

Performance of tree species in two arboretums of the Institute of Animal Science

G. Achan, G. Febles, T. Ruíz, J. Alonso and Aida Noda

Instituto de Ciencia Animal, Apartado Postal 24, San José de las Lajas, Mayabeque, Cuba

Email: gachan@ica.co.cu

Information is provided about the performance of tropical trees and shrubs that can be used in agricultural areas for different productive aims. The technique of multivariate analysis (clusters) was applied for data processing. The arboretum 1 was sown with 50 species in the Experimental Center of Pastures and Forages, and the arboretum 2 with 36 species in the cattle unit "Genético 4", both facilities are located at the Institute of Animal Science. Out of all the species of the arboretum 1, *Adenantha pavonina*, *Enterolobium contortisiliquum*, *Sophora tomentosa*, *Siderocarpus flexicaulis*, *Bauhinia purpurea*, *Pongamia pinnata* and *Lonchocarpus punctatus* were noteworthy due to their higher survival (100%), growth, and lower acceptance. In the arboretum 2, *Caesalpinia paucijuga*, *Peltophorum affricanum*, *Enterolobium contortisiliquum*, *Casia moschata*, *Albizia lebbekoides*, *Colvillea racemosa* and *Moringa oleifera* reached greater height, and agreed with those of higher survival. The most consumed genera in the two arboretums were *Erythrina*, *Bauhinia* and *Albizia*. The species of greatest intake in the two arboretums was *Albizia caribaeae*, and those of lowest, *Enterolobium contortisiliquum* and *Siderocarpus flexicaulis*. Further studies are recommended about those of best performance, mainly in the arboretum 1, which could have insecticide action.

Key words: *arboretum, survival, growth, acceptability*

Trees and shrubs play a preponderant function in the environment sustainability and harmony. In Cuba, studies of Febles *et al.* (2001) reported that these characteristics should predominate in current cattle production conditions, primarily in tropical and subtropical developing countries, and even in the developed countries. In this regard, in regions such as Nigeria, Cobbina *et al.* (1990) and Gutteridge (1990) have developed several studies on tropical tree species selection.

The setting of arboretums in any region of the world, in research, educational and production centers, has various and important objectives. Among them, it is noteworthy their utilization as naturalist sampling of important plants in cattle production and other sectors, and as educational material for their direct use in pre-graduation and post-graduation teaching. Arboretums permit knowing and identifying a great diversity of species from various families in a relatively small space. Besides, they are educational material for researchers related to physiology, biochemistry, nutrition, husbandry, animal and plant management and production, among others.

The Department of Pastures and Forages at the Institute of Animal Science works since, approximately, 1990 in the preliminary evaluation, selection and discrimination of tree and shrub species, mainly from the Meliaceae, Verbenaceae, Moringaceae and Leguminosae families.

In order to make more precise these considerations, this study stemmed from the criteria of Garea (2006), who noted that the evaluation and monitoring system is a dynamic, technical, rigorous, transparent and educational process, supported in data, information, sources, and diverse and trustworthy agents incorporated to the

process of decision making.

The objective of this work was presenting information on the performance of tree species, sown in two arboretums located at the Institute of Animal Science.

Materials and Methods

Procedure. The seeds of all the species came from periodical collections performed in the Botanical Garden of Cienfuegos and in the National Botanical Garden. The species were sown in a crystal house, in polyethylene bags, at a rate of two seeds per bag. The seeds were sacrificed mechanically, making a small cut in the upper part, in the area contrary to the embryo location.

At the start of the rainy season, when the plants were of around 30 cm in height, had healthy and strong appearance, they were transplanted to the field and sown on typical red ferrallitic soil of middle fertility in Havana province (Hernández *et al.* 1999). They were distributed in furrows at 3 m apart y 2 m between plants. Throughout the experimental period, samplings were performed in three plants per species in monthly intervals. The survival and the growth of each plant were measured in centimeters with a graduated ruler. They were kept free of weeds. The corresponding weeding was performed around each of the plants. No irrigation or fertilization was applied in the experimental areas.

A test of acceptability was performed with ten dairy cows in both arboretums. The grazing was performed from 7:00 a.m. to 10:00 a.m. and the test was conducted during two rotations. The acceptability was quantified through the times each species was accepted, since the second and third day of permanence of the animals in the experimental areas. A range from 1 to 6 was used to establish the acceptability of each species, where 1 represents that of greatest intake, and 6 that of lowest.

In order to know the degree of similarity between the species, as to the growth and survival, the technique of multivariate analysis (clusters) was used through the SPSS statistical software (Visauta 2007).

Figure 1 provides the rainfall accumulation means of the five experimental years for the arboretums 1 and 2, as well as average temperatures of this period.

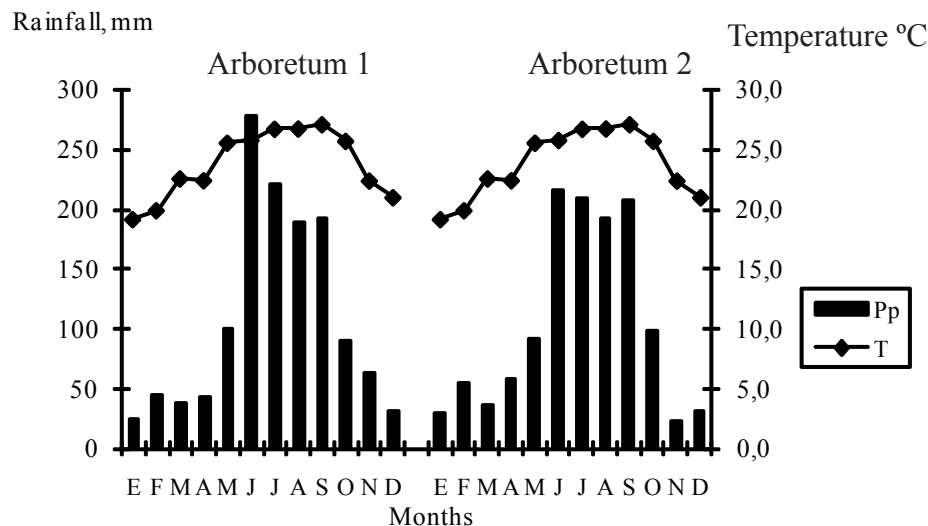


Figure 1. Performance of the rainfall accumulation (Pp) and the temperatures (T) throughout the experimental period.

Arboretum 1. Experimental Center of Pastures and Forages. Fifty species of the Leguminosae families were studied, as well as one of the Moringaceae. Five plants from each species were sown in bags in crystal houses in April, 2001. They were irrigated periodically to facilitate plant germination, emergence, and growth. Out of the 50 species previously sown in crystal house, 42 were transferred to the field. The rest did not persist.

Arboretum 2. Dairy Unit Genético 4. Thirty-six species of the Leguminosae subfamilies were used, besides Moringaceae and Meliaceae. The same procedure was performed for the sowing in crystal house. Five plants per species were sown in September, 1994.

Results and Discussion

When a research is conducted with a large group of species, varieties or ecotypes, the utilization of multivariate analysis should be conceived through some of its expressions. The information can be classified through this technique (Febles *et al.* 2007).

In this research, the group of species under study was intended to be explained and characterized, with the object of finding similarities, differences and relationships between them, in a way that further research is facilitated through adequate measures, arranged according to the productive goal.

It is noteworthy that the species that remained alive in the arboretums at the end of the experiment were

resistant to the attack of leaf cutting ants (*Atta insularis*). This outcome is transcendent, because these plants are in advantageous conditions with respect to the rest. Besides, this is the first information on the character of these species. The data from the two arboretums only provide the performance of the species that survived, that is, the species that did not survive were, mainly,

due to the stress provoked by the attack of the leaf cutting ants, referred previously by Febles *et al.* (2008) as "expression of environmental stress". These authors drew the conclusion that neither the soil nor the climatic conditions were a limiting factor for the plants express their potential (figure 1). This result will be discussed in a more comprehensive form when assessing the survival and height measures.

Table 1 shows the cluster analysis. Table 2 presents the range of acceptance by the animals in the arboretum 1. In the first instance, six groups were formed. The groups 1, 2, 3, and 5 had 100 % of survival, and the height was between 133.3 cm and 324.5 cm. In these four groups 66.3 % of the total of species was included (*Sophora tomentosa*, *Siderocarpus flexicaulis*, *Bauhinia purpurea*, *Enterolobium contortisiliquum*, *Lonchocarpus punctatus*, *Adenantha pavonina*, and *Pongamia pinnata*).

A similar performance between the species of greater survival was reported for *Adenantha pavonina* (Gutteridge 1990) in Australia and for *Bauhinia purpurea* in Cuba (Toral 2000). It was also similar for the rest, except for *Sophora tomentosa*, whose result was controversial (Febles and Ruiz 2003).

If this finding is related to the information in table 2, it can be proved that seven of the taxa were located in the scales 4, 5, 6; that is, they corresponded to the less consumed species and represented 66.3 % of the total. This showed that there could be a relationship

Table 1. Position and dispersion statistics for survival (%) and growth (cm) of the species found in the cluster analysis in the arboretum 1

Groups of variables	Species forming each groups	\bar{X}	SD
1 Survival	<i>Sophora tomentosa</i>	100.00	-
1 Growth		216.00	-
2 Survival	<i>Siderocarpus flexicaulis</i>	100.00	-
2 Growth		133.30	-
3 Survival	<i>Bauhinia purpurea</i>	100.00	-
3 Growth	<i>Enterolobium contortisiliquum</i> <i>Lonchocarpus punctatus</i>	262.57	14.26
4 Survival	<i>Bauhinia variegata</i> var. <i>candicans</i>	44.33	19.63
4 Growth	<i>Albizia caribaeae</i> <i>Erythrina berteroaana</i>	197.50	2.50
5 Survival	<i>Adenanthera pavonina</i>	100.00	-
5 Growth	<i>Pongamia pinnata</i>	324.50	24.32
6 Survival	<i>Ormosia panamensis</i>	33.30	-
6 Growth		270.00	-

Tabla 2. Acceptability by the animals of tree species in the arboretum 1.

Species	Range of intake per bovine animal					
	1	2	3	4	5	6
<i>Enterolobium contortisiliquum</i>					X	
<i>Albizia caribaeae</i>			X			
<i>Adenanthera pavonina</i>					X	
<i>Bauhinia variegata</i> var. <i>candicans</i>	X					
<i>Bauhinia purpurea</i>		X				
<i>Pongamia pinnata</i>					X	
<i>Lonchocarpus punctatus</i>					X	
<i>Sophora tomentosa</i>				X		
<i>Siderocarpus flexicaulis</i>						X
<i>Ormosia panamensis</i>						X
<i>Erythrina berteroaana</i>		X				

1 Very consumed
6 Not consumed

between both indicators and the acceptance per animal. Different performance was confirmed between the species, due to their similarities and differences.

In an earlier work, it was known that a group of trees under study were resistant to the *Atta insularis* pest (Febles *et al.* 2008). This trait agreed with a group of species showing lower acceptance in the test with the animals, greater survival and higher growth: *Sophora tomentosa*, *Siderocarpus flexicaulis*, *Enterolobium contortisiliquum*, *Lonchocarpus punctatus*, *Adenanthera pavonina*, and *Pongamia pinnata*. This latter represented 63.6 % of the total of the taxa in the arboretum 1.

It was likeable that there was some organic insecticide that might act as repellent and poison in presence of pest attack. There were evidences of

this for the *Lonchocarpus* genus (Anon 1979). The repellence and death of individuals of *Atta insularis* were observed in a test developed at the Department of Pastures at the Institute of Animal Science (Achan 2008).

In the literature revised (Roig 1974 and Febles *et al.* 2006) there is not information about most of the plants under study, mainly the corresponding to this group that survived to environmental stress during two years.

Only one work developed in Colombia (Giraldo *et al.* 2006) have been analyzed, in which the herbivorous and the foraging behavior of the leaf-cutting ant (*Atta cephalotes*) in plantation of *Montana quadrangularis*. Two plantations of this tree having *Tithonia diversifolia* or not were compared.

With this species, there was lower percentage of

hervivorous behavior in *Montana quadrangularis* (8 vs 22 %), higher general vigor of the trees, shorter period of vulnerability of the leaves to the attack of the leaf-cutting ants, absence of foraging behavior, and other characteristics in respect to the area without it.

In this same arboretum, in the cluster analysis there were two groups having four species: *Bauhinia variegata* var. Candican, *Albizia caribaeae*, *Erythrina berteroana* and *Ormosia panamensis*. They had a performance different to that of the groups 1, 2, 3, and 5; that is, the first three were quite consumed by the animals, having lower survival and lower height. These taxa were more resistant to the pest attack, which could be indicative of a process of adaptation and resistance of these species to stress.

Ormosia panamensis is the exception, although its survival was of 33 % and its height reached up to 270 cm. This species was quite resistant to the pest, which did not limit its sustained growth.

In Cuba and Australia, satisfactory results were reported, as to acceptability and growth, for *Albizia caribaeae*, *Erythrina berteroana* and *Bauhinia variegata* var. Cándida, and the rest of the species (Rivero y Licea 2004 y Toral *et al.* 2006), except for *Sophora tomentosa*, whose result was controversial (Febles y Ruiz 2003). Nevertheless, some of the plants cited did not have a satisfactory performance, which could be related to the different responses to the environment where they grow (Febles and Ruiz 2003).

Tables 3 and 4 provide information of the arboretum

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2. Out of 15 species as total, six groups were formed. Out of them, three gathered eight taxa, for 53.3 % of the total.

These groups were outstanding due to their higher survival (group 1, 2 and 4). In respect to growth, in group 1 and 4 it was higher, with 700.0 cm and 950.0 cm, respectively. The group 2 only reached 360.0 cm. The species *Albizia lebbekoides*, in group 5, was that of best growth (1200.0 cm), although with lower survival (62.5 %).

As in the arboretum 1, there was coincidence between the less consumed species. *Siderocarpus flexicaulis* and *Enterolobium contortisiliquum* are recorded in the bibliography as resistant to the pest *Atta insularis* (Febles *et al.* 2008).

Colvillea racemosa, *Albizia caribaeae*, and *Bauhinia acuminata* were more accepted by the animals. This agreed with the observation for the arboretum 1 and with the criteria of Toral and Simón (2001) and Toral *et al.* (2006) for the *Albizia* genus in Cuba.

The rest of the species were grouped in the cluster 3: *Moringa oleifera*, *Albizia lucida*, *Bauhinia acuminata* and *Caesalpinea mexicana*. In Cuba, studies of Febles *et al.* (2008) reported lower height and survival, as well as lower resistance to the environmental stress provoked by the leaf-cutting ant (*Atta insularis*), although it should be noted that they were kept present. The standard deviation was, in general, more variable than in the arboretum 1, ranging from 12.7 to 70.7, according to the group. This proved variation between the values of the biological indicators in each group, and similarity or not of the species in each.

Table 3. Position and dispersion statistics for survival (%) and growth in centimeter of the species found in the analysis of clusters in the arboretum 2

Groups of variables	Species forming each group	\bar{X}	SD
1 Survival	<i>Caesalpinea paucijuga</i>	100.00	-
1 Growth		700.00	-
2 Survival	<i>Peltophorum africanum</i>	88.40	16.13
2 Growth	<i>Siderocarpus flexicaulis</i> <i>Cassia moschata</i> <i>Peltophorum dasyrachis</i> <i>Colvillea racemosa</i>	360.00	54.77
3 Survival	<i>Moringa oleifera</i>	47.50	22.88
3 Growth	<i>Albizia lucida</i> <i>Bauhinia acuminata</i> <i>Caesalpinea mexicana</i>	125.00	50.00
4 Survival	<i>Enterolobium contortisiliquum</i>	74.00	12.73
4 Growth	<i>Albizia caribaeae</i>	950.00	70.71
5 Survival	<i>Albizia lebbekoides</i>	62.50	-
5 Growth		1200.00	-
6 Survival	<i>Pterocarpus indicus</i>	45.50	17.68
6 Growth	<i>Azadirachta indica</i>	525.00	35.36

Table 4. Acceptability of tree species by the animals in the cattle unit Genético 4, arboretum 2

Species	Range of intake per bovine animals					
	1	2	3	4	5	6
<i>Caesalpineia paucijuga</i>					X	
<i>Peltophorum affricanum</i>					X	
<i>Moringa oleifera</i>						X
<i>Enterolobium contortisiliquum</i>						X
<i>Albizia lucida</i>				X		
<i>Albizia caribeeae</i>			X			
<i>Siderocarpus flexicaulis</i>						X
<i>Bauhinia acuminata</i>			X			
<i>Cassia moschata</i>				X		
<i>Caesalpineia mexicana</i>					X	
<i>Albizia lebbekoides</i>				X		
<i>Peltophorum dasyrachis</i>						X
<i>Pterocarpus indicus</i>					X	
<i>Colvillea racemosa</i>		X				
<i>Azadirachta indica</i>					X	

1 Very consumed

6 Not consumed

When analyzing the performance of the standard deviation in both arboretums, it was lower in the indicator survival in respect to growth, where there were higher values. This result may show higher or lower variation between the species in each group. However, a deeper examination is needed.

When making a global analysis of the results of this experiment, the indicators had similarity and differences between the species, which could be of use to define research lines with different productive aims. One of the principal characteristics proved in this experiment are the elements of intra-specific variability, expressed by the large number of groups formed in the cluster analysis. This variability can be used in benefit of the genetic improvement, and be manifested in its response to the environment. Through selection, with higher genetic variability, more gains are attained in adaptation value. This analysis is of great value, considering that most of the tropical tree species have not been tamed or genetically worked to attain stable genotypes through genetic selection and improvement (Dawson *et al.* 1998).

In this study, the utilization of multivariate statistics was essential. The grouping of data was attained through the cluster analysis, which led to higher compression and grouping of the results. When there is heterogeneity between species, it is recommendable to form groups related by similarity, in a way that their study permits having adequate technical and practical alternatives (Torres 1992).

There was differentiated response between species, which constitutes an aspect of great relevance. Some taxa were more adaptable, tolerant and flexible to the

environment than others, and expressed their genotype plasticity due to the measurements and observations made.

The adaptability, aptitude, flexibility, stability, genotype plasticity, variability and tolerance, in respect to the stressing elements of the environment, are aspects expressing the phenologic performance and playing an important role in any analysis of this type (Febles *et al.* 2006).

The prevailing environment can be considered of relative selection pressure, permitting the variability in the species could be expressed freely. This consideration is not theoretical. In case it were, it could have been impossible to find variability and predict a response to the environment, positive or not, and show it in populations from the theoretical considerations. The most plastic genotype forms can colonize larger amount of environments, whereas the others can tolerate little differences, and reach a more limited distribution.

More advanced researches showed that the species in the arboretums have been used in biochemical studies that could derive in physiological and nutritional assessments. Among the most studied genera, there are *Enterolobium*, *Bauhinia*, *Albizia*, *Erythrina*, *Moringa*, *Azadirachta*, *Caesalpineia*, *Lonchocarpus*, *Sophora* and *Pongamia*. The studies were related to the phytochemical screening and the determination of secondary metabolites that could constitute anti-nutritional factors (saponins, tannins, alkaloids, flavonoids and triterpens) (Galindo 2003).

Rodríguez *et al.* (2010) studied the effect of including *Albizia lebbekoides* and *Enterolobium contortisiliquum* in the rumen fermentation of sheep. These works are

characterized by their originality and utility.

As a result of this study, at present, there is a considerable group of species that can be used with different purposes. Out of the species from the arboretum 1, *Adenantha pavonina*, *Enterolobium contortisiliquum*, *Sophora tomentosa*, *Siderocarpus flexicaulis*, *Bauhinia purpurea*, *Pongamia pinnata* and *Lonchocarpus punctatus* are noteworthy, due to their higher survival and growth and lower acceptance by the animals.

The species that remained in the arboretum 1 were resistant to the attack of leaf-cutting ants. Those that did not survive were, mainly, by the attack of this pest.

In the arboretum 2, the species attaining greater height agreed with those showing higher survival: *Caesalpineae paucijuga*, *Peltophorum africanum*, *Enterolobium contortisiliquum*, *Casia moschata*, *Albizia lebbekoides*, *Colvillea racemosa* and *Moringa oleifera*.

Erythrina, Bauhinia and Albizia were the most consumed genera in the two arboretums.

The species of greatest intake was *Albizia caribaeae*, and those less consumed were *Enterolobium contortisiliquum* and *Siderocarpus flexicaulis*.

Further studies are recommended with species showing better performance, primarily with those of the arboretum 1 from the Experimental Center of Pastures and Forages, which could have insecticide effect.

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