CARBON ISOTOPE DISCRIMINATION POTENTIAL IN AFFORESTED PLANTATION OF SOUTHERN TAMIL NADU, INDIA

C. N. HARI PRASATH*, A. BALASUBRAMANIAN AND S. RADHAKRISHNAN

Department of Silviculture,
Forest College and Research Institute, Mettupalayam - 641 301, Tamil Nadu, INDIA
e-mail: prasathforestry@gmail.com

ABSTRACT

To investigate the carbon isotope discrimination and water use efficiency, a study was conducted at Sivagangai District, Tamil Nadu, South India. The tree species planted *viz.*, *Tectona grandis*, *Gmelina arborea*, *Dalbergia sissoo*, *Bambusa vulgaris* var. *vulgaris* and *Swietenia macrophylla* for assessing the carbon isotope discrimination potential. Among the five tree species studied, the carbon isotope discrimination ($\Delta^{13}C$) was highest in *Bambusa vulgaris* var. *vulgaris* with 21.01 per cent followed by *Dalbergia sissoo* (19.62 %), *Gmelina arborea* (19.56 %), *Swietenia macrophylla* (19.28 %) and lowest $^{13}C/^{12}C$ discrimination was observed in *Tectona grandis* with 18.53 per cent. The maximum carbon isotope discrimination potential in tree species helped in water use efficiency in plantation under wasteland conditions.

INTRODUCTION

Carbon isotope signatures can integrate water status history of trees, but more research is needed before to screen a specific protocol in site adaptability. Usually, tree carbon contains two stable isotopes namely $\Delta^{12}C$ and $\Delta^{13}C$. Among these two, $\Delta^{12}C$ is the most abundantly present and light in weight and whereas, $\Delta^{13}C$ is heavier isotope of carbon and the availability is in less quantity. Tree growth and carbon isotopic composition ($\Delta^{13}C$) are two variables strongly influenced by site water availability. The carbon isotope discrimination differed significantly among tree species and among populations within species. Of the all coniferous species, Pinaceae (Abies, Larix, Picea, Pinus, Pseudorsuga) had higher Δ discrimination than species in the Cupressaceae (Juniperus) family (Zhang *et al.,* 1996). The inverse relationship between specific leaf area (SLA) and water use efficiency (WUE) indicating that genotypes with thick leaves (low SLA) under moisture stress conditions may be water use efficient (Babu *et al.,* 2015).

The leaf samples were collected from each plant and subsequently analyzed for the composition of stable carbon isotopes, $\Delta^{13}C$ in that *L. pennellii* had higher $\Delta^{13}C$ values than *L. esculentum* at all soil moisture levels, and the $\Delta^{13}C$ values for each genotype increased with decreasing soil moisture (Martin *et al.,* 1988). The negative correlation between growth and carbon isotope discrimination, when it was consistency with variation in photosynthetic capacity between the species of *Abies alba* (Bert *et al.,* 1997). However, there was no significant correlation between discrimination values and growth, where the water availability was high. The trees with very long branches had reduced water supply in upper branches and therefore had lower stomatal conductance in relation to photosynthesis capacity consequently lower $\Delta^{13}C$ values. The leaves at the top of the canopy had high leaf $\Delta^{13}C$ values, while leaves at the bottom of the canopy had lower leaf $\Delta^{13}C$ values. Earlier carbon isotope discrimination works were carried out based on the concept of conifers trees alone, but still there is no much evidence in broad leaf trees (Tropical species).

Based on the above understanding, the current study is designed to assess the carbon isotope discrimination potential in afforested plantation of tropical trees species grown in Southern Tamil Nadu.

MATERIALS AND METHODS

The experimental area, Energy Plantation Projects India Public. Ltd. (EPPI) plantation was located at Nattarasankottai village, Sivagangai district in Tamil Nadu that receives an annual average rainfall of 500 - 600 mm and mean annual temperature of 35.2ºC (Minimum of 30.6ºC and Maximum of 43ºC). The soil type of the plantation site is red sandy clay soil with the pH and EC of 5.35-5.75 and 0.11dSm^{-1} respectively. The tree species selected for the investigation of carbon isotope discrimination are *Tectona grandis* Linn. , *Gmelina arborea* Roxb., *Dalbergia sissoo* Roxb., *Bambusa vulgaris* var. *vulgaris* and *Swietenia macrophylla* King with a spacing of 2.5 m x 2.5

Table 1: Carbon isotope (c¹³/c¹²) discrimination potential of tree species

Sl.No	Treatment	Leaf	Branch	Stem	Root	Mean
1	*Tectona grandis*	19.09	18.13	18.77	18.12	18.53
2	*Gmelina arborea*	21.17	19.5	18.85	18.73	19.56
3	*Dalbergia sissoo*	21.67	19.5	19.25	18	19.62
4	*Bambusa vulgaris* var. *vulgaris*	21.37	21.11	21.29	20.29	21.01
5	*Swietenia macrophylla*	20.56	18.29	19.2	19.07	19.28
	SEd	0.09	0.06	0.07	0.05	0.05
	CD(0.05)	0.2	0.13	0.16	0.12	0.11
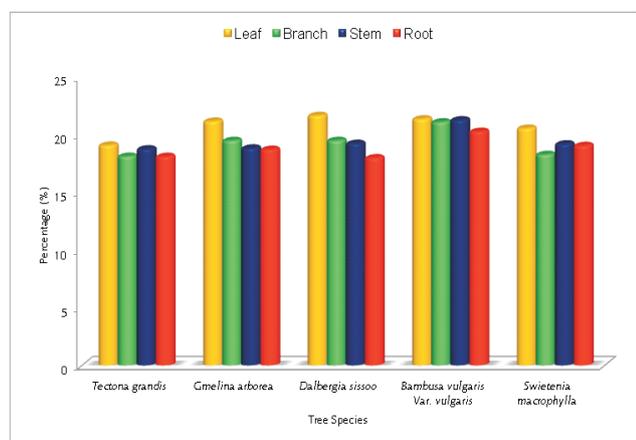
Figure 1: Carbon isotope (c¹³/c¹²) discrimination potential of tree species

m and 20 plants per replication in Randomized Bloc Design (RBD).

The $\Delta^{13}C$ was measured in samples of different tree species in 3 year grown afforested plantation. The leaves were oven dried at 70°C and after 5 days of complete drying, the samples were powdered in a willy mill. Care was taken to prevent any mixing of different samples by washing the willy mill with alcohol after grinding each sample. Powdered samples were placed in a glass vials and properly labeled before analysis of the stable isotope ratios. The $\Delta^{13}C$ of the tree samples were determined using the Isotope Ratio Mass Spectrometer (IRMS) found at National Facility for stable isotope studies in Biological Sciences present at Department of Crop Physiology, University of Agricultural Science, Bengaluru, Karnataka .

The data obtained were subjected for statistical analysis to evaluate the possible relationship between the different parameters and analysis of variance employing statistical methods described by Panse and Sukhatme (1957) using AGRES software developed by Tamil Nadu Agricultural University (TNAU) Coimbatore.

RESULTS AND DISCUSSION

Plants discriminate against $\Delta^{13}C$ discrimination, when they fix carbon through photosynthesis. The isotopic signature in plant tissues is influenced by both environmental variables and genetics. Measurement of carbon isotope discrimination in plant tissues ranks not only the plant's water use efficiency (WUE), defined as carbon gain to water loss (Farquhar and Richards, 1984). Crops grown in stress environments as its

yield are associated with the capacity of the plant to maintain CO_2 assimilation (Singh and Vaishali, 2015).

Carbon isotope discrimination varies across the world, including annuals and perennials, evergreen and deciduous, trees and grasses, and so on. The $\Delta^{13}C$ estimation reflects the productivity and water use efficiency of tree species even under difficult environmental condition. The present study observed that highest $\Delta^{13}C$ discrimination (21.01 %) by *Bambusa vulgaris* var. *vulgaris* followed by *Dalbergia sissoo* (19.62 %). The $\Delta^{13}C$ estimation reflects the productivity and water use efficiency of tree species even under difficult environmental condition.

The changes in $\Delta^{13}C$ constitute an integrative variable of water status occurring seasonally as a result of changes in soil water status and air temperature (Garcia *et al.,* 2004). Hence, it is presumed that Pine trees are more likely to show a better correlation between $\Delta^{13}C$ and water status than annual plants, because of the tree's increased tolerance to moisture deficit and perennial growth habit (Waring and Silvester, 1994). The low performing species, *Tectona grandis* and *Gmelina arborea* shown very high photosynthetic and transpiration rate, but showed poor growth performance. So these above two factors indicate that, *Tectona grandis* and *Gmelina arborea* not able to maintain water relation and so it resulted with poor productivity (Table 1 and Fig. 1). This lowest productivity has again been confirmed by $\Delta^{13}C$ discrimination estimation, which indicated lowest $\Delta^{13}C$ discrimination of 18.53 % and 19.56 % respectively in *Tectona grandis* and *Gmelina arborea*.

ACKNOWLEDGEMENT

REFERENCES

Babu, Venkatesh D., Sharathkumar Reddy, Y. and Sudhakar, P. 2015. Identification of high water use efficiency and high yielding ragi genotypes for rainfed conditions. *The Ecoscan (Special issue).* **8:** 121-124.

Bert, D., Leavitt, S. W. and Duopouey, J. L.1997. Variation of wood "¹³C and water use efficiency of *Abies alba* during the last century. *Ecology.* **78:** 1588-1596.

Farquhar, G. D. and Richards, R. A. 1984. Isotopic composition of plant carbon correlates with water use efficiency of wheat genotypes. *Aust. J. Plant Physiol.* **11:** 539-552.

Garcia, G. Ricardo, Armando Gomez, Javier Lopez, Jesus Vargas and William R. Horwath. 2004. Tree growth and d13C among populations of *Pinus greggii* Engelm. *At two contrasting sites in Central Mexico. Forest Ecology and Management.* **198:** 237-247.

Martin Bjorn, Yvonne and Thortenson, R. 1988. Stable carbon isotope composition, water use efficiency and biomass productivity of *Lycopersicon esculentum, Lycopersicon pennellii* and the F1 Hybrid. *J. Plant Physiology.* **88:** 213-217.

Panse, V. G. and Sukhatme, P. V. 1957. Statistical methods for agricultural workers (Ref. Edn.). *ICAR,* New Delhi. pp. 152-165.

Singh, N. P. and Vaishali. 2015. Proline accumulation for improving stay green trait to combat with environmental abiotic stress in wheat (*Triticum aestivum*). *The Ecoscan (Special issue).* **8:** 241-246.

Waring, R. H. and Silvester, W. B. 1994. Variation in foliar "^{13}C values within the crowns of Pinus radiata trees. *Tree Physiology.* **14:** 1203-1213.

Zhang, J., Marshall, J. D. and Fins, L. 1996. Correlated population differences in dry matter accumulation, allocation, and water use efficiency in three sympatric Conifer species. *For. Sci.* **42:** 242-249.