Emergence and initial development of four forage tree legumes present on the plateau of Maracaibo, Venezuela

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ABSTRACT

The objective of the study was to evaluate the effect of different pre-germination treatments, as well as the morphological characteristics of the emerged seedlings in four forage tree legumes: *Albizia lebbeck*, *Prosopis juliflora*, *Samanea saman* and *Enterolobium cyclocarpum*, present on the plateau of Maracaibo, Zulia state, Venezuela. A randomized block experimental design, with four repetitions, was used. The applied treatments were: scarification with sandpaper (SS), soaking in water (SW) and immersion in hot water (IHW), in seeds with different storage times (ST). The following factors were evaluated: emergence percentage (EP), emergence rate (ER), seedling height (SH), root length (RL), number of leaves (NL), number of nodes (NN) and stem diameter (SD). In *A. lebbeck* the time of SW and the interaction between SS and IHW showed significant differences in the EP. In the *P. juliflora* seeds, the individual effects of ST, SW and IHW showed differences in the EP. The SS influenced the EP of the *P. juliflora* seeds without endocarp and those of *E. cyclocarpum* and *S. saman*. It is concluded that the SS in seeds of *A. lebbeck*, *P. juliflora* without endocarp, *E. cyclocarpum* and *S. saman*; as well as the utilization of *P. juliflora* seeds with endocarp –fresh or stored during three months and treated with hot water for five minutes– allowed to increase emergence. The seedlings showed normal and homogeneous development.

Key words: *Albizia lebbeck*, emergence, *Enterolobium cyclocarpum*, *Prosopis juliflora*, *Samanea saman*

INTRODUCTION

In Venezuela cattle feeding is based on the use of forage and balanced supplements, which have high prices. This situation has generated the need to search for complementary alternatives for animal feeding, among which are tree legumes, with high crude protein content and excellent adaptation (García *et al*., 2008; Navarro, 2009). The incorporation of these species, as well as improved pastures in the grazing area, is an agroforestry practice which allows to improve productivity and increase the sustainability of livestock production systems. In Latin America, agroforestry systems use a limited number of tree species and, in many cases; legumes constitute another element of the livestock production ecosystem and not a protein source (García *et al*., 2008).

In the Zulia state, Venezuela, only a few farmers of livestock production tradition know the usefulness in animal feeding of the foliage from some tree legumes, which have multipurpose qualities, Among them, *Albizia lebbeck*, *Prosopis juliflora*, *Enterolobium cyclocarpum* (Jacq.) Griseb. and *Samanea saman* can be mentioned. It is common to find these species in different zones of the Maracaibo plateau, Zulia state, for which they could be used in production systems. A simple way to do this is to allow the development of the seedlings that grow naturally in the fields or forests.

The seeds of tree legumes frequently have impermeable or extremely hard coats which prevent germination; thus, they generally require a pre-germination treatment such as scarification with sandpaper, soaking in water and immersion in hot water. Nevertheless, there is little information about the propagation and initial development of some of these species under the conditions of the country (Sánchez and Ramírez, 2006; Hernández *et al*., 2011; Ramírez *et al*., 2012), specifically in the Zulia state.

Therefore, the objective of this work was to evaluate the effect of different pre-germination treatments, as well as the morphological characteristics of the emerged seedlings, in four forage tree legumes (*Albizia lebbeck*, *Prosopis juliflora*, *Samanea saman* and *Enterolobium cyclocarpum*), present on the Maracaibo plateau, Zulia state, Venezuela.

MATERIALS AND METHODS

Study location. The trial was conducted in the university nursery of the School of Agronomy, University of Zulia (LUZ), Zulia state, Venezuela. It is located at 10º 41' 12" North latitude and 71º 38' 05" West longitude, at an altitude of 25 masl. In addition, it is framed in an ecological zone of very dry tropical forest, with rainfall from 500 to 600 mm per year; and annual temperature averages of 29 ºC, relative humidity of 79 % and evapotranspiration of 2 500 mm (Sánchez and Ramírez, 2006).

Seed collection, preparation and storage. The *A. lebbeck* and *P. juliflora* seeds were collected from mature pods of trees belonging to the green areas of the School of Agronomy, University of Zulia; the *S. saman* seeds, in the farm "El Táparo", of the Jardines del Lago sector; and the *E. cyclocarpum* seeds, in the farm "Las Marías", El Laberinto sector (both farms are located in the José Ramón Yépez parish, Jesús Enrique Lossada municipality, Zulia state). In the case of *A. lebbeck*, the pods –dry and yellow– were taken before dehiscence occurred. Before extracting the seeds, the pod ends, apex and basis, were discarded in the four species; as well as those pods with mechanical and insect damage. In *A. lebbeck*, *E. cyclocarpum* and *S. saman* the seeds were extracted, those of higher size were selected and the small, deformed, flattened and perforated by insects were discarded; this last condition was frequent in *A. lebbeck*. The *P. juliflora* pods were soaked in drinkable water during four days, with water change every 12 h. Afterwards the seeds were extracted with the endocarp –hard squared structure that encloses the seed– (Sánchez and Ramírez, 2006), they were rubbed several times with a metallic mesh to eliminate the fruit remainders and the very small seeds were discarded. The endocarp was carefully removed from a group of seeds with a pair of scissors.

In the four species, the seeds were selected and then washed, protected with the fungicide Vitavax® and stored, according to the description made by Ramírez *et al*. (2012); although they were dried during four days. After the fungicide application, the *A. lebbeck* seeds were sprayed with the insecticide Lorsban®4E (Chlorpyrifos) at 1 %, because during the selection many of them were detected to be perforated by weevils near the embryo. The *A. lebbeck* seeds were stored for 21 days; the *E. cyclocarpum* and *S. saman* seeds, for 1 and 3 months; the *P. juliflora* seeds with endocarp, during 1, 6, 12, 18 and 24 months; and the *P. juliflora* seeds without endocarp, for 1 and 3 months.

Treatments. In the *A. lebbeck* seeds two trials were conducted. The first one consisted in six treatments generated from the combination of scarification with sandpaper (SS) No. 80, during 0, 20 and 40 minutes –in four and eight sessions of five minutes each– with the immersion in hot water (IHW) at 80 ºC, for 0 and 5 minutes; afterwards, they were removed from the water. In the second trial six soaking times (ST) in drinkable water were evaluated: 0, 6, 12, 24, 36 and 48 hours, at room temperature (29 ºC) and with water changes every 12 hours.

In *P. juliflora* three experiments were evaluated; the first one was carried out with 24 treatments obtained from the combination of storage time (ST) of the seeds with endocarp (0, 1, 6, 12, 18 and 24 months) and soaking in water (0, 24, 48 and 96 hours), with changes every 12 hours. In the second trial ten treatments were applied from the combination of IHW time (0, 5, 10, 15 and 20 minutes) using seeds with endocarp –fresh or stored for three months–. In the third essay the time of SS was evaluated during 0, 20 and 40 minutes, in seeds without endocarp –fresh and stored for one and three months–. Two similar trials were conducted (fourth and fifth) with the *E. cyclocarpum* and *S. saman* seeds. The seeds planted immediately after the process of extraction, selection and protection (with fungicide and/or insecticide) were called no-storage or fresh seeds.

Seeding. The planting of the *E. cyclocarpum* and *S. saman* seeds, as well as that of the first trial of *A. lebbeck* and *P. juliflora* was made on beds with substratum of sand (plant layer) and organic matter (washed cattle manure) in a 2:1 rate, previously disinfected with hot water. In each treatment four rows, 100 cm long separated by 10 cm, were used. In each row 50 seeds were planted, with a 2-cm separation. In the other experiments of *A. lebbeck* and *P. juliflora* the seeds were planted in black polyethylene trays, with 50 holes (5 cm wide and long x 8,5 cm deep), and the above-described

substratum was used; one seed was planted per hole and four trays were used for each treatment.

Seeding depth, in the beds as well as in the trays, was 1 cm. Irrigation was manually performed, every two days on the beds and daily on the trays. Weed control was manually done, once every week. The trials of *A. lebbeck*, *E. cyclocarpum* and *S. saman* were conducted in the propagator area which was covered by saran-type mesh, providing 40 % of shade. The *P. juliflora* trials were located in an area under full sunlight, because it had been previously observed that emergence and seedling growth were lower and slower under shade (unpublished data).

Measured variables. The number of emerged seeds was counted and the plumule emergence was considered, to determine the emergence percentage (EP) and the emergence rate (ER) (Perozo, Ramírez, Gómez and Buitrago, 2006). Twenty-four days after planting *A. lebbeck*, *E. cyclocarpum* and *S. saman*, and 56 days after planting *P. juliflora*, the following variables were evaluated: seedling height (SH), root length (RL), number of leaves (NL), number of nodes (NN), and stem diameter (SD). SH and RL were measured in centimeters, with a graduated ruler; SH was measured from the shoot apex to the base of the seedling, and the RL was measured from the latter to the apex of the main root. In order to determine the NL and NN, the number of leaves and nodes present in each plant was counted. The SD was measured in millimeters with a *vernier* caliper.

Experimental design and statistical analysis. In each species, a randomized block design was used, with factorial arrangement and four repetitions; except in the second experiment of *A. lebbeck*, in which there was only one study factor with six levels of water soaking. The statistical analysis was made through the GLM (general linear model) procedure of the SPSS program, version 12 (Pérez, 2005). The interactions were determined by means of the least squares difference (LSD) test. The EP was transformed through the arcsine $(x+1)^{1}/_{2}$ equation to adjust it to normality. In addition, the descriptive statistics was calculated: means, standard deviations, minimum and maximum values, as well as the modes and medians of SH, RL, NL, NN and SD.

RESULTS AND DISCUSSION

In the *A. lebbeck* seeds, the effects of the SS and the IHW, as well as the interaction between the SS and the IHW, had significant effects only on the variable EP, 20 days after seeding (table 1). The SS –during 20 and 40 minutes without IHW– had a similar performance, but it was different from the other treatments and allowed to obtain the highest EPs; although the value at 20 minutes was a little higher. The IHW for five minutes severely reduced emergence, only few seeds could emerge since day 12; afterwards it remained constant.

This proved that the water temperature at 80 ºC during five minutes inhibited emergence in this species, which is associated to the death of the embryo of most seeds; the embryo's susceptibility to high temperatures suggests the evaluation of temperatures and exposure times lower than the ones used in this study. This result also showed that the seed coat is likely to have a thin impermeable layer which is easily softened when submerging the seeds in hot water. In studies conducted with *Leucaena leucocephala* and *Peltophorum pterocarpum* high EPs (91.5 and 84,0 %, respectively) have been obtained using the same temperature during a longer time -10 minutes– (Atencio, Colmenares, Ramírez and Marcano, 2003; Sánchez and Ramírez, 2006). The inhibiting effect of high temperatures on the embryo was also apparent in *A. lebbeck*, when the seeds were put in water at 80 ºC, during three minutes (Navarro, 2009); as well as in leucaena, under conditions of 100 ºC, for 60 seconds (Sánchez, 2002). Nevertheless, with *A. lebbeck* seeds –subject to 80 ºC, for three minutes, and a control– the EPs were observed to be very similar (22.9 and 20.6 %, respectively) (Navarro, Febles, Torres y Noda, 2010). On the other hand, in fresh seeds scarified with water at 80 ºC, during two minutes and placed in chamber alternating temperatures of 25 and 35 ºC, germination was 43.2 % (González, Sánchez, Reino y Montejo, 2009).

The EPs of *A. lebbeck* indicated that it is convenient to use scarification with sandpaper during 20 minutes, because the amount of seedlings increased in 24.3 %, when compared with the seeds without pre-germination treatment. This type of scarification allowed to break the physical dormancy and removed the first layers of lignified cells, present in the seed coat (Sánchez and Ramírez, 2006); this facilitated the hydration phase of the seed, the gaseous exchange and the onset of the enzymatic processes that occur in the first stages of germination, which favors seedling emergence (Atencio *et al*., 2003; Sánchez and Ramírez, 2006; Ramírez *et al*., 2012). Mutha, Bohra,

Burman and Harsh (2004) also reported that mechanical scarification increased emergence in *A. lebbeck*, which coincides with the results of this experiment.

In general, *A. lebbeck* emergence began since the fourth day, with progressive increases until day 16, and then it became constant (table 1). The seeds scarified with sandpaper reached the highest EPs (between 40,3 and 53,5 % of emergence) at 12 days, and between 72,2 and 81,9 % on day 16. Regarding the average number of days required for seedling emergence or ER, it oscillated between 10,1 and 12 days. Although in this variable there were no differences among the treatments, the lowest ERs were found in the seeds scarified during 20 and 40 minutes.

With relation to the times of SW at room temperature, they had significant effects on the EP in *A. lebbeck*, 20 days after seeding (table 1). No differences were detected between the seeds without soaking (0 hours) and the ones submerged in water until 24 hours –with water changes every 12 hours–, although the highest EPs were recorded; this showed that it is not necessary to soak them. Similar results were obtained by Navarro (2009) and Pereira *et al*. (2009), when soaking *A. lebbeck* seeds during 24 hours (at room temperature), with which neither increase nor decrease of their germination capacity was observed.

The SW times –equal to or higher than 36 hours– had an inhibiting effect on emergence and were higher at 48 hours, associated to the anaerobic condition that is created by a water excess trapped between the cotyledons, which could have suffocated the embryo due to a reduction in the oxygen supply (anaerobic condition); this is essential in the respiration process of seeds which occurs during germination (Atencio *et al*., 2003). No differences were found in this trial either among the treatments or soaking times for the ER, which occurred between 10,1 and 12,6 days, and is very similar to that obtained in experiment one.

The highest EP values in both *A. lebbeck* trials exceeded those reported in other studies. In this sense, in the seed germination of this species –with a month of storage at room temperature, without treatment– Navarro (2009) reported 40,1 %; and with 24 hours of soaking in water, 36,4 %. Regarding emergence, Navarro *et al*. (2010) obtained 17,8 % in seeds with –and without– 24 hours of hydration. González *et al*. (2009) reported 44 % of germination in fresh seeds scarified with water at 80 ºC, during two minutes; afterwards, they were hydrated until approximately the end of phase I of germination, and they were dehydrated before being put to germinate in chamber, alternating temperatures of 25 and 35 ºC. Ramos, Bugarín and Espinosa (2011) reached 54 % of emergence when nicking each seed. Pereira *et al*. (2009) reported 58,7 % in seeds –dark in color– without treatments; and 61,3 %, in seeds soaked during 24 hours before planting. Navarro (2009) obtained 38,9 % in fresh seeds and 40,9 %, in seeds with one month of storage (in both cases without pre-germination treatments).

The statistical analysis in *P. juliflora* showed that only the ST of the seeds and the SW showed significant differences in the EP, 42 days after seeding (table 2); the interaction between ST and SW did not influence that variable. The seeds –with endocarp– without storage reached the highest EP. This treatment was different from the other STs (1 to 24 months), among which there were no differences, and recorded the lowest EPs (between 7,6 and 12,3 %). The fact that the *P. juliflora* seeds –with endocarp– stored until 24 months have shown emergence capacity (table 1) is a very important datum, for which it would be convenient to continue the studies on the dormancy and emergence of stored seeds.

The results in *P. juliflora* showed that the use of seeds with endocarp, without storage (EP: 65 %) is a technique or alternative for obtaining seedlings in this species. However, it is essential that the seeds are planted immediately after the soaking period and the protection treatment with fungicide. Such soaking in freshly collected seeds could have contributed to soften the seed coat and to the onset of the first germination phase; the radicle was not visible before seeding. The EPs largely exceeded the ones reported by Sánchez and Ramírez (2006), who achieved 29 % of emergence in seeds with endocarp collected on the same day of planting.

Regarding the SW factor, it had significant effects on the EP; the times 0, 48 and 96 hours showed the lowest percentages and were statistically equal. The seeds soaked during 24 hours in water obtained the highest EP (35.1 %), which was below the one indicated for the seeds with endocarp, planted after soaking in this work. Yet, the EP recorded at 24 hours was considered higher than the 3 % (21 days) reported by D'Aubeterre, Principal and García (2002) for seeds soaked during 24 and 48 hours.

Table 1. Effect of the time of SW and IHW on the EP and ER in *A. lebbeck* seeds.

Experiment 1		EP (%)					ER (days)
Sandpaper No. 80 (min)	Water 80°C (min)	4 days	8 days	12 days	16 days	20 days	
0	0	2,6	23,4	40,3	56,6	57,6[b]	11,5
	5			2,6	2,6	2,6[c]	12,0
20	0	20,2	40,2	53,5	81,9	81,9[a]	10,4
	5			3,0	3,0	3,0[c]	12,0
40	0	21,5	38,7	46,4	72,2	72,3[a]	10,1
	5			3,5	3,5	3,5[c]	12,0
SE ±						1,09	0,17
Experiment 2				EP (%)			ER (days)
Soaking in water (h)		4 days	8 days	12 days	16 days	20 days	
0		3,4	22,8	42	57,8	58,7[a]	11,4
6		7,6	28,9	38,2	61,7	62,9[a]	11,3
12		7,3	30,2	40,1	60,2	60,2[a]	10,8
24		18,5	35,6	42,3	65,3	65,3[a]	10,1
36		5,1	12,3	16,8	23,2	28,2[b]	11,9
48		0,6	2,6	8,8	14,2	14,2[c]	12,6
SE ±						0,62	0,18

Means with different letters significantly differ ($p < 0,05$).

Table 2. Effect of the storage time, soaking in water and SS, on the EP and ER in *P. juliflora* seeds.

Experiment 1 / Variable	Storage time in seeds with endocarp (42 das[1])						
	0 month	1 month	6 months	12 months	18 months	24 months	SE ±
EP	65,0[a]	12,3[b]	10,5[b]	10,2[b]	9[b]	7,6[b]	0,65
ER	20,5	20,6	22,9	21,4	19,6	23,2	0,29
	Time of soaking in water						
	0 h		24 h		48 h	96 h	
EP	12,1[b]		35,1[a]		15,4[b]	13,8[b]	0,31
ER	21,2		22,8		20,6	22,9	0,23
Experiment 2 / Variable	Seeds without storage		Stored seeds (3 months)				
	Hot water at 80°C (min)						
	0	5-20	0	5	10	15	20
EP	66,8[a]	-	10,5[b]	63,5[a]	17,1[b]	18,1[b]	17[b]
ER	21,3		22,2	20,8	22,6	23,5	24,2
Experiment 3 / Variable	Time of SS No. 80 (min) of seeds without endocarp (28 das)						
	0 min		20 min		40 min		
EP	28,2[b]		97,3[a]		95,1[a]		1,13
ER	21,6		16,3		17,8		0,56

[1]: days after seeding
Means with different letters significantly differ ($p < 0,05$)

In the second trial with *P. juliflora* significant differences were observed among the applied pre-germination treatments in the EP of the seeds with endocarp, 42 days after seeding (table 2). When seeds with endocarp –fresh or without storage–, or stored (3 months) and previously treated with hot water during 5 minutes, were planted, high EPs (66.8 and 63.5 %, respectively) were achieved; these treatments were statistically equal. The response of the first treatment coincides with the one detected in the previous trial, and that of the second experiment, with the report by Zare, Tavili and Javad (2011); these authors stated that hot water during 5 and 10 minutes improved emergence (70-75 %), although they did not specify the temperature.

The hot water treatment (5-10 minutes) applied to the *P. juliflora* seeds without storage did not produce emergence. This performance was similar to that of stored seeds treated with water at 80 ºC for longer times (10-20 minutes), which could have caused the death of the embryo. This response is similar to the low percentage (around 3 %) reported by D'Aubeterre *et al*. (2002), when using water at 80 ºC during 5 and 10 minutes of exposure. It is important to mention that the EPs in the times of exposure to high temperatures (from 10 to 20 minutes) showed the adaptation or tolerance capacity of the *P. juliflora* seeds.

In the third *P. juliflora* trial –with seeds without endocarp (table 2)– and in the one with *E. cyclocarpum* and *S. saman* (table 3), the SS time showed significant differences only in the EP, at 42 days; the ST and the interaction between the SS and ST did not cause differences in EP. The three species showed high EPs in the seeds stored during three months; if it is considered that the *P. juliflora* seeds did not have the endocarp, it would be convenient to continue the studies with higher STs. The SS during 20 and 40 minutes was statistically similar in the *P. juliflora* seeds without endocarp, as well as in the *E. cyclocarpum* and *S. saman* seeds; both times allowed the highest EPs (tables 2 and 3). Thus, the SS during 20 minutes was enough to break seed dormancy in the three tree legumes. The EP in the *P. juliflora* seeds without endocarp and without scarification coincides with the report by Sánchez and Ramírez (2006), who obtained 15,7 and 11.5 % of emergence in fresh *P. juliflora* seeds without endocarp, or with 21 days of storage. It was also similar to the EP (21,5 %) in non-scarified seeds without endocarp (Miranda *et al*., 2011). The EPs in the *P. juliflora* seeds without endocarp, scarified during 20 minutes, were similar to the ones reported in other studies (Reginald, Avin and Al-Minji, 2007; Miranda *et al*., 2011; Zare *et al*., 2011), although the exposure time was not mentioned and in some of them the number of the sandpaper used was not specified.

The results are also similar to the ones reported by Ramos *et al*. (2011), who obtained 57 % of emergence in *P. juliflora* seeds. The ER in *P. juliflora* seeds without endocarp occurred between 16,3 and 21,6 days, and was a little lower in the scarified seeds (table 2).

Regarding *E. cyclocarpum*, the seeds showed a high degree of dormancy due to the impermeability of their coats, which could be broken by scarifying them with sandpaper during 20 minutes, thus obtaining 100 % of emergence. The EPs of *E. cyclocarpum* exceed that indicated by Ramos *et al*. (2011) in scarified nicked seeds, and the one reported by Hernández *et al*. (2011) in the control seeds. In addition, they are different from the study conducted by Robles (2010), who obtained between 99 and 100 % of emergence for three types of seed size without treatments. The SS treatments had significant differences in the ER of *E. cyclocarpum*. Emergence occurred approximately six days after planting, when the seeds were scarified with sandpaper (table 3); in this regard, Robles (2010) observed that emergence occurred between three and 10 days after seeding.

The EPs of *S. saman* indicated that the control seeds (without pre-germination treatments) had high germination capacity (81,9 %), which increased to 100 % of emergence when they were scarified with sandpaper for 20 minutes. These EPs stand out with regards to those reported by Gómez, Olivera and Botello (2009) for fresh control seeds (29 %), submerged in water at boiling point during 15 minutes (67 %) and at room temperature for 24 hours (69 %), 30 days after planting. Regarding germination, Kabir, Zafar and Shafiq (2011) reported 88,3 % in *S. saman*, 12 days after placing the seeds on Petri dishes with distilled water. The ER of *S. saman* occurred between 11,5 and 13,6 days (table 3).

In this study it was found that the scarification with sandpaper during 20 minutes allowed obtaining high EPs in the four forage tree species. This technique is environmentalist, simple, practical and economical; it can be performed manually by introducing the seeds in a cylindrical container (for example, food containers which have

Table 3. Effect of the time of scarification with sandpaper on the emergence percentage and emergence rate in *E. cyclocarpum* and *S. saman*.

Time of SS (min)	EP (%) *E. cyclocarpum*					ER (days)
	4 days	8 days	12 days	16 days	20 days	
0	-	-	-	10	12,5[b]	16,8[a]
20	63,8	81,3	93,8	100	100[a]	6,4[b]
40	67,5	81,3	92,5	97,5	97,5[a]	6,1[b]
SE ±					2,03	1,76
			S. saman			
0	8,3	21,7	36,2	58,3	81,9[b]	13,6
20	15	45	70	82,5	100[a]	11,5
40	16	43,2	67,1	78,4	98[a]	11,6
SE ±					0,41	0,39

Means with different letters significantly differ ($p<0,05$).

13 cm of diameter x 16 cm of height), covered inside with sandpaper, to make gyratory movements with the hands afterwards, in five-minute sessions –or less–. In case of scarifying lots of moderate- and large-size seeds, a system could be created with several cylinders connected to a crank, or the system could be automated with the aid of an engine that allows low-speed turns.

In the four species, the evaluated treatments did not produce significant effects on the SH, RL, NL, NN and SD (table 4). Those variables showed low values of standard deviation and variation coefficients, lower than or very close to 20 %; although in them there was a considerable range between the highest and the lowest value. The mode and the median of most variables were similar, which indicated that they had a normal trend. These results proved that the seedlings of *A. lebbeck*, *P. juliflora*, *E. cyclocarpum* and *S. saman* showed a normal and homogeneous aspect, as well as low variability; such characteristics were ascribed to seed selection and preparation, which allowed an excellent quality. In some studies it has been reported that germination and emergence depend on seed quality (Perozo *et al*., 2006; Flores, Moratinos, Ramírez and García, 2009; Yüceda and Gültekin, 2011; Ramírez *et al*., 2012).

The initial development of *E. cyclocarpum* and *S. saman* was the fastest, because they showed the highest seedling height around 24 days after planting. They were followed by *A. lebbeck* and, finally, *P. juliflora* (56 days), which recorded the highest number of leaves and nodes. Regarding the morphological variables, some bibliographic references only specify SH and NL for *A. lebbeck*, *P. juliflora* and *E. cyclocarpum* under the conditions of the Mexican state of Nayarit; and classify the first two as species of lower or slow growth, and *E. cyclocarpum* as higher (Ramos *et al*., 2011), which coincides with the observations made in the experiments; although in this case *P. juliflora* differed because it showed higher NL. Under laboratory conditions, on Petri dishes at 20 ºC, a SH of 7,6 cm has been found 12 days after planting (Kabir *et al*., 2011).

In this research, the SH and NL of *S. saman* and *E. cyclocarpum* at 24 days are close to the report by Ramos *et al*. (2011) 21 days after planting for *E. cyclocarpum* (SH: 15 cm and NL: 5,5); although they differ a little from *A. lebbeck* (SH: 7 cm and NL: 2,5) and *P. juliflora* (SH: 17 cm and NL: 6,2) at 42 days. Robles (2010) reported that the SH in *S. saman* oscillated between 23,74 and 29,62 cm, values which are higher than the ones obtained in this work. It is important to emphasize that in the four species the presence of nodules in the roots was observed (between 95 and 100 % of the seedlings), associated to the symbiosis with the nitrogen-fixing *Rhizobium*, in agreement with the report by Yüceda and Gültekin (2011). The success in transplant was also high, around 98 %.

The information generated in this research, regarding applied treatments to improve emergency and the morphological characteristics of *A. lebbeck*.

Table 4. Morphological characteristics of *A. lebbeck*. *P. juliflora*, *E. cyclocarpum* and *S. saman* seedlings.

Variable / Indicator	SH (cm)	RL (cm)	NL	NN	SD (mm)
	A. lebbeck (24 das)				
Mean	10,1	19,3	4,9	4,7	1,6
Standard deviation	0,9	2,9	0,4	0,5	0,4
Maximum value	11,6	16,2	4,1	4,0	1,1
Minimum value	8,2	23,6	5,5	5,5	2,0
Mode	9,9	16,2	5,0	4,1	1,7
Median	10,1	19,1	5,0	4,7	1,7
Variation coefficient (%)	8,6	14,8	9,1	10,4	16,5
SE±	0,25	0,83	0,12	0,14	0,15
Observations: 356					
	P. juliflora (56 das)				
Mean	17,5	19,6	14,9	14,0	1,8
Standard deviation	1,8	1,5	2,1	2,2	0,4
Maximum value	19,9	18,0	12,0	11,0	1,2
Minimum value	13,1	22,4	18,6	17,4	2,4
Mode	17,7	18,0	13,0	16,9	1,9
Median	17,5	19,1	14,1	14,3	1,9
Variation coefficient (%)	10,2	7,7	13,8	15,9	21,0
SE±	0,49	0,44	0,57	0,62	0,11
Observations: 372					
	E. cyclocarpum (24 das)				
Mean	13,4	15,6	5,1	4,8	1,5
Standard deviation	2,7	2,9	0,8	0,9	0,3
Maximum value	9,1	11,5	4,0	4,0	1,1
Minimum value	16,7	19,5	6,0	6,0	1,9
Mode	11,3	13,2	6,0	6,0	1,1
Median	12,6	14,7	5,1	4,3	1,5
Variation coefficient (%)	19,8	18,3	16,3	19,5	20,3
SE ±	0,71	0,77	0,22	0,27	0,09
Observations: 378					
	S. saman (24 das)				
Mean	14,8	18,4	6,1	5,5	1,4
Standard deviation	1,5	1,3	0,8	0,6	0,3
Maximum value	12,3	16,2	5,0	4,2	1,1
Minimum value	17,8	20,9	7,0	6,3	1,9
Mode	14,3	18,0	7,0	5,2	1,2
Median	14,5	18,3	6,0	5,2	1,2
Variation coefficient (%)	10,4	7,2	13,4	11,7	21,0
SE ±	0,43	0,38	0,23	0,17	0,09
Observations: 536					

SH: seedling height, das: days after seeding, SD: stem diameter, RL: root length, NL: number of leaves, NN: number of nodes.

P. juliflora, *E. cyclocarpum* and *S. saman* seedlings could be considered as a great contribution for the propagation of these species in Venezuela and in the Zulia state, because nowadays there is a lack of information about them. According to the SHs and RLs, it is convenient to plant directly in bags with a height higher than the RL, in order to prevent malformations of the root system. In the case of the transplant from seedbeds or trays to bag, it is suggested to be done as early as possible, as the seedlings reach a minimum of three true leaves, independently from the fact that most of them have not emerged, in order to achieve success. It decreases as the plants are taller, because it causes higher physiological stress (Flores *et al*., 2009; Ramírez *et al*., 2012).

The SS treatment was concluded to improve noticeably the emergence of the four tree legumes and quicken it in *E. cyclocarpum*. The seedlings showed normal and homogeneous growth: in *E. cyclocarpum* and *S. saman* it was fast; in *A. lebbeck*, moderate; and in *P. juliflora*, slow. According to the storage times, the *P. juliflora* seeds with endocarp can remain viable up to 24 months; while the *P. juliflora* seeds without endocarp, as well as the *E. cyclocarpum* and *S.saman* seeds –stored for three months– showed high emergence percentages, for which to continue the studies with this factor is required.

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UNIVERSIDAD AGRARIA DE LA HABANA "FRUCTUOSO RODRÍGUEZ PÉREZ", FACULTAD DE AGRONOMÍA, CENTRO DE ESTUDIOS DE DESARROLLO AGRARIO Y RURAL

ESTACIÓN EXPERIMENTAL DE PASTOS Y FORRAJES "INDIO HATUEY"

TESIS PRESENTADA EN OPCIÓN AL GRADO CIENTÍFICO DE DOCTOR EN CIENCIAS AGRÍCOLAS

Título: Modelo de gestión estratégica. Experiencias en la UBPC "El Zapato", municipio Martí, provincia de Matanzas

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En algunas organizaciones productivas agropecuarias cubanas se han formulado estrategias, sin embargo, aún no se dispone de un proceder organizativo (por ejemplo, modelo y procedimientos asociados) consciente, integrador y sistematizado, para la gestión estratégica que apoye las decisiones. Ello generó la necesidad de concebir un modelo de gestión estratégica para apoyar la toma de decisiones; apropiado en estas organizaciones. Se parte de diversos modelos conceptuales y de aplicación, asociados a la educación, la investigación agropecuaria y el desarrollo local, con énfasis en el modelo CIPP, para brindar una concepción del modelo de gestión estratégica (MGE), con las premisas y características que lo sustentan; el modelo se estructura en cuatro etapas interconectadas, que permiten formular la planificación estratégica, y su posterior implementación y control, con un enfoque holístico, como fundamento del conjunto de procedimientos desarrollados que constituyen su estructura metodológica, auxiliados de un sistema de información geoespacial y de indicadores que apoyan la toma de decisiones. Para su implementación, a partir del año 2006, la UBPC "El Zapato" fue objeto de estudio práctico, lo cual mostró la posibilidad y conveniencia de que dicho modelo constituya un instrumento pertinente para apoyar la toma de decisiones dirigidas a establecer programas de desarrollo sostenible en unidades básicas de producción cooperativa. Esta implementación permitió demostrar la hipótesis general de investigación, por la capacidad explicativa, consistencia lógica, factibilidad, flexibilidad y pertinencia del MGE, integrándolo a los procesos de toma de decisiones, así como apreciar los resultados tangibles e intangibles derivados de su implementación.