International Journal of Bio-resource and Stress Management 2015, 6(1):041-050
DOI: 10.5958/0976-4038.2015.00009.3

Full Research Article

Branching Pattern and Leaf Crown Architecture of Some Tree and Shrubs in Northeast Mexico

Ratikanta Maiti*[1], Humberto G. Rodriguez[2], N. C. Sarkar[3] and Ashok K. Thakur[4]

[1]Universidad de las Americas, Departamento de Quimica y Biologia, Santa CatarinaMartir, C.P., Puebla (72820), Mexico
[2]Universidad Autonoma de Nuevo Leon, Facultad de CienciasForestales, Carr. Nac. No 85, km 145,
Linares, Nuevo Leon, 67700 Mexico.
[3]Dept. of ASEPAN, Institute of Agriculture, Visva-Bharti, Sriniketan, Birbhum (Dist), West Bengal (731 236), India
[4]Dept. of Seed Science and Technology, Dr Y S Parmar University of Horticulture and Forestry,
Nauni, Solan, HP (173 230), India

Article History

Manuscript No. AR1100b
Received in 21st November, 2014
Received in revised form 5th December, 2014
Accepted in final form 7th January, 2015

Correspondence to

**E-mail*: ratikanta.maiti@gmail.com

Keywords

Branching pattern, leaf crown architecture, tree, shrub

Abstract

Branching pattern and crown architecture are the important component of plant growth and development of any plant species. The leaf area and photosynthesis efficiency mainly depended on the crown architecture. There are many models developed for estimation of yield of various plant products of different species in different environments. These models are used for virtual evaluation of a plant or tree species which would otherwise take decades together to know the potential of species or cultivars. Here, the research findings in this respect pertaining to the shrubs and tree species of the North East Mexico has been reviewed. The branching habit has been classified as monopodial, simpodial and pseudomonopodial, while the crown architecture as globose and irregular.

1. Branching Pattern of Trees

The branching patterns of trees show large variability depicting various canopy architectural patterns. It is an interesting mechanism of tree species for its capacity to capture solar energy by leaves acting as solar panel. Each species extends its branches arising from its main stem depending upon the available space with its neighbours. Foresters adopt various silvicultural practices to manage species varying in branching pattern. Various studies have been undertaken to describe and analysing branching patterns of trees. Few scientists developed mathematical models to analyse branching patter. The selected literatures on branching patterns of trees is reviewed hereunder.

A study has been made on the efficiency of branching patterns, the relation of average numbers and lengths of tree branches to size of branch size of branch. Size of a branch defined by branch order or its position in the hierarchy of tributaries. Similar to river drainage nets, a definite logarithmic relation was found to exist between branch order and lengths and numbers. This relation can be quantified in tree branching systems, and several random-walk models in both two and three dimensions. Besides, the most probable arrangement appears to minimize the total length of all stems in the branching system within other (Leopold, 1971).

A study has been undertaken on non-stationarity of tree branching patterns and bifurcation ratios. Branching patterns in organisms have been analysed by using branch ordering and bifurcation ratio techniques. The data on four species reveal two specific patterns of non-stationarity that are directly related to morphological patterns of shoot development. Average bifurcation ratios appear to be inappropriate descriptions of tree branching patterns, since they are based solely on relative branch position and ignore biologically (Steingraeber and Waller, 1986).

Pickett and Kempf (1980) investigated the branching and leaf display of dominant forest shrubs and understory trees in central New Jersey with an objective to determine (1) whether branching differentiation occurs in shrubs which reach optimum development in different successional environments, (2) the contrast in branching of small trees between field and forest and (3) the nature of within-crown branching plasticity in a mature canopy tree. They observed that shrubs do not differ widely in gross branching structure (ratio of terminal to supporting branches) and propose that branch angle, length and alteration of leaf orientation may be significant display characters. Small trees show markedly variable response to open *versus* closed habitats, demonstrating the expected increase in branching ratio in open environments. Within, but not outside, the forest, earlier successional species were more variable in branching. A single canopy tree crown also demonstrated alteration of leaf display components, including increased length and wider angle of branches, but not branch ratio in the shaded, lower crown. They suggest some of the morphological traits of shrub branching may be important in determining their leaf display. Finally, they discuss differences in shrub and tree habit, such as cloning and the presumably reduced costs of support in shrubs, which may explain the failure of shrubs to exploit the same component of branching strategy as trees important details of form and development (Steingraeber and Waller, 1986).

Heuret et al. (2003) studied the branching patterns and the growth units of monocyclic or bicyclic annual shoots on the main axis of 5 year old red oaks in a plantation in south-western France. They described for each growth unit, as the production of axillary branches associated with each node in the form of a sequence. For a given category of growth units, homogeneous zones (i.e., zones in which composition in terms of type of axillary production does not change substantially) were identified on such sequences using a dedicated statistical model called a hidden semi-Markov chain. Branching patterns shown by the growth unit of monocyclic annual shoots and on the second growth unit of bicyclic annual shoots were very similar. Branches with a 1-year delay in development tended to be polycyclic at the top of the growth unit and monocyclic lower down. The number of nodes shown by the branched zone of the growth unit of monocyclic annual shoots was stable, irrespective of the total number of nodes of the growth unit. In contrast, the second growth unit of bicyclic annual shoots exhibited a correlation between the number of nodes in the branching zone and the total number of nodes.

Trees can be identified by the shape of their silhouette such as V-shaped, columnar, pyramidal, round, oval. Trees exhibit a variety of forms depending on their branching patterns. The arrangement and position of the branches on a tree give the tree a definite shape. The three positions of branches can be pointing upward from the trunk, pointing straight out from the trunk, or pointing downward from the trunk. There are three main forms:

a. Excurrent: the main stem goes straight to the entire height of the tree, with branches forming patterns; e.g., evergreens.
b. Decurrant: the main stem continues up about halfway, then splits into more than one main branch; e.g., fruit trees.
c. Columnar: the main trunk continues the full height of the tree, with the branches forming only at the top; e.g., palm trees.

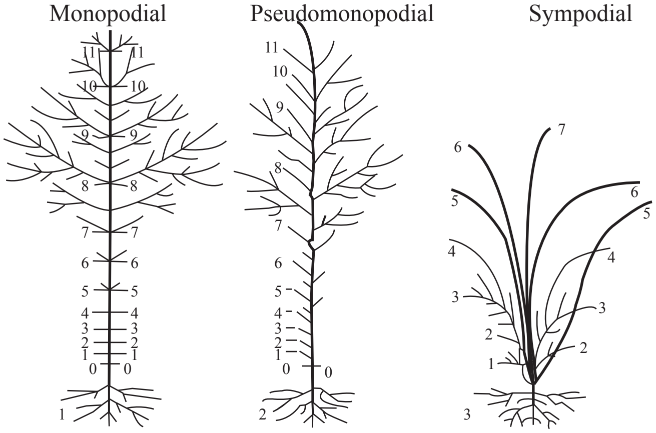
Branching pattern can be classified in three categories.

a. Monopodial when branchings start from main stem.
b. Pseudomonopodia when the branches derived from secondary banches from monopodial types.
c. Synpodial when branches start from the ground level.

In the following pictures, the branching pattern of different woody species of the thorn scrub, north-eastern Mexico is shown:

A systematic study has been undertaken on the branch systems of trees in the University of Arizona. According to the authors, their study represents the first empirical test of a theory University of Arizona ecology professor Brian Enquist helped develop in 1998.That theory holds that a tree's branching structure - specifically, the width and length of its branches - predicts how much carbon and water a tree exchanges with the environment in relation to its overall size, independently of the species. This theory can be used to scale the size of plants to their function, such as amount of photosynthesis, water loss and respiration, especially in light of climate change (Lisa Patrick Bentley, a postdoctoral fellowship in Enquist's laboratory. All of the tree species they studied have very similar branching patterns regardless of their difference in appearance. In addition, there are similar general ecological, biological, and physical principles that resulted in a similar branching architecture across those species over the course of evolution (Stolte, 2013).

According to Bentley, there is a relationship between the size and shape of branches how much water the trees lose through



evaporation. They found the theory to be correct in that it allows for predictions about a tree's function depending on its size, and also in that the theory's principles apply across species, despite their differences in appearance.

A preliminary study in classifying the branching systems of few trees and shrubs in the Northeast of Mexico has been made as summarised below:

It is concluded that t both the crown architecture and branching patters are the characteristics of a tree species which can be related to the adaptation of each species to a particular environment. The organization of these features contributes to the productivity of a particular species in a particular environment. The intensity of these traits of each species varies in understory and open environment. Therefore, concerted research inputs need to be addresses in this aspect. In order to assess the productivity of trees. Besides, there is a necessity of the characterization of plant of the species in a particular forest ecosystem,

2. Tree Crown Architecture

The tree crown depicts the top part of the tree, which consists of branches that grow out from the main trunk and contain support the various leaves used for photosynthesis. The variability of crown architecture in different species of woody plants in a forest offers beautiful landscape in a particular forest. It is of great interest to the landscape architect as well as to the foresters for their selection for a particular landscape. This is the most vital part of a tree species contributing to its productivity through the process of photosynthesis. This is highly dependent on the mode of branching arrangement, its size and leaf orientation in the branches. The branches forming different shapes characteristics of a species. While all trees feature a crown, several types of crowns adorn different types of trees. Thus, tree crowns are adapted to fit the role. The variability in crown architecture among tree species in a forest ecosystem confers characteristics of great interest of aesthetic architect and silviculturists for the identification of the species.

The crown of the trees are responsible to capture solar radiation serving as solar panel, thereby, not permitting the sunrays reaching the ground. The crown of the trees refers to the upper layer of leaves. The classification of crown architecture of the trees and shrubs of the Tamaulipan thornscrub belong to three categories:open (39%) of the sky is obstructed by the crown of the three crowns); medium closed (of 40-69% of sky is obstructed by the crown of the trees) or closed (70-100%) of the sky is covered by the crown).

The crown architecture of the trees varies in forms: globose, pyramidal, conical, elliptic, rectangular or irregulars. The growth habits of the crown vary among them. In general, are semi-erect, but its branches may be vertical, erect, extended or opens. These forms are influenced by the form and diameter of the crown and the height of the plant. Other variable is the distribution of the branches, irregular, horizontal or ascending. The leaf apex varies such a obtuse, pointed, round, or apiculate.

Isebrands and Nelson (1982) described the crown architecture of short-rotation and branch morphology and distribution of leaves within the crown of *Populus* 'Tristis' related to biomass production in northern Wisconsin. The relationship of leaf area to above ground biomass productivity was also estimated for the same trees. The first-order branches within the trees showed acrotony and were predominantly long shoots. No branching higher than third-order was observed. Leaf size and specific leaf weight were greatest on the current terminal shoot and decreased from the upper portion of the crown to the base. Ninety-five percent of the long shoots in the 6-year-old trees were in the three upper most vertical strata (5-8 m) and 95% of the short shoots were in the lowermost leaf-containing vertical strata (3-6 m). Long-shoot leaves had higher specific leaf weights than short-shoot leaves attached to branches on the same height growth increment. Leaf-area indices (LAI) were 7.6 and 8.8 $m^2.m^{-2}$for the 5 and 6-year-old stands, respectively. Leaf area $tree^{-1}$ was linearly related to the above ground biomass of the tree. The linear regression line for the relationship between leaf area and D^2H ($diameter^2 \times height$) for the 6-year-old trees in the study was statistically different from that of the 5-year-old-trees. The results suggest that this relationship may serve as a useful quantitative index of crown closure in poplar stands. The results also suggest some crown morphological criteria useful for selection and breeding of improved poplar trees for short-rotation intensive culture.

Subsequently, O'Connell and Kelty (1994) analysed the crown architecture of understory and open-grown white pine (*Pinus strobes* L.) saplings of 15 understory saplings and 15 open-grown saplings that were selected to have comparable heights (mean of 211 cm, range of 180-250 cm). Mean ages of understory and open-grown trees were 25 and 8 years, respectively. Understory treesshowed a lower degree of apical control, shorter crown length, and more horizontal branch angle, contribution to a broader crown shape than that of open-grown trees. Total leaf area was greater in open-grown saplings than in understory saplings, but the ratio of whole-crown silhouette (projected) leaf area to total leaf area was significantly greater in understory pine (0.154) than in open-grown pine (0.128), indicating that the crown and shoot structure of understory trees exposed a greater percentage of leaf area to direct overhead light. Current-year production of understory white pine gave significantly less than that of open-grown white pine, but a higher percentage of current-year production was allocated to foliage in shoots of understory saplings. The overall change to a broader crown shape in understory white pine was qualitatively similar, but much more limited than the changes that occurred in fir and spruce. This may prevent white pine from persisting in understory shade as long as fir and spruce saplings.

Similarly, Ceulemans et al. (1990) studied crown architecture, including branching pattern, branch characteristics and orientation of proleptic and sylleptic branches in five poplar clones (*Populus deltoides*, *P. trichocarpa* and *P. Trichocarpa* ×*P. deltoids* hybrids), grown under intensive culture in the Pacific Northwest, USA. Branch characteristics measured were number, length, diameter, biomass and the angles of origin and termination. The results suggest that genotype has a major influence on crown architecture in *Populus*. Clonal differences in branch characteristics and branching patterns were observed thatshowed striking differences in crown form and architecture. Branch angle and curvature showed significant difference among clones, and among height growth increments within clones. Branch length and diameter were significantly correlated among them in all clones. Sylleptic branches and the considerable leaf area they carry have important implications for whole tree light interception, and thus, play a critical role in the superior growth and productivity of certain hybrid poplar clones. The considerable variation in branch characteristics implies a strong justification for including them in selection and breeding programs for *Populus*.

Gilmore and Seymour (1997) studied crown architecture of *Abies balsamea* from four canopy positions. Data collected from four distinct canopy positions from each of 39 *Abies balsamea* trees were used to construct models to describe the cumulative leaf area distribution within the crown and to predict the needle mass of individual branches, the average branch angle, branch diameter, branch length, and crown radius whorl^{-1}, and the average number of living branches whorl^{-1}. They tested the hypothesis that regression models are equal among canopy positions and that a model to predict branch needle mass is valid at the northern and southern extremes of the central climatic zone of Maine. Canopy position had an effect on the models constructed to predict needle mass, branch angle, branch diameter, branch length, crown radius, and the number of living branches whorl^{-1}. However, compared with an expanded model that incorporated parameters calculated for each crown class, there was only a small loss in model precision when a general model constructed from data pooled from all crown classes was used to predict needle mass, branch angle, and branch diameter. Regression equations unique to each crown class were needed to predict crown shape and leaf area distribution in the crown satisfactorily. Our branch needle mass model, which was constructed from data collected at the southern extreme of the central climatic zone of Maine, consistently underestimated needle branch mass when applied to the northern extreme of the central climatic zone

Moorthy et al. (2011) made field characterization of olive (*Olea europaea* L.) tree crown architecture using terrestrial laser scanning (TLS) data. Intelligent Laser Ranging and Imaging System (ILRIS-3D) data was obtained from individual tree crowns at olive (*Olea europaea*) plantations in Córdoba, Spain. From the observed 3D laser pulse returns, quantitative retrievals of tree crown structure and foliage assemblage were obtained. Best methodologies were developed to characterize diagnostic architectural parameters, such as tree height (r^2=0.97, rmse=0.21m), crown width (r^2=0.97, rmse=0.13m), crown height (r^2=0.86, rmse=0.14m), crown volume (r^2=0.99, rmse=2.6m^3), and Plant Area Index (PAI) (r^2=0.76, rmse=0.26 m^2 m^{-2}). This research demonstrates that TLS systems can potentially be the new observational tool and benchmark for precise characterization of vegetation architecture for improved agricultural monitoring and management.

It may be concluded that the architecture of tree crown show large variation in shape, form, very few monopodial, mostly pseudomonopodial and few sympodial types. A combination of these classes of branching systems confer beauty to the landscape to the ecosystem. Very few species possess typical architecture of aesthetic architect which may be useful for town planning. We selected the species for good architecture for planting in urban areas: *Cordia boissieri*, *Diospyros texana*, *Ebanopsisebano*, *Celtis pallida*, *Parkinsonia texana* and *Havardia pallens* for planting in semiarid regions of Mexico.

In general, most of the tree species possess open canopy leaves with medium narrow leaves, very few with broad leaves with ramifying branches, with open canopy leaves. Sympodial types with narrow leaves exist in between other types of crown architecture. Sympodial types show profuse branching from the base of the plant with spreading thinner branches around. There is necessity to quantify the proportion of different plant species with medium broad leaves in a forest ecosystem for detecting the mode of co-existence and adaptation as well as for their capacityinthe captureof solarradiation and sharing available spaces with the neighbouring species.

In our visit to mangrove forests in tropical rainforest in Rviera Maya, a region of antique Maya Culture, Mexico, it was observed mangrove species possess monopodial to pseudomonopodial branches arising from the main stem, dichotomously branched and posses semi-broad thick leaves with waxy coating to avoid loss of water by transpiration. Mangroves possess open canopy leaves, for efficient capture of solar radiation for photosynthesis, necessary for vital functions.

They produce enormous hanging rhizophorous roots with fleshy and porous holes for absorption of moisture and oxygen for respiration. These rhizophores grow downwards lastly; fix them to the ground serving as support to the main plant, thereby act as barrier for tourists to enter mangrove forests. The inundated lower branches of rhizophores roots serve as a breeding ground for fishes, crabs and other sea animals. We also observe that the trees prevalent in rainforests on the way to Rieria Maya possess open canopy leaves with high capacity to capture solar radiation. In our visit to arid lands of Arizona, Mezquites (*Prosopis* sp.) is the dominant gregarious tree that possesses pseudomonopodial branching and open canopy leaves. The plants possess specific morpho-anatomical and physiological mechanism of resistance to drought in the arid lands.

Crown architecture and its extension contribute remarkably to the capacity of a species on carbon capture from the atmosphere through photosynthesis, In this respect, a study has been undertaken on the role of crown architecture for light harvesting and carbon gain in extreme light environments with a realistic Light capture and carbon gain by plants from low (forest understory) and high (open Mediterranean-type ecosystems) light environments were simulated with a 3-D model (YPLANT), which was developed specifically to analyse the structural features that determine light interception and photosynthesis at the whole plant level. Distantly related taxa with contrasting architectures showed similar efficiencies of light interception (functional convergence). The results show large differences between habitats in architecture depending on whether light capture must be maximised or whether excess photon flux density must be avoided. These differences are observed both at the species level and within a species because of plastic adjustments of crown architecture to the external light (Valladares and Peaarcy, 2000)

A three-dimensional crown architecture model has been developed for the assessment of light capture and carbon gain by understory with the objective of assessing the light capture and whole-plant carbon gain consequences of leaf display in understory plants. This model was constructed on the basis of geometrical measurements taken in the field on the projected image of a plant so that light absorption from any direction can be assessed. The photon flux density (PFD) from a given direction was measured from the canopy openness derived from hemispherical canopy photographs and equations simulating the daily course of direct and diffuse PFD. For diffuse PFD, the directional fluxes and absorbed PFD were integrated over 160 different directions representing 8 azimuth classes and 20 elevation angle classes. Direct PFD absorption was estimated for the time that a solar track on a given day intersected a canopy gap. Assimilation rate was simulated for the sunlit and shaded parts of leaves separately and then summed to give the whole-plant carbon gain. Comparisons of simulations for a tropical forest edge species, *Clidemia octona*, and an understory species, *Conostegia cinnamomea*, exhibit the operation of the model and show that the edge species is more efficient at capturing side light while the understory species is slightly more efficient at capturing light from directly above, the predominant light direction in this environment. Self-shading within *Conostegia* crown and steep leaf angles in the *Clidemia* crown decreased light capture efficiencies for light from directly above. Whole-plant daily carbon gain was much higher in the forest edge site, mostly because of the additional PFD available in this site. However, simulations for both species in the understory light environment reveal that the higher light capture efficiencies of the understory species in this environment conferred a 27% advantage in carbon gain in this environment (Pearcy and Yang, 1996.).

Yokozawa et al. (1996) established the relationships between crown architecture and species coexistence using the diffusion model and the canopy photosynthesis model for multi-species plant communities. The study was undertaken on two species having different crown shapes [conic-canopy plant (CCP) and spheroidal-canopy plant (SCP)], for various initial mean sizes at the establishment stage and physiological parameter values (photosynthetic rate, etc.). Recruitment processes were not incorporated into the model, and thus simulations were made for the effects on the pattern of species coexistence of either sapling competition starting from different sapling banks or competition in single-cohort stands with little continual establishment of species until a stand-replacement disturbance. The following predictions were derived: (1) SCPs can establish later}slowly in the lower canopy layer even if they are overtopped by a CCP which established first}rapidly; (2) if SCPs established first}rapidly and occupy the upper canopy layer, a CCP can rarely establish later}slowly in the lower canopy layer; (3) smallest-sized CCPs can persist well in the lowermost canopy layer overtopped by a SCP, suggesting a waiting strategy of CCP's saplings in the understorey of a crowded stand; (4) even if CCPs established first}rapidly and occupy the upper canopy layer, an SCP can establish later}slowly in the lower canopy layer. Therefore, the species diversity of SCPs which established first} rapidly and occupy the upper canopy layer limits the number of CCP species which can establish later} slowly. In contrast, the species diversity of CCPs which established first} rapidly and occupy the upper canopy layer does not affect the number of SCP species which can establish later} slowly. The combination of initial sizes of a CCP and an SCP at the establishment stage (i.e. establishment timing) affects the segregation of vertical positions in the canopy between the two species with different crown shape, and not only species-specific physiological traits but also crown architecture greatly affects the coexistence pattern between species with different crown architectures. The theoretical predictions obtained here can explain coexistence patterns found in single-cohort conifer-hardwood boreal and sub-boreal forests, pointing to the significance of crown architecture for species coexistence

A study was undertaken on the convergence in light capture efficiencies among tropical forest understory plants with contrasting crown architectures as case of morphological compensation Leaf and crown characteristics were observed for 24 tree and herbaceous species of contrasting architectures from the understory of a lowland rainforest. Light-capture efficiency was estimated for the crowns of the different species with a three-dimensional geometric modeling program. Causal relationships among traits affecting light absorption at two hierarchical levels (leaf and whole crown) were quantified using path analysis. Light-capture and foliage display efficiency were found to be very similar among the 24 species studied, with most converging on a narrow range of light absorption efficiencies (ratio of absorbed vs. available light of 0.60-0.75). Exceptionally low values were found for the climber vines and, to a lesser extent, for the Bromeliad *Aechmeama gdalenae*. Differences in photosynthetic photon flux density (PFD) absorbed unit^{-1} leaf area by individual plants were mostly estimated by site to site variation in PFD and not by the differences in crown architecture among individuals or species. Leaf angle, and to a lesser extent also supporting biomass, specific leaf area, and internode length, had a significant effect on foliage display efficiency. Potential constraints on light capture such as the phyllotactic pattern were generally offset by other compensatory adjustments of crown structure such as internode length, arching stems, and plagiotropy. The variety of shoot morphologies capable of efficiently capturing light in tropical forest understories is greater than initially thought, extending over species with very different phyllotactic patterns, crown architectures, leaf sizes, and morphologies (Valladares et al., 2002).

Pearcy et al. (2005) investigated crown architecture in sun and shade environments: assessing function and trade-offs with a three-dimensional simulation model Sun and shade environments exhibit markedly different constraints on the photosynthetic performance of plants. This study focuses on the role of architecture in maximizing light capture and photosynthesis in shaded under stories and in minimizing exposure to excess radiation in open high light environments. Understanding these contrasting roles of architecture is facilitated by application of a three-dimensional structural-functional model, Y-plant. Surveys of understory plants demonstrate l a diversity of architectures but a strong convergence at only modest light-capture efficiencies because of significant self-shading. Simulations with *Psychotria* species revealed that increasing internode lengths would increase light-capture efficiencies and whole plant carbon gain. In high light environments, leaf angles and self-shading provide structural photoprotection, treby minimizing potential damage from photoinhibition. Simulations reveal that without these structural protections photoinhibition of photosynthesis is likely to be much greater with daily carbon gain significantly decreased.

3. Materials and Methods

This study was carried out at the experimental station of Facultad de Ciencias Forestales, Universidad Autonoma de Nuevo Leon, located in the municipality of Linares (2447 N.99 32 W), at elevation of 350 m. The climate is subtropical or semiarid with warm summer, monthly mean air temperature vary from 14.7°Cin January to 23°C in August, although during summer the temperature goes up to 45°C. Average annual precipitation is around 805 mm with a bimodal distribution. The dominant type of vegetation is the Tamaulipan Thorn scrub or subtropical Thorn scrub wood land. The dominant soil is deep, dark grey, lime-grey, vertisol with montmorrillonite, which shrink and swell remarkably in response to change in moisture content.

In view of the literatures mentioned we made a preliminary survey of plant crown structure of 30 species (trees, shrubs) and classified them. Later we took photo image of few selected species in order to select species with good landscape.

4. Results and Discussion

On the basis of general survey we classified 30 species during winter season, December to February, 2014 to 2015.

It is observed that among the thirty species surveyed only few species are sympodial viz,

Monopodia (2):

Leucophyllum frutescens, Leucophyllum frutescens

Sympodial (8):

Harvadia pallens, Zanthoxylum fagara, Forestiera angustifolia, Karwinskia humboldtiana, Croton suaveolens, Amyris texana, Bernardia myricifolia, Leucophyllum frutescens

Pseudopodial: The rest 20 are pseudopodial.

Out of the species surveyed we selected the following species with landscape characteristics

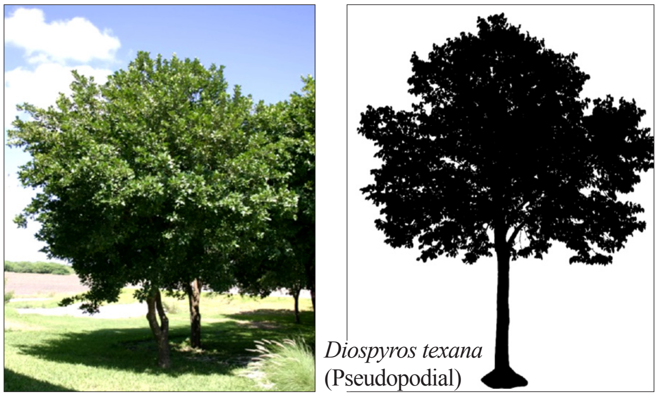
Plant crown architecture Image

Out of these 9 species we selected the species *Cordia boissieri, Diospyros texana, Ebenopsis ebano, Celtis pallida, Parkinsonia*

Cordia boissieri (Pseudopodial)

Condalia hookeri (Sympodial)

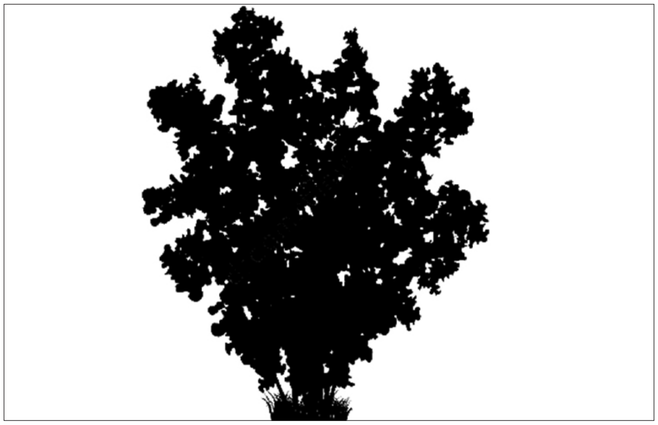
Leucophyllum frutescens (Sympodial)



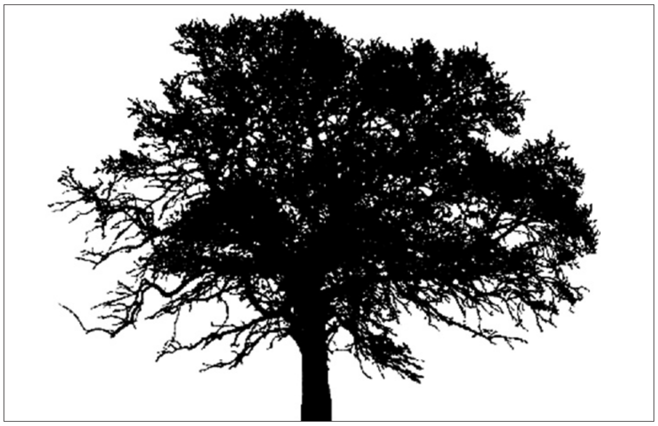
Diospyros texana
(Pseudopodial)

Ebenopsis ebano
(Pseudopodial)

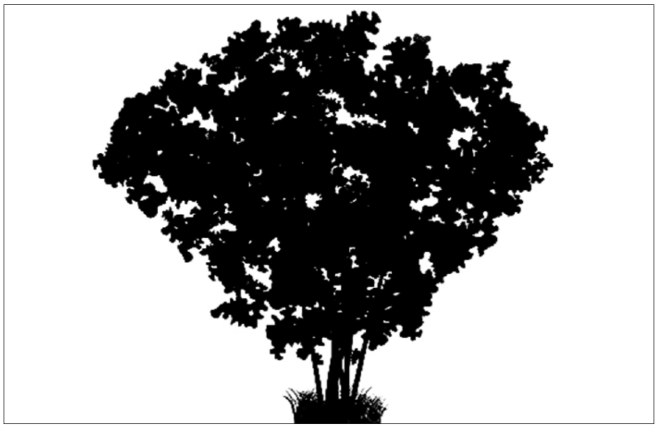

Celtis pallida (Sympodial)

Bernardia myricifolia (Sympodial)

Leucophyllum frutescens (Sympodial)

Leucophyllum frutescens (Sympodial)

Specie	Types of branching	Types of crown
Helietta parvifolia	Pseudomonopodial	Irregular
Sargentia gregii	Pseudomonopodial	Globose
Guaiacum angustifolium	Monopodial	Irregular
Ebenopsis ebano	Pseudomonopodial	Irregular
Harvadia pallens	Sympodial	Irregular
Condalia hoockeri	Pseudomonopodial	Irregular
Zanthoxylum fagara	Sympodial	Irregular
Cordia boissieri	Pseudomonopodial	Globose
Acacia berlandieri	Pseudomonopodial	Irregular
Diospyros texana	Pseudomonopodial	Globose
Celtis pallida	Pseudomonopodial	Irregular
Forestiera angustifolia	Sympodial	Irregular
Diospyro spalmeri	Pseudomonopodial	Globose
Parkinsonia texana	Pseudomonopodial	Globose
Acacia farnesiana	Pseudomonopodial	Globose
Sideroxylon celastrina	Pseudomonopodial	Globose
Caesalpinia mexicana	Pseudomonopodial	Irregular
Karwinskia humboldtiana	Sympodial	Globose
Croton suaveolens	Sympodial	Irregular
Amyris texana	Sympodial	Irregular
Leucaena leucocephala	Monopodial	Irregular
Ehretia anacua	Pseudomonopodial	Irregular
Gymnosperma glutinosum	Monopodial	Irregular
Celtisla evigata	Pseudomonopodial	Globose
Acacia rigidula	Pseudomonopodial	Irregular
Acacia shaffneri	Pseudomonopodial	Irregular
Prosopis laevigata	Pseudomonopodial	Globose
Leucophyllum frutescens	Monopodial	Irregular
Bernardia myricifolia	Sympodial	Irregular
Leucophyllum frutescens	Sympodial	Globose

texana, which could be planted in urban areas in park for their beautiful landscape. Besides these species have extended leaf crown structure for capture of carbon as discussed by different authors (Isebrands and Nelson, 1982), O'Connell and Kelty (1994), Ceulemans et al. (1990), Isebrands and Nelson (1982), O'Connell and Kelty (1994), Ceulemans et al. (1990). Among 15 species surveyed three species are tolerant to cold, most of the rest are medium tolerant, only few are susceptible, among them *Helietta parvifolia, Sargentia gregii, Guaiacum angustifolium* are found to be tolerant to cold.

These species possess open canopy leaves which have higher photosynthetic capacity compared to close canopy ones. It has been documented by different authors that Crown architecture and its extension contribute remarkably to the capacity of a species on carbon capture from the atmosphere through photosynthesis (Valladares and Peaarcy, 2000; Pearcy and Yang, 1996; Yokozawa et al., 1996). Therefore, the large variability in tree crown structure and canopy extensions depict clearly the variability in the capacity in photosynthetic capacity for co-existence in an forest ecosystem,

5. Conclusion

The branching habit and canopy architecture play pivotal role in the growth and development of any species. These parameters are used in mathematical models for virtual simulation of evaluation of various species and their varieties or race. The information compiled shall be helpful in selection of right species or race for North East Mexico.

6. References

Ceulemans, R., Stettler, R.F., Hinckley, T.M., Isebrands, J.G., Heilman, P.E., 1990. Crown architecture of *Populus* clones as determined by branch orientation and branch characteristics. Tree Physiology 7(1-2-3-4), 157-167.

Gilmore, D.W., Seymour, R.S., 1997. Crown architecture of *Abies balsamea* from four canopy positions. Tree Physiology 17(2),71-80.

Heuret, P., Guedon, Y., Guerard, N., Barthemy, D., 2003. Analysing branching pattern in plantations of young red oak trees (*Quercus rubra* L., Fagaceae). Annals of Botany 91(4), 479-492.

Isebrands, J.G., Nelson, N.D., 1982. Crown architecture of short-rotation, intensively cultured *Populus* II. Branch morphology and distribution of leaves within the crown of *Populus* 'Tristis' as related to biomass production. Canadian Journal of Forest Research 12(4), 853-864.

Leopold, L.B., 1971. Trees and streams: The efficiency of branching patterns. Journal of Theoretical Biology 31(2), 339-354.

Moorthy, I., Miller, J.R., Jimenez-Berni, J.A., Zarco-Tejada, P., Hu, B., Chen, J., 2011. Field characterization of olive (*Olea europaea* L.) tree crown architecture using terrestrial laser scanning data. Agricultural and Forest Meteorology 151(2), 204-214.

O'Connell, B.M., Kelty, M.J., 1994. Crown architecture of understory and open-grown white pine (*Pinus strobus* L.) saplings. Tree Physiology 14(1), 89-102.

Pearcy, R.W., Muraoka, H., Valladares, F., 2005. Crown architecture in sun and shade environments: assessing function and trade-offs with a three-dimensional simulation model. New Phytologist 166(3), 791-800.

Pearcy, R.W., Yang, W., 1996. A three-dimensional crown architecture model for assessment of light capture and carbon gain by understory plants. Oecologia 108(1), 1-12.

Pickett, S.T.A., Kempf, J.S., 1980. Branching patterns in forest shrubs and understory trees in relation to habitat. New Phytologist 86(2), 219-228.

Steingraeber, D.A., Waller, D.M., 1986. Non-stationarity of tree branching patterns and bifurcation ratios. Procedings of the Royal Society of London. Series B, Biological Sciences 228, 187-194.

Stolte, D., 2003. One tree's architecture reveals secrets of a forest, study finds. (http://phys.org/news/2013-08-tree-architecture-reveals-secrets-forest.html).

Valladares, F., Peaarcy R.W., 2000. The role of crown architecture for light harvesting and carbon gain in extrme light environments with a realistic. Anales del Jardin Botanico de Madrid 58(1), 3-16.

Valladares, F., Skillman, J.B., Pearcy, R.W., 2002. Convergence in light capture efficiencies among tropical forest understory plants with contrasting crown architectures: a case of morphological compensation. American Journal of Botany 89(8), 1275-1284.

Yokozawa, M., Kubota, Y., Hra, T., 1996. Crown architecture and species coexistence in plant communities. Annals of Botany 78, 437-447.