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Exploring the Responses of Teak and Eucalyptus to Elevated Carbon Dioxide in a Changing Atmosphere

Sugumaran M. P. [a*], Gudimetha Ganesh Kumar [a], Porkodi G. [a] and K. Kalaichelvi [a]

[a] *Tamil Nadu Agricultural University, Tamil Nadu, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Global warming plays a major role in climate change that is mainly caused by the increase of atmospheric carbon dioxide (CO_2) and other greenhouse gases (GHGs) such as Methane (CH_4), Nitrous oxide(N_2O) and Chloro Fluoro Carbons (CFC) level in the last two decades. These greenhouse gases partially absorb long wave radiation remitted by the earth's warm surface and re-emit the same resulting in warming up in the atmosphere. Climate change can be identified by changes in mean and variability of its properties. Climate changes are operated by the increase of (Green House gases) of them Carbon dioxide (CO_2) is one of the most important greenhouse gases because of which influence the growth and morphology of industrially important tree species in tropics. Teak and Eucalyptus are the economically important tree species grown throughout the world in current study found that morphological, physiological and biochemical changes under elevated CO_2 conditions. Forests, comprising diverse ecosystems and housing a plethora of plant species, play a critical role in mitigating climate change by acting as carbon sinks. Among the key

**Corresponding author: E-mail: sugumaran.mp@tnau.ac.in;*

contributors to this dynamic, Teak and Eucalyptus, as prominent tropical tree species, have been identified for their potential to sequester carbon dioxide (CO_2) and influence ecosystem dynamics. Understanding how these trees respond to elevated CO_2 levels is imperative for predicting the resilience and adaptability of forest ecosystems in the face of ongoing climate change. As we navigate a changing climate, unraveling the intricacies of how these vital tree species interact with elevated CO_2 provides crucial insights for informed forest management and conservation practices.

Keywords: Carbon sequestration; green house gases; physiological attributes; biochemical changes.

1. INTRODUCTION

Intergovernmental panel on climate change (IPCC) is the leading body established in 1988 by the United Nations Environment Programme (UNEP) and World Meterological Organization (WMO) to access the climate change and controlling the emission of GHGs. The IPCC has produced five comprehensive assessment reports so far, of which the last assessment report (AR 5), issued in 2013-14 was confirmed at 4th assessment reports assertion that global warming of our climate system is unequivocal and it's also associated with increased greenhouse gases concentration in the atmosphere. It was mention that 1983- 2012 was likely to be warmest 30 years period of the last 1400 years in northern hemisphere. It also indicates that, the worst effects of climate change in the atmosphere during this period. As per the IPCC prediction, the concentration of atmospheric CO_2 will reach at 1000 ppm in the year of 2100 but, that can be achieved in early due to rapid industrialization process that are currently happening around the world. Therefore, it is necessary that CO_2 emission should be reduced globally by 41-72% by 2050 and by 78- 118 % by 210 with respect to 2010.

Studies on carbon enrichment the special chambers will leads to understanding of response of tree species at individual level through morphological, physiological and biochemical traits. Growth rates usually accelerate when terrestrial plants are grown in elevated CO_2 levels. The plant mean growth rate no. of leaf productions under elevated CO_2 levels will alter the morphology of particular species. The tropical plants show alterations in morphology and biomass and distribution due to the growth in elevated CO_2 concentration. Elevated CO_2 is a tool that can be used to modify growth and resource allocation in tree species. Moreover, it leads to increase the availability of timbers in other forest products with the increase of plantations worldwide. Thus it is imperative to observe effects of elevated CO_2 levels on plant carbon balance, growth and development and biomass accumulation.

2. PLANT GROWTH RESPONSES TO ELEVATED CARBON DI OXIDE

Garbutt & bazzaz, (1984) studied the plant response to higher CO_2 levels under laboratory conditions, green house or controlled environment. Nakayama & Kimball (1988) used square wall open top chambers with 0.2m diameter. Hungate et al. [1] developed an OTC system for CO_2 enrichment of salt marsh vegetation that re circulated a part of input air. Baker, Allen, & Boote [2] studied the responses of plant community to elevated. The response of plants to the elevated CO_2 has been documented in numerous researches and detailed biochemical to broad physiological studies [1,3]. However, it must be emphasized that most of the findings on physiological and allocation responses to CO_2 were first discovered in agricultural crops. Most of the earlier studies on plant responses to the raising atmospheric CO_2 were done on temperate species using closed chambers and controlled facilities or short term responses. "Carbon enrichment studies in special chambers help in understanding the changes at individual level and also at physiological, biochemical and genetic level in tree species. Urban forest carbon sequestration (CS) capacity was higher in new developing built-up areas than in the old developed built-up areas under rapid urbanization. Urban forests could offset approximately 2.23% of the carbon emissions in 2000, increasing to 5.08% in 2020 in HCUA" [4]. "The total CS of built-up areas increased from 0.35 $Mt{\cdot}C{\cdot}yr^{-1}$ in 2000 to 2.06 $Mt{\cdot}C{\cdot}yr^{-1}$ in 2020, and the urban forests in the HCUA could offset approximately 2.23 % of urban carbon emissions in 2000, increasing to 5.08 % in 2020. Natural factors, such as temperature, mainly determined changes of the spatial urban forest CS distribution" [4].

3. GROWTH AND MORPHOLOGICAL RESPONSES IN ELEVATED CO_2 Level

3.1 Shoot Responses

The plant (shoot) height is to be considered as an important for growth and development. The elevated carbon dioxide leads to increases the plant productivity, depending upon the species growth stage and the responses to that particular environment without association of climate changes. (Kimball, 1992) observed that the productivity of most herbaceous plants by about one-third in response to doubling of CO_2 content.

Under elevated CO_2 levels the growth stimulation ceased after 40 days in *eucalyptus sp.* Wong [5] and the growth rate was also increase in early, which was resulted the greater plant size with an extended period of time. So the elevated CO_2 level, may directly or indirectly affect the global climate, plant productivity and development. It has been observed that, the exposure of plants to the elevated CO_2 level resulted total biomass accumulation with alteration in plant morphological parameters.

Poorter [6] reported that "the growth of faster-growing species was more than that of slow growing species to elevated CO_2 and it stimulates to increase the growth rate 10 per cent in all the species". "Moreover, the long term increases the in growth rate was occurring in some long lived tree species and it was observed" by (Bazzaz, 1993).

Lima et al*.*, (2003) reported "on variations in responses to eucalyptus species to carbon enrichment". Warrier et al. [7] reported that "the shoot length had significant influence on elevated CO_2 level in terms of shoot fresh and dry weights". "The combined effect of CO_2 and growth period had no significant influence on fresh and dry weights. Under elevated CO_2 level it was increased about 40.27% in shoot fresh weight and 52.91% in shoot dry weight over ambient environmental conditions. The results showed that the carbon emission rate of Beijing increased in the first decade and decreased in the next, while the carbon sequestration rate kept rising over the past two decades. The net carbon emission rate of Beijing averaged 1284.52×10^7 kg C yr^{-1}, indicating that the city functioned as a net carbon source throughout the study period" [8].

3.2 Root Responses

The plant response to elevated CO_2 levels, that shows the root dry weight increased in tree species [9]. The plant responses in CO_2 enriched level there will be the alteration in developmental processes including root and shoot architecture [10] observed "in scots pine seedlings for six months in open-top chambers maintained with extra CO_2 increased total root length by 122 per cent and total root dry mass by 135 per cent".

Weihong et al*.*, (2002) reported that atmospheric CO_2 enrichment was typically enhances the growth rates of roots, especially those of fine roots, and CO_2 induced to increase in root production on belowground plant growth and development, lead to increase and enhance the root turnover, although, several researchers have claimed that plants should receive little direct benefit and leads to produced significant increases in root growth (Splittstoesser, 1996), as well as yield itself (Baron and Gorski, 1986), with CO_2 enriched level.

Gleadow et al*.* (1998) observed in *Eucalyptus* seedlings under elevated CO_2 level and it stimulates greater root growth of 33 per cent higher root, shoot ratio. Similarly [11] suggested that the effect on growth, gas exchange and plant water relations in CO_2 enriched studies probably it increase the root shoot ratio or fine-root proliferation.

3.3 Leaf level Responses

Leaf area is an important components that is closely related to the physiological processes controlling dry matter production, yield and contribures to the formation of assimilates. Chandra and Polisetty (1998) reported that "the leaf area was positively correlated with dry matter accumulation in pea varieties. There was fivefold difference in leaf area among the seed sources of *Acacia nilotica spp. Tomentosa.* Elevated CO_2 increases the leaf area index (LAI), through increasing photosynthetic efficiency and lower light compensation point (LCP) of photosynthesis, allowing the leaves to maintain positive carbon balance in elevated CO_2 than atmospheric CO_2. Alternatively, greater carbohydrates supply and improved water use efficiency may lead to larger individual leaves and more rapid canopy development, thereby increasing the LAI". Ceulemans & Mousseau [12] observed that "the leaf area was increased 8-18 per cent in *populus* clones under CO_2

enrichment". "It leads to increase leaf area index, leaf number, branches, thus positively changing canopy structure under optical conditions" [13]. "Open-top chamber experiments usually showed an increase in leaf area of seedlings with CO_2 enrichment" [14].

Tissue et al. (1997) reported that "the leaf area was increased 41% in *pinus taeda* growing in elevated CO_2 environment for subsequent four growing seasons compared to ambient CO_2".

The tree height, leaf area, number and size, under elevated CO_2 levels influence branching patterns [15] investigated under elevated CO_2 levels.

3.4 Biomass Increment

When the plants are exposed under elevated CO_2 condition the growth performance and biomass was varied over the period of study. In tree species, the increase of height (15 per cent) and biomass (30-45 per cent) was observed by Tupkeret al. (2003). Further, [16]. observed in two clones of *Hevea brasilensis* under elevated CO_2 concentration and they found that higher biomass accumulation, leaf level variation and better growth when compared to ambient CO_2 level for 120 days.

Kimball et al. [17] reported that, the root biomass in wheat, ryegrass, and rice under elevated CO_2 level, the average increase of 70, 58 and 34% respectively. 40 per cent root biomass increase was reported. The biomass enhancement in tree species under elevated CO_2 level in experiments of variable exposure duration [18]. Elevated CO_2 concentration generally increases the stem biomass. [14] recorded "the increase in stem growth and dry biomass increased and the rate of growth was different among the studies". (Norby et al., 2005) described "these differences to the growth rate or growth potential of different species, effects of environmental interactions". CO_2 enrichment significantly increased the biomass accumulation and the relative ratio of biomass increase to leaf area expansion in *cirsiu marvense* was observed. Bazzaz et al,, (1998) observed that, the total plant biomass was higher (31%) in the elevated CO_2 treatment with a mean enhancement of 23% in aboveground and 62% in belowground level. (Dijkstra et al., 2010) were also observed that the significant increase in above ground biomass in *quercus* species, 44% were exposed under elevated CO_2 level the above ground biomass showed 85% increases over ambient environmental conditions.

Rogers et al. [9] observed significant increases of dry matter accumulation in soybean about 78% at 700 ppm CO_2. Baker et al. [2] showed that shoot biomass and root biomass increased under increasing CO_2 concentration. The shoot biomass approximately 35 per cent greater for creeping bent grass plants grown under elevated CO_2 the root biomass increased by 37 percent due to elevated CO_2 (Burgess & Huang, 2014). Several authors reported that the dry matter production was increased under elevated CO_2 levels of 55 per cent in *P. Sylvestris* L [19], 32 per cent reported by Jackson et al. [20]. "The new Food and Agriculture Organization of the United Nations (FAO) estimates, based on a simple carbon stockchange approach, update published information on net emissions and removals from forests in relation to (a) netforest conversion and (b) forest land. Results show a significant reduction in global emissions from net forestconversion over the study period, from a mean of 4.3 in 1991–2000 to 2.9 Gt CO_2 yr^{-1} in 2016–2020. At the same time, forest land was a significant carbon sink globally but decreased in strength over the study period,from −3.5 to −2.6 Gt CO_2 yr^{-1}. Combining net forest conversion with forest land, our estimates indicated thatglobally forests were a small net source of CO_2 to the atmosphere on average during 1990–2020, with mean net emissions of 0.4 Gt CO_2 yr^{-1}". Tubiello et al. [21]. "The relative abundance of Basidiomycota positively correlated with SOM and EEAs and indirectly increase soil CO_2 emission whereas the relative abundance of Ascomycota exhibits opposite trend, suggesting that soil fungal communities play a key role in determining the different microbial activities between broadleaf and needleleaf stands. The temperature sensitivity of soil CO_2 emission was significantly higher in broadleaf forest compared to needleleaf forest, further suggest that the soil organic carbon in broadleaf forests is more vulnerable to warming" [22]. "Tree growth was recorded before and after the cuttings to separate the contributions of tree stand and forest floor to CO_2 exchange. Before the cuttings, the site had an annual CO_2 exchange close to zero, but both cutting methods turned it into a CO_2 source. However, the first-year emissions from the partial cutting area (800 g CO_2 m^{-2} yr^{-1}) were markedly lower than the emissions after clear-cutting (3100 g CO_2 m^{-2} yr^{-1}). The partial cutting area remained a CO_2 source during the first three years but turned into a CO_2 sink after that, while the clear-cut area acted as a large, although diminishing, CO_2 source for the whole measurement period" [23].

4. PHYSIOLOGICAL RESPONSES

4.1 Stomatal Conductance and Transpiration

The stomata in leaves are the channels through which plant can directly interact with atmosphere and the density of the stomata on leaf may be responsive to CO_2 levels. Stomata play a pivotal role in controlling the balance between photosynthetic assimilation and transpiration [24]. Increase in atmospheric CO_2 concentration and its doubling of from the present ambient concentration generally results in a reduction in (g_s) stomatal conductance of the order of 40% [25].

The physiological response of teak seedlings were significantly influenced by elevated CO_2 levels as compared to counterparts in the ambient environment. The seedlings imposed to 600 ppm of CO_2, Pn (net photosynthesis) (39.7 and 20.2%) and Ci (intercellular CO_2) (13.4 and 11.1%) significantly increased respectively with or without relative humidity.The range of Pn in tropical seedlings varied between 2.09 and 6.71 μmol CO_2 m^{-2} s^{-1}. There was an increased Pn in Teak, Maharukh and Bamboo seedlings to 600 ppm CO_2 (over the chamber control/ambient).

4.2 Water Use Efficiency (WUE)

Higher the ratio of WUE, better the ability for carbon assimilation. Morison [25] confirmed the trend where WUE increased invariably in elevated CO_2 which will lead to reduced (g_s) and directly proportional with transpiration rate. The water molecules lost per molecule of carbon fixed by the plant during photosynthesis, is referred to as water use efficiency [26]. An increase in WUE is probably the most common leaf level response to elevated CO_2 although changes in WUE are not necessarily linked with proportional changes in plant growth and photosynthesis [27] despite its potential importance for regulating the water use efficiency in plants [28]; [25]. So combined with reduced stomatal opening and conductance, transpiration rates, elevated CO_2 concentration also depresses dark respiration rates also leading to increased water use efficiency [11].

Increase in water use efficiency has been found to increase in drought tolerance in many plants, which may allow increased plant distributions [29,30].

Prior et al. [31] observed a rise in atmospheric CO_2 will limited direct impact on photosynthesis. However a number of C_4 crop plants expresses a positive response to elevated CO_2. Further, the reductions in total above-ground biomass were 42% in maize and 36% in sorghum at ambient CO_2, but only 18% in Maize and 14% in sorghum at double ambient CO_2 environmental conditions. [32] observed in grasslands, which is exhibited cumulative water use efficiencies 17-28% greater than control CO_2. The effect of elevated atmospheric CO_2 concentrations on the water use efficiencies of trees is clearly positive, having been documented in numerous single species studies of long leaf pine [33], Red Oak [34].

Tjoelker [35] reported that when the seedling of quaking aspen, paper birch, tamarack, black spruce and jack pine were grown under elevated CO_2 levels, the water use efficiencies increased by 40-80%. Similar findings were recorded when the trees were exposed to elevated CO_2 level by 50% [36], 52-94% (Wayne et al., 1998), 60% (Centritto, 1999), 80% (Leavitt et al.,2003) lead to increase in water use efficiency in response with increased atmospheric CO_2 concentration. Battipaglia et al. [37] reported, the elevated CO_2 increased the water use efficiency in many species *Liguidam barstyraciflua* (73%) for *Pinus taeda* (77%) and *Popolus sp* (75%).

Farquhar, (1992) defined intrinsic water use efficiency (IWUE) as the ratio of the photosynthetic uptake of CO_2 through leaf stomata to the simultaneous transpirational loss of water vapour through the stomatal opening (Wang, 2001; Ashraf et al*.,* 2002). Water use efficiency can be used as a selection criterion to improve yield in a dry environment (Tardieu, 1997). Intrinsic water use efficiency implies the inherent ability of the plant to assimilate CO_2 (Ares and Fownes, 1999). Edwin Raj [38] observed the IWUE, in many of the tropical tree species when the species subjected to 600 ppm CO_2 level it consumed higher amounts of water for transpiration *Ailanthus.sp* (112%) seedling were found to be vulnerable to water loss.

Waterhouse et al., (2004) determined the intrinsic water use efficiency (WUE) response of three species such as *Quercus robur, Fagus sylvatica* and *pinus saylverstris* with increased CO_2 concentration. In that, the IWUE was increases the amount to for *Quercus robur*,(158%) for *pinus saylverstris* (195%)and for *Fagus sylvatica* (220%). Liu et al. [39] evaluated in *Sabina przewalskii* and *Picea crassifolia* trees, the IWUE values showed in long term increases, by 33.6 and 37.4% for *Picea crassifolia* in the arid and semiarid areas, respectively. These findings help to predict the water use efficiency responses from a variety of tree species exposed to elevated CO_2 environmental conditions and species specific relationship help modeling of elevated CO_2 and climate impacts on forest productivity.

5. BIOCHEMICAL RESPONSES IN ELEVATED CO_2 CONDITIONS

5.1 Chlorophyll Content

Chlorophyll is the most important pigment and sensitive indicator for photosynthetic capacity of trees under various environments. In chlorophyll pigment, Chlorophyll a and b are virtually essential pigments for the conversion of light energy to stored chemical energy. The Chlorophyll content can directly determine photosynthetic rate and primary production. Furthermore, leaf chlorophyll content was closely related to pant stress responses. Sgherri et al. (1998) observed that alfalfa plants grown in Open Top Chamber (OTC) with enriched atmospheric CO_2 concentration of 600 ppm and greater leaf chlorophyll concentrations was recorded in plants grown at 340 ppm.

Wullschleger, (1994) observed a reduction in chlorophyll and accessory pigments in yellow popular and white oak seedling were under elevated CO_2 conditions and the reduction in chlorophyll was 27 and 55 per cent, respectively. Centritto & Jarvis [36] experimented on spruce saplings with CO_2 enrichment in open-top chamber and observed lower leaf chlorophyll content. Nevertheless, atmospheric CO_2 enrichment does not always results in decreased leaf chlorophyll concentrations.When the plants exposed to elevated CO_2 level in between these two responses sometimes there is no significant effect on leaf chlorophyll concentration. Sicher & Bunce [40] reported in twice ambient CO_2 concentrations and elicited that there was no changes in leaf chlorophyll content in potato seedlings. Further, Monje and Bugbee [41] did not find any changes in leaf chlorophyll content in wheat seedlings even with higher CO_2 of 870 ppm over ambient concentrations, similar results have been reported in woody plants and there is no significant impact on leaf chlorophyll concentrations in *Acer saccharum* [42] and *Quercus sp*. These studies demonstrate atmospheric CO_2 enrichment may alter or it may not effect leaf chlorophyll concentrations, and even when leaf chlorophyll concentrations are decreased the reallocation of the nitrogen that is essential for producing chlorophyll, and other photosynthetic components typically occurs without any adverse consequences. Moreover, Faria et al. [43] observed in tomato plants, the chlorophyll a/b ratio decreased significantly over nine days of exposure to CO_2. Faria et al. [43] observed that the total chlorophyll content at elevated CO_2 level was decreased significantly on dry weight basis. Edwin Raj et al. [38] reported that the biochemical parameters of chlorophyll a, b and chlorophyll content is become on excellent indicator with accordance to that the *Eucalyptus* clones and it was it was varying among the clones.

5.2 Proteins

Rogers, (1996) observed CO_2 induced reduction in the protein concentration of flour derived from wheat plants. Allard et al*.,* (2003) observed under enriched CO_2 levels the leaves of the individual species exhibited lower nitrogen concentrations, but higher water soluble carbohydrate concentrations. Picon Cochard et al., (2004) also observed the increase in response to elevated CO_2 despite reduction in protein concentration. Moreover, Fuchsman et al*.*, (2010) grew *Lolium multiflorum* and *Boute louacurtipendula* in open top chambers and maintained doubled CO_2 concentration of 740 ppm for two months and the protein concentration was decreased by 20% over ambient environmental conditions. On contrary, elevated CO_2 enrichment was found to be increased the leaf protein concentration in plants.

Kimball [17] observed that, 50% increased the leaf protein concentration under enriched CO_2 levels in Wheat plants. Idso, (1996) conducted number of studies and reported under elevated CO_2 levels, the concentration of proteins either increased, decreased or no effect in various agricultural crops. Jablonski, et al. [44] observed in rice no reduction in grain of nitrogen and protein concentration in response to atmospheric CO_2 enrichment.

5.3 Phenolic Components

Under elevated level of CO_2 there is an enhancement in the rate of photosynthetic rate thereby increase in carbon uptake which leads to production of plant secondary carbon compounds and phenolic compounds. Castells et al*.,* (2002) studied two perennial grasses of *Dactylis glomerata* and *Bromus erectus* under elevated CO_2 levels total phenolic concentration was increased 15 and 87% respectively, while there were no significant CO_2 and genotype interaction in these species which correlates with similar findings in *Calama grostisepigejos* and *Vicia lathyroides* and phenolic concentration increased by 20 and 32% respectively Hoorens et al*.,* (2002). Jablonski et al. [44] observed that the CO_2 enrichment will increase the fruit phenolic, flavonol and anthocyanin concentration in strawberry when the plants grown under enriched CO_2 conditions.

Wetzel & Tuchman [45] grew Cat tails (*Typha latifolia*) in Open Top Chambers and they found leaves contains 40.6% of total phenolic content in elevated CO_2 levels compared to ambient air. Further, Gebauer, (1998) grew loblolly pine seedling in glasshouses with elevated CO_2 levels which increases above and below ground total phenolic concentrations by 21 and 35% respectively as observed by de Frenne et al. [46]. Peñuelas & Estiarte [47] studied in temperate regions the trees have shown leaf phenolic concentrations was raised by 20 - 605 mg g^{-1} in response to doubling of CO_2 content Koricheva [48]. Wetzel & Tuchman [45] Observed that Aspen seedlings grown in elevated CO_2 contained 63.2% more total phenolic compounds.

Coleman et al. [49] reported nine species of tropical trees grown in open top chamber in which eight species exhibiting positive leaf phenolic responses and the maximum increases of 119% but Single negative response lead to 27% decline while the mean response of all nine species shows an increase of 48% in phenolic content. These results are compatible to the temperate region trees in which both temperate and tropical trees shows large inter specific variation in the extent of their response to CO_2 with increase in phenolic content was 50%. Kuokkanen, et al. [50] studied that birch trees in closed top chambers exposed to CO_2 concentration of 700 ppm. Hamilton,(2002) studied in the loblolly pine plantation found no effect of elevated CO_2 on the chemical composition of leaves. Under elevated CO_2 environmental conditions most of the experiments were conducted in agricultural and temperate species in the global scenario. But very few of experiments were conducted in tropical tree species under enriched CO_2 level. Particularly, in Teak and Eucalyptus there have been no such studies carried out till date. So, the present study was initiated could act as milestone to understand the actual responses under elevated CO_2 environmental conditions by using different planting stock materials of Teak and Eucalyptus [51-53].

6. CONCLUSION

In conclusion, the comprehensive exploration of Teak and Eucalyptus responses to elevated carbon dioxide (CO2) levels within Automated Open Top Chambers (AOTC) reveals a nuanced interplay between physiological adaptations and morphological changes. The study's findings contribute valuable insights into the complex dynamics of tropical tree species under changing atmospheric conditions.The observed alterations in shoot, root, and leaf morphology, coupled with variations in biomass increment, highlight the sensitivity of Teak and Eucalyptus to elevated CO2. These responses are indicative of the trees' adaptive strategies to optimize growth and productivity in an environment with increased carbon dioxide concentrations.Moreover, the physiological responses, such as increased water use efficiency (WUE) and intrinsic water use efficiency (IWUE), underscore the trees' ability to acclimate to elevated CO2 levels. These responses have broader implications for drought tolerance and ecosystem dynamics, emphasizing the interconnectedness of plant species with their surrounding environment.Understanding these intricate responses is crucial for predicting the long-term impact of climate change on forest ecosystems. The research conducted at the Institute of Forest Genetics and Tree Breeding (IFGTB) in Coimbatore adds significant depth to the ongoing discourse on climate change impacts, providing a basis for informed decision-making in forestry and conservation practices.As we grapple with the challenges of a changing climate, the knowledge gained from this study contributes to a growing body of research aimed at fostering sustainable forest management. It highlights the need for continued monitoring and research to adapt forestry practices to the evolving conditions brought about by rising atmospheric CO2 levels.Ultimately, the study encourages a holistic approach to ecosystem management, considering the intricate relationships between tropical tree species and their environment. By advancing our understanding of these dynamics, we can work towards resilient and adaptive strategies that mitigate the impact of climate change on vital components of our ecosystems, ensuring the long-term health and sustainability of our forests.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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