rows and 20 cm between propagules, at a depth of 8-10 cm. Irrigation was performed throughout the observation period (80 days), moment at which the growth was interrupted in order to conduct the study.

Measured variables. The amount of sprouted plants, quantity of rooted plants, number of branches (all those emerging from each propagule were taken as branches), number of leaves and weight of the roots in the rooted plants, were measured.

The percentage of sprouted and rooted plants was calculated from the average of each plot. In each treatment 80 plants were measured (20 in each plot).

Statistical analysis. The data were processed by means of a multifactorial ANOVA, through the statistical pack InfoStat, version 1.1. In addition, Duncan's multiple comparison test was used, for a significance level of 0,05.

RESULTS AND DISCUSSION

Figure 1 shows the sprouting and rooting percentage of the propagules for each variety. In this sense, yu-62 reached 100 % of sprouted cuttings, without differing from the tigreada (used as control) which showed 98 %. The others had lower values (91, 87 and 69 % for yu-62, universidad and murcia, respectively).

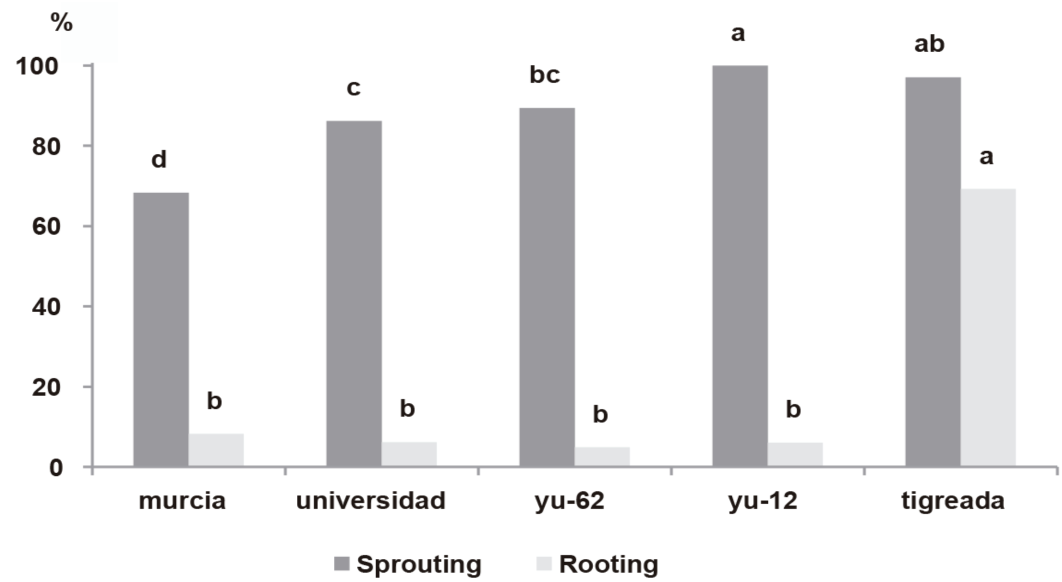
However, regarding plant rooting, tigreada differed significantly ($p < 0,05$) from the other varieties, reaching 70 % of the total planted cuttings. Yu-12, yu-62, universidad and murcia showed low values, which oscillated between 4 and 8 %.

According to Boschini and Álvarez (2002), the sprouting efficiency of mulberry propagules depends, to a large extent, on the nutrition of the mother plant. If it is considered that in this research the percentages of sprouted plants were higher than those of the rooted ones, it can be stated that the response of the propagules of the newly-introduced varieties could have been related to a good nutritional reserve and that it varied when they became independent plants.

On the other hand, tigreada had good emergence and rooting percentages in studies conducted in different environments (Fernández *et al*, 2002; Noda *et al*., 2004; Pentón *et al*., 2007). This shows the reproduction capacity of this variety in different climate ranges and could be another cause of the different performance with regards to the other varieties.

The shoot emergence and plant rooting are shown in table 1. The propagules showed important differences ($p < 0,05$), according to the position they occupied along the branch they were taken from.

The highest sprouting percentages (93 and 90 %) were obtained when using the basal and medial parts of the branch, without showing statistical differences between both; but with differences with regards to the apical part, which was the one with the lowest response (84 % of the total plants). Seemingly,



Different letters for sprouting and rooting significantly differ $p < 0,05$ (*$p < 0,05$)
Sprouted propagules: SE ± 3,6* Rooted propagules: SE ± 0,6*

Fig. 1. Percentage of sprouted and rooted propagules in each variety.

Table 1. Percentage of sprouted and rooted plants by effect of the branch part used.

Branch part	Sprouted plant	Rooted plants
Basal	93[a]	21
Medial	90[a]	17
Apical	84[b]	17
SE ±	3,6*	2,6

Different letters indicate significant differences ($p \leq 0,05$)
* $p < 0,05$

the apical effect of the branch is not determining in the formation of new plants, which is possibly associated to the presence of meristematic tissues with immature buds, unlike the medial and basal zones (Machado, 2011).

The effect of the branch part was not significant on plant rooting. Suzuki *et al*. (1998) recommend searching for other selection criteria for cutting extraction, such as bud maturity and the season in which this activity is performed, aspect on which further study should be conducted in later trials, specifically for each variety.

Table 2 shows the effect of the interaction between variety and extracted branch part, on the number of branches grown in the plants. The tigreada variety –planted from the apical and medial parts– reached the highest number of branches and differed significantly ($p < 0,05$) from the other treatments. These results coincide with those obtained by Vargas *et al*. (2002) and Fernández *et al*. (2002), when characterizing the agronomic performance shown by this variety in the establishment stage. In addition, according to Caballero *et al*. (2006), branching is a consequence of nutrient accumulation in the emission spots of the shoots, as well as of the root development of the plant, which can account for the results obtained in this experiment.

With regards to the other treatments, the number of grown branches was significantly lower in all the cases. This could be related to the low percentage of rooting shown by the propagules of these varieties, because the production of new leaves during propagation by cuttings should be considered as indicator of a functional process, because the synthesis of the necessary factors for the formation of new roots occurs in the forming leaves (Davies, 1995; Castrillón *et al*., 2008; Suárez *et al*., 2008).

It should be taken into consideration that no reports have been found in literature about the asexual reproduction capacity of the varieties universidad, yu-12, yu-62 and murcia, efficiently reproduced by

Table 2. Effect of the interaction variety-branch part used, on the number of branches.

Variety	Branch part	Number of branches
	basal	3,18[a]
tigreada	medial	3,01[a]
	apical	2,25[b]
	basal	1,80[c]
yu-12	medial	1,59[cde]
	apical	1,33[defg]
	basal	1,48[cdef]
yu-62	medial	1,46[cdef]
	apical	1,20[fgh]
	basal	2,36[b]
murcia	medial	1,68[cd]
	apical	0,90[h]
	basal	1,53[cdef]
universidad	medial	1,26[efgh]
	apical	1,08[gh]
SE Int. ±		1,14

Different letters in each row indicate significant differences ($p < 0,05$)

botanical seed, which could influence their agamic reproduction capacity.

The effect of the interaction between variety and branch part was also significant on the number of branches emitted in each treatment (table 3). The tigreada variety –planted from the basal part– reached the highest number of leaves (29), and differed significantly from the others ($p < 0,05$).

Likewise, Fernández *et al.* (2013) obtained high leaf yields in the tigreada variety (12,5 t/ha), which coincides with the results reported by Espinosa and Benavides (1996) in Costa Rica. These authors stated that this variety responds efficiently to light and high temperatures. Such aspect can be determinan in the establishment and growth of some species, and should be studied in the specific case of the new mulberry introductions. On the other hand, the universidad variety –reproduced from the apical part of the plant– was the treatment with the lowest development, with an average of two leaves per plant.

Regarding the root weight there was no interaction, but a significant effect of the independent factors was found.

The tigreada variety significantly differed ($p < 0,05$) from the others in the weight of its roots (2,67 g), as it is shown in table 4; which could have been given by their good growth due to its effectiveness in the reproduction by propagules. It is known that the main functions of the roots are plant fixation to the soil, absorption of water and mineral nutrients and their transportation to the rest of the plant. For such reasons, the good root growth and development allows the plant to establish rapidly and its morphoagronomic characteristics to be significantly remarkable, as it occurred with the tigreada variety during the research. In the other varieties the root weight was not higher than one gram in any case, which could have been due to the low percentage of rooted propagules.

On the other hand, the basal branch part favored the highest weight of the roots, with which it differed significantly ($p < 0,05$) from the medial and apical parts (table 5).

Studies conducted by Boschimi and Rodríguez (2002) about the effect of the basal, medial and apical parts of the branch on root emergence proved that the cuttings extracted from the basal and medial parts responded efficiently. The results can be comparable, if it is taken into consideration that root weight is related to the quantity and the capacity of each branch part to produce roots and rootlets from a bud; however, the authors also used indole-butyric acid (IBA) as stimulating hormone, and inferred that its application responds favorably in the cuttings extracted from the basal part.

Table 3. Effect of the interaction variety -branch part on the number of leaves.

Variety	Branch part	Number of leaves
tigreada	basal	29,23[a]
	medial	23,81[b]
	apical	20,73[c]
yu-12	basal	6,90[de]
	medial	4,46[efg]
	apical	3,10[fg]
yu-62	basal	3,95[fg]
	medial	3,48[fg]
	apical	3,18[fg]
murcia	basal	8,30[d]
	media	5,53[ef]
	apical	4,41[efg]
universidad	basal	5,84[def]
	media	3,40[fg]
	apical	2,53[g]
SE Int. ±		5,77

Different letters in each row indicate significant differences ($p < 0,05$)

Table 4. Effect of the variety on the root weight.

Variety	Root weight (g)
tigreada	2,67[a]
yu-12	0,42[b]
yu-62	0,07[b]
murcia	0,15[b]
universidad	0,30[b]
SE ±	0,02

Different letters in each row indicate significant differences ($p < 0,05$)

Table 5. Effect of branch part on the root weight.

Branch part	Root weight (g)
Basal	1,08[a]
Medial	0,50[b]
Apical	0,59[b]
SE ±	0,02

Different letters in each row indicate significant differences ($p < 0,05$)

When analyzing the treatments, it is necessary to emphasize that the tigreada variety (used as control), corroborated once more the reports by other authors such as Benavides (1996), Benavides (2002), Martín (2004), Noda *et al*. (2004) and Pentón *et al*. (2007) about its capacity and response to efficient sprouting from propagules. Yet, yu-12, yu-62, universidad and murcia did not have that performance in the reproduction by cuttings, aspect that should continue to be studied in different months of the year, using rooting stimulators.

Likewise, the branch part used for propagation had a significant effect, especially those that were extracted from the basal and medial parts. This indicates that mulberry has a similar performance to that of many plants that are asexually propagated (Noda, 2006); which is mainly due to the reserve content found in higher concentration in those sections of many trees and shrubs (Boschini and Rodríguez, 2002).

It is concluded that the interaction of the factors variety and branch part was determinnant in branch formation and the number of leaves. In addition, the tigreada variety showed the best morphoagronomic performance during the experimental period; while yu-12, yu-62, universidad and murcia did not respond efficiently to reproduction from propagules. The basal and medial parts were determining in leaf and root emergence and root weight. To repeat this experiment in nursery, in different months of the year, and to use biological products that stimulate propagule rooting, is recommended.

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