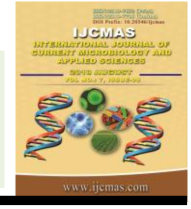
Int.J.Curr.Microbiol.App.Sci (2018) *7*(8): 3932-3942

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 08 (2018)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2018.708.405

Growth Response of *Calophyllum inophyllum* L. Seedlings to Elevated Carbon Dioxide Enriched with Certain Nutrients

Supriya K. Salimath[1*], Ramakrishna Hegde[1], R.N. Kencharaddi[1], Clara manasa[1] and Vasudev Lamani[2]

[1]*College of Forestry, Ponnampet (University of Agricultural and Horticultural Sciences, Shivamogga), India*
[2]*College of Horticulture, Mudigere (University of Agricultural and Horticultural Sciences, Shivamogga), India*

**Corresponding author*

Keywords

Climate change, Elevated CO_2, Nutrients, Seedling growth, Biomass

Article Info

Accepted:
22 July 2018
Available Online:
10 August 2018

A B S T R A C T

The daily average concentration of carbon dioxide (CO_2) in the atmosphere rose above 400 parts per million (ppm) for the first time on record in 2013, up from 280 ppm before the Industrial Revolution. The CO_2 fertilization hypothesis stipulates that rising atmospheric CO_2 has a positive effect on tree growth due to increasing availability of carbon. Hence, an attempt was made to understand the response of *C. inophyllum* seedlings to the elevated CO_2 condition when they are grown in nutrient rich soils. Three month old seedlings were subjected to total nine treatments with four replication. Each replication having 20 seedlings were applied with two doses of NPK (0.5 g and 1 g per plant) and were allowed to grow under both open and elevated CO_2 conditions. Seedling collar diameter increment of seedlings was negatively affected without any nutrient supplement under elevated CO_2 condition. A significant increase in the total height growth of seedlings was observed under elevated CO_2 condition. The elevated CO_2 positively influenced the volume index of seedlings under all the and positive and higher response index value of the biomass increment to the elevated CO_2 condition indicated that application of nutrients under elevated CO_2 could produce seedlings with higher biomass.

Introduction

Global climate change is the catch-all term for the shift in worldwide weather phenomena associated with an increase in global average temperatures. It's real and temperatures have been going up around the world for many decades. The increased volumes of carbon dioxide and other greenhouse gases released by the burning of fossil fuels, land clearing, agriculture, and other human activities, are believed to be the primary sources of the global warming that has occurred over the past 50 years. The daily average concentration of CO_2 in the atmosphere rose above 400 parts per million (ppm) for the first time on record in 2013, up from 280 ppm before the Industrial Revolution (FAO, 2015). As the CO_2 concentration in the atmosphere rapidly approaches 450 ppm, it will affect the forest conditions in terms of area, composition, health etc., allowing increases in growth rates in some areas while endangering the survival of species and forest communities in others. The CO_2 fertilization hypothesis stipulates that rising atmospheric CO_2 has a positive effect on tree growth due to increasing availability of carbon (Huang *et al.,* 2007). Significant positive pho- to synthetic acclimation responses would be noticed if a large sink is available to accommodate excess carbon as seen in the tree species, *G. arborea*. The up-regulation of photosynthesis under elevated atmospheric CO_2 in *G. arborea* suggests that this tree could potentially become a dominant species with better net primary productivity under future global climate change scenario. If photosynthetic acclimation can be decreased either through breeding or by potential recombinant DNA technology, many of the C_3 and C_4 food crops could profit more from the constant increase in the atmospheric CO_2 concentrations and the concomitant changes in the global climate (Reddy *et al.*, 2010). Hence, it is prudent to understand the response of tree species in the initial stages, as seed and seedlings, to the elevated carbon dioxide conditions from the point of climate change and global warming in the future. *Calophyllum inophyllum* L. of family Guttifereae (Clusiaceae) is a tree species native to India, East Africa, South East Asia, Australia and South Pacific and is commonly called as ‘Indian laurel’. It is an important biofuel species, mainly found in coastal and highland regions which are vulnerable to climate change. In the present study, an attempt was made to understand the response of *C. inophyllum* seedlings to the elevated CO_2 condition when they are grown in nutrient rich soils.

Materials and Methods

The experiment was carried out at College of Forestry, Ponnampet, Kodagu, Karnataka. The elevated CO_2 condition was created in the poly tunnel (Fig. 1) by the decomposition of cow dung spread on its flooras per the procedures given by Devakumar *et al.*, (1996). Everyday observation of temperature and CO_2 concentrations in the polytunnel were recorded at 9.30 AM, and 4.00 PM using CO_2 analyzer (GC 2028) and monthly average was computed (Table 1). The experiment was laid out in Factorial Randomized Complete Block Design by considering three factors of NPK in two levels. Three month old seedlings were subjected to total nine treatments with four replication. Each replication having 20 seedlings were applied with two doses of NPK (0.5 g and 1 g per plant) (Table 2) and were allowed to grow under both open and elevated CO_2 conditions.

Observations on the seedling growth parameters were taken twice during the study. One before the applications of treatments and second after 90 days of application of treatments. Following parameters were recorded.

Seedling collar diameter (mm)

Collar diameter was measured at collar region of the seedling by using a digital caliper and was expressed in millimeters.

Seedling height (cm)

Height of seedling was measured from the base of the shoot to the growing tip of the plant by using the measuring scale and it was expressed in centimeters.

Growth increment

To nullify the variations in the seedlings, the observations on the initial and final growth of collar diameter, height and number of leaves were taken after 90 days of treatment application. The average of the difference between the initial and final readings was calculated. The difference in growth which was expressed as the increment in each treatment was calculated using the following formula and further statistical analysis was carried out.

Growth increment = Mean final growth after 90 days - Mean initial growth

These growth increments were calculated for Collar diameter expressed as Diameter Increment (DI, mm), Seedling height increment (HI, cm) and number of leaves increment (LI).

Relative growth rate (RGR)

The plants under each treatment were calculated for Collar diameter (RGRD), Seedling height (RGRH) and number of leaves (RGRL) using the formula:

$$\text{Relative Growth Rate (RGR)} = \frac{\text{Final Reading after 90 days} - \text{Initial Reading}}{\text{Initial reading}}$$

Volume index increment (cm^3)

Volume index of each seedling were calculated both for initial and final observations using the formula:

Volume index= d^2h

Where,

d = Collar diameter of the seedling
h= Height of the seedlings

The increment of the volume of seedlings at each treatment was calculated and expressed as Volume index Increment (Vi) using the formula:

Volume index Increment= Final Volume index – Initial Volume index

Biomass estimation

The plants were extracted from the polythene bags after 90 days of treatment application and roots were washed by using tap water. The fresh weight of plants was recorded and the plant samples were dried in hot air oven at 70º C till a constant weight attained and weighed using digital balance and expressed as dry weight (g). Biomass index was calculated by taking the difference of total dry weight of seedlings under each treatment at the initial and final period. This biomass index was used to calculate the relative growth rate of biomass index (RGRB).

Response index

Response of the species to elevated carbon dioxide was determined by calculating the response index (Hegde *et al.*, 1993) using the following formula:

$$\text{Response Index} = \frac{\text{Treatment mean} - \text{Control mean}}{\text{Control mean}}$$

Results and Discussion

In general, most of the growth parameters showed significantly higher values in elevated CO_2 conditions than in open condition. There was a substantial increase in the collar diameter (1.50 mm) and height growth (15.67 cm) of seedlings under elevated CO_2 conditions than in the seedlings grown in open condition (Table 3). The average biomass increment per seedling (6.95 g) and the average volume index increment of individual seedling (6.99 cm^3) were found to be significantly higher under elevated conditions than in open condition. The relative growth rates for collar diameter (0.38), height (1.21), the number of leaves (0.57), biomass increment (3.16) and volume index increment (3.26) recorded significantly higher values under elevated CO_2 conditions (Table 4).

When compared with different nutrient treatments under open and elevated conditions diameter increment showed no significant difference between the treatments under open and elevated CO_2 conditions (Table 3). However, significant difference was observed among the treatments for height increment under open and elevated conditions. Control treatment of elevated condition recorded a maximum height of 19.89 cm followed by the T9 of elevated condition (19.59). The lowest value for biomass increment was recorded by the T6 (1.94) of open condition with the highest value by T5 of elevated condition (10.30). The values for volume index increment ranged from 3.80 in T7 of open condition to 9.87g under control of the elevated condition. The highest value for RGR for collar diameter was obtained under control (0.45) and T8 (0.45) of the elevated condition followed by the T9 (0.43) of the open condition. (Table 4). The highest growth rate in height was recorded in T9 under open condition (1.72) followed by 1.44 in control of the elevated condition. T9 of elevated condition recorded highest rate of biomass increment of 4.57g followed by the control of elevated condition 4.16g. There was no evidence of significant interaction effect among the different volume index increment rate (Table 4). Minimum value was found in T3 (1.52) and T5 (1.52) of open condition with T9 of elevated condition recording a maximum value (4.57). To assess the effect of elevated condition on the seedling growth parameters response index were calculated and are depicted in Table 6. The influence of elevated Co2 under each treatment will be discussed hereunder:

Seedling collar diameter increment

Exposure of seedlings to the elevated concentration of CO_2 will increase the plant growth rate in the initial stages. Similarly, there was significant increase in collar diameter of *C. inophyllum* seedling due to elevated CO_2 concentration in initial stage. This might be due to higher photosynthetic rate and lower respiration and photorespiration seen when plants are grown in an atmosphere of higher CO_2 concentration (Long and Drake, 1992). Evidences from the literatures shows that it is possible to increase collar diameter by growing plants under high elevated CO_2 (Kimball, 1983 and Devakumar *et al.*, 1998). The application of nutrients may supplement the growth rate up to a threshold level beyond which the dosages resulted in the lethal effect (Fig. 2). Same trend was followed in RGR for collar diameter where the highest response index value was recorded under T8 (9.05) followed by a value of 2.69 under T7 treatment (Table 5).

Seedling height increment

In the present study, a significant increase in the total height growth of seedlings was observed under elevated CO_2 condition. There are sufficient number of studies which support this results (Kilpeläinen *et al.,* 2005 and Warrier *et al.*, 2013; Kimball, 1983; Devakumar *et al.*, 1998 and Kumar *et al.*, 2001). The elevated CO_2 increase the carboxylation efficiency relative to oxygenation resulting in reduced photorespiration. According to the CO_2 stimulation hypothesis, if the nutrient deficient conditions are avoided, this growth rate can be enhanced to certain extent (Fig. 2). A higher response index for the height increment (1.63) was recorded in T9 treatment followed by T6 (1.54) which implied that the height growth could be enhanced to the tune of one and half times or more than the similar treatment in open condition. Relative growth rate is a measure of growth of plant per unit weight over a specific period. The response of plant height when subjected to elevated CO_2 condition was positive as indicated by the positive response index values (Table 5).

Table.1 Mean monthly temperature and CO_2 concentration

Month	Temperature (°C)		CO_2 concentration (ppm)	
	Control	**Elevated**	**Control**	**Elevated**
June 2016	24.5	26.14	402.25	830.25
July 2016	24.3	25.16	400.26	833.9
Aug 2016	25.2	26.42	401.58	833.84
Sept 2016	25.6	26.13	403.14	832.2
Oct 2016	25.8	26.52	402.54	833.58
Nov 2016	26.1	26.33	401.91	831.46

Table.2 Nutrient treatment combinations

T1	Control ($N_0P_0K_0$)
T2	$N_{0.5}P_{0.5}K_{0.5}$
T3	$N_{0.5}P_{0.5}K_1$
T4	$N_{0.5}P_1K_{0.5}$
T5	$N_{0.5}P_1K_1$
T6	$N_1P_{0.5}K_{0.5}$
T7	$N_1P_{0.5}K_1$
T8	$N_1P_1K_{0.5}$
T9	$N_1P_1K_1$

Table.3 Seedling growth parameters at two CO_2 concentrations and different nutrient treatments

FACTOR	TREATMENTS	DI (mm)	HI (cm)	LI (#)	BI (g)	VII (cm^2)
OPEN	$N_0P_0K_0$ (T1)	1.86	12.65^{bc}	2.22 (1.49)	7.92	7.94
	$N_{0.5}P_{0.5}K_{0.5}$ (T2)	1.49	7.73^{ab}	2.04 (1.43)	9.80	4.91
	$N_{0.5}P_{0.5}K_1$ (T3)	1.23	8.81^{ab}	3.24 (1.80)	4.89	5.22
	$N_{0.5}P_1K_{0.5}$ (T4)	1.32	7.81^{ab}	3.20 (1.79)	4.58	5.07
	$N_{0.5}P_1K_1$ (T5)	1.18	8.66^{ab}	3.24 (1.80)	5.50	4.73
	$N_1P_{0.5}K_{0.5}$ (T6)	0.98	7.16^{a}	3.13 (1.77)	1.94	4.33
	$N_1P_{0.5}K_1$ (T7)	0.81	11.28^{bc}	2.53 (1.59)	4.58	3.80
	$N_1P_1K_{0.5}$ (T8)	0.89	11.65^{bc}	4.66 (2.16)	3.00	4.02
	$N_1P_1K_1$ (T9)	1.74	9.92^{ab}	3.17 (1.78)	4.41	5.43
Average open		**1.28**	**9.52**	**3.00 (1.73)$^{+}$**	**5.18**	**5.05**
ELEVATED	$N_0P_0K_0$ (T1)	1.84	19.89^{d}	4.04 (2.01)	6.65	9.87
	$N_{0.5}P_{0.5}K_{0.5}$ (T2)	1.55	13.52^{bc}	2.96 (1.72)	5.93	7.11
	$N_{0.5}P_{0.5}K_1$ (T3)	1.45	13.87^{c}	4.41 (2.10)	7.17	5.70
	$N_{0.5}P_1K_{0.5}$ (T4)	1.39	14.98^{cd}	4.04 (2.01)	6.55	6.00
	$N_{0.5}P_1K_1$ (T5)	1.68	18.27^{d}	4.12 (2.03)	10.30	9.16
	$N_1P_{0.5}K_{0.5}$ (T6)	1.01	10.98^{b}	4.24 (2.06)	7.22	4.23
	$N_1P_{0.5}K_1$ (T7)	1.22	13.18^{bc}	3.88 (1.97)	6.35	4.91
	$N_1P_1K_{0.5}$ (T8)	1.75	16.71^{cd}	3.76 (1.94)	4.77	7.70
	$N_1P_1K_1$ (T9)	1.65	19.59^{d}	4.00 (2.00)	7.63	8.26
Average elevated		**1.50**	**15.67**	**4.00 (1.98)**	**6.95**	**6.99**
S. EM (±) for Treatments		**0.20**	**1.22**	**0.17**	**1.76**	**1.22**
S. EM (±) factors		**0.07**	**0.41**	**0.06**	**0.59**	**0.41**
CD (0.05) for Treatments		**NS**	**3.482**	**NS**	**NS**	**NS**
CD (0.05) factors		**0.19**	**1.16**	**0.16**	**1.68**	**1.16**

Table.4 Seedling growth parameters at two CO_2 concentrations and different nutrient treatment

FACTOR	TREATMENTS	RGRD	RGRH	RGRL	RGRB	RGRVI
OPEN	$N_0P_0K_0$ (T1)	0.42	0.89^{b}	0.26^{b}	2.82	2.82
	$N_{0.5}P_{0.5}K_{0.5}$ (T2)	0.34	0.54^{a}	0.24^{b}	1.78	1.78
	$N_{0.5}P_{0.5}K_1$ (T3)	0.26	0.59^{a}	0.37^{c}	1.52	1.52
	$N_{0.5}P_1K_{0.5}$ (T4)	0.28	0.54^{a}	0.37^{c}	1.53	1.53
	$N_{0.5}P_1K_1$ (T5)	0.26	0.59^{ab}	0.40^{cd}	1.49	1.52
	$N_1P_{0.5}K_{0.5}$ (T6)	0.21	0.51^{a}	0.35^{c}	2.06	1.41
	$N_1P_{0.5}K_1$ (T7)	0.19	0.97^{bc}	0.29^{bc}	1.42	1.97
	$N_1P_1K_{0.5}$ (T8)	0.22	0.97^{bc}	0.72^{f}	1.78	2.03
	$N_1P_1K_1$ (T9)	0.43	0.75^{ab}	0.02^{a}	2.21	2.77
Average open		0.29	0.71	0.34	1.84	1.93
ELEVATED	$N_0P_0K_0$ (T1)	0.45	1.44^{cd}	0.57^{e}	4.16	4.16
	$N_{0.5}P_{0.5}K_{0.5}$ (T2)	0.37	0.87^{b}	0.45^{d}	2.54	2.54
	$N_{0.5}P_{0.5}K_1$ (T3)	0.38	1.10^{bc}	0.62^{e}	3.00	2.99
	$N_{0.5}P_1K_{0.5}$ (T4)	0.37	1.21^{c}	0.59^{e}	3.15	3.15
	$N_{0.5}P_1K_1$ (T5)	0.40	1.19^{c}	0.57^{e}	3.26	3.26
	$N_1P_{0.5}K_{0.5}$ (T6)	0.25	0.87^{c}	0.63^{e}	1.96	1.98
	$N_1P_{0.5}K_1$ (T7)	0.32	1.11^{bc}	0.55^{e}	2.74	2.69
	$N_1P_1K_{0.5}$ (T8)	0.45	1.36^{c}	0.55^{e}	3.10	4.01
	$N_1P_1K_1$ (T9)	0.42	1.72^{d}	$0.56^{S.}$	4.57	4.57
Average elevated		6.99	0.38	1.21	0.57	3.16
S. EM (±) for Treatments		**0.065**	**0.11**	**0.08**	**0.44**	**0.36**
S. EM (±) factors		**0.02**	**0.04**	**0.03**	**0.15**	**0.12**
CD (0.05) for Treatments		**NS**	**0.32**	**0.23**	**NS**	**NS**
CD (0.05) factors		**0.04**	**0.10**	**0.08**	**0.42**	**0.36**

Table.5 Response index values for different seedling parameters under elevated CO_2 conditions

	DI	HI	LI	VI	BI	RGRD	RGRH	RGRL	RGRVI	RGRB
T1	-0.01	0.57	0.34	0.24	-0.16	0.08	0.6	1.18	0.24	0.48
T2	0.04	0.75	0.20	0.45	-0.39	0.08	0.62	0.84	0.45	0.43
T3	0.18	0.57	0.16	0.09	0.47	0.47	0.87	0.67	0.09	0.97
T4	0.05	0.92	0.13	0.18	0.43	0.3	1.25	0.60	0.18	1.06
T5	0.42	1.11	0.13	0.94	0.87	0.54	0.99	0.41	0.94	1.19
T6	0.71	1.54	0.72	0.07	2.72	1.04	2.18	1.74	0.64	0.05
T7	2.37	1.48	3.95	0.47	0.39	2.69	1.52	6.37	1.87	0.93
T8	3.00	0.63	2.49	1.90	0.59	9.05	5.45	2.14	1.81	0.74
T9	0.25	1.63	0.49	0.48	0.73	0.30	2.14	1.23	1.00	1.07

Fig.1 Poly tunnel used for creation of elevated CO_2 condition

Fig.2 Response of Seedling collar diameter increment, height increment and biomass increment to elevated CO_2 conditions

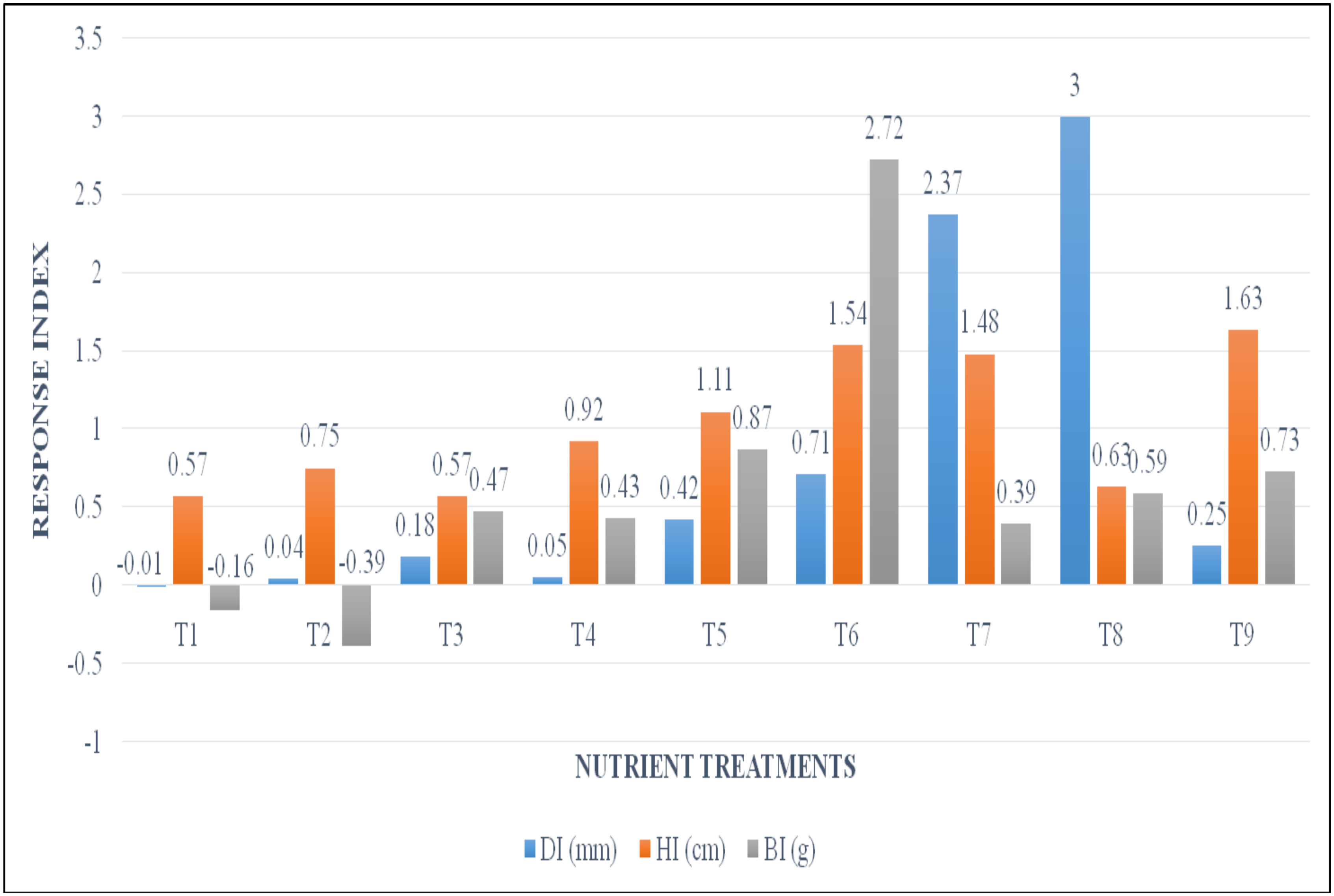
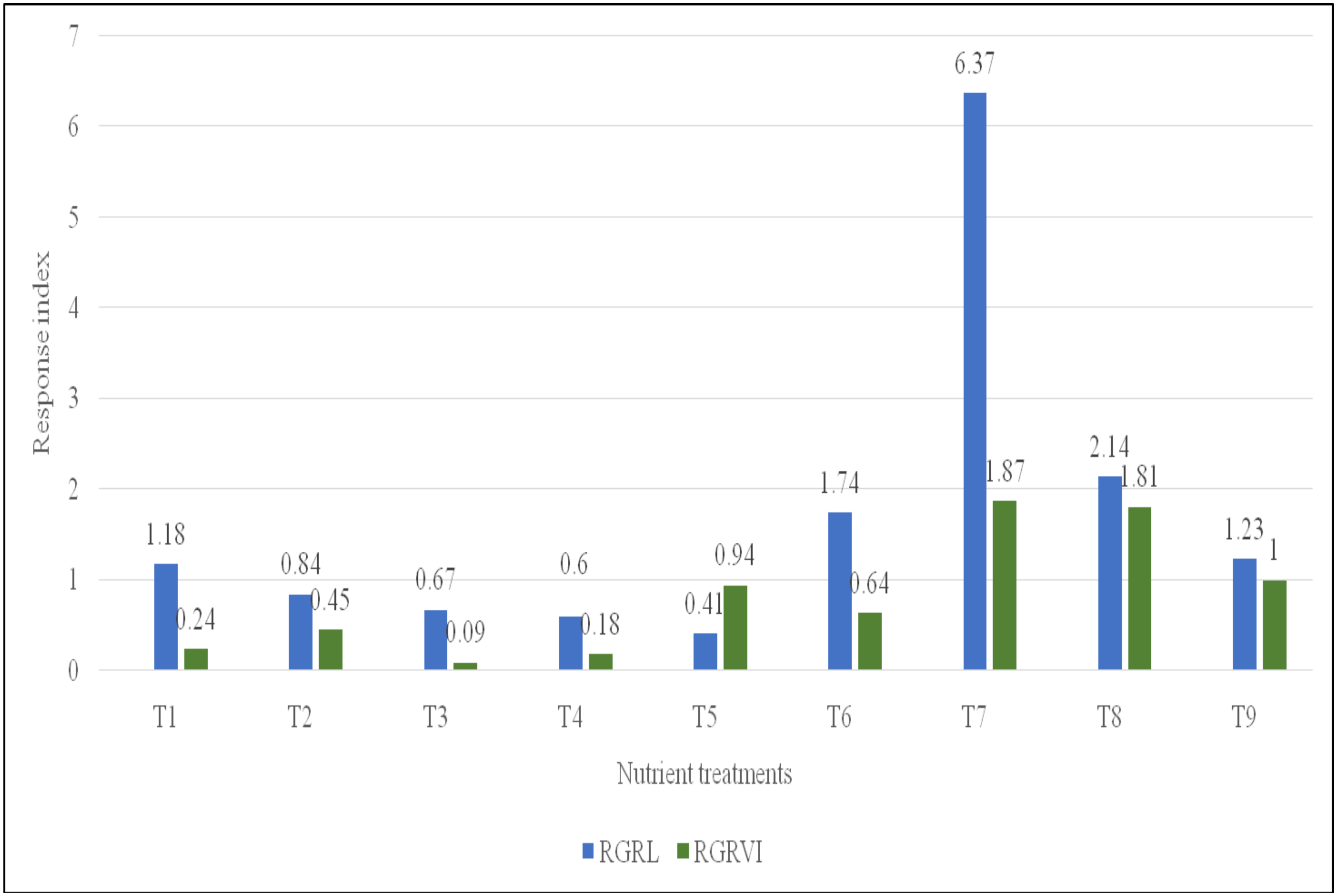


Fig.3 Response of relative growth rate for leaf number increment and volume index increment to elevated CO_2 condition



The highest response index was recorded by the T8 (5.45) treatment followed by T6 (2.18) and T9 (2.14). The results were in line with the findings of Brown (1989) who recorded the higher relative growth rate for seedlings height under elevated CO_2 condition when supplemented with higher dosages of nitrogen.

Leaf number increment

Elevated CO_2 condition supplemented with higher nutrient dosages resulted in production of more number of leaves (Table 3). Response index for relative growth rate on number of leaves was positive and varied to certain extent with different dosages of nutrients (Table 5; Fig. 3).

The maximum response index value of 6.37 was produced under T7 treatment. Based on the results of the study it could be concluded that adequate availability of nutrients could increase the leaf production in plants under elevated CO_2 conditions which would be essential for higher photosynthesis.

A significant increase in height and collar diameter growth resulted in considerable increment in the volume index of the seedlings under elevated CO_2 condition (Table 3; Fig. 3).

Volume index increment

Further, the elevated CO_2 positively influenced the volume index of seedlings under all the treatments as indicted by the positive response index values with maximum value under treatments with higher levels of nutrients. The finding was in accordance with the results of Oskarsson *et al.,* (2006) who recorded an increased volume index of seedlings of *Betula pubescens*, *Larix sibirica* and *Picea sitchensis* which were subjected NP fertilization.

Biomass Increment

The findings of biomass increment in the present study revealed a significant increase in the biomass of the seedlings under elevated CO_2 conditions (Table 3). The positive and higher response of the biomass increment to the elevated CO_2 condition indicated that, application of nutrients under elevated CO_2 could produce seedlings with higher biomass (Fig. 2). Fathurrahman *et al.,* (2016) opined that the elevated CO_2 increases the chlorophyll content of the seedlings which results in the higher photosynthetic ability.

This could be attributed to increased biomass of seedlings under the elevated CO_2 conditions. Similar results were found by Lotfiomran *et al.,* (2016) where an increased biomass of seedlings of *Fagus sylvaestica* under elevated conditions was observed, however, the interaction effect of fertilization of seedlings with Nitrogen and elevated CO_2 was absent. Same fact could be ascribed to the increased relative growth rate for biomass index (Table 5) in the present study, where, the elevated CO_2 increased the relative growth rate for seedling biomass (Brown, 1989).

The study revealed that, under elevated conditions, application of higher levels of nutrients can yield good quality seedlings. Seedling collar diameter increment of seedlings was negatively affected without any nutrient supplement under elevated CO_2 condition.

However, elevated CO_2 condition with adequate nutrient supplements could increase the diameter growth of seedlings even up to three folds (T8). A significant increase in the total height growth of seedlings was observed under elevated CO_2 condition. The elevated CO_2 positively influenced the volume index of seedlings under all the and positive and higher response index value of the biomass increment to the elevated CO_2 condition indicated that application of nutrients under elevated CO_2 could produce seedlings with higher biomass. In the scenario of climate change, if the CO_2 concentration in the atmosphere is doubled, the species can adapt with available nutrients. Seedling growth can be enhanced by supplementing nutrients under elevated CO_2 condition.

Acknowledgement

We acknowledge the college of Forestry, Ponnampet and all its faculty for providing all the facilities to carry out the research.

References

Brown, R.K., 1989. Carbon dioxide enrichment accelerates the decline in nutrient status and relative growth rate of *Populus tremuloides* Michx. Seedlings. *Tree Physiol.* 8:161-173.

Devakumar, A. S., Udaykumar, M. and Prasad, T. G., 1996. A simple technique to expose tree seedlings to elevated CO_2 conditions for increased initial growth rates. Curr. Sci. 71(6).

Devakumar, A.S., Shayee, M. S.S., Udayakumar, M. and Prasad, T.G., 1998. Effect of elevated CO_2 concentration on seedlings growth rate and photosynthesis in *Heveabrasilinsis*. *J. Biosci.* 23:33-39

FAO (Food and agricultural organization, Rome), 2015. The State of Food and Agriculture: 1-20

Fathurrahman, F., Nizam, M.S., Juliana, W.W.A., Doni, F. and Radziah, C. C.M.Z., 2016. Growth improvement of rain tree (*Albiziasaman* Jacq. Merr) seedlings under elevated concentration of carbon dioxide (CO_2). *J. of pure and app. Microbiology*. 10(3). 1911-1917

Hegde, R., Gopakumar, K. and Kannan, C.S., 1993. Effect of leaf extract of Mangium *(Acacia mangium* Willd.) on germination behavior of vegetable seeds. *My forest.* 31(1):9-11.

Huang, J.G., Bergeron, Y., Denneler, B., Berninger, F. and Tardif, J., 2007, Response of Forest Trees to Increased Atmospheric CO_2. *Critical Reviews in Plant Sciences*. 26(5), 265-283. http://dx.doi.org/10.1080/07352680701626978

Kilpeläinen, A., Peltola, H., Ryyppö, A. and Kellomäki, A., 2005. Scots pine responses to elevated temperature and carbon dioxide concentration: growth and wood properties. *Tree Physiol.*25. 75–83

Kimball. W., 1983. Gas exchange in plants. *Kimbells boil.* p.22

Kumar, P., Reddy, R. and Devakumar, A.S., 2001. Effect of elevated carbon dioxide on seedling growth rates of some forest tree species. *My For*. 37. 663-668.

Long, S.P. and Drake, B.G., 1992. Photosynthetic CO_2 assimilation and rising atmospheric CO_2 concentrations. In: Baker, N.R., Thomas, H. (Eds.), Topics in Photosynthesis. Elsevier, Amsterdam. 69–103.

Lotfiomran, N., Köhl, M. and Fromm, J., 2016. Interaction effect between elevated co_2 and fertilization on biomass, gas exchange and C/N ratio of European beech (*Fagus sylvatica* L.). *Plants*. 5(38). 1-13

Oskarsson, H., Sigurgeirsson, A. and Rasmussen, K., 2006. Survival, growth, and nutrition of tree seedlings fertilized at planting on andisol soils in Iceland: Six-year results. 229. 88–97

Reddy, A., Rasineni, G.K. and Raghavendra, A.S., 2010. The impact of global elevated CO_2 concentration on photosynthesis and plant productivity. *Curr. Scie.* 99(1). 46-57

Warrier, R. R., Buvaneswaran B., Priyadharshini. P. and Jayaraj. R.S.C, 2013. Growth response of three plantation species of the tropics exposed to elevated CO_2 levels. *J. Resar*. 24(3). 449−456.

How to cite this article:

Supriya K. Salimath, Ramakrishna Hegde, R.N. Kencharaddi, Clara manasa and Vasudev Lamani. 2018. Growth Response of *Calophyllum inophyllum* L. Seedlings to Elevated Carbon Dioxide Enriched with Certain Nutrients. *Int.J.Curr.Microbiol.App.Sci.* 7(08): 3932-3942.
doi: https://doi.org/10.20546/ijcmas.2018.708.405