Forest Research
Open Access

Maiti, et al., Forest Res 2016, 5:2
DOI; 10.4172/2168-9776.1000175

Review Article Open Access

Adaptive Morpho-physiological Traits of Woody Plants for Co-existence in a Forest Ecosystem

Maiti R[1*], Rodriguez HG[1] and Kumari A[2]

[1]*Facultad de Ciencias Forestales, Universidad Autonoma de Nuevo Leon, Carr. Nac. No. 85 Km 45, Linares, Nuevo Leon 67700, México*

[2]*Agricultural College, Professor Jaya Shankar Telangana State Agricultural University, Polasa, Jagtial, Karimnagar, India*

***Corresponding author:** Maiti R, Facultad de Ciencias Forestales, Universidad Autonoma de Nuevo Leon, Carr. Nac. No. 85 Km 45, Linares, Nuevo Leon 67700, México, Tel: 52-8116597090; E-mail: humberto.gonzlez@uanl.mx

Rec date: Mar 28, 2016; **Acc date:** Apr 19, 2016; **Pub date:** Apr 25, 2016

Abstract

The paper put forward few hypothetical concepts for co-existence and adaptation of woody plant species in a Tamaulipan thorn scrub, Northeastern Mexico. The hypotheses have been put forwarded on the basis of our results on various morphological, anatomical and eco-physiological traits of a Tamaulipan thorn scrub, North-eastern Mexican. Few future research lines are suggested to confirm the hypothesis.

Keywords: Woody plants; Co-existence; Adaptation; Morphological; Anatomical; Eco-physiological traits

Introduction

In a forest ecosystem different species of plants grow in a harmony without competition but sharing natural resources such as solar radiation, carbon dioxide and other natural resources in the atmospheric horizon as well as harnessing water and nutrients through roots distributed in different soil profiles. In the forest ecosystem various species of trees and shrubs extend their branches in the available spaces (niches) in between neighboring species, thereby function as solar panel for the capture of solar radiation. Different woody plants attain different heights, thereby facilitating each species to absorb solar energy without competing with its neighbours, showing co-existence and co-adaptation to the environments. The co-existence of the spectrum of trees and shrubs maintain biodiversity, thereby offering amicable landscape on land surface. Simultaneously the plants absorb solar energy radiation with the help of chlorophyll in the leaves and carbon dioxide, and liberation of oxygen through the process of photosynthesis and finally convert them in biomass and carbon in the timbers as source of energy of fuel and product of the industry. The energy stored in the biomass serve as source of energy required for plant metabolism, liberated through the process of respiration. This in turn reduce carbon dioxide accumulated in the atmosphere and increasing pollution by constant emission of greenhouse gases (GHGs) burning of fossil fuels, and other human activities such as logging, deforestation etc. thereby endangering the safety of the lives of mankind and animal kingdom. Forests are savior of our lives as well serving as sources of various necessities of our life, thereby urging the need of their sustainable use. Therefore, there is a necessity to maintain biodiversity in the forest ecosystem [1].

In the context of the above discussion we want to narrate here our conceptual hypothesis of the co-existence and adaptation of the woody plants in a forest ecosystem. In this respect different plant components and plant functions contribute differently in the mechanism of co-existence and adaptations in the environments which needs to be verified.

On the basis of our research on various s experimental biology, several hypothesis are build up on the basis of our research results in a Tamaulipan Thorn scrub ecosystems. We want to cite only few examples. We need to keep in mind the genetic, interspecific and climatic effects in the expression of the various plant components in a forest system.

Tree crown

In a forest the top of each tree species maintain typical crown architecture with their spreading branches varying among species in their niches, thereby absorbing solar radiation falling on the top, horizontal and lateral direction. The crown architecture of different woody plant species attain at different height, thereby sharing mutually the available solar energy without affecting their neighbours (Figures 1 and 2).

Figure 1: *Cordia boissieri* (Pseudopodial).

Figure 2: *Leucophyllum frutescens* (Sympodial).

Branching pattern and branching density

There exist a large variation in branching pattern and branching density, thereby functioning as solar panel in the capture of solar energy. Each species produce typical branching pattern and branching density, thereby extending to the available spaces with the neighbours [2]. High density of branches with closely overlapping leaves may block the incoming solar radiation leading to less productivity of timber but high productivity of biomass which need to be verified (Figures 3 and 4).

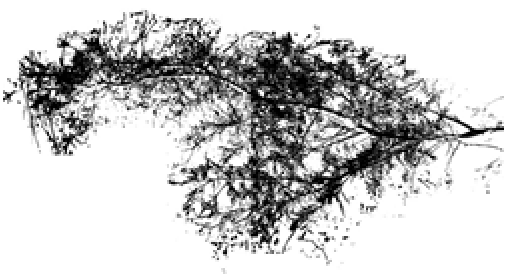

Figure 3: *Guaiacum angustifolium* (High density).

Figure 4: *Havardia pallens* (Low density).

Leaves

Leaves play important roles in the capture of solar energy through pigments (chlorophyll) and absorption of carbon dioxide and liberation of oxygen, leading to the production of biomass and carbon stored in timbers [3]. There exists a large variability in the morphology, size, shape, leaf area and anatomical structures among various species which help in the capture of solar energy in the available space with neighbours for photosynthesis varying among species which in turn help in co-existence of the species in a forest ecosystem (Figures 5 and 6).

Figure 5: *Eysenhardtia texana* scheele.

Figure 6: *Croton suaveolens* torr.

Leaf size variation: In venation pattern, leaf venations function as mechanical function (skeleton) and transport of water and nutrients through xylem from the petiole and carbohydrates downwards from the leaves to the stem through phloem. Petiole through petiole. There exist large variability in venation pattern and venation density and thickness of veins among species, thereby helping in co-existence and adaptation of the woody plant species (Figures 7 and 8).

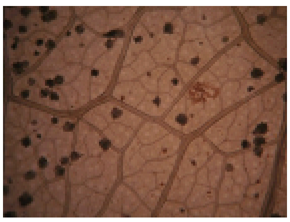

Figure 7: *Diospyros palmeri* (High density).

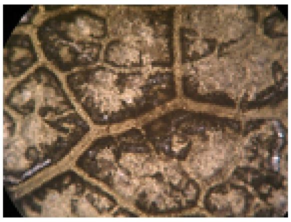

Figure 8: *Sargentia greggii* (Low density).

Leaf anatomy plays an important role in adaptation of the species in xeric environments owing to the interspecific variation in the type of stomata, frequency, presence, absence of stomata, sunken stomata, cuticular thickness, presence of trichomes, compactness of palisade cells [4]. For example low frequency, absence of stomata, sunken stomata, trichome density, cuticle thickness and compact palisade tissue contribute to drought resistance. There exists a large interspecific variation in leaf anatomical structures thereby helping in co-existence and adaptation of the woody plants in a forest (Figures 9 and 10).

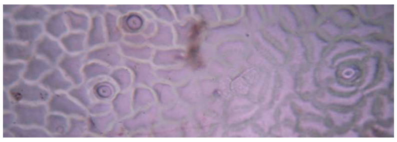

Figure 9: *Amyrys texana* (adaxial surface) (Stomata infrequent).

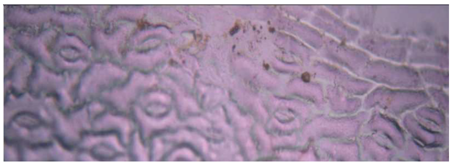

Figure 10: *Senegalia gregii* (adaxial) (More stomata).

In petiole anatomy, thick and long petiole help in exposing leaves to solar radiation out of leaf canopy, on the other hand the variation in petiole anatomy help in the adaptation of woody plants in arid condition [5]. There exist variations in circular thickness, presence of trichome, layers of collenchyma layers, thickness of sclerenchyma band and vascular bundle area which contribute to the adaptation of woody plant species to xeric habitats (Figures 11 and 12).

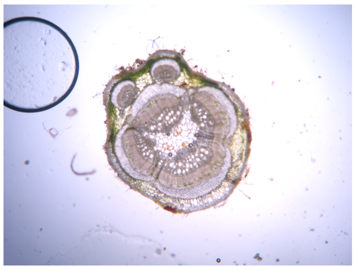

Figure 11: *Acacia berlandieri* (Strong mechanical tissue).

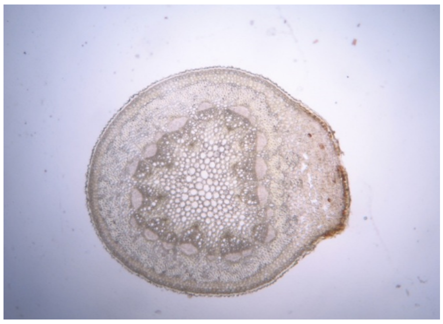

Figure 12: *Berberis chococo* (Weak mechanical tissue).

Wood anatomy

Wood is a hard structure composed by wood fibers, vessels and wood parenchyma produced by the secondary activity of cambium. Intensity of thick-walled wood fiber cells, ray cells, xylem vessels, and wood tissue compactness contribute to wood quality and utility. Wood serves a building skeleton and also transport of water and nutrients in a woody plant. Our studies reveal a large variability in wood anatomical structures among woody species which help also in taxonomic delimitation and adaptation of the species in xeric and cool environments [6,7]. It has been well documented that woody plant species having narrow and multiple vessels help to offer resistance to cavitation (Emboling) in hot summer and cool environments. Many species in semiarid regions of Tamaulipan Thorn Scrub possess narrow vessels revealing their adaptation to hot and cool climates. Concerted research needs to be directed to relate the xylem density and narrow vessels with water relation of the species as reported in recent studies by other authors (Figures 13 and 14).

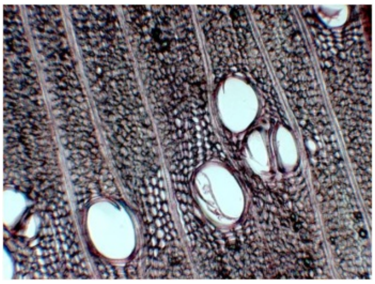

Figure 13: *Acacia berlandieri* (Large vessels).

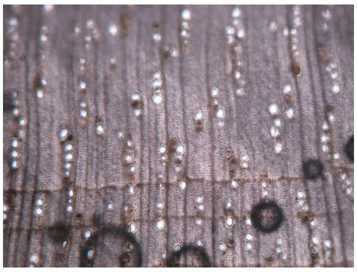

Figure 14: *Amyris madrensis* (Narrow vessels).

Physiological and biochemical traits

Apart from plant characteristics mentioned above several physiological and biochemical traits help in the growth, development and adaptation of woody plants in the edaphic, and climatic conditions. We mention few of them, except photosynthesis, respiration and water relations well documented in the literatures [8].

Plant pigments: Leaf pigments (chlorophyll, carotenoids) contribute to plant metabolism with respect to the capture of solar radiation by chlorophyll. There exist a large variability in the contents of chlorophyll and carotenoid showing variability in the capacity of absorption of solar energy among woody plant species to, thereby helping in their co-existence in the forest ecosystem.

We selected the following species with high total chlorophyll and carotenoids (in all mg g^{-1} fw).

Chlorophyll total (Chl a+b): *Ebenopsis ebano* (2.253), *Leucaena leucocephala* (1.687), *Gynosperperma glutinosum* (1.528), *Amyrys texana* (1.506), *Cercidium angustifolia* (1.497).

Carotenoids: *Berberis chococo* (0.585), *Diospyros palmeri* (0.433), *Gymnosperma glutinosum* (0.33), *Amyrys texana* (0.438), *Ebenopsis ebano* (0.425).

There is a need to verify the efficiency of these selected species with plant productivity.

Epicuticular wax: Woody plant species possess epicuticular shining leaf surface which help in the reflection of solar radiation, thereby reducing leaf temperature and imparting drought resistance. There exists a large variability in epicuticular wax among woody plant species studied which in turn show variation in adaptation to drought as well as co-existence in the ecosystem [9,10].

We selected during summer season species with high epicuticular wax such as *Forestiera angustifolia* (702.04 μg/cm^2), *Diospyros texana* (607.65 μg/cm^2), *Bernardia myricifolia* (437.53 μg/cm^2), *Leucophylum frutscens* (388.50 μg/cm^2), which could well be adapted under semi-arid environments for their efficiency in the reflection of radiation load, reduced transpiration, gas exchange and probably impart drought resistance [11-13].

Leaf nutrients: Leaves of trees and shrubs possess various macro- and micronutrients which contribute to the growth and development of plants as well as serve as sources of animal nutrition. There exist large variations in macro and micronutrients among species which help in co-existence of the species in the ecosystem. We selected various species with high macro and micronutrients.

We mention here only top five species for each nutrient (in all mg g^{-1} fw).

Cu: *Cordia boissieri* (30.71), *Croton suaveolens* (26.67), *Celtis pallida* (25.98), *Blumelia celastrinum* (25.24).

Fe: *Acacia farnesciana* (259.79), *Acacia rigidula* (252.33), *Blumelia celastriana* (249.09), *Croton suaveolens* (229.13).

Zn: *Salix lasiolepis* (144.86), *Cordia boissieri* (51.87), *Parkinsonia aculeate* (51.86), *Eysenhardtia polystachya* (51.39).

K: *Croton suaveolens* (75.62), *Cordia boisiieri* (45.58), *Celtis pallida* (49.60), *Acacia rigidula* (38.75).

Mg: *Ehretia anacua* (9.45), *Condalia hookeri* (6.50), *Parkinsonia aculeate* (5.29), *Hellieta parviflora* (3.15).

P: *Croton suaveolens* (2.45), *Prosopis, laevigata* (1.65), *Celtis laevigata* (1.57).

% Protein: *Gymnospermum glutinosum* (36.81), *Diospyros texana* (36.55), *Blumelia celastrinum* (33.02), *Celtis pallida* (25.75).

% C: *Leucophylum frutescens* (49.97), *Forestieria angustifolia* (49.47), *Blumelia celastrianum* (49.29), *Acacia berlandieri* (49.29).

% N: *Gymnospermum glutinosum* (5.89), *Blumelia celastrinum* (4.21), *Celtis pallida* (4.12), *Acacia berlandieri* (3.82).

C/N ratio: *Sargentia greggii* (23.13), *Quercus virginia* (21.51), *Croton suaveolens* (20.16), *Diospyros palmeri* (17.36).

There is a need to study the efficiency of these selected species for the productivity of the plants.

Carbon sequestration (carbon fixation): Woody plant species vary widely in the capacity of carbon fixation (absorption of carbon dioxide throughout the process of photosynthesis) and storage of carbon in biomass and timber which help in their co-existence and adaptation in the ecosystem [14-16].

We selected the trees and shrubs selected with high carbon concentration were *Eugenia caryophyllata* (51.66%), *Litsea glauscens* (51.34%), *Rhus virens* (50.35%), *Forestiera angustifolia* (49.47%), *Gochantia hypoleuca* (49.86%), *Forestiera angustifolia* (49.47%), *Pinus arizonica* (49.32%), *Cinnamomum verum* (49.34%), *Blumelia celastrina* (49.25%), *Tecoma stans* (48.79%), *Acacia rigidula* (48.23%), *Eryobotria japonica* (47.98%), *Rosamarinus officinalis* (47.77%).

There is a necessity to verify the efficiency of these selected species with their productivity.

In the context of the results obtained we may conclude that the great diversity in morphological and anatomical traits and various eco-physiological traits among diverse woody plant species in a Tamaulipan Thorn Scrub help in the co-existence and adaptation of woody plant species. Concerted research activities need to be directed to confirm the hypotheses put forward.

Conclusions

The study reveals that a large diversity in morpho-anatomical and eco-physiological traits among woody species in Tamaulipan thorn scrub on the basis of which several hypothesis are built up which need to be confirmed in future studies. The woody species selected for few eco-physiologically efficient traits should be tested for their performance in growth, development and the productivity of the species concerned.

References

1. Maiti R, Rodriguez HG, Karfakis TNS (2014) Variability in leaf canopy architecture may be related to photosynthetic efficiency and carbon fixation. IJBSM 5: 20-25.
2. Maiti R, Rodriguez HG, Karfakis TNS (2014) Variability in leaf traits of 14 native woody species in semiarid regions of northeastern mexico. IJBSM 5: 475-479.
3. Maiti R, Rodriguez HG, Kumari A (2015) Tree and shrubs with high carbon fixation/concentration. Forest Res S1: 003.
4. Maiti R, Rodriguez HG (2015) Phenology, morphology and variability in pollen viability of four woody trees (Cordia boissieri, Parkinsonia texana, Parkinsonia aculeate and Leucophyllum frutescens exposed to environmental temperatures in Linares, Northestern Mexico. Forest Res S1: 002.
5. Maiti R, Rodriguez HG, Sarkar NC, Thakur AK (2015) Branching pattern and leaf crown architecture of some tree and shrubs in Northeast Mexico. International Journal of Bio-resource and Stress Management 6: 41-50.
6. Maiti R, Rodriguez HG, Narvaez RIV, Sarkar NC (2015) Carbon and nitrogen content in leaf tissue of different plant species, Northeastern Mexico. International Journal of Bio-resource and Stress Management 6: 113-118.
7. Maiti R, Rodriguez HG, Karfakis TNS (2014) Variability in leaf canopy architecture may be related to photosynthetic efficiency and carbon fixation. IJBSM 5.
8. Maiti R, Rodriguez HG, Para AC, Paloma SV (2015) Characterization of wood fibres of scrubs and tree species of the tamaulipan thornscrub, Northeastern Mexico and its possible utilization. Forest Research 4: 154.
9. Maiti R, Rodriguez HG (2015) Eco-physiologically highly efficient woody plant species in Northeastern Mexico. Forest Res 4: e122.
10. Maiti R, Rodriguez HG (2015) Mystery of coexistence and adaptation of trees in a forest ecosystem. Forest Res 4: e120.
11. Maiti R, Rodriguez HG, Kumari A, Diaz JCG (2015) Perspectives of branching pattern and branching density in 30 woody trees and shrubs in tamulipan thornscrub, Northeast of Mexico. Forest Res 4: 160.
12. Maiti R, Rodriguez HG (2015) Wood anatomy could predict the adaption of woody plants to environmental stresses and quality of timbers. Forest Res 4: e121.
13. Maiti R, Rodriguez HG, Kumari A, Sarkar NC (2015) Variability in epicuticular wax in 35 woody plants in linares, Northeast Mexico. Forest Res 5: 162.
14. Maiti R, Rodriguez HG, Narvaez RIV (2015) A Study on autoecology and ecophysiology of Chile Piquin (Capsicum annuum Aviculare Dierb), a wild chilli of high medicinal and commercial value in Northeast Mexico. International Journal of Bio-resource and Stress Management 6: 292-299.
15. Maiti R, Rodriguez HG, Kumari A, Sarkar NC (2016) Macro and micronutrient contents of 18 medicinal plants used traditionally in Nuevo Leon, Northeast Mexico. Pak J Bot 48: 271-276.
16. Maiti R, Rodriguez HG, Ivanova NS (2016) Autoecology and ecophysiology of woody shrubs and trees. In: Maiti R, Gonzalez H (eds.). John Wiley and Sons, Ltd.