Research Progress on Trees and Shrubs of Economic Importance in Northeast Mexico

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Article History

Article ID: IJEP146
Received in 25th Jan, 2017
Received in revised form 24th March, 2017
Accepted in final form 15th April, 2017

Abstract

The present paper present in brief summary of research advances undertaken by Dr. Maiti during the last four years as visiting research scientist in Forest Science Faculty, Universidad Autonoma de Nuevo Leon, Mexico. The research deals with morphology, branching pattern, anatomy, plant traits, few physiological-biochemical traits such leaf pigments, epicuticular wax, leaf macro and micronutrients, carbon sequestration. The results reveal that there exists a large variability among woody trees and shrubs (more than 30 species) in various morpho-anatomical and physiological and anatomical traits mentioned. These variations in different traits determine the adaptive capacity of the species in the semiarid regions of Northeast Mexico.

Keywords: Anatomy, carbon sequestration, epicuticular wax, nutrients, phenology, pigments, shrubs, trees

1. Introduction

Trees and shrubs in a forest are savers of our life and animal kingdom which help in conversion of toxic gas liberated by burning of fossil fuels and other human activities and finally stored as carbon energy in timber and biomass during the process of photosynthesis and liberation of oxygen for our respiration. Increasing global warming associated with increasing emission of green house gases (GHGs), illegal logging and other human activities have great negative impact on the productivity of trees and shrubs. They supply fire wood, timber of great commercial importance, fences and several domestic goods. On other hand, they feed grazing animals forage of high nutritional values and give shelter to animals in the forest. We need to conserve them and make sustainable use, For efficient management there is a great necessity to study morphology, of leaves and stems,, anatomy, branching patter, phenology and physiology and biochemistry of these useful trees and shrubs.

During last four years we selected more than 30 species of woody trees and shrub grown at Linares, Northeast of Mexico and studied various aspects mentioned above. This is a typical semiarid region with high summer temperature exceeding 45 degree and winter temperature going down to 3 degree, even below zero degree some times. These species have several adaptive morphological-structural and physiological -biochemicalmechanism for co-existence and adaptation to drought conditions. We mention herein a brief results of each of these morphological, anatomical and physiological and biochemical characteristics. Most of results are published mentioned in the references.

2. Leaves

Leaves help in the growth and development of the plant, exchange of gases, metabolism, carbon asimilaion and respiration of plants. There exists a large variability in leaf morphology, size, shape, leaf apex, margins, leaf area, leaf specific weight which help in the co-existence and adaptation of these species in a forest ecosystem.

3. Branching Pattern and Branching Density

Branching pattern and branching density act as solar panel to capture solar energy required for carbon assimilation and its storage as carbon in timber. There exist a large variability in branching patter and branching density among species, thereby varying in capture of solar energy and also help in co-existence. Branching patterns may be monopodial, pseudo-monopodial or sympodial. Large variations are also found in density of branching, high, medium or low density which could be related to carbon assimilation of the species.

4. Plant Traits

Large variations are observed in plant traits, plant height, canopy cover, diameter and height of basal trunk, open or close canopy (paper in press). It is expected that the woody species with open canopy have greater capacity of photosynthesis compared to those of with close leaf canopy because most of the leaves are not exposed to solar radiation. This hypothesis needs to be confirmed in future study.

5. Anatomy

Anatomy of leaves and woodplay an important role in adaptation of the species in semiarid conditions.

5.1. Leaf anatomy

5.1.1. Leaf surface (dermal anatomy)

There exist large variations in leaf surface anatomy of the species with respect to frequency, size of stomata, presence or absence of the stomata on the upper leaf surface. Many of the woody species possess very low frequency of stomata, or absence of stomata or the presence of sunken stomata which help in the reduction of transpiration through upper surface which could be related to water relation and water balance of the species. These species, of course have more number of stomata on the lower leaf surface.

5.1.2. Anatomy of leaf lamina

In a transverse section of leaf the woody species show large variation in cuticular thickness, density of trichome, layers of palisade cells, compact or loose. The species with thick cuticle, high density of trichomes, compact and long palisade could be related to reduction of transpiration and could be related to drought resistance which needs to confirm in future study.

5.1.3. Petiole anatomy

Petiole plays an important role in the conduction of water and translocated through xylem and phloem respectively from stem to the leaves. Large variations are observed in petiole thickness, cuticle thickness, thickness of collenchyma below epidermis, presence of scerenchyma patch and thickness of vascular bundle area which could be related to the daptation and efficiency of metabolism. This needs to be confirmed in future study.

5.1.4. Venation pattern

Venation helps to give mechanical strength against rupture by wind and conduction of water and translocates. There exist large variations in thickness, density of venation and vein islets which could be related to metabolic capacity of the particular species which needs to be studied in future research.

5.2. Wood Anatomy

Wood/timber is of great commercial importance. The quality and utility of wood are dependent largely on wood anatomical structure. A study on wood anatomy of 33 woody species demonstrates a large variation in wood anatomical traits such as size and density of xylem vessels, types of axial parenchyma, wood rays, density of fibres and compactness of wood. These traits could be related to quality and utility of a timber of a particular species. Variation in wood anatomical traits could help in taxonomic identification of the species. We observed large variation in size and wall thickness of wood fibre cells which could be related to wood quality and utility. It is expected that woody species with highly compact woody tissue, more thickwalled wood fibres could produce timber for fabrication of strong furniture; on the other hand the species having fibre cells with broad lumen and thin cell wall could be recommended for god paper pulp. This hypothesis need to beconfirmed in future study.

6. Phenology

In a forest different plant species flower, produce fruits and start seed dispersal in different time, thereby maintaining their life cycle without competing with neighbors. There exists a large variability in pollen viability among specie. Knowledge on the phenology of the species is essential for efficient forest management. In our study on few woody species we observed a large variation among the species in phonological events.

7. Wood Density

Wood density contributes to the strength of wood. We observed large variation in wood density among 37 woody species which could be related to quality of wood of a particular of woody species. This hypothesis needs to be confirmed.

8. Physiology and biochemistry

Physiology and biochemistry contribute to the growth and development and also adaptation of the species to semiarid environments. We study only few aspects of these aspects.

9. Pigments

Leaf pigments (chlorophyll a, b, and carotenoids) contribute to growth and development of the woody species in photosynthesis. We observed large variations in leaf pigments among woody species studied. These variations in pigments could be related to the photosynthetic capacity which needs to be confirmed.

10. Leaf Epicuticuar Wax

Many woody species in this semiarid region possess waxy coating, epicuticular wax. It is reported that leaf epicuticular wax helps in reflection of incoming solar radiation on leaf surface, thereby reducing leaf temperature and impart drought resistance. We observed large variations in epicuticular wax in 37 woody species.

11. Leaf Macro and Micronutrients

Leaf nutrients contribute to the growth and development of the woody species. We observed large variation in the contents of macro and micronutrients among species. There is necessity to study the efficiency of woody species with high nutrient contents with the growth and productivity of the particular species.

12. Macro and Micro-nutrients

Plants require various macro and micronutrients for their growth and development which they absorb from soil profiles with the help of roots and accumulate in plant organs and leaves. We reported that there exist large variations in macro nutrients (C, N, P) and micronutrients (Mg, Zn, Fe) and proteins in leaves among species.

There exists a large in leaf nutrient contents (macro and micro) of 37 woody species of Northeast of Mexico in the leaves in, three macronutrients (P, Mg, K, protein, C, N, C/N and three micronutrients (Cu, Fe, Zn). Among macronutrients P: varied from 0.78 to 243 (mg g^{-1} dw), the species containing high P are *C. suaveleons* (2.43), *E. polystachya* (1.84), *P. laveagata* (1.65), *P. aculeata* (1.56), *A. farnesiana* (1.54).

Mg (mg g^{-1} dw) varied from 0.22 to 9.45 mg g^{-1} dw. The species containing high Mg (mg g^{-1} dw) are *E. anacua* (9.45), *C. hookeri* (6.50), *P. aculeata* (5.29). K (mg g^{-1} dw) range from 11.54 to 75.62 mg g^{-1} dw. The species containing high K are *C. suvaleolen* (75.62), *C. boissieri* (45.58), *C. pallida* (42.6).

Protein (%) varied from 1.81 to 36.81%. The species containing high protein are *G. glutinosa* (36.81), *L. macropoda* (27.69). *A. shaffneri* (27.0), *B. myricifolia* (26.3), *C. pallida* (25.75), *E. polystachyya* (25.36).

Carbon (%) varied from 30.07 to 49.97%. The species containing high C are *L. frutescens* (49.97), *F. angustifolia* (49.47), *B. celastrina* (49.25), *A. berlandieri* (49.18), *A. rigidula* (48.23), *G. glutinosum* (46.19), *A. farnesiana* (46.17), *C. suaveolens* (45.17), *S. gregii* (44.07).

Nitrogen (%) varied from 1.89 to 5.89%. The species containing high N % are *G. glutinosum* (5.89), *L. macropoda* (4.43), *A. shaffneri* (4.32), *B. myricifolia* (2.21), *C. pallida* (4.12), *E. polystachya* (4.06), *C. macrum* (4.01).

C:N ratio range from 75 to 23.13. The species containing high C:N ratio are *S. gregii* (23.13), *L. frutescens* (22.17), *Q. virginiana* (21.95), *D. texana* (21.58), *B. celastrina* (20.35), *C. suveolens* (20.16).

With respect to micronutrients, Cu (μg g^{-1} dw) varied from 2.8 to 30.71 μg g^{-1} dw. The species containing high Cu (mg g^{-1} dw) are *C. boissieri* (30.71), *C. suveleons* (26.87), *C. pallida* (25.98), *B. celastrina* (23.24), *A. farnesiana* (24.62). Fe (μg g^{-1} dw) varied from 48.47 to 280.55 μg g^{-1} dw. The species containing high Fe (μg g^{-1} dw) are *C. boissieri* (280.55), *C. pallida* (276.89), *A.* farnesiana (259.76), *C. laevigata* (234.09), *A. rigidula* (252.33), *B. celastrina* (249), *C. suveolens* (229.19), *G. glutinosum* (167.4), *P. aculeata* (165.63). Zn (μg g^{-1} dw) varied from 10.23 to 144.86. The species containing high Zn are *S. lasiolepis* (144.86), *S. boissieri* (51.87), *P. acueata* (51.66), *E. polystachya* (51.39), *F. angustifolia* (48.56), *P. laevaegata* (48.47), *A. shaffneri* (44.60), *C. lavaegata* (42.28), *D. texana* (41.45), *E. anacua* (40.07 μg g^{-1} dw). The species selected for the highest macro and micronutrients may be utilized for confirming their physiological efficiency and probable better growth and productivity. The species having high nutrients could serve as good source for the plants during nutrient deficiency to sustain growth and good sources of nutrients for grazing wild animals. We selected various species having high nutritional values in the leaves.

13. Carbon Sequestration (Carbon Fixation)

Trees and shrubs have capacity for carbon fixation (carbon sequestration n) from atmosphere and store carbn in timbers and biomass, thereby reduce carbon load and reduce pollution.

A study was undertaken to determine carbon and nitrogen content among 40 plant species of diverse growth habit with a view to select species with high carbon fixation (carbon content) and nitrogen content. In this study, we selected few species with high carbon fixation such as *Eugenia caryophyllata* (51.66%), *Litsea glauscensens* (51.54%), *Rhus virens* (50.35%), *Gochantia hypoleuca* (49.86%), *Pinus arizonica* (49.32%), *Eryobotrya japonica* (47.98%), *Tecoma stans* (47.79%), *Rosamarinus officinalis* (47.77%). Few of these species could be recommended for plantation in CO_2 polluted areas to reduce carbon load. In addition these, high carbon concentration could serve as good source of energy. We selected few species with high nitrogen content such as *Mimosa malacophylla* (8.44%), *Capscicum annuum* (6.84%), *Moringa oleifer* (6.25%), *Azadirachta indica* (5.85%), *Eruca sativa* (5.46%), *Rosamarinus officinalis* (5.40%), *Mentha piperita* (5.40%). These species could serve as good sources of nitrogen for health care. We selected few species with high C/N ratio such *Arbutus xalapensis* (26.94%), *Eryngium heterophyllum* (24.29%), *Rhus virens*(22.52%), *Croton suaveolens* (20.16%), *Cinnamomum verum* (19.89%) which may be related to high production of secondary metabolites and antioxidants (Rodriguez et al., 2015a, b).

The carbon fixation/carbon concentration estimated in certain trees and shrubs indicated that there are certain tree species with high ability to fix atmospheric carbondioxide into their biomass. The trees and shrubs selected with high carbon concentration were *Eugenia caryophyllata* (51.66%), *Litsea glauscensens* (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%), *Bumelia celastrina* (49.25%), *Tecoma stans* (48.79%), *Acacia rigidula* (48.23%), *Eryobotria japonica* (47.98%), *Rosamarinus officinalis* (47.77%). Few of these species may be selected for plantation in highly carbon dioxide polluted areas in cities, road sides and factory areas with high emisssion of carbon dioxide (Maiti et al., 2014).

14. Conclusion

The research undertaken at Linares, Northeast Mexico on various morphological-anatomical, and physio-chemical traits of more than 30 species of woody trees and shrubs reveals large variations in all these traits which could be related to adaptive strategy of the species. A good knowledge of these traits could help in effective management of the forest and sustainable use of the species in the forest ecosystem. The variations in wood anatomical traits could determine the quality and utility of particular timber. Very little research is available in these lines of research we discussed. We discussed also several potential lines of research in various aspects for future researchers.

15. References

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