International Journal of Bio-resource and Stress Management 2015, 6(6):707-718

DOI: 10.5958/0976-4038.2015.00109.8

Full Research Article

Variation in Leaf Traits of 34 Trees and Shrubs in Summer Season in Linares, North-Eastern Mexico

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Article History

Manuscript No. AR1493
Received in 20th November, 2015
Received in revised form 5th September, 2015
Accepted in final form 5th December, 2015

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Keywords

Seasonal variability, specific leaf area, dry weight, moisture content

Abstract

The study undertaken in 34 species of trees and shrubs in the municipality of Linares, Nuevo Leon in Forest Faculty of Universidad Autonoma de Nuevo Leon for seasonal variations in leaf traits has revealed that there exists large variations in leaf area (cm^2), specific leaf area (cm^2 g^{-1}) and leaf dry mass (g), petiole length and moisture content both in Winter and Summer seasons. Leaf area (cm^2) ranged from 0.733 to 215.926 (cm^2), leaf dry mass from 0.006 to 1.463 (g), specific leaf area from 11.833 to 1982.780 (cm^2), leaf length from 0.700 to 51.00 (cm), leaf breadth from 0.400 to 22.400 (cm) and petiole length from 0.100 to13.00 (cm). Leaf area showed highly significant positive correlations with leaf dry weight (g) (r=0.94), leaf length (r=0.88), leaf breath (r=0.807), and petiole length (r=0.71) while the leaf dry weight showed highly significant correlation with leaf length (r=0.88), leaf breadth (r=0.775), and petiole length (r=0.734). Specific leaf area did not show any significant correlations with any of the variables studied. Therefore, leaf area, leaf length, petiole length has significant roles in plant productivity and reveals that there exists interspecific diversity among distict leaf characteristics which in turn determine distinct functional trends among the community studied.

1. Introduction

The vegetation in Northeast of Mexico localized in the centre of Nuevo Leon possesses predominantly diversity of species of shrubs and trees with diverse structure and association (Foroughbakhch et al., 1989, 2005). The vegetation of this region is exposed to extreme temperature, infertile andsaline soil and irregular low precipitation (Villanueva, 1993; Lopez, 2006; Alvarado et al., 2008). The characterization of leaf morphology based on the qualitative and quantitavecharacteristics have been documented (Gonzalez, 2001). In a study, the quantitative and multivariate statistical data (Meade and Parnell, 2003) of the leaf morphology and floral structure have been utilized on the taxonomic classification and the identification of (*Quercus*).

The patterns of foliar morphology determine the capacity of adaptaion to the environmental condition (Givinish, 1987). It is reported that the variations in foliar patterns are related with the phenological variation of the leaves depending on the gradients of altitudes, latitudes and edaphic conditions (Tang and Ohsawa, 1999). On the otherhand, the variation in morphological patterns isinfluenced by the availability of water, wind velocity, light intensity and inter specific variations (Futuyma, 1998). The foliar morphology is basically determined on genetic basis but it is exposed to intense selection pressure in the environments, thereby expressing different forms and foliar size (Aguiar et al., 2002).

A study on 10 foliar morphological traits and budburst phenology in *Ulmus minor* in two successive years in northern, central and southern Italy and in Francereveals that the chilling requirements on the trial site were not satisfied. The actual state of knowledge regarding dormancy in the *Ulmus genus* is not known well. Morphological characters seem to show a greater phenotypic plasticity with respect to phenologicaltraits (Santini et al., 2004).

The leaf area (LA) is a fundamental aspect of research on plant physiology in agriculture and dendrology (Broadhead et al., 2003). The leaf area plays an important role in the majority of the processes in agronomy, biology, environment and physiology which include the analysis of growth, photosyntheisis, transpiration, light interception, biomass estimation and water balance (Kucharik et al., 1998). The plant physiologists, biologists and agronomists have demonstrated the importance of leaf area (LA) in the growth analysis, the estimation of potential biological and agronomic yield, basis of the efficient use of solar radiation and mineral nutrition (Sonnentag et al., 2008).

The Tamaulipan Thorn scrub forest with an area of 200,000 km² in the Northeast of Mexico is constituted by deciduous, evergreen or perennial vegetation with a wide range of growth pattern, diversity of foliar length, dynamics of diverse phonological stage (Gonzalez, 2001). These species are utilized in the Northeast of Mexico for various products such as construction of fences; manufacture of agricultural equipments, besides fire woods, production of carbonand other uses in crops and pastures (Correa, 1996).

The leaf morphology may vary remarkably among species and within species with respect to structure, dimensions, types of margins, form, size of petiole, venation pattern, dry weight per unit area, moisture content, canopy, stomatal density, presence of trichomes and cuticular composition (Parker, 1982; Press, 1999). The dimensions and structures of these variablesare highly variable under different environmental conditions such as altitude (Francisca and Torres, 2003), latitude (Rico and Palacios, 1996; King and Mandonald, 1999), precipitation (Klich, 2000), temperature (Reich et al., 2004), edaphic conditions (Mallarino et al., 2001), quality and quantity of light (Pearcy and Yang, 1998; Valladares et al., 2000; Balaguer et al., 2001; Gamage et al., 2003; Kikuzawa, 2003; Reich et al., 2004), moisture availability (McDonald et al., 2003) leaf positions (Mitchell et al., 1999; Valladares et al., 2000; Gonzalez , 2001).

The leaves are sensitive to the environmental changes during the process of evolution and may exhibit phenotypic plasticity although not clearly known. Mello, (2006) undertook a simulation model toevaluate the morphological variations exposed to gradients of moisture availability and light in the leaves *Quercus acutissima* and *Robiniapseudo acacia*. Variations in size, form and venation pattern were exhibited owing to the effects of environment and or allometry. These wide morphological variations were shown along the gradients. The size ofleaf reduced with decrease in moisture content.

There exists a general hypothesis for the species with wide range of distribution, that they have a greater phenotypic plasticity compared to thosewith limited distribution (Futuyma and Moreno, 1988). The environmental changes lead to phenotypic plasticity and physiological functions). The phenotypic plasticity is one of the mechanisms of the plant for its survival to adverse environmental conditions (Bradshaw, 1965; Sultan, 1995; Schlichting, 2002). It is reported that the phenotypic plasticity is frequently represented as one form of reaction of individual plants to the environment (De Kroon et al., 2005).

In the case of the species with wide distribution there exist two models which tend to explain its success to colonize in new sites. One of the models pertains to ecotypes adapted locally and once established, each population of the species may exhibit differential changes as the result of change occurring frequently by local selection. Thus, due to this differentiation in ecotypes they can be accommodated in different environments among habitats exhibiting, the range of the distribution of the species locally. On the other hand, the alternative model considers that the individuals of widely distributed species have potential of phenotypicplasticity in response to wide range of environmental changes, thereby exhibiting tolerance to environmental changes (Gianoli, 2004).

The leaf area of a species at a particular stage is defined as the capacity of the plant cover for intercepting photosyntheically active radiation (PAR) required for elaboration of tissues and organic matter. Therefore, the growth and the productivity of a crop is the result of a genotype and its interaction with its environments (Rincon et al., 2007). Growth analysis is at present a tool for crop improvement, crop physiology and crop ecology (Poorter et al., 1996).

The main functions of the leaves are photosynthesis, transpiration, respiration and storage. The leaf characteristics are found exposed to continuous process of selection under environmental changes and have capacity to adaptation to these changes.

With respect to specific leaf area, Shipley (1995) undertook a study to determine the effects of specific leaf area (SLA) in growth characteristics in a wide variety of 34 herbaceous species. He observed that all species having large leaves had lower SLA though this pattern was not detected in the interspecific level. However, the recent studies demonstrate that the production of dry matter unit^{-1} of leaf area increase with an increase with the size of leaf and yield inversion (light capture) and decrease with an increase of leaf size (Milla and Reich, 2007; Niklas et al., 2007). This is valid both among and within the species through the production of biomass and growth forms (Milla and Reich, 2007; Niklas et al., 2007). This is probably attributed to the differences in biomass among productive tissues compared to the small leaves (Niinemets et al., 2006 and 2007). However, studies have shown general tendency of differences of these traits among species (Shipley, 1995; Niklas et al., 2007) or showed intra-specific tendency (Shipley 1995; Milla and Reich, 2007).

Alvarez (2006), analysed variation in leaf morphology in *Quercuscrassi folia* at three different stages of canopy (basal, intermediate and apical) localized in National park, El Chico, Hidalgo. Each of the characteristics viz., petiole length and others presented one pattern variation in different localities. Zuniga et al. (2009) undertook a study on leaf morphological variation of *Q. laeta,* en el Parque Nacional Los Marmoles measuring 17 morphological characters in 470 leaves collected at the middle of canopy of 47 trees, all showing normal distribution. The analysis of variance in the morphological traits showed significantdifferences in the leaves of *Q. Laeta* among localities in some morphological traitsonly.

2. Materials and Methods

The study was undertaken in June to July in the municipality of Linares, Nuevo Leonin Forest Faculty of Universidad Autonoma de Nuevo Leon (24°47´ N; 99°32´ O), at sea level of 350 m snm. The type of climate present as cited by Gonzalez et al. (2006) is subtropical and semiarid condition with hot summer. The average monthly air temperatures oscillate between 14.7 °C in January to 3 °C in August, although the common temperature in summer is 45 °C. The average annual precipitation is approximately 805 mm with a bimodal distribution. This site is situated in soils which are dark brown deep vertisols. The predominant vegetation is Tamaulipan Thorn Scrub or subtropical thorn scrub (COTECOCA-SARH, 1973; SPP-INEGI, 1986).

2.1. Vegetative materials

Fifty leaves from each species were taken at random from five plants (10 leaves from each plant). The species utilized in the present study are mentioned in Table 1. Fifty leaves were sampled (10 leaves from 5 plants) for measuring leaf length,

Table 1: List of 34 Species

Sl. no.	Species and type	Sl. no.	Species and type
1.	*Diospyros palmeri* Eastw (Ebenaceae, tree)	18.	*Karwinskia humboldtiana* (Schult.) Zucc. (Rhamnaceae)
2.	*Sargentia greggii* S. Wats (Rutaceae, tree)	19.	*Condalia hookeri* M.C. Johnst (Rhamnaceae
3.	*Eysenhardtia polystachya* Ortega, Sarg. (Fabaceae, shrub)	20.	*Croton suaveolens* Presl. (Euphorbiaceae)
4.	*Sideroxylon celastrinum* (Kunth) T.D. Penn (Sapotaceae, tree)	21.	*Cordia boissieri* A.DC. (Boraginaceae, tree)
5.	*Amyris texana* (Buckley) P. Wilson (Rutaceae, shrub)	22.	*Helietta parvifolia* (A. Gray) Benth. (Rutaceae, tree)
6.	*Bernardia myricae* folia (Scheele) Benth. and Hook. F. (Euphorbiaceae, shrub)	23.	*Forestiera angustifolia* Torr. (Oleaceae, shrub)
7.	*Leucophyllum frutescens* (Berland) I.M. Johnst (Scrophulariaceae, shrub)	24.	*Acacia rigidula* Benth (Fabaceae, tree)
8.	*Guaiacum angustifolium* Engelm (Zygophyllaceae, shrub)	25.	*Diospyros texana* Scheele. (Ebenacea, tree)
9.	*Ebenopsis ebano* (Berland.) Barneby and J.W. Grimes (Fabaceae, tree)	26.	*Quercus virginiana* Mitl. (Fagaceae, tree)
10.	*Havardia pallens* (Benth.) Britton and Rose (Fabaceae, tree)	27.	*Fraxinus greggii* A. Gray (Oleaceae, tree)
11.	*Ehretia anacua* (Teran and Berland.) I.M. Johnst (Boraginaceae, tree)	28.	*Lantana macropoda* Torr (Verbenaceae, shrub)
12.	*Celtispallida Torr* (Ulmaceae, shrub)	29.	*Gymnosperma glutinosum* (Spreng.) Less (Asteraceae, shrub)
13.	*Zanthoxylum fagara* (L.) Sarg. (Rutaceae, shrub)	30.	*Acacia farnesiana* (L) Willd. (Fabaceae, tree)
14.	*Caesalpinia mexicana* A. Gray (Fabaceae, tree)	31.	*Acacia berlandieri* Benth. (Fabaceae, tree)
15.	*Celtis laevigata* Willd. (Ulmaceae, tree)	32.	*Prosopis laevigata* (H. & B.) Jonhst (Fabaceae, tree)
16.	*Cercidium macrum* I.M. Johnst (Fabaceae, tree)	33.	*Retama sphaerocarpa* (L.) Boiss (Fabaceae, shrub)
17.	*Leucaena leucocephala* (J. de Lamarck) H.C. de Wit (Fabaceae, tree)	34.	*Acacia schaffneri* (S. Watson) F.J. Herm. (Fabaceae, shrub)

leaf breadth and petiole length. The leaf area, leaf specific area and leaf dry weight were then calculated. The leaf area (cm^2) is quantified using leaf area analyser (mark LI-COR (model LI-3100, Lincoln, Ne, USA). The dry weight of leaf is taken after drying in an oven at 60 °C for 72 hours. The moisture content (g) of the leaf is calculated measuring the difference of fresh weight and dry weight of leaf. The specific leaf area ($cm^2 g^{-1}$) is calculated as a relation of leaf area (LA) /dry weight of leaf (DRWT).

3. Results and Discussion

The thirty four species evaluated for morphological variations in leaf traits in North-eastern, Mexico, Nuevo Leon have exhibited a wide range of variability. The variations in different leaf trait variables of these species are shown in Table 2.

It is observed that the species studied (34) showed large variations in the dimension of leaf traits (Table 3). Leaf area (cm^2) ranged from 0.733 to 215.926 (cm^2), leaf dry mass from 0.006 to 1.463 (g), specific leaf area from 11.833 to 1982.780(cm^2), leaf length from 0.700 to 51.00 (cm), leaf breadth from 0.400 to 22.400 (cm) and petiole length from 0.100 to13.00 (cm).

The statistical analysis showed significant differences in leaf area (cm^2), specific leaf area ($cm^2 g^{-1}$) and leaf dry mass (g), leaf length (cm), leaf breadth (cm) and petiole length among 34 species studied.

The variables of leaf traits studied are shown graphically below (Figure 1-6). With respect to leaf area (cm^2), *C. Mexicana* had high value (109.18 cm^2), followed by *C. boissieri* (97.48 cm^2), and *L. leucocephala* (94.742 cm^2), the species *S. gregii* (66.76 cm^2), followed by *A. berlandieri* (50.58 cm^2) had medium leaf area values while *L. frutescens* (2.172 cm^2) and *F. angustifolia* (1.334 cm^2) recorded minimum leaf area values. The variability in leaf area was attributed to the variations in relative leaf lengths and leaf breadths of these thirty four species. With respect to leaf length the species *R. sphaerocarpa* exhibited maximum leaf length of (about 33.56 cm), while it was the least in *L. frutescens* (2.74 cm), *C. macrum* (1.972 cm). The species *L. leucocephala* (17.586 cm), *G. glutinosum* (16.052 cm), *A. berlandieri* (15.608 cm) showed medium leaf lengths. Maximum leaf breadth was observed in *C. mexicana* (15.582 cm), followed by *S. gregii* (13.674 cm) and *L. leucocephala* (13.436 cm). Though the species *Aberlandieri* (9.848 cm), *C. boisseri* (8.612 cm) and *H. pallens* (7.882 cm) showed medium leaf breadth values, the species *R. sphaerocarpa* (1.05 cm) and *F. angustifolia* (0.652 cm) showed minimum values of leaf breadth. These 34 species also exhibited variations in leaf dry weights, specific leaf area and petiole lengths. Highest value of leaf dry weight (0.837 g) was recorded in *C. Mexicana*, followed by *S. gregii* (0.692 g). Medium leaf dry weight values (0.678 g) and (0.624 g) were recorded in *L. leucocephala* and *C. boisieri* respectively. The species *C. macrum* (0.016 g) and *F. angustifoli* (0.009 g) showed minimum values of leaf dry weight.

With respect to specific leaf area, the species showing high values were *K. humboldtiana* (212.177 $cm^2 g^{-1}$), followed *C. hookeri* (199.191 $cm^2 g^{-1}$), *G. glutinosum* (186.996 $cm^2 g^{-1}$). The species showing medium values were *A. texana* (138.92 $cm^2 g^{-1}$), *H. pallens* (137.918 $cm^2 g^{-1}$) and those with minimum specific leaf area values were *R. sphaerocarpa* (64.532 $cm^2 g^{-1}$), *F. greggii* (59.546 $cm^2 g^{-1}$) respectively. The species *C.*

Table 3: Summary of the Kruskal-Wallis test to detect significant differences in leaf area (cm^2), specific leaf weight ($cm^2 g^{-1}$), and leaf dry weight (g) among 34 species in summer and winter, north-eastern, Mexico

Variable	Statistical	
	χ^2	Value *p*
Leaf area (cm^2)	1561.174	<0.001
Leaf drymass (g)	1550.761	<0.001
Specific leaf area ($cm^2 g^{-1}$)	1102.922	<0.001
Leaf length (cm)	1535.756	<0.001
Leaf breadth (cm)	1570.274	<0.001
Petiole length (cm)	1530.337	<0.001

Table 2: Test of normality (statistics of Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) (n=1700) for leaf parameters measured

Variable	Statistical						
	Average	Median	SD	Minimum value	Maximum value	K-S	S-W
Leaf area (cm^2)	20.557	9.263	29.842	0.733	215.929	0.257	0.639
Leaf drymass (g)	0.172	0.080	0.237	0.006	1.463	0.242	0.675
Specific leaf area ($cm^2 g^{-1}$)	129.669	123.556	76.182	11.833	1982.780	0.131	0.469
Leaf length (cm)	7.524	5.000	6.605	0.700	51.000	0.192	0.727
Leaf breadth (cm)	4.445	3.100	3.877	0.400	22.400	0.199	0.794
Petiole length (cm)	1.246	0.800	1.233	0.100	13.000	0.193	0.796

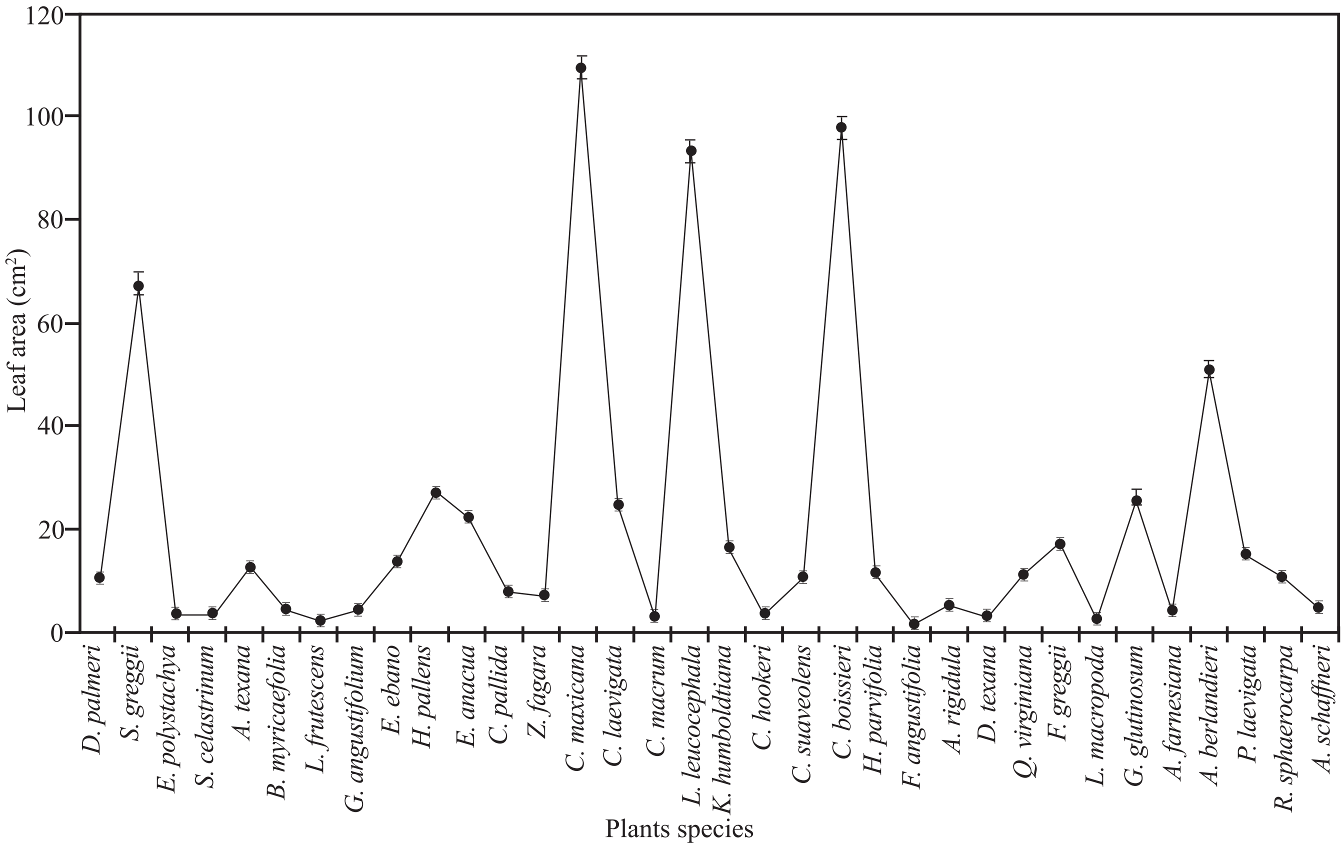

Figure 1: Variation of leaf area of 34 trees and shrubs species

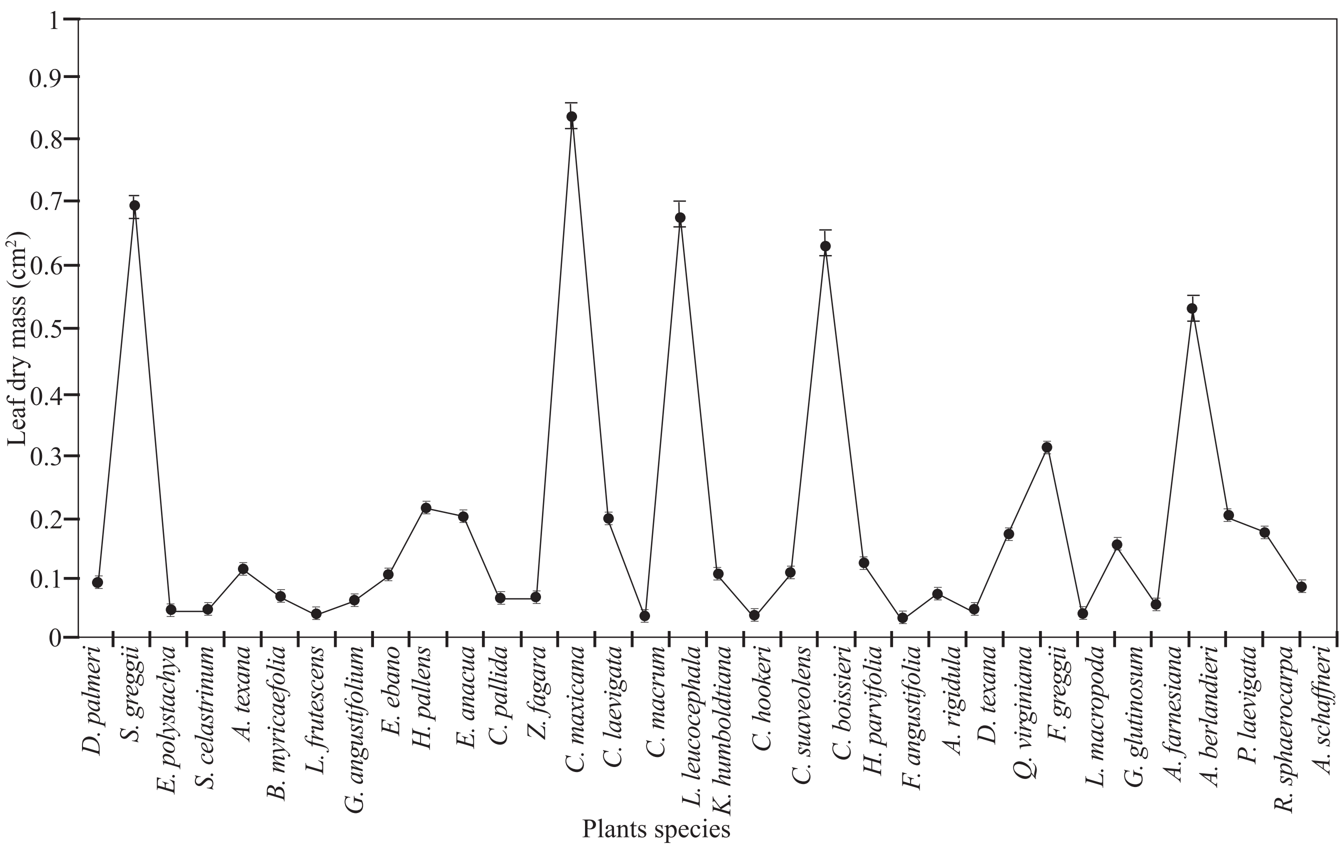

Figure 2: Variation of leaf dry mass of 34 trees and shrubs species

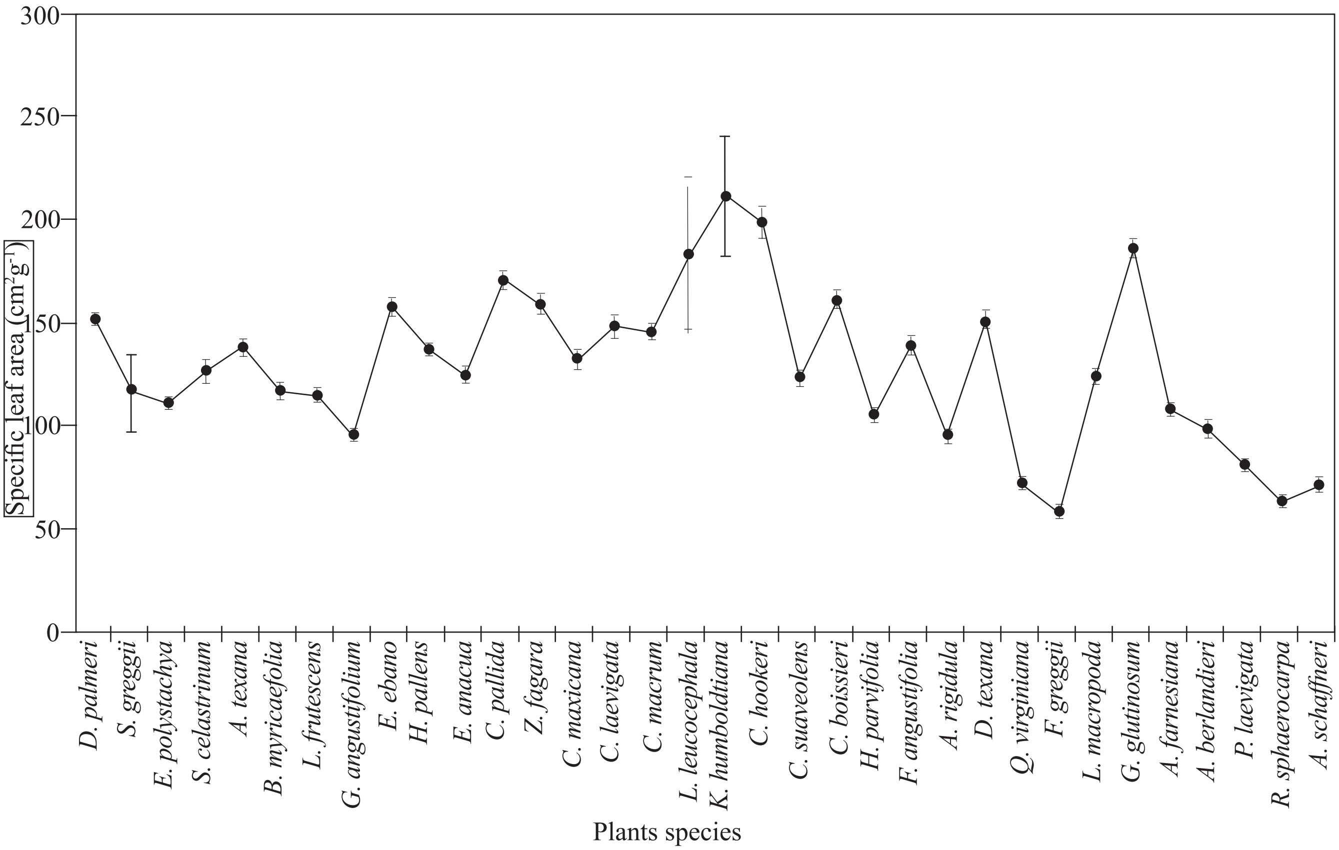

Figure 4: Variation of specific leaf area of 34 trees and shrubs species

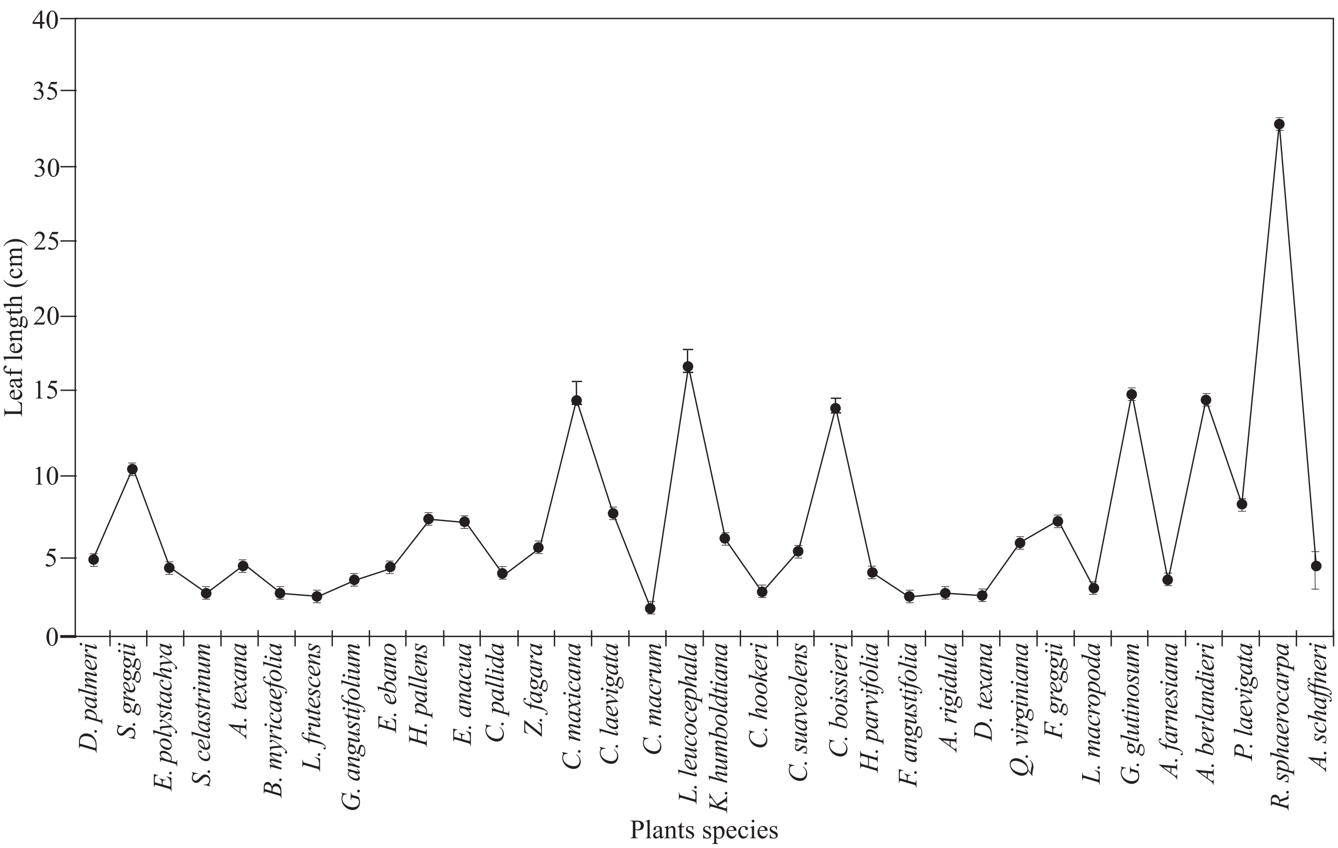

Figure 4: Variation of Leaf length of 34 trees and shrubs species

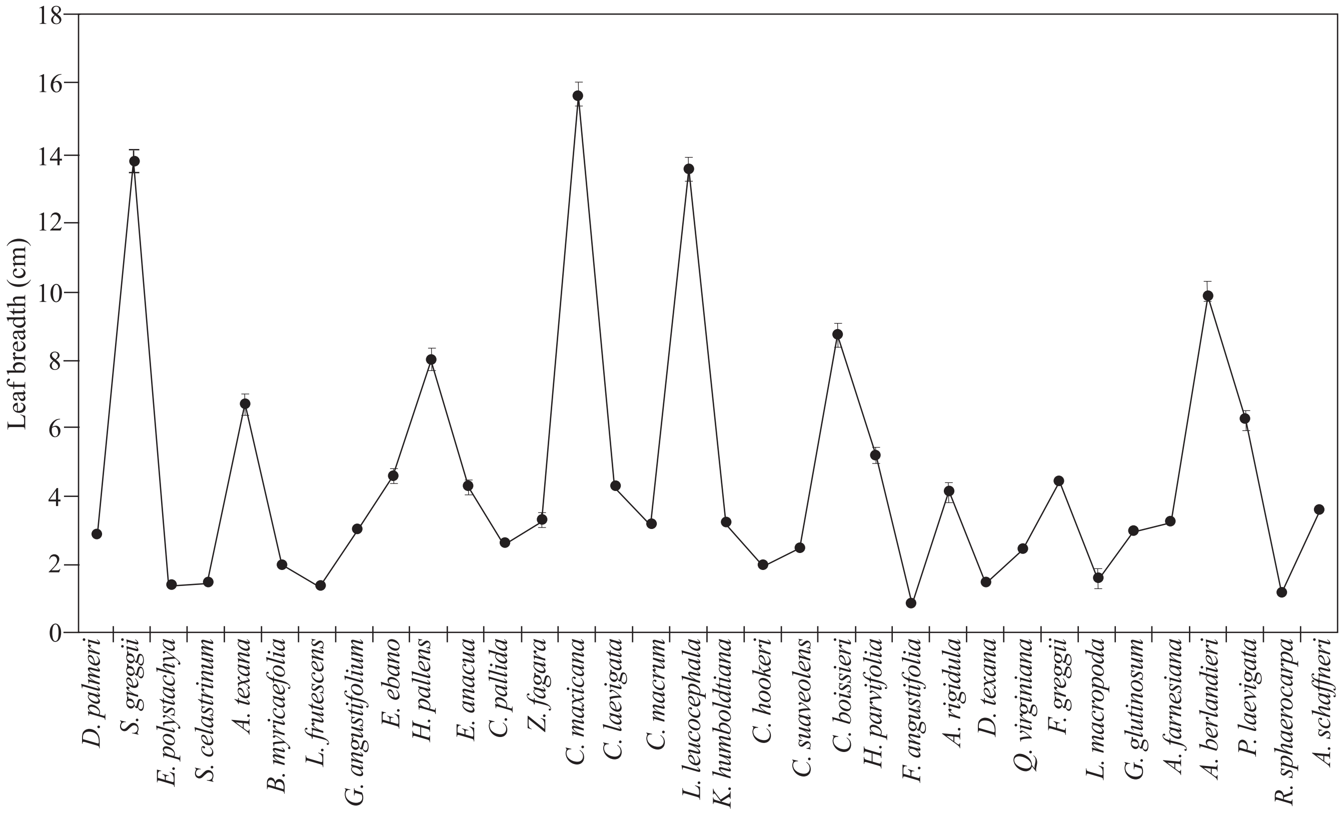

Figure 5: Variation of Leaf breadth of 34 trees and shrubs species

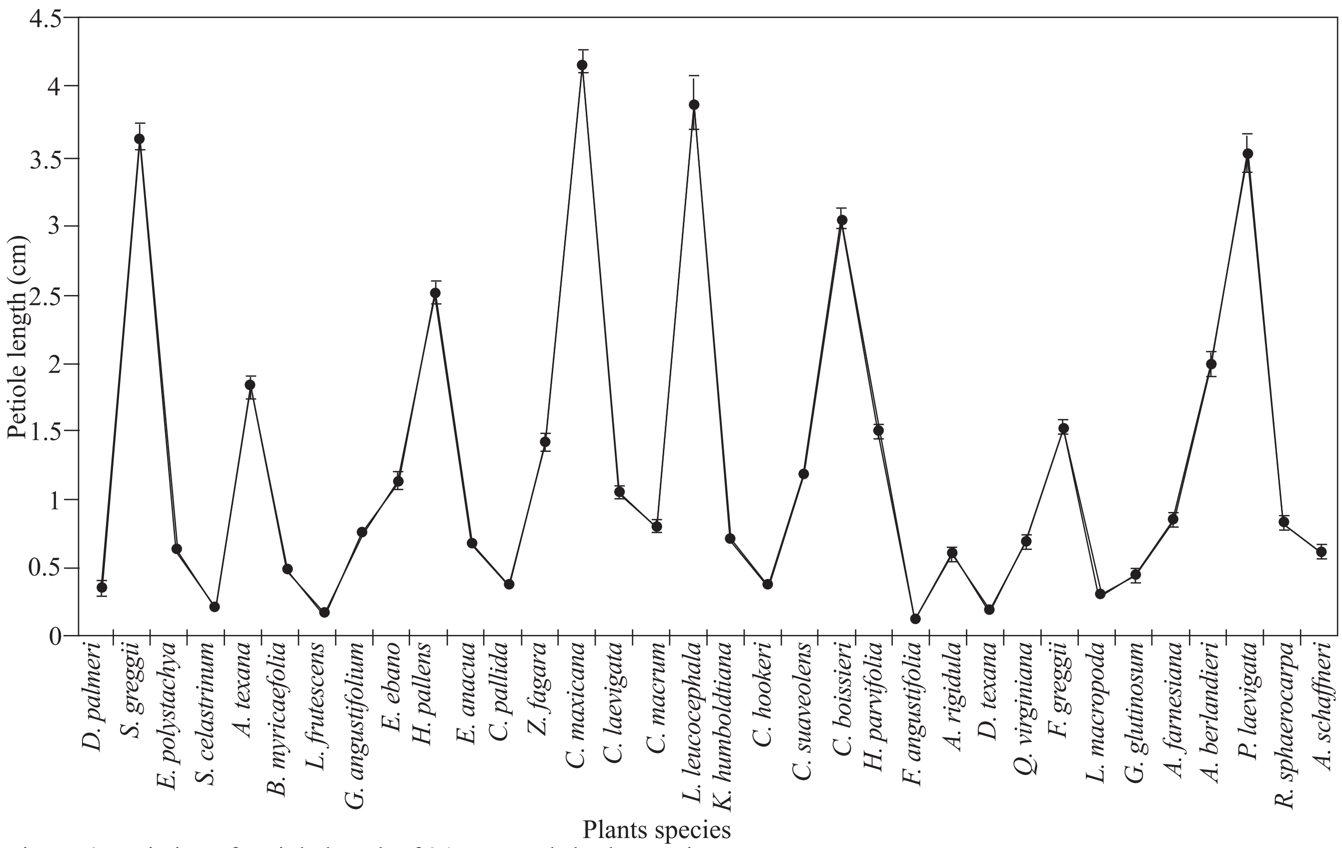

Figure 6: Variation of Petiole length of 34 trees and shrubs species

Mexicana (4.172 cm) followed by *L. leucocephala* (3.65 cm) and *P. laevigata* (3.522 cm) recorded maximum petiole length, while it was minimum in *L. frutescens* (0.156 cm) and *F. Angustifolia* (0.122 cm).

It is observed from Table 4, that there are significant correlations for some traits studied. For example, leaf area shows highly significant positive correlations with leaf dry weight (g) (r=0.94), leaf length (r=0.88), leaf breath (r=0.807), and petiole length (r=0.71). Leaf dry weight shows highly significant correlation with leaf length (r=0.88), leaf breadth (r=0.775), and petiole length (r=0.734). Leaf breadth shows highly significant correlation with petiole length (0.806). Specific leaf area does not show any significant correlations with any of the variables studied. Therefore, leaf area, leaf length, petiole length have significant roles in plant productivity.

The results observed in the present study reveal that there exist interspecific diversity among distict leaf characteristics. The distinct leaf characteristics determine distinct functional trends among the communities studied (Quero et al., 2009). With respect to leaf traits such as leaf length, leaf breadth, and petiole length, there exist wide spectrum of the foliar variations among the species studied which may vary in different environments. We oberved seasonal variations of leaf area, leaf dry weight and specific leaf area (Maiti et al., IJBSM in press). In this respect, other researchers reported that there exist a spectrum of foliar variations within a determined community and this variation may partially explain the coexistence of the species (Diaz et al., 1998). The leaf chracteristics studied by Alvarez (2006) in *Uercuscrassi folia* suggest modifications of foliar morphology are mainly attributed basically to distinct environmental factors and conditions. However, other characteristics studied are associated with the patterns of mophological architecture, which probably reflects differentiated genotypes in the regionin response to genetic changes at the local level. In the present study we observed large variations in leaf morphology with respect to leaf length, leaf breadth and petiole length showing significant correlations among them, thereby showing the role of these traits in plant productivity. The species having long petiole have advantage to push and expose the leaves for better capture of solar radiation namely *C. Mexicana* (4.172 cm), *L. leucocephala* (3.65 cm), *P. laevigata* (3.522 cm).

Some authors report that the patterns of morphological variations in the natural populations are the products of gene flow, natural selection and phenotypic plasticity (Zuniga et al., 2009). In this respect, the species of TamaulipanThorn Scrub are exposed to a diversity of adverse abiotic stress factors such as extreme temperature, nutrient deficiency and others, owing to which the species develop physiological mechanisms of adaptation to these environmental stresses (Gonzalez et al., 2000). Recently we observed large variations in leaf morphological traits, leaf surface anatomical structure, epicuticular wax which may contribute to the adaptation of some species to semiarid environments of Northeast Mexico (Maiti et al., not published). In this respect, Gonzalez and Oyama (2005) mentioned that the leaves are the main photosynthetic organs in plants. Being highly sensitive, the leaves are continuosly exposed to different environmental conditions, thereby affecting their phenologicalcycles and growth rates. Studies on these aspects are rare in this region. This information is of great importance for understanding the natural regeneration, and the processes of adaptation of the species to waterand abiotic stresses and also for taxonomy. Quero et al. (2009) working on the Mediterranean forests in the south of Iberian gulf report that there exists spectrum of leaf variations for phylogenetic diversity, which are partially determined by the climatic variationand local environmental conditions. Taking into considerations of few leaf traits we select few species for adaptation to semi-arid environments of Northeast Mexic such as *C. boissieri, C. mexicana*, *L. Leucocephala*, *S. gregii*, *P. lavaegat*a, and *R. spaerocarpa* which need to be confirmed in future studies in the context of anatomical, biochemical and physiological traits.

Besides, this diversity of morpho-physiological traits observed in the present studystrategies may contribute to the coexistence of the species within the community. In this respect, (Gonzalez et al., 2000) mention that the fresh weight of leaves among the species, might be attributed to water use efficiency and the anatomical properties among the

Table 4: Correlation coefficients (Spearman) and significance among leaf variables studied (n=1700)

Variable	V_1	V_2	V_3	V_4	V_5	V_6
V_1. Leaf area		0.940	0.083	0.880	0.807	0.710
V_2. Leaf drymass	.001		-0.226	0.882	0.775	0.734
V_3. Specific leaf area	.001	.001		-0.053	-0.003	-0.135
V_4. Leaf length	.001	.001	0.028		0.587	0.629
V_5. Leaf breadth	.001	.001	0.911	.001		0.806
V_6. Petiole length	.001	.001	.001	.001	.001	

leaves and the leaf area which in turn influence the process of transpiration, reflect the leaf moisture status. We observed large variations in leaf area and leaf dry weight in the present study. Besides as the leaf moisture content may be related to the productivity of the root systems for absorption of greater amount of water from the soil which may reflect greater turgidity of the leaves. Besides the wax content and cuticular thickness may also influence the water status of the leaves (Salisbury and Ross, 1994). We observed variations in the specific leaf area among the species which coincided with other authors that the specific leaf areaexpress the thickness of the leaves and this issensitive to environmental factors (Santos and Segura, 2005). The specific leaf area is the ratio of leaf area/dryweight which determines the adaptation of the species in a particular environment. The specific leafareaon the other hand explain to a greater extent the variation in the growth among the species. It is reported that the species with much higher growth under optimum conditions have greater specific leaf leaf area (Poorter and Garnier, 1996). An increase in specific leaf area indicates that the leaf produce lower biomass unit^{-1} leaf area. This variable is strongly related with a variety of physiological and chemical parameters. The species with greater specific leaf areaare considered to possess higher concentrations of cytoplasmic components such as proteins, minerals and organic acids. At the same time, they present higher concentrations of N and high rate of photosynthetic activity. In the present study the species with higher specific leaf area are *K. humboltdiana* (212.177 cm^2 g^{-1}), followed *C. hookeri* (199.191 cm^2 g^{-1}), *G. glutinosum* (186.996 cm^2 g^{-1}) showing better adaptation in summer. The species with lower specific area possess greater quantity of cell wall components, specifically lignin. These types of leaves are very hard and less attractive to grazing wild animals. These species are also characterized to possess greater amount of dry matter (dry weight/fresh weight), and present greater longevity in roots and leaves (Poorter and Garnier, 1996). However, each characteristic may be associated with the phylogenetic origin of each species. It is suggested that the large petiole favor greater capture of light by the leaves as observed in the present study. On the other hand, those with short petiole or sessile were overlapped and receive lower amount of light (Zuniga et al., 2009). In the present study the species with longer petiole length are *C. mexicana* (4.172 cm), *L. leucocephala* (3.65 cm), *P. laevigata* (3.522 cm) which could have greater capacity of capturing the solar radiation. Salisbury and Ross (1994) infer that the reduction of water content is accompanied by the loss of turgour and withering, leading to the cease of cellular expansion, close of stomatas, reduction of photosynthesis and the interference of many other metabolic processes. It is reported that the decrease of leaf area reduce the transpiration in the leaves exposed to strong radiations which improve water use efficiency. At the same time, the leaves with higher quantity of biomass unit^{-1} area (as observed in few species in the present study) could be more efficient in water use efficiency and nutrients in arid environments. These may be affected by nutritional variations and or moisture, light intensity, temperature, altitude, atmospheric concentration of CO_2, seasonal variations and leaf age (Navarro, 2004). The other variables which influence the leaf area is the leaf form which indicate that the greater length of the leaf and lower breadth of the same, reduce the transpiration. On the otherhand, a leaf of more oval shape tend to present more leaf area for transpiration and subsequently lower moisture content, although this variable also depends on the density of stomatas or leaf moisture and soil moisture contents (Gonzalez et al., 2000).

It may be suggested that the greater leaf area and leaf dry weight reflect a lower specific leaf area. In this respect, Perez et al. (2004) reported greater specific leaf area decrease with the lead dry weight in the leaves of pasture "mulato" (*Brachiaria* hibrido, cv). With respect to other variable leaf area studied, the species with greater leaf area *C. Mexicana* had high value (109.18 cm^2), followed by *C. boissieri* (97.48 cm^2), and *L. leucocephala* (94.742 cm^2). It has been reported by (Alvarez, 2006) that thespecies with lower leaf area (as observed in the presnt study in *L. frutescens* (2.172 cm^2), *F. angustifolia* (1.334 cm^2) might be owing to the fact that the leaves are exposed more to solar radiation and they have lower thickness (lower specific leaf area) and more oval which grow under shade. In high humid conditions, the leaves are much finer and with greater leaf area than in dry area and high temperature for water saving (Quero et al., 2009). In the context of the above facts, when the abiotic factors are more or less stable with respect to the quality and quanity of light, there was a reduction of leaf area when the incidence of light reduce in the plant canopy depending on the orientation, distribution and leaf size (Niinemets, 1998) which in turn contribute to determine morphotypes as a fuction of the the type of incident light in the canopy (Roth et al., 2001). In the case of deciduous shrubs, with respect to drought escape, they are considered better adapted to exposure to prolonged periods of water deficit; the common strategy is the reduction of leaf area, mainly for the seasonal loss of leaves (Pereira and Chavez, 1993).

4. Conclusion

In a plant, canopy leaves exhibit variability in various morphological and phonological traits in response to the climatic variabilities. These traits enable in understanding the phonological cyles and growth rates of the tree species with an adaptive feature of capturing solar radiation into the biomass. Studies on these aspects are rare in this region. This information is of great importance for understanding the natural regeneration, and the processes of adaptation of the species to water and abiotic stresses and also for taxonomy and productivity of the species.

5. Acknowledgement

The authors are highly thankful to Haydee Alejandra Dueñas Tijerina, Mayela Isabel Linan Gonzalez, and Jeff Christofher Gonzalez Diaz for their dedicated work.

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