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Botanical report

ISSN 2319 - 8230 (Print)

Article ID : br151213103

2013: Volume No. 2(2): 9-13.

Studies on Growth and some Biochemical Parameters of *Ceiba pentandra* (L.) Gaertn. exposed to short term Elevated Concentrations of CO_2

S. Euchrista Immaculate Sylvia *and K. Muthuchelian

Received: 07 October 2013 / Accepted: 24 November 2013 / Published Online: 15 December 2013

Abstract

Four weeks old seedling of *Ceiba pentandra* (L.) Gaertn. was exposed to elevated concentrations of CO_2 in controlled environment chamber for four weeks. The treatment had definite positive effect on growth parameters such as root length, shoot length and leaf area and biochemical parameters such as starch, sugar and total chlorophyll content.

Citation

Euchrista Immaculate Sylvia, S and Muthuchelian, K. 2013. Studies on Growth and some Biochemical Parameters of *Ceiba pentandra* (L.) Gaertn. exposed to short term Elevated Concentrations of CO2. *Botanical Report*,2(2): 9-13.

Present Address

S. Euchrista Immaculate Sylvia
Department of Physics,
St. Mary's College (Autonomous),
Thoothukudi – 628 001, India.

K. Muthuchelian
Department of Bioenergy, School of Energy, Environment and Natural Resources,
Madurai Kamaraj University, Madurai - 625 021,
India

Manuscript Type : **Research Article**
Received Manuscript : **Via Email**
Approved Letter : **Received**
Funding Source: UGC-FRP, New Delhi
Conflict of Interest : **Nil**
Manuscript Full Responses: **Authors**

*To whom Corresponding Author
E-mail to: sylvianov15@gmail.com

Submission manuscripts info:
botanicalreport@yahoo.com

Article ID : br151213103 2013: Volume No. 2(2): 9-13.

1. Introduction

Atmospheric green house gases are rapidly increasing due the human activities and the continued increase in concentration of green house gases in the atmosphere is likely to lead to climate change resulting in large changes in ecosystem, leading to possible catastrophic disruption of livelihood, economic activity, living condition and human health (IPCC 2001). Green house gases, mainly water vapour are essential for maintaining the temperature of the earth, without them earth would likely be so cold as to be uninhabitable. Of the green house gases the most important gas is carbon dioxide, being uniformly distributed all over the earth's surface. Beginning in 1700 societal changes brought about by the industrial revolution increased the amount of carbon di oxide entering the atmosphere. The major sources of carbon di oxide include fossil fuel combustion for industry, transportation, space heating, electricity generation and cooking and vegetation changes in natural prairie, woodland, and forested ecosystem. CO_2 in earth's atmosphere is currently at a globally averaged concentration of 0.0385% or 385 parts per million and is increasing by about 2 ppm each year (Pidwirny, 2006). It is further estimated that in the next century the level of CO_2 is expected to increase to 700 ppm (Coviella and Trumble, 1999). Green house gases induce global warming, which is a consequence of green house effect. The present global warming is attributed to the increase in atmospheric concentration of green house gases during the industrial period (from 1750 to 2005) carbon- di-oxide from 280ppm to 380ppm. The global green house gases emission have increased 70% from 1970 to 2004 (IPCC 2000). Increasing atmospheric concentrations of CO_2 influence the plants growth and intermediary metabolism. Scientists recognize that CO_2 is essential for plant life undergoing photosynthesis. If the concentration of atmospheric CO_2 available to plants increases, plants may be able increase their rate of photosynthesis and thus grow more vigorously (Campbell *et al.,* 1988; Bowes, 1991; Baker and Allen, 1994; Sarah *et al.,* 1999). Elevated CO_2 is the primary variable that influences growth, yield and increases aboveground biomass (Bender *et al.,* 1999).Though increased atmospheric carbon di oxide and global warming have an additional deleterious environmental effects it is reported that elevated CO_2 is the primary variable that influences growth, yield and increases aboveground biomass. Climatologists and scientists recognize CO_2 gas as major air pollutant. This necessary evil could be made successfully counteracted by understanding the source oriented measures in local level. Tree species tested under green house gas stress condition will provide relevant cost effective climate friendly measure in the technological era.

2. Materials and Methods

The present study in laboratory condition was carried out to find out the effect of elevated level of carbon-dioxide on fast growing tree species like *Ceiba pentandra*. This study examines the growth and photosynthetic characteristics of tree species grown at various elevated concentrations of CO_2 (500, 750, 1000 ppm) for a period of thirty days. The seeds were sown in plastic pots filled with garden soil (pH 6.9). Seeds soaked in water for 24hrs were germinated and grown for 30 days in growth chamber with supplementary light giving an approximately 16 hrs light period and 8hrs dark periods. Then the plants were divided into two sets. First set of plants was transferred to a specially designed chamber for providing elevated concentrations of carbon dioxide for 30 days. Supplemental CO_2 was provided by CO_2 cylinder stored outside the chamber. CO_2 was delivered under pressure with a separate flow meter to the chamber. The concentration of carbon dioxide inside the chamber was monitored using a hand held instrument, CO_2 meter (Lutron electronic model: GCH-2018) All the pots were watered twice daily with tap water. Non-treated plants served as control. After 30 days few seedlings were harvested by carefully uprooting from the soil, washed with water and analyzed for growth and biochemical parameters the value of chlorophyll was calculated using Lichtenthaler and Hartmut, 1987 formula. Estimation of soluble sugar (Jayaraman, 1981) and starch (Hodge and Hofreiter, 1962) were found using standard procedures**.**

3. Results and Discussion

The results obtained for the effect of different concentration of CO_2 on growth parameters of *C. pentandra* are presented in table 1. Significant increase in root growth, shoot growth and leaf area was observed in treated samples throughout experimental period. However maximum increase was found at 750 ppm of CO_2. Different concentrations of CO_2 showed significant changes in the chlorophyll content, starch and sugar. In all treatments increase in chlorophyll content was observed and the increase in all the treatments was higher than control and maximum was noticed at 750 ppm of CO_2. Increase in total chlorophyll content of leaf, starch and sugar is also shown in present investigation (Fig. 1-3).

Table 1: Effect of elevated concentrations of CO_2 on growth parameters of *C. pentandra* grown under potted condition.

Parameters	CO_2 concentration ppm			
	380	500	750	1000
Root length (cm)	06.52±0.605	08.27±0.406 (27)	13.14±0.504 (102)	11.56±0.826 (77)
Shoot length (cm)	11.77±0.669	14.48±0.656 (23)	16.04±0.619 (036)	15.79±0.512 (34)
Leaf area(cm^2)	30.00±0.940	36.00±0.510 (20)	50.30±0.600 (068)	42.10±0.410(40)

The value in parentheses represents the percent increase over the control. ; Each value represents the mean of 10 plants with ± standard deviation; Ambient CO_2 is treated as control.

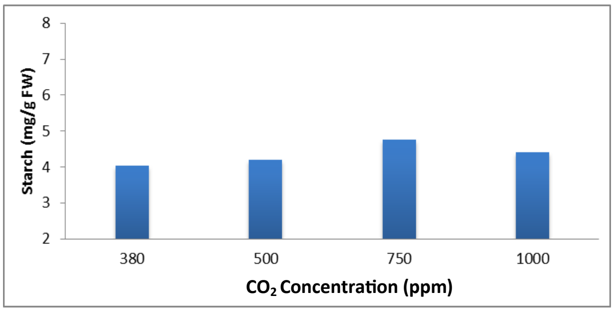

Fig.1 Effect of elevated CO_2 on starch (mg/g FW) of *C. pentandra* grown under potted condition

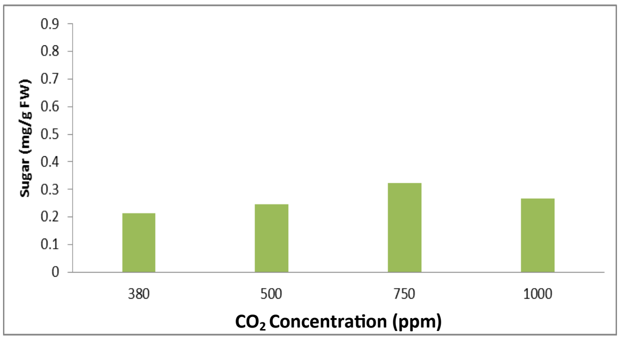

Fig.2 Effect of elevated CO_2 on sugar (mg/g FW) of *C. pentandra* grown under potted condition

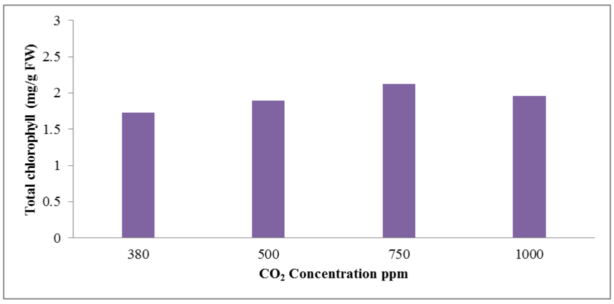

Fig.3 Effect of elevated CO_2 on total chlorophyll (mg/g FW) of *C. pentandra* grown under potted condition

The increase in starch content may be due to an increase in photosynthetic activity which could be the result of the increase in photosynthetic pigments. The increase in sugar could be the direct consequence of an increase in soluble starch content of the seedlings under elevated CO_2 conditions. One of the most consistent effects of elevated atmospheric CO_2 on plant is an increase in the rate of photosynthetic carbon fixation by leaves (Anisworth and Rogers, 2007). Carbon di oxide concentrations are also an important factor in regulating the openness of stomata, pores through which plants exchange gases, with the external environment. Open stomata allow CO_2 to diffuse into leaves for photosynthesis, but also provide a pathway for water to diffuse out of leaves. As CO_2 concentration increased plants can maintain high photosynthetic rates with relatively low stomatal conductance (Taub, 2010).

Stimulation of photosynthesis and plant growth is the direct effects of CO_2, which is beneficial for plants (Bazzaz, 1990; Jablonski *et al.,* 2002). Elevated CO_2 is reported to stimulate the growth and yield of plants (Deepak and Agrawal, 1999). Elevated CO_2 also leads to changes in the chemical composition of plant tissues. Due to increased photosynthetic activity, leaf nonstructural carbohydrates (sugars and starches) per unit leaf area increase on average by 30 – 40% under FACE elevated CO_2 (Anisworth 2008; Anisworth and Long 2005). There is a vast amount of literature on the direct effects of CO_2 enrichment on plants and in turn their effect on the ecosystem. Controversial results have been reported between short time and long time exposure to high CO_2. Ong *et al.,* (1998) studied the effects of elevated CO_2 (350, 515 and 3360 ppm) on the fern's photosynthesis and growth. It was reported that after forty days after germination, light-saturated rates of net photosynthesis were 22% and 114% greater at 515 and 3360 ppm, respectively, than they were at 350 ppm. Increased carbon uptake resulting from this initial stimulation of photosynthesis is reported to alter the balance of supply and capacity to use carbohydrates, with the result that non-structural carbohydrate concentrations invariably increase within leaves grown at elevated CO_2 (Drake *et al.*,1997).

From the results obtained from the present investigation it is inferred that growth parameters and biochemical parameters of *C. pentandra* were enhanced and responded positively when exposed to short term elevated concentrations of CO_2. Tree species *C. pentandra* can be grown which will provide relevant cost effective climate friendly measure in the technological era to reduce CO_2.

4. Acknowledgements

The author is thankful to University Grant Commission, New Delhi, for providing F.D.P facility and authorities of Madurai Kamaraj University, Madurai, and St. Mary's College (autonomous), Thoothukudi for the encouragement given to carry out the research work.

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