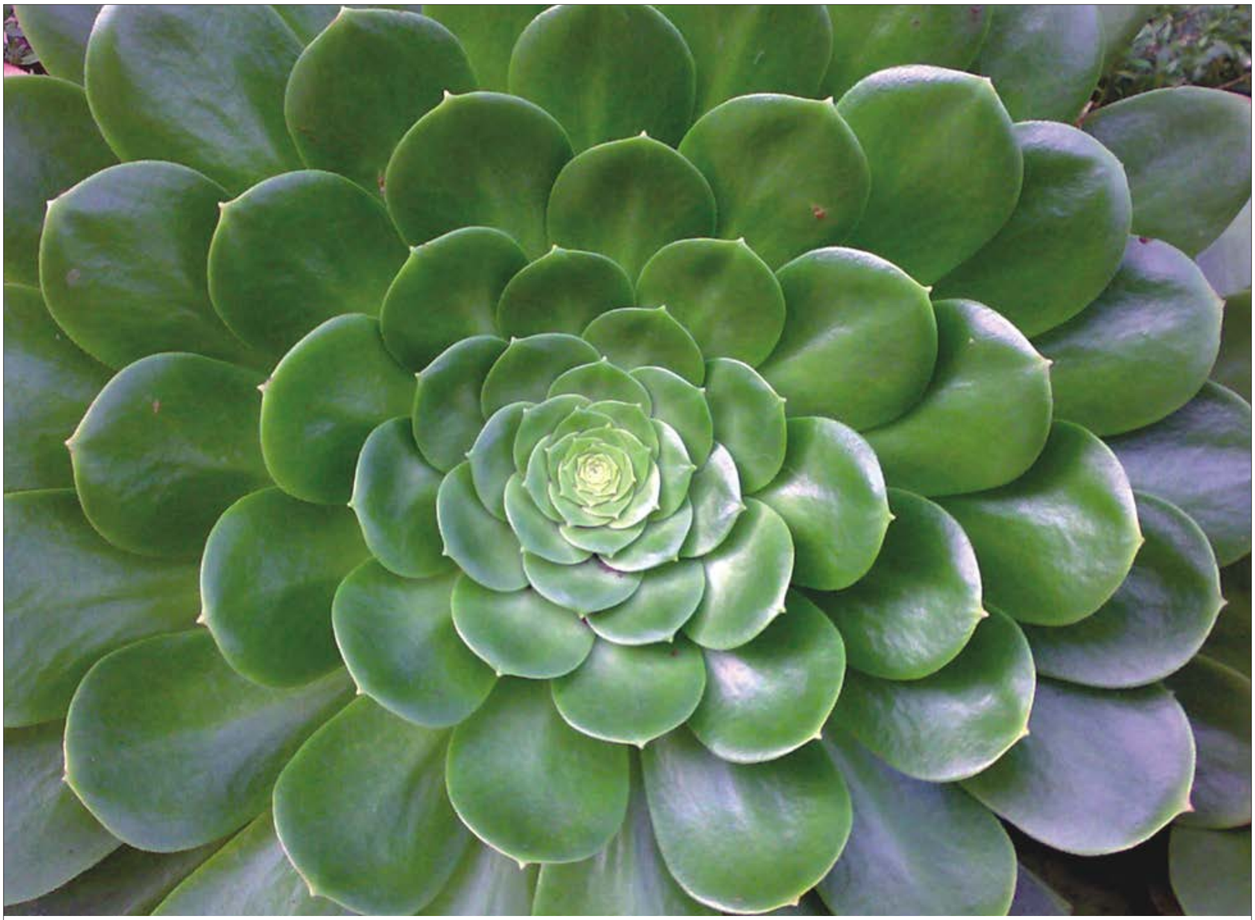

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Gmelina arborea Roxb. Seedlings Treated at Elevated Temperature in Plant Growth Chamber

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ABSTRACT

Elevated temperature has positive and/or negative effects on seedlings of forest trees. Aim of the study was to compare the impact of three higher temperature conditions with control temperature to *Gmelina arborea* Roxb. (family: Verbenaceae) seedlings growing in a plant growth chamber. Similar sized seedlings randomly selected from same origin were treated with three elevated temperature (30/20, 32/22 and 34/24°C) and compared with control temperature (26.31/16.54°C) at a day/night combinations. Measurements were made for height, collar diameter and increase or decrease of leaf number of the studied seedlings during the observation period. Seedlings height growth was found positive for the examination period rather favourable to elevated temperature conditions than control. Seedlings grown at three successive elevated temperatures showed significantly ($p \leq 0.05$) higher growth than control temperature. However, collar diameter growth was found insignificant with respect to temperature treatment and days. Number of leaves development was found negatively responded to elevated temperatures. With successive elevated temperature, leaf shedding increased significantly which might be due to maximum thermal entropy given to plants. Thus, elevated temperature might increase seedlings shoot height significantly, where, leaf number might negatively react; leading them to a long seedling with less leaves.

Key words: *Gmelina arborea*, seedlings response, temperature elevation, growth chamber

INTRODUCTION

According to IPCC (2007), global temperature will change at a range between 1.8 and 4.00°C at 2090-2099 relative to 1980-1999 within different climate change scenarios. As Bangladesh is a poor country with limited resources but contributed less to global emission, scenarios for future temperature elevation might be 3.4°C (IPCC., 2007). According to National Adaptation Programme for Action (NAPA) report, the country would face an additional 2.4°C temperature increase by 2100 (MoEF., 2009). Agrawala *et al*. (2003) found an experimental elevation in temperature in between two seasons' monsoon and winter respectively as 0.8 and 1.1°C, 1.1 and 1.6°C and 1.9 and 2.7°C by the year 2030, 2050 and 2100. Therefore, an increase in 2-4°C is very much evident in the country which will lead her to become the worst affected due to climate change (MoEF., 2008).

Due to climate change effects, forest flora may experience the extreme threat of elevated temperature at different stages of their lives (Rahman *et al*., 2012). As, it is apparent that there is a close relation between the climate and the vegetation it supports (Champion *et al*., 1965).

Climate is a key factor which determines the productivity and distribution of forest flora (Rahman *et al*., 2015). Several studies pointed out that, temperature increase may lead the forest ecosystem to change considerably in forest growth over the next century (Kellomaki *et al*., 1997). Response to elevated temperature and precipitation change, forest flora might experience greater survivability challenge in a climate change prone country like Bangladesh (Rahman *et al*., 2013). Moreover, physical responses of plants to change in climatic factors like temperature, precipitation and abiotic factors like salinity intrusion may lead positive or negative effects (Rahman, 2012). Some factor may promulgate growth while other may stunts their vigour. Results depict that elevated temperature alone might be positive for *Swietenia macrophylla* seedlings (Rahman *et al*., 2013).

Seedling performance in the planting site depends on its growth potential and the degree to which conditions in the area allow its growth potential to be expressed. The degree to which seedlings are conditioned to the environment in the planting site will have the greatest influence on their performance immediately after planting (Corpuz and Carandang, 2012). The resistance to stress of forest tree seedlings during the initial phases after planting is fundamental for assuring fast establishment and long-term survival of artificial regeneration (Walsh *et al*., 2014). Present research chose to study on *Gmelina arborea* Roxb. (family: Verbenaceae) seedlings to enunciate this species' ability to withstand higher temperature than its normal range (21-28°C; Jensen, 1995) at its initial stage of life. Similar previous experiments were taken in place with *Artocarpus chaplasha* and *Swietenia macrophylla* and found with different results; positive growth at elevate temperature for *Swietenia macrophylla* (Rahman *et al*., 2013) and negative growth and survivability of *Artocarpus chaplasha* (Rahman *et al*., 2012) at elevated temperature.

Gmelina arborea is a medium-sized deciduous and fast growing tree (Jensen, 1995; Zabala, 1990). It has been widely planted in Southeast Asian countries including Bangladesh, Myanmar, Thailand, Southern China, Vietnam, Indonesia and the Philippines (Jensen, 1995). The species occurs naturally from latitudes 5-30°N and longitudes 70-110°E. Its altitudinal range is approximately 50-1300 m in areas with distinct dry seasons in the countries of Bangladesh, Cambodia, China (Yunnan and Kwangsi Chuang provinces), India, Laos, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam (Dvorak, 2003; Lauridsen and Kjaer, 2002; Duke, 1983; Hossain, 1999). In Bangladesh, it occurs mainly in the forests of Chittagong, Cox's Bazaar, Chittagong Hill Tracts, Dhaka, Mymensingh and also raised in plantations (Das and Alam, 2001; Hossain, 2005). *Gmelina arborea* is found in a wide range of conditions from sea level to 1200 m elevation and annual rainfall from 750-5000 mm. According to Luna (1996), mean maximum and mean minimum temperature is 52 and 15°C, respectively and it grows best on deep, well drained, base-rich soils with pH between 5.0 and 8.0. Growth is poor on thin, highly leached acid soils (F/FRED., 1994).

This experiment might be helpful in asking the answer whether *Gmelina arborea* would be tenable to elevated temperature condition in future or not. For this, temperature-humidity-light controlled plant growth chamber was used to enunciate stated seedling growth. Olszyk *et al*. (1998) reported that responses to elevated atmospheric temperature over several years in controlled-environment chamber facility shows plant morphological disturbances.

MATERIALS AND METHODS

Materials: A temperature-humidity-photoperiod regulated plant growth chamber (Fig. 1) was used at the tree propagation laboratory, IFES, University of Chittagong, Bangladesh. Temperature

Fig. 1: Temperature-humidity-photoperiod controlled plant growth chamber (Source: Professor Dr. Mohammed Al-Amin)

records were taken by atmospheric thermometer placed at outdoor condition to measure existing temperature. Height and collar diameter of seedlings were measured using meter scale and slide callipers, respectively.

Seedling replicates: As small sized seedlings ware considered being more sensitive to stress conditions than bigger seedlings (Walsh *et al*., 2014), seedlings of same age and origin (seeds collected from mature mother tree at the Chittagong University campus) were used for treatments. Forty seedlings were taken, where replication was ten for each thermal treatment.

Container preparation: Container or pot planting is the authentic method to experiment with seedlings when treated with abiotic factors like temperature or light. Seedlings were transplanted from germination bed to a 15×11 cm plastic bag which was filled with a mixture of 1.4 kg of sandy loam soil and cowdung (3:1 ratio).

Experimental design: A one-factor split-plot experimental design with ten randomly assigned complete replications was used in four different thermal growing conditions.

Study site and period: The experiment was conducted in the Nursery (for control) and the Tree Propagation Laboratory (for growth chamber) at Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh. Study conducted during the month of January, February and March, 2009. The mean monthly temperature varied from 19.44°C in January to 28.88°C in May (UNEP., 2001; Islam *et al*., 1979). However, within 100 days of observation, average control temperature was 26.31/16.54°C at day/night combination.

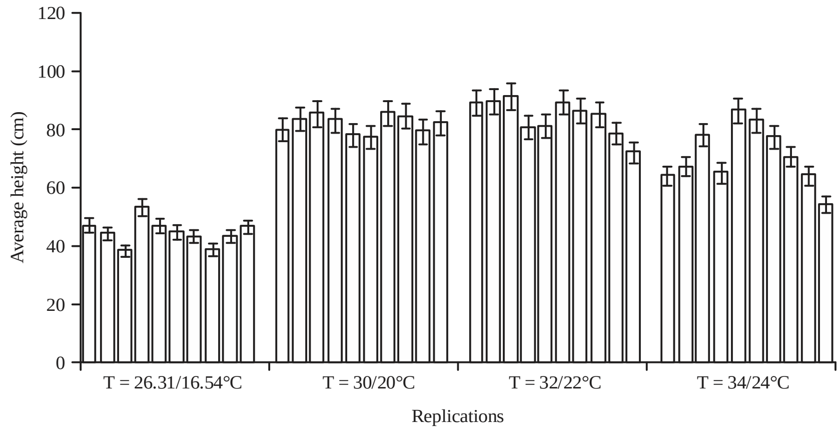

Fig. 2: Height growth comparison of *Gmelina arborea* at different temperature scenarios

Methods: Seedlings reared at the plant growth chamber (Fig. 2) where temperature, light intensity and relative humidity were controlled strictly. The growth chamber was programmed with a peak temperature of 30/20, 32/22 and 34/24°C at three different times and with relative humidity 80% at peak point. Ramping (increase) of temperature and humidity was 0.02 and 0.01, respectively. Day light was considered at maximum i.e., twelve hours a day because Mejia *et al*. (2008) showed that seedlings growth of this species depends largely on light availability. Data collected about the height, collar diameter and number of leaves of the seedlings recorded at every eleventh day.

Data analysis: After more than three months of observation, data was plotted and analyzed. Growth data of height, collar diameter and leaf number were measured by subtracting final measurement with initial measurement during the observation. Statistical software used to analyze the growth measurements was Minitab 14. Two way analysis of variance (ANOVA) was used to analyze both responses: seedling growth with temperature and successive growing days.

RESULTS

Seedlings of *Gmelina arborea* grown in a plant growth chamber at elevated temperature showed a positive response in height growth during study period. Figure 2-4 show mean height; collar diameter and leaf number development growth after thermal treatments given to same origin and same age seedlings. Seedling height grew significantly ($p \leq 0.05$) at higher temperature condition. However, 30/20 and 32/22°C thermal treatment showed increased growth where, at 34/24°C seedling grew lower than previous two. All three elevated temperature treatment pose an increased growth to seedlings in their height with respect successive growing days. During the observation, collar diameter grew almost similar with insignificant difference at different thermal treatments compared to control temperature. However, leaf number development showed a negative response to elevated temperature. With increasing temperature from 26.31/16.54 to 34/24°C, leaf number development deceased significantly ($p \leq 0.05$). This may be due to increased occurrences of leaf fall of the samples. Thus, elevated temperature tends to decrease seedlings leaf number due to several morphological reasons.

Seedlings grew everyday at three different parameters, however, height growth was prominent than other two. Growth rate reduced later during the observation (Table 1).

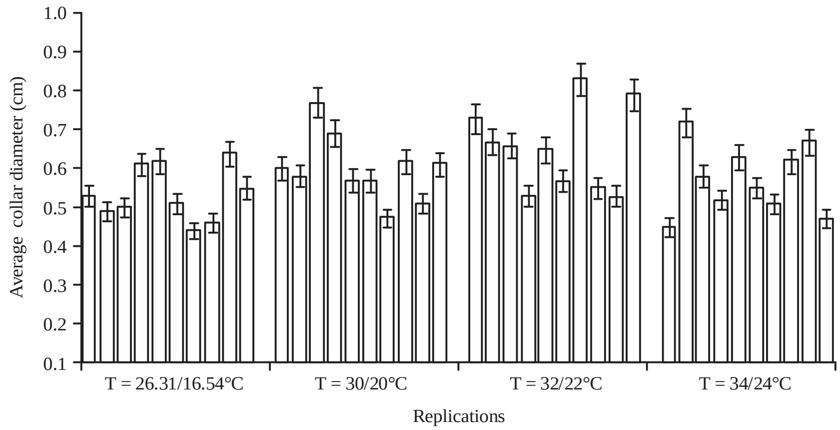

Fig. 3: Collar diameter comparison of *Gmelina arborea* at different temperature scenarios

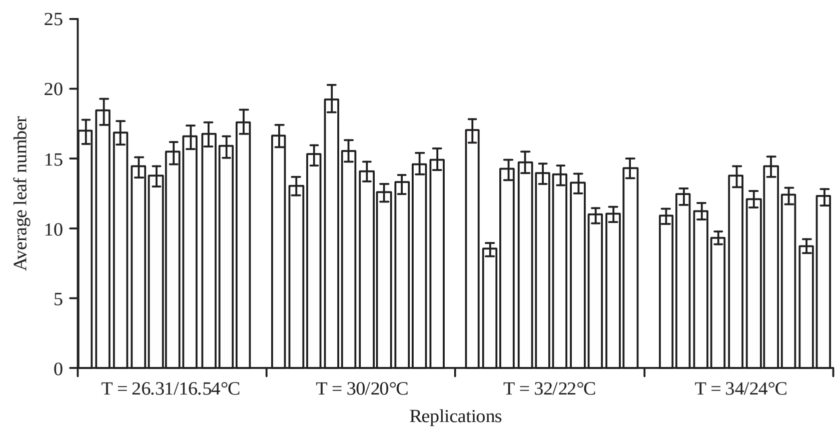

Fig. 4: Comparison of leaf number of *Gmelina arborea* at different temperature scenarios

Table 1: Statistical analysis of the effect of growing period and treatments on growth performance of *Gmelina arborea*

Treatments and sources of variations	DF	F	p
Elevated temperature			
Height	3	346.73	0.00
Collar diameter		75.11	0.06
Number of leaf development		23.74	0.00
Subsequent days			
Height	10	24.45	0.00
Collar diameter		21.13	0.05
Number of leaf development		11.48	0.00

DF: Degree of freedom, F: Values at fisher's test, p: Probability distribution at 95% confidence interval ($p \leq 0.05$)

DISCUSSION

The temperature, to which seedlings were exposed after leaving the nursery and the duration of the exposure, can dramatically alter their survival and growth rate. The effects may be direct, affecting tissue viability, or indirect, affecting respiration, transpiration and plant-water relations. Environmental conditions which seedlings experience must be measured to determine how those conditions may have altered seedling physiology and affected outplanting survival performance (Gasvoda *et al*., 2002).

Some species reported to have better growth at higher temperature and some failed to show significant growth at higher ambient temperature. As germination and survival in the initial months represent a critical period for forest tree species (Ruano *et al*., 2009), present study considers experimenting with *G. arborea* seedlings at elevated temperature in controlled environment plant growth chamber. Within a plant growth chamber condition, mature trees can never be experimented; however, seedlings of similar age and origin can be better suited to assess their response and adaptability in elevated temperature (Rahman *et al*., 2013).

Favourable elevated temperature may grow floral species positively, as it was reported that seedling survival and growth increased both under the future climate regime in USA for black spruce (*Picea mariana*) (Wang *et al*., 1994). With increased temperature and CO_2, forest ecosystems may grow faster, mature earlier and die younger (Ryan, 1991). Several studies pointed out that temperature increase may lead the forest ecosystem to change considerably in forest growth over the next century (Kellomaki *et al*., 1997).

While experimenting with tropical tree seedlings in a controlled-environment plant growth chamber, elevated temperature (30, 32 and 34°C) showed positive growth for *Swietenia macrophylla* seedlings, rather most favourable for its growth in height, however, collar diameter and leaf number may remain unaffected (Rahman *et al*., 2013). *Lagerstroemia speciosa* showed tolerance with high temperature when grown at elevated temperature in controlled growth chamber conditions and initial growth was better than existing temperature in comparison to medium high and high temperatures for *Albizia procera* (Ullah, 2008). Ahmed (2007) found a positive response to elevated temperature between 31.58 and 39.6°C for germination and initial growth performance of *Shorea robusta*. Ullah and Al-Amin (2008) found *Cassia fistula* to be grown better at 34.58°C than 32.78, 36.18 and 36.78°C, respectively.

Development in leaf number during elevated temperature treatment may promulgate or decrease due to anatomical and further morphological responses which need to be assessed in future experiments. This may be due to the obsession layer developed in between leaf and the stem caused from water stress (Jochum *et al*., 2007). For *Anthocephalus chinensis*, mean number of leaves per seedlings at 28°C (4.1) and 32°C (3.2) was found significantly higher than that at 24°C (Kotoky *et al*., 2000). Four clones of the dark-leaved willow (*Salix myrsinifolia*) seedlings were grown in closed-top plant growth chambers with factor: Temperature (T) (2-5°C above control). At elevated temperature there was less branch and leaf material in relation to stems than at the control temperature (Veteli *et al*., 2002).

There are some negative responses also where seedlings of *Artocarpus chaplasha* showed stunted growth and mortality to elevated temperature conditions (Al-Amin, 2009; Rahman *et al*., 2012). Seedlings of *Artocarpus chaplasha* reared at different temperatures and saline water treatments showed stunted growth than reared at existing outdoor temperature irrigated with regular fresh water. Thus, this species may not thrive at higher temperature and salinity intrusion at its early growing period. Seedling growth at three different parameters such as height, collar diameter and number of leaves showed that with increasing temperature individuals respond negatively. Moreover, the combined effect of high salinity and higher elevated temperature results in seedling mortality (Rahman *et al*., 2012).

Thus, due to favouring dry season like *Swietenia macrophylla*, *Gmelina arborea* may also suit elevated temperature in near future and withstand with better shoot growth performances.

CONCLUSION

For plants growth and morphological dynamics, atmospheric temperature plays an important role. Forest tree seedlings are subjected to climatic factors like temperature, precipitation, humidity etc. Like any other natural resources they also react against any sort of imbalance or change in their popular environment. Climate change induced increase in atmospheric temperature may lead forest tree seedlings toward positive or negative response. *Gmelina arborea* is a common plantation species in the tropics. Seedlings of this species act diversely against elevated temperature. Height growth might be promulgated; however, seedlings may become more leafless due to higher thermal condition. Considering all its impact, this species may experience a positive response due to temperature increase in near future at plantations of the drier part of the globe.

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