Plant Archives Vol. 21, No. 2, 2021 pp. 813-815 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no2.124

USE OF DIMENSION ANALYSIS OF DIFFERENT TREE PLANTATIONS TO STUDY LAND USE CHANGE IN DRY TROPICS

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(Date of Receiving : 15-05-2021; Date of Acceptance : 23-07-2021)

ABSTRACT

Urban land use change (ULUC) is the major environmental problem of the present century. Restoration of degraded urban lands is considered successful if it fulfils all the environmental, social and economic sustainability criteria. The present study investigated the tree dimension analysis in terms of stem girth at breast height (GBH), tree height, and canopy cover for different tree plantations involving *Tectona grandis* plantation, *Terminalia arjuna* plantation and *Eucalyptus citriodora* plantation in dry tropics. Among the three tree plantations, the height and GBH were maximum in *Eucalyptus* followed in decreasing order by *Terminalia* and lowest in *Tectona* plantations whereas in case of canopy although *Eucalyptous* had widest canopy cover but the lowest was found in *Terminalia* plantatins.

INTRODUCTION

Land is essential natural resource for existence of the life. Excessive exploitation of land has resulted in several land use changes (LUC). Urbanization is an anthropogenically driven LUC (Nuissi and Siedentop, 2021), where the effect of several factors including climate and mismanagement of soil has lead to the formation of degraded land. Urbanization involves the conversion of land from non-urban to urban area. Urban land use change (ULUC) has adversely affected the ecosystem structure, function and various services (Kumar and Ghoshal, 2017; Wang *et al.*, 2021) including the soil organic matter (SOM) dynamics (Liu *et al.*, 2018a; Sun *et al.*, 2020; Wang *et al.*, 2020). ULUC has become a major concern worldwide in general and especially in tropics as tropical soil they are nutrient limited and highly wheathered (Nuissi and Siedentop, 2021). Restoration of degraded lands has become a challenge globally (Singh *et al.*, 2017). A restoration strategy is considered successful if fulfills all of the environmental, social, and economic sustainability criteria, (Singh and Ghoshal, 2014).

Among several strategies tree plantation has been advocated for the restoration of urban degraded lands as root and litter of tree are helpful in improving the health of soil (Day *et al.*, 2010; Singh *et al.*, 2021). Planting native and exotic, tree species may play an important role not only by providing various natural resources but also improve the soil quality by increasing SOM through carbon sequestration.

The role of tree dimensions such as girth at breast height (GBH), height, and canopy is crucial for determining a tree's growth pattern, productivity, and potential for carbon sequestration in any ecosystem. A tree's girth (measured at breast height GBH) and canopy or stem height (measured at the top of the canopy or below the first branch, i.e. bole height) are the most common measurements used to determine its size (Shugart *et al.*, 2010). GBH alone is a good predictor of biomass, especially when many trade-offs between accuracy, cost, and measurement feasibility are considered (Kebede and Soromessa, 2018). The height of a tree is one of the most critical factors in determining its biomass (Phalla *et al.*, 2018), and has an impact on ecosystem variability, including carbon sequestration.

The canopy size, on the other hand, represents the light interception and growing conditions of individual trees within the stand and indicates leaf area. Canopy of a tree also reflect the pattern of biomass allocation, height growth, leaf display (Osada, 2011). As a result, canopy structure influences a variety of factors, including within-stand environmental conditions stand productivity, stand stability and resilience, habitat structure, and even a stand's aesthetic appeal (Hans Pretzsch, 2014).

Therefore, the aim of the present study was to analyze the tree dimension in terms of GBH, height and canopy for different tree plantations to study urban land use changes in dry tropics.

MATERIAL AND METHODS

Study sites

The three different tree plantations were selected for the present study including: 1) *Tectona grandis* Linn. plantation (TG) 2) *Terminalia arjuna* (Roxb.)DC. plantation (TA) and

3) *Eucalyptus citriodora* Hooker plantation (EC). All the plantation sites were situated at Banaras Hindu University, Varanasi, Uttar Pradesh, between 25^0 15'N latitude, $82^0$59' E longitude and at 76 m above the mean sea level altitude. The climate of this region is dry tropical monsoon with marked seasonality with respect to temperature and precipitation. The entire year can be divided into three distinct seasons (a) dry and hot summer (April to June 30-36^0 C mean temperature), (b) warm and humid rainy (July to Sept 24-34^0C) and (**c**) cool and dry winter (Nov to Feb 15-18^0C). The rainy season has ~80% of about 1100 mm long-term total mean rainfall. October and March being the transitional months. The mean monthly minimum and maximum temperatures, respectively, varied from 14.2 to 32^0 C and 25.5 to 42.8^0 C.

All the three tree plantation which were raised with the objective of the restoration of the degraded lands in urban landscape. *Tectona* plantation was done about 22 years ago in 2000 by BHU administration. *Tectona* was planted in row with the inter row and interplant distance of ~4 m. Arjun (*Terminalia arjuna*) plantation was about 25 years old and was planted in row with inter row distance of ~ 3-4m and interplant distance was ~ 2 m. While, *Eucalyptus* plantation was more than 50 years old.

Experimental design

Experimental design involved three replicates of each land use type. Each replicate site was divided into three study sites. From each study sites two samples were taken for the tree dimensions analysis.

Methodology

Tree dimension studies involved girth at breast height (GBH), height (H) and canopy (C). GBH was measured by using the measuring tape, wrapped around the tree trunk at breast height (1.5 m) above the mid slope of the tree's base and taken the measurement in meter (Bruce and Schumacher, 1950). Height of each tree was measured by using a meter stick method to the ground and elementary trigonometry as described by Leverett and Bertolette (2015) and Bruce and Schumacher (1950). The canopy measurement was done by axis method (Leverett and Bertolette, 2015). Where two measurements of the widest spreads crown were taken at 90^0 to one another and the distance on the ground of the axis was measured. The average of the axis distances was used to estimate the canopy of a tree.

Statistical analysis

All the data were analyzed by SPSS package (version 16). All the values are expressed as mean ± standard error. Least significant difference (LSD) was used for comparing means.

RESULTS AND DISCUSSION

Considerable variations in various tree dimension parameters were observed among the different tree plantations (Table-1). Among all the three tree plantations, the mean GBH was maximum in *Eucalyptus* plantation (1.55±0.173), and was followed in decreasing order by *Terminalia* plantation (1.08±0.037), and minimum in *Tectona* plantation (0.891±0.0716). The height of all the three tree plantation showed similar trends that of GBH i.e. *Eucalyptus* plantation was tallest, followed in decreasing order by *Terminalia* and *Tectona*. In case of canopy cover although maximum values was found in case of *Eucalyptus* plantation, yet minimum was found in *Terminalia* and not in *Tectona* plantation as was found in case of GBH and height. Thus the trend of canopy was different from that of height and GBH. Thus, *Eucalyptus* had highest GBH and canopy cover and tallest among the three tree plantations.

Individual tree height and diameter are the most widely measured variables in growth and yield of biomass and carbon budget models for calculating tree volume, site index, and other key factors (Zhange *et al*., 2014). Mishra *et al*. (2013) suggested that tree having higher GBH may play important role in sequestering CO_2 from atmosphere rather than tallest trees. They also reported that higher the girth and biomass, higher will be the potential of sequestering carbon. Mc Gregor *et al*. (2020) reported that taller tree face major challenges of water lifting from longer distance against the effect of gravity and frictions and hence may also have lower drought tolerance because of more microenvironment and ecological factors. Crowns of tallest tree are more exposed which is related with higher evaporative requirement (McGregor *et al*., 2020). The link between tree height and girth is critical for understanding tree growth patterns and determining tree biomass (Mugasha *et al*., 2013; Sumida *et al*., 2013). It may vary within the same species with different tree size, stand densities, species composition, stand age and site condition.

The woody crown architecture, or branching pattern, determines a significant pattern of the canopy structure as leaf orientation and distribution affect canopy density, light interception, and carbon assimilation (Broeckx *et al*., 2012). The canopy cover provides a better understanding of stand productivity, and hence necessary to identify and quantify the underlying traits that contribute to canopy structure. The size of a tree's canopy and the structure of its crown impact the productivity of the ground flora via influencing light penetration and canopy microclimate, such as temperature, vapour pressure deficit, and wind speed (Medhurst and Beadle, 2001).

On the basis the present study it may be predicted that eucalyptus plantation having taller trees with higher girth, canopy would improve the quality of soil and sequester more carbon to the soil in long term among the tree plantations studied and hence Eucalyptus plantation may be recommended for the restoration of urban degraded land in dry tropics. However more study involving soil quality analysis is required for the better understanding and management of urban degraded lands in dry tropics.

Table 1: Variation in Girth, height, and canopy of three tree plantations i.e. TG (*Tectona grandis*), TA (*Terminalia arjuna*), EC (*Eucalyptus citriodora*). The value are mean±SE. LSD value are at $p < 0.05$.

Tree dimension(m)	TG	TA	EC	LSD
GBH (m)	0.891±0.071	1.086±0.037	1.55±0.12	0.239
H (m)	11.968±0.76	17.031±0.29	27.384±0.29	1.619
C (m)	5.225±0.26	3.975±0.15	6.719±0.46	1.42

Code: GBH= Girth at breast height (m), H= Height (m), C= Canopy (m)

Acknowledgement

We thank the Head and the Coordinator, Centre of Advanced Study in Botany, Department of Botany, for providing required facilities, Council of Scientific and Industrial Research (CSIR), New Delhi, India for Junior Research Fellowship to Mr. Rahul Kumar and University Grants Commission, New Delhi, India for providing University Research Fellowship to Ms. Priyanka Soni, Ms. Fahami Zaya and Amrita Kumari.

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