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Artocarpus chaplasha: Establishment and Initial Growth Performance at Elevated Temperature and Saline Stresses

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Abstract

Like any other natural resources, forest flora may experience the extreme threat of elevated temperature and saline water submergence at different stages of their lives i.e. from germination to maturity due to climate change effects. The overall aim of the study was to measure the effect of higher temperatures along with saline water irrigation on survival and initial growth during seedling stage of *Artocarpus chapalasha*. The experiment was conducted in temperature-humidity-photoperiod regulated plant growth chamber during stipulated period to measure the growth performance of randomly selected seedlings. Within three different elevated temperatures viz. 30°C, 32°C and 34°C, the seedlings were given three different saline conditions such as 0.5 g/L, 1.5 g/L and 2.5 g/L NaCl concentrations. Results found from the experiment was that, seedlings of *Artocarpus chaplasha* reared at different temperatures and saline water treatments showed stunted growth than reared at existing outdoor temperature (26.31°C) irrigated with regular fresh water. Seedling growth at three different parameters such as height, collar diameter and number of leaves showed that with increasing temperature individuals respond negatively to increasing saline condition. The seedling's growth occurred at every day in height, collar diameter and leaf. However, growth rate reduced later during the observation. The combined effect of high salinity and higher elevated temperature results in seedling mortality. Therefore, *Artocarpus chaplasha* may not thrive at higher temperature and salinity intrusion at its early growing period in plantation and natural forest areas.

Key Words: *Artocarpus chaplasha* ROXB, elevated temperature, plant growth chamber, saline stress, seedling growth and survival

Introduction

The Earth's climate would warm an additional 1.4-5.8°C between 1990 and 2100 (Watson 2001). Major climate change induced challenges are rise of sea level, wider salinity in the surface, ground and soil in the coastal zone (WB 2000). According to the Intergovernmental Panel on Climate Change (IPCC 2007), Bangladesh would face 3.4°C temperature increase within the year 2100 as the country is a poor one with limited resources but contribute less to global emission. According to MoEF (2009), the country would face an additional 2.4°C temperature increase and an 88 cm sea level rise by 2100. Thus, Bangladesh is the worst affected due to climate change impacts (MoEF 2008).

Climate is a key factor which determines the distribution

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of plants and as when temperature and rainfall patterns change, the ranges of both animal and plant species change (Al-Amin 2011). Tree establishment and growth are generated by environmental gradients and topographic differentiation (Colmore 2003). Response of elevated temperature to forest flora depends on the climatic conditions such as temperature, precipitation, humidity and light intensity. 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). Prolonged floods would severely affect growth of many timber species, while it would cause high incidence of mortality for *Artocarpus* species (MoEF 2005). Seedlings of *Artocarpus chaplasha* showed negative response to elevated temperature conditions (Al-Amin 2009). Mahtab (1992) identified that if there would temperature rise there will be salinity intrusion in southern part of Bangladesh.

Artocarpus chaplasha Roxb. is under the family Moraceae (USDA 2010). It is a deciduous tree species. It is distributed through out the sub-Himalayan track and outer hills from Nepal Eastwards ascending to Assam, Arunachal Pradesh, Bangladesh, Myanmar and Andaman (Singh et al. 2003). It grows well where mean maximum temperature is 36-40°C, mean minimum temperature is 15-30°C, and rainfall is between 203 cm and 508 cm. this species is found in foothills, along the bank of stream possessing clayey soil with good drainage, moist lateritic, rich deep loam soil (Troup 1921, 1986; Zabala 1990; Luna 1996; Das and Alam 2001).

Considering silvicultural requirements and changing climate scenarios for future in Bangladesh the potential suitable lands for indigenous species like *Anisoptera scaphula*, *Hopea odorata*, *Artocarpus chaplasha*, *Swietenia mahagony*, *Albizia lebbeck*, *Albizia procera*, *Lagerstroemia speciosa*, *Cassia fistula*, *Melocanna baccifera*, *Terminalia belerica* and *Heritiera fomes* may decrease significantly in future by the year 2100 (Al-Amin and Rahman 2011). Others (Al-Amin and Khanam 2008) found that this species will not be suitable for plantation as the seedlings do not withstand elevated temperature.

Therefore, a need may exist to ensure whether the *Artocarpus chaplasha* might survive or not at initial stage in the plantation to elevated temperature and saline stresses as there large areas are planted each year by this species in foothills and valleys.

Materials and Methods

Materials

Initial growth performance of *Artocarpus chaplasha* at three different parameters viz. height, collar diameter and number of leaves were measured by meter scale, slide callipers and manual reading respectively. For temperature, light and humidity control the seedlings were reared in the Weiss Gallenkamp fitotron Plant Growth Chamber (Tree propagation laboratory, IFES, University of Chittagong). Temperature records were taken by atmospheric thermometer placed at outdoor condition to measure existing temperature.

Study site and period

The experiment was conducted in the nursery and Tree Propagation laboratory of 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 varies from 19.44°C in January to 28.88°C in May (Islam et al. 1979; UNEP, 2001).

Samples

Seedlings of same age and origin were germinated at the Tree Propagation Laboratory, IFESCU. Forty seedlings of *Artocarpus chaplasha* were then hardened. Their height, collar diameter and number of leaves were recorded in record sheet. The experimental used for the present research was Split Plot Experimental design, where a number of treatments were given to plants.

Methods

Initial growth performances in three saline water treatment (NaCl concentrations of 0.5 gl^{-1}, 1.5 gl^{-1} and 2.5 gl^{-1}) in each of the three different higher temperature viz. low (30°C) elevated, mid (32°C) elevated and high (34°C) elevated comparing with existing variable (averaging 26.31°C during study period, collected from IFESCU Tree Propagation Laboratory) temperature were measured during observation. For temperature control at different higher temperatures, the seedlings were reared in the Weiss

Gallenkamp Plant Growth Chamber where the temperature, light intensity and relative humidity were controlled strictly. The growth chamber was programmed with a pick temperature of 30°C, 32°C and 34°C and with relative humidity 80% at pick point. Ramping increase of temperature was 0.02 and for humidity it was 0.01. Day light was considered at maximum twelve hours a day. The study was conducted with heating the seedlings at day and night time both. Therefore, programming was done according to this context. Un-purified salt from salt bed of coastal areas of Chittagong district was collected and packed in vacuum packet to protect them from moisture intrusion. Solution of NaCl with water according to predetermined amount was irrigated to each seedling as treatment at every day. Data collected about the height, collar diameter and number of leaves of the seedlings recorded at every fourth day. At least three seedlings were tried separately in existing temperature and no saline. Replications for each plot were three. After three months observation the data were analyzed. Statistical software used to analyze the growth measurements was Minitab 2002 version 13.2. Growing seedlings in a controlled Plant Growth Chamber and observing their performances is supported by Al-Amin and Khanam (2008); Al-Amin and Afrin (2011); Ullah and Al-Amin (2008); Kotoky et al. (2000).

Results and Discussion

Average height growth of Artocarpus chaplasha

Growth in seedling height was measured for different temperature and saline conditions which is shown in Fig. 1.

Fig. 1 shows that after the study period height growth of *Artocarpus chaplasha* seedlings (replicates) was found almost similar to existing temperature (26.31 °C). However, seedlings showed reduced growth at elevated temperature and saline concentrations. With increasing temperature and NaCl concentrations seedlings grew less than existing condition. Higher temperature (34°C) combined with saline (1.5 g/L and 2.5 g/L) cause mortality of seedlings which are showing no height growth in the graph.

Ullah and Al-Amin (2008) found that *Cassia fistula* showed promising growth at 34.58°C followed by 32.78°C (existing temperature), 36.18°C and 36.78°C. Height growth of *Taxadium distichum* and *Sapium sebiferum* seedlings were affected by salinity with 0 and 2 ppt (parts per ton) water, but heights of plants watered with 10 ppt water were significantly lower. Diameter growth was much more variable. *Sapium sebiferum* can survive larger & higher salinities thus increasing its chance of survival in coastal areas where salinity levels are rising (Corner 1994). Leaf and height growth were significantly reduced after 3 and 5 days following exposure to salinity respectively for all four experimented poplar clones (Fung et al. 1998). Mean shoot

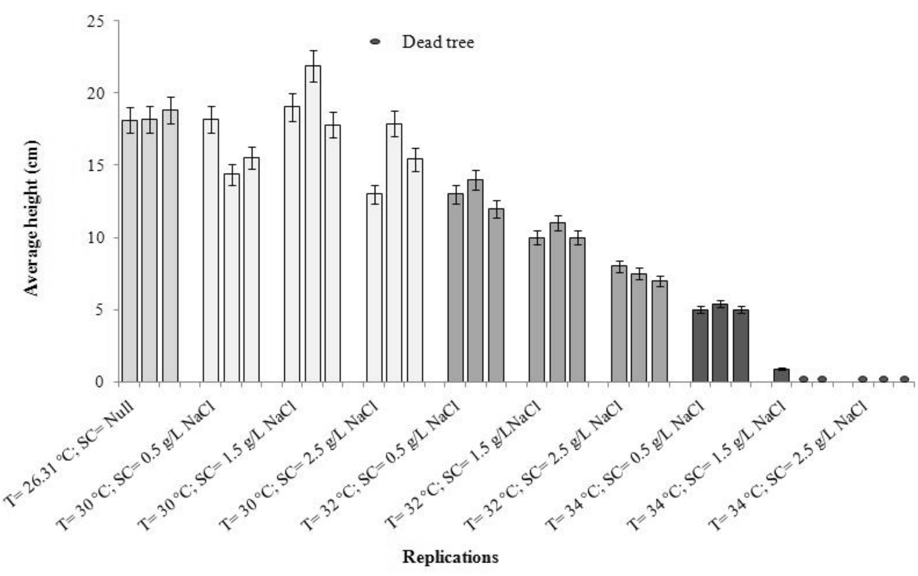

Fig. 1. Height growth of *Artocarpus chaplasha* under different temperatures (T) and saline concentrations (SC).

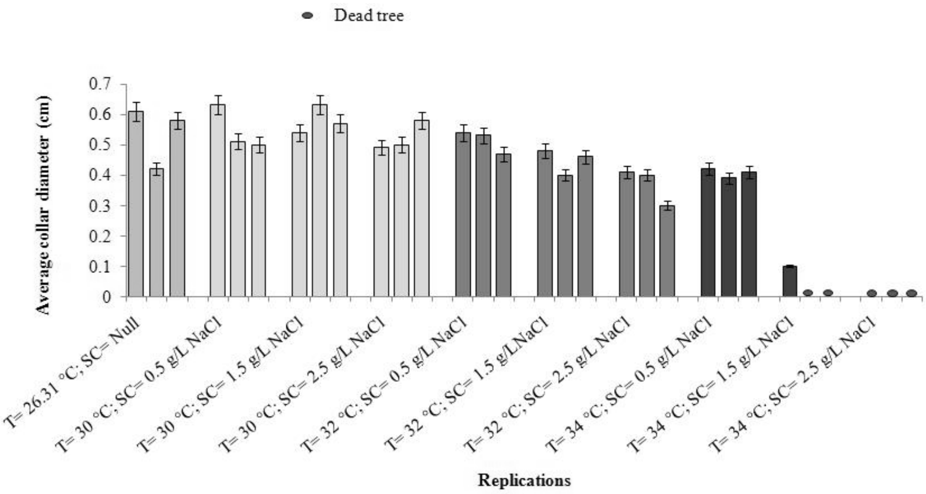

Fig. 2. Collar diameter growth of *Artocarpus chaplasha* under different temperatures (T) and saline concentrations (SC).

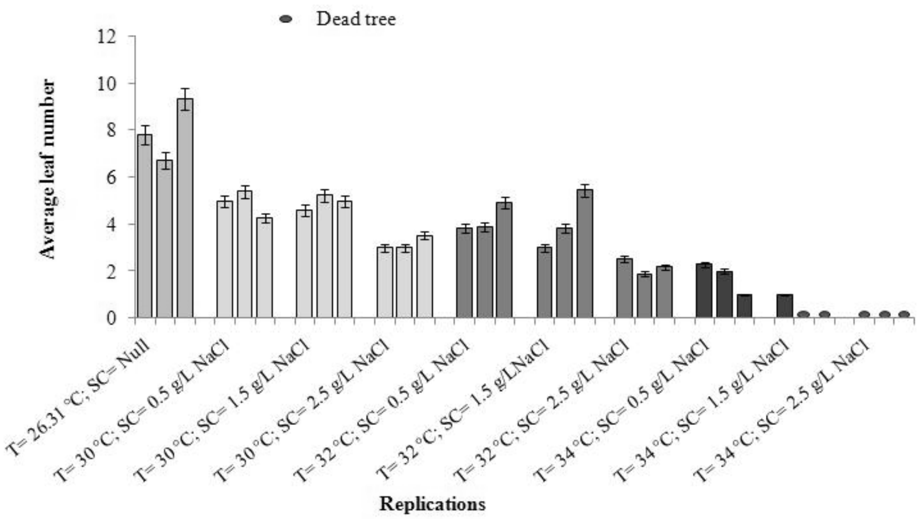

Fig. 3. Leaf number development of *Artocarpus chaplasha* under different temperatures (T) and saline concentrations (SC).

length of *Anthocephalus chinensis* were found to be highest (1.1 cm) at 28°C than 32°C (0.9 cm) and 24°C (0.2 cm) after rearing in a plant growth chamber for six weeks. The effect of interaction was also found to be statistically significant (Kotoky et al. 2000).

Average collar diameter growth of Artocarpus chaplasha

Growth in collar diameter of studied seedlings was satisfactory at 30°C with all saline conditions. At 32°C with higher saline growth slightly decreased. Seedlings showed mortality at 34°C with high concentrations of NaCl (Fig. 2).

Ullah and Al-Amin (2008) found Cassia fistula to be grown better at 34.58°C than 32.78°C, 36.18°C and 36.78°C respectively.

Average number of leaf development of Artocarpus chaplasha

Average number of leaf developed during the observation period showed that as temperature rises and salinity increases, seedlings of *Artocarpus chaplasha* shed their leaves. This condition led to total leaflessness of the seedlings with respect to succeeding thermal and salinity con-

Table 1. Effect of days and higher temperature with saline on growth performance of *Artocarpus chaplasha* (statistical analysis)

Sources of variations	F value	p value	Remark (significant at p=0.05)
Effect of higher temperature and saline condition on height of seedling	27.43	0.00	Highly significant
Effect of higher temperature and saline condition on number of leaf of seedling	41.6	0.00	Highly significant

dition (Fig. 3).

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 but did not differ significantly from each other. The interaction effect for leaf number was found to be statistically significant (Kotoky et al. 2000).

Table 1 indicates that the seedling growth reduced drastically in height, collar diameter and leaf after treatments given. Higher temperature and saline stress significantly affected the growth in height and number of leaf development.

Artocarpus chaplasha may not withstand with the high scenario of the climate change and found better growth in mid-scenario than the low and high scenario (Al-Amin and Khanam 2008). It may tolerate water logging during its initial growth but responsive to water stresses. At higher water stress conditions seedlings showed stunted growth (Al-Amin and Afrin 2011). 34.58°C is more suitable temperature than existing temperature (32.78°C) and other elevated temperatures (36.18°C and 36.78°C) for early establishment and growth of *Cassia fistula* when treated in a Growth chamber (Ullah and Al-Amin 2008).

Leaf, stem and root of sunflower and maize showed an almost similar growth reduction due to salinity. During early seedling growth, salinity and soil texture affected the development of the seedlings that showed symptoms of water stress in the form of lower leaf water potential, stomatal conductance and evapotranspiration. The higher the salinity, the lower the leaf area and dry matter production of trees (Katerji et al. 1994). During seedling growth, elevated temperatures associated with global warming may reduce both main and lammas-flush growth, thereby altering tree productivity (Olszyk et al. 1998). Consequently, during early growth under field-like soil moisture and fertility conditions, elevated temperatures associated with global warming may reduce shoot height, but not necessarily stem diameter (Tingey et al. 1998). Results also found from temperate forests that, Conifer tree growth was reduced under all future climate change scenarios in California, USA. Productivity in mature stands was reduced by 18 % by the end of the century (Battels et al. 2006). Potted plants of *Asteriscus maritimus* were submitted to irrigation with saline water (150 days of exposure to 0, 70 and 140 mM NaCl daily irrigation) to assess the effect on growth parameters. Plants under saline and water stress conditions showed lower biomass and an early reduction in leaf expansion growth (Rodriguez et al. 2005).

Conclusions

Artocarpus chaplasha is an indigenous forest tree species which grows almost all the valleys of the hilly regions of Bangladesh. As Bangladesh is a low lying country, the valleys and other depressions may experience the threat of salinity intrusion in the near future. Result of the study shows that this species may not thrive at higher temperature and salinity intrusion at its early growing period. Establishment of any forest plantation greatly depends on seedling/initial establishment. Therefore, in the face of climate change and its adverse affect on the biological diversity, *Artocarpus chaplasha* may not be suitable for plantation in the areas where salinity may intrude now and then, mostly in the coastal and offshore areas of the country.

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