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Trees and Shrubs with High Carbon Fixation/Concentration

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Abstract

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.

Keywords: Carbon fixation; Shrubs; Global warming; Greenhouse gases

Introduction

The constant emission of carbon dioxide by combustion of fossil fuels from the factories and burning of woods is a great menace increasing pollution in the atmosphere. This increased concentration of carbon dioxide is thus endangering the security of mankind and animals. This has direct effect on climate changes and on enhanced global warming, thereby, reducing crop productivity and aggravating poverty. This increased global warming is associated with incessant logging, illegal anthropogenic activities and conversion of forest to agriculture. These have enhanced the emission of greenhouse gases (GS), in particular the carbon dioxide load in the atmosphere, which was increased several folds leading to pollution and climate change [1]. This has caused a great concern to the security of mankind and animal life and reduced crop productivity worldwide. Concerted research activities have been directed to mitigate it. Plants capture carbon and store it in various reserves, plant organs and agricultural products, terrestrial or geologic reserves. Different technologies are adopted in different countries in relation to carbon dioxide capture and sequestration but attained little success to reduce CO_2 load from the atmosphere.

Carbon sequestration refers to the process of capturing carbon dioxide (CO_2) from the atmosphere that is derived from various anthropogenic (human) activities and its constant emission from large-scale factories. Once captured, the CO_2 gas (or the carbon portion of the CO_2) is compressed and put into long-term storage. There exist two major types of CO_2 sequestration: terrestrial and geologic. Terrestrial sequestration includes land management practices that maximize the amount of carbon that remains stored in the soil and plant material for the long term. Unlike terrestrial or biologic, geologic sequestration, carbon sequestration process involves the storage of carbon via agricultural and forestry practices. Geologic sequestration involves injecting carbon dioxide released from factories, power plants etc., into deep underground surface for long term permanent storage.

The U.S. Environmental Protection Agency has taken action plan to reduce carbon pollution from power plants. Carbon capture and sequestration is one of the technologies that new power plants can employ to meet the standards. EPA' Green house Gas Program (GHGRP) collects information from facilities in many industry types that directly emit large quantities of GHGs, suppliers of certain fossil fuels and facilities that inject CO_2 underground. Carbon dioxide (CO_2) capture and sequestration (CCS) could play an important role in reducing greenhouse gas emissions. Keller et al., [2] analysed carbondioxide (CO_2) sequestration as a strategy to manage future climate change in an optimal economic growth framework. They considered that CO_2 sequestration is not a perfect substitute for avoiding CO_2 production because CO_2 leaks back to the atmosphere and hence imposes future costs.

Plants contribute a lot in the capture of Carbon dioxide load from the atmosphere in the process of photosynthesis, synthesis of carbohydrate and store carbon in its biomass. Variation in carbon fixation by photosynthesis is related to variation of carbon deposition in plant species. Carbon is the source of energy for plants. During photosynthesis, plants take in CO_2 and give off the oxygen (O_2) to the atmosphere. The oxygen released is available for respiration. The plants retain and use the stored carbon for growth to guide all metabolic functions.

Various research inputs have been undertaken to analyse carbon fixation/accumulation of carbon in different plant organs and select plants with high carbon fixation capacity.

Carbon fixation in trees as a micro optimization process leads to the location of carbon in plant organs. John Hof, John Hof [3] demonstrates how optimization procedures commonly used in microeconomics can be directly applied in studying ecological systems. John Hof [3] developed two alternative economic-analog models of carbon fixation in trees. In the first model, the plant is modelled as a maximizer of net carbon gain (a profit analog). The second models carbon 'revenue' as the minimum of two functions that relate carbon gain to leaf and root biomass, respectively.

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Reforestation is a novel technique adopted by EPA to reduce carbon load emitted by factories coal mine areas from the atmosphere. Storing carbon in forests is cheaper than paying carbon tax. This technique is implemented in coal mining areas in Eastern United States and South East Colorado project. It is an ideal example. The fixation of CO_2 into living matter sustains all life on Earth and embeds the biosphere with geochemistry. Braakman et al. [4] constructed the complete early evolutionary history of biological carbon-fixation, relating all modern pathways to a single ancestral form. They observed that innovations in carbon-fixation built the foundation for most major early divergences in the tree of life. Their findings are based on a novel method that fully integrates metabolic and phylogenetic constraints. It is concluded that the most common form for deep-branching autotrophic carbon-fixation combines two disconnected sub-networks, each supplying carbon to distinct biomass components. Using metabolic constraints they reconstructed a "phylometabolic" tree with a high degree of parsimony. It traces the evolution of complete carbon-fixation pathways and has a clear structure down to the root.

Okimoto et al. estimated net carbon fixation of a representative mangrove tree in South-East Asia, Rhizophora, but it concluded that these estimated values were significantly higher than the results produced by the growth curve analysis method, which produced 1.1-35.2 Mg C ha^{-1} yr^{-1}.

Xinjie Wang et al. [5] studied variability of Larixolgensis in different organs in North-Eastern China. The results showed that the weighted mean carbon concentration by biomass was approximately 48.15%. In this study, the carbon concentration of aboveground tree organs is ranked with descending order as living branch>bark>foliage>dead branch>stem; and in the belowground, it is ranked as large roots>stumps>thick roots>medium roots>small roots. The carbon concentration differed significantly between tree organs, while there was no significant difference between trees with different ages.

With respect to the role of plants in capturing CO_2, Jiménez Pérez et al. [6] investigated carbon concentration in pine-oak forest species of the Sierra Madre Oriental. Revista mexicana de ciencias forestales. The components of the above-ground biomass considered were stem, branches, bark and leaves of the species *Pinus pseudostrobus*, *Juniperus flaccida*, *Quercus laceyi*, *Quercus rysophyla*, *Quercus canbyi* and *Arbutus xalapens.* The species with the highest carbon concentration was *Juniperus flaccida* (51.18%), while *Q. rysophylla* had the lowest (47.98%). Among the different components of the tree the component i.e., leaves of *Arbutus xalapensis* (55.05%) had the highest carbon concentration. There were highly significant differences between the various components by species group; the highest concentration was found in the bark of conifers (51.91%), compared to the bark of the broadleaf species, which had the lowest (45.75%). In the context of the role of plants in the capture of Carbon dioxide from the atmosphere, the objective of the present study is to determine carbon fixation and its accumulation in various native and exotic species in Mexico.

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 (2447N.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°C in January to 23°C in August, although during summer the temperature goes up to 45°C. Average annual precipitation is around 805 mm with bimodal distribution.

The plant samples (leaves) from eighty species of several tree and shrubs from Northeast of Mexico as well as from few exotic species including barks were collected for carbon fixation/ carbon concentration studies.

Chemical analysis

The plant samples were collected and placed to dry on newspaper for a week. The leaves were separated from the rest of the plant and were passed twice through a mesh of 1 × 1 mm in diameter using a mill Thomas Wiley and subsequently dried for more than three days at 65°C in an oven (Precision model 16EG) to remove moisture from the sample and later these were placed in desiccators. A 2.0 mg of the sample was weighed in a AD 6000 Perkin balance Elmer in a vial of tin, bent perfectly. This was placed in Chons analyzer Perkin Elmer Model 2400 for determining carbon, hydrogen and nitrogen. For estimating the mineral contents, the samples were incinerated in a muffle oven at 550°C for 5 hours. Ashed sample is digested in a solution containing HCL and HNO_3, using the wet digestion technique [7]. Carbon foliar content (% dry mass basis) was carried out in 0.020 g of milled and dried leaf tissue by using a CHN analyser (PerkinElmer, model 2400).

Results and Discussion

Eighty trees, shrubs and native forest species were evaluated for the carbon fixation or carbon concentration studies for identifying a tree/ shrub species with high carbon fixation ability. Out of these, 25 species were selected with high carbon fixation capacity. These are depicted in Table 1. It is observed from Table 1, that the species with growth habit, mostly herbs, shrubs and few trees contained reasonably high carbon content ranging from 45 to 51%.

The large variability in carbon fixation among the species exhibit variabilty in the capacity of conversion of atmospheric carbon dioxide load to organic carbon to be stored in plants biomass. Further, these also have the capacity in reducing carbon load in the atmosphere. The results of this study coincide with the finding of several authors. Owing to increasing global warming, various studies have been directed in the estimation of carbon fixation and selection of species with high carbon fixation capacity in various species [6,8] with an objective to select species with high carbon fixation which have capacity to reduce atmospheric carbon dioxide load, thereby reduce contamination. In the present study, among the eighty species that were analysed for carbon sequestration certain species were found to have higher capacity to fix atmospheriec carbon dioxide. The species with high carbon fixation selected 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 could be recommended for plantation in carbon dioxide polluted areas to reduce carbon load. In addition, these with high carbon concentration could serve as a good source of energy to the patients suffering from various diseases as some of these species also have medicinal properties and are used as ingredients in the preparation of medicines. Similar study has been undertaken by Jiménez Pérez et al. [6] on carbon concentration of conifers where few species contained 51% carbon which coincides with few species in the present study.

Conclusion

The species with high carbon fixation with arboreal habit could be planted in polluted areas and in areas identified for new town planning

Scientific name	Family	Type	%C
Cinnamomum verum (bark)	Lauraceae	Tree	49.34
Eugenia caryophyllata	Myrtaceae	Tree	51.66
Bumelia celastrina	Sapotacee	Tree	49.25
Acacia berlandieri	Fabaceae	Tree	49.18
Acacia farnesiana	Fabaceae	Tree	46.17
Melia azadirachta	Meliaceae	Tree	45.11
Moringa oleifer	Moriginaceae	Tree	45.96
Carya illinoiensis (stem)	Juglandaceae	Tree	44.27
Pinus arizonica Engelm	Pinaceae	Tree	49.32
Buddleja cordata	Buddlejaceae	Tree	45.7
Hedeoma palmeri	Lamiaceae	Bush	46.38
Leucophyllum frutescens	Scrophulariaceae	Shrub	49.97
Acacia rigidula	Fabaceae	Shrub	48.23
Chrysactinia mexicana	Asteraceae	Bush	45.04
Rhus virens	Anacardiaceae	Bush	50.35
Litsea glauscesens	Lauraceae	Bush	51.34
Arbutus xalapensis	Ericaceae	Bush	49.1
Eryobotria japonica	Rosaceae	Bush	47.98
Gochnatia hypoleuca	Asteraceae	Bush	49.86
Forestiera angustifolia	Oleaceae	Shrub	49.47
Rosamrinus officinalis	Lamiaceae	Bush	47.77
Croton suaveolens	Euphorbiaceae	Bush	45.17
Gymnosperm aglutinosum	Asteraceae	Shrub	46.19
Tecoma stans	Bignoniaceae	Bush	48.79
Mimosa malacophylla	Leguminosae	Sub Bush	45.15

Table 1: Species with high carbon fixation capacity.

to reduce carbon dioxide load in the atmosphere and reduce the effect of global warming on climate change.

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