



## Growth performance of tree species in agroforestry system in terai region of West Bengal, India

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DOI: 10.5958/2455-7129.2020.00018.7 **ABSTRACT**

### Key Words:

Collar diameter, increment, silvihorticultural system, survival

Survival and growth performance of four tree species viz., *Bischofia javanica*, *Elaeocarpus floribundus*, *Swietenia macrophylla* and *Cinnamomum zeylanicum* was studied under silvihorticultural system in the model farm of the Department of Forestry, Uttar Banga Krishi Viswavidyalaya during 2016-2019. *B. javanica* obtained highest growth in terms of collar diameter 10-12 cm class and height (3.80 m) followed by *S. macrophylla* and *E. floribundus* with collar diameter 6-8 cm and height growth 3.50 and 2.13 m respectively and *C. zeylanicum* also exhibited 6-8 cm class and lowest height growth (1.5 m). The study also indicated a stability of species survival in *S. macrophylla* (100%), *B. Javanica* (98%) and *E. floribundus* (90%) and *C. zeylanicum* (37.5%) for terai region. *B. javanica* was the best performing species for all parameters including growth of collar diameter, height and volume increment. There is need for further investigation for nutrition management to obtain optimal growth condition.

### INTRODUCTION

Deforestation and global warming have become severe calamity in global prospective, particularly in developing countries under the umbrella of development along with tree cover is sacrificed into farms, pastures and other land use process repeatedly in the recent years (FAO 1995). However, the tree cover is limited to 2.89% of the geographical area

of India (ISFR 2019). This resulted biodiversity loss, serious soil erosion, depletion of plant nutrients, gradual degradation and decline in land productivity and its carrying capacity, silting of major river basins causing recurrent floods in plains, drying up of perennial streams as well as ecological imbalances (Borthakur et al. 1985). In this regard agroforestry system, created

harmony with a dynamic and ecologically based natural resource management system, that, integrated woody perennials in farm lands to make the approach diversifying and sustainably viable production system along with increase the social, economic and environmental benefits (Leakey 1996). Seedling survival after outplanting is a complex process (Landis et al. 2010). However, plants have a high range of acclimation capacity to changing environment including fluctuating light (Yamashita et al. 2000) and soil nutrients (Osone et al. 2014, Saravanan 2020), resulting well adaptation to unfavourable site conditions. The successful establishment of seedling is based upon the phenological and physiological characteristics and different locality factors including environmental conditions (Sukhbaatar et al. 2020). Survival percentage in field condition is also an important factor for any successful plantation. Seedling quality is governed by the genetic make-up of the parent trees and the physical growth of the seedlings (Bahnasy and Ismail 2019). The suitable tree-crop interaction facilitates positive response on productivity, conservation of soil fertility and microclimate, efficient nutrient cycling and management of weed and pest (Ong and Kho 2015) along with initial growth performance.

*Terai* region of West Bengal is a rich repository of diversified tree species. In the present day context of intensive afforestation/ reforestation or plantation programme, a number of tree species are planted either by the forest department or people on the basis of their growth potential and their utilization.

The present investigation was aimed to study the comparative growth performance, increment and survival percentage of four tree species viz., *Bischofia javanica*, *Elaeocarpus floribundus*, *Swietenia macrophylla* and *Cinnamomum zeylanicum* in silvicultural system. *Bischofia javanica* Blume (Bischofiaceae) is a straight and irregularly inter-locked grained, fairly coarse and even textured timber which is used for constructing bridges and house,

boats, and paper and pulp (Luna 1996). It is a very good fuel wood having high calorific value and seed yield a drying oil (21.4%) which is useful for surface coating of the products (CSIR 1990). *Elaeocarpus floribundus* L. (Elaeocarpaceae) is a potential minor fruit crops in north-eastern parts of India, widely grown in homestead gardens. Matured fruit pulp is pleasantly acidic and edible. It has excellent antibacterial activity against food-borne bacteria as fruit contains various bioactive compounds (Sircar and Mandal 2017). *Swietenia macrophylla* King (Meliaceae) is a commercially important timber prized for its beauty, durability and colour and also used for multifarious purposes such as furniture, boats, musical instruments etc. *Cinnamomum zeylanicum* Blume (Lauraceae) is an evergreen tree and has delicate fragrance and warm sweet taste bark, which is extensively used as a spice or condiments.

## MATERIALS AND METHODS

The study was conducted in the model farm of the Department of Forestry, Uttar Banga Krishi Viswavidyalaya during 2016-2019. The site is located at 26°23'40"N latitude and 89°23'12"E longitude. The humid subtropical climate was mostly dominated over the region and soil is alluvial sandy loam in nature. One year old nursery raised seedlings were planted under alley cropping system with grid of 5m x 5m for *B. javanica* and *E. floribundus*, whereas it was 6m x 5m spacing for *S. macrophylla* and *C. Zeylanicum*. The data on survival percentage, plant height and collar diameter were recorded for three years in the winter season when the active growing season was actually ended. The plant volume was calculated by using the formula  $V = \text{Height} * \text{Basal area} * 0.5$ , where 0.5 was the form factor irrespective of any species or taper as suggested by Butterfield and Espinoza (1995). The Current annual increment was also calculated by using the volume increment data to specify the suitability of species for the particular

region. The mean annual increment was also calculated as the ratio of the current annual increment with the year value. Distribution of the stems per collar diameter class was calculated for different species to determine the evenness in subsequent years.

## RESULTS AND DISCUSSIONS

The rate of survival is very essential for success or failure of any plantation activity. An appraisal of table 1 indicates that the survival rates varied over time among the species. All species showed full survival percentage in the initial period with proper management of water and optimum care. The species particularly *B. javanica*, *E. floribundus* and *S. macrophylla* exhibited 100% survival where as *C. zeylanicum* showed 21.88% mortality in second year. Similarly, *S. Macrophylla* showed highest (100%) survival rate in subsequent year followed by *B. javanica* (98%) and *E. floribundus* (90%), but *C. zeylanicum* was found the lowest survival (37.5%).

*zeylanicum* showed the increasing trend of mortality from the beginning of the experiment until the end of the monitoring period. This variation might be due to the suitability of the particular species to this site condition. This finding is similar with the findings obtained in earlier studies as 79.5 - 84% survival rate was recorded in *Swietenia mahagoni* in Amazon basin after 19 month of planting (Escalante et al. 2012). In a similar study, *B. javanica* showed low mortality (1.9 %) in response to the typhoon (cyclone) disturbance in Japan, which indicated the versatility and intense rooting system of the plant (Abe et al. 2020). *E. floribundus* had higher survival rate (90%) was recorded in transplantation of seedlings into fallows and partially established vegetation (Uhl 1987) and capable of effective restoration of degraded forest areas (Thong et al. 2020). Jayasinghe et al. 2018 also reported the similar findings as obtained in the present study on *C. zeylanicum*.

**Table 1:** Survival percentage of different species in field condition

Species	1 <sup>st</sup> year	2 <sup>nd</sup> year	3 <sup>rd</sup> year
<i>Bischofia javanica</i>	100%	100%,	98%
<i>Elaeocarpus floribundus</i>	100%	100%,	90%
<i>Swietenia macrophylla</i>	100%	100%,	100%
<i>Cinnamomum zeylanicum</i>	100%	78.125%	37.5%

The seedling height and collar diameter varied in subsequent years among the different species (Table 2). In first year, the collar diameter growth varied between 0-2 cm and *E. floribundus* had highest height growth (0.45 m) followed by *S. macrophylla* (0.39 m) and *B. javanica* (0.33 m) whereas, the lowest height growth was observed in *C. Zeylanicum* (0.25 m). In the second year, *B. javanica* obtained the highest growth in terms of collar diameter (6-8cm) and height ( $2.17 \pm 0.10$  m); *S. macrophylla* and *E. Floribundus* shifted to 4-6cm collar diameter class attaining the height growth of  $2.00 \pm 0.05$  m and  $1.84 \pm 0.16$  m respectively and *C. zeylanicum* exhibited 2-4cm collar diameter class and

height (0.73 m). In third year, *B. javanica* attained the highest collar diameter (10-12 cm) class and height (3.80 m). *S. Macrophylla*, *E. floribundus* and *C. Zeylanicum* obtained 6-8 cm collar diameter class but *C. zeylanicum* obtained the least growth in height (1.50 m).

The growth of collar diameter and height of *B. javanica* is similar to the result of Combalicer et al. 2005 obtained in watershed areas. It might be due to better water use efficiency of the plant. Shahapurmath et al. 2020 also reported similar height growth in *Moringa* and *Gliricidia*. Bahnasy and Ismail (2019) revealed that the growth physiology of *S. macrophylla* seedlings indicating more

responsive to the seedling height. Thong et al. (2020) reported about the better growth performance in terms of collar diameter and height of *E. floribundus* in the subtropical region as environmental variables had no impact on the regeneration and growth of

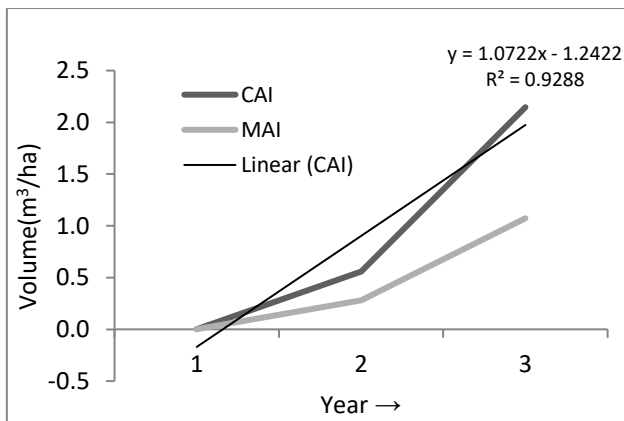
this particular species. The result on growth of collar diameter and height of *C. Zeylanicum* is in agreement with the findings of Goswami and Tewari (2011).

**Table 2:** Plant Growth in field condition

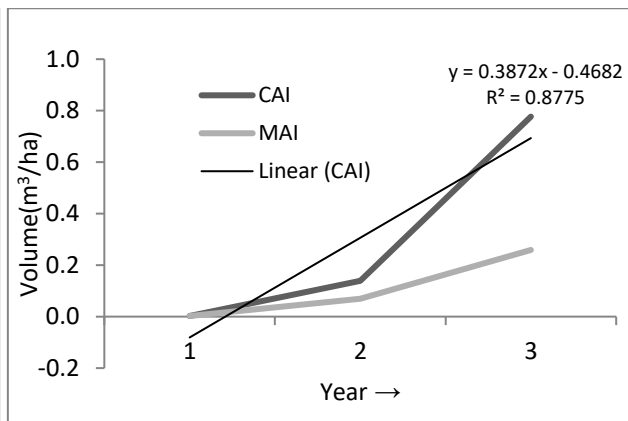
Year	Collar diameter (cm)	Height (m)			
		<i>Bischofia javanica</i>	<i>Elaeocarpus floribundus</i>	<i>Swietenia macrophylla</i>	<i>Cinnamomum zeylanicum</i>
1 <sup>st</sup>	0-2	0.33±0.01	0.45±0.03	0.39	0.25±0.02
2 <sup>nd</sup>	0-2	0.70±0.06	0.60±0.05	0.67±0.10	0.39±0.05
	2-4	1.01±0.14	1.18±0.07	1.55±0.06	0.73
	4-6	1.77±0.06	1.84±0.16	2.00±0.05	
	6-8	2.17±0.10			
3 <sup>rd</sup>	0-2			1.04±0.27	1.11
	2-4	1.42±0.24	1.42±0.09	1.71±0.25	1.15±0.14
	4-6	1.90±0.06	1.90±0.08	2.52±0.12	0.97±0.01
	6-8	2.62±0.10	2.13±0.11	3.50±0.13	1.50
	8-10	2.91±0.12			
	10-12	3.80			

The increment curve was plotted on the basis of periodic volume increment during the period of study. In initial year the highest volume increment was recorded in *E. floribundus* (0.003 m<sup>3</sup> ha<sup>-1</sup>) followed by *S. Macrophylla* (0.002 m<sup>3</sup> ha<sup>-1</sup>) and *B. Javanica* (0.001 m<sup>3</sup> ha<sup>-1</sup>); whereas, *C. Zeylanicum* had lowest (0.0003 m<sup>3</sup> ha<sup>-1</sup>) volume increment (Fig. 1 to 4). The highest volume increment was recorded in *B. javanica* (0.559 m<sup>3</sup> ha<sup>-1</sup> and 2.146 m<sup>3</sup> ha<sup>-1</sup>)

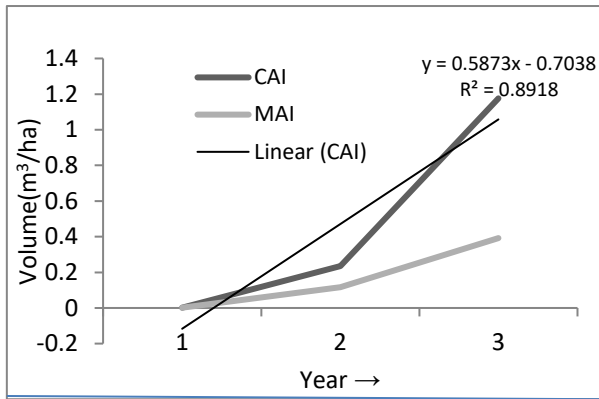
in 2<sup>nd</sup> and 3<sup>rd</sup> years respectively, followed by *S. Macrophylla* (0.234 m<sup>3</sup> ha<sup>-1</sup> and 1.176 m<sup>3</sup> ha<sup>-1</sup>) and *E. floribundus* (0.139 m<sup>3</sup> ha<sup>-1</sup> and 0.777 m<sup>3</sup> ha<sup>-1</sup>) while *C. Zeylanicum* exhibited lowest (0.006 m<sup>3</sup> ha<sup>-1</sup> and 0.262 m<sup>3</sup> ha<sup>-1</sup>) volume increment. The variation in volume and increment among the species might be due to the suitable site condition most importantly soil condition. These results are well in line with the findings of Aguilos et al. (2020).



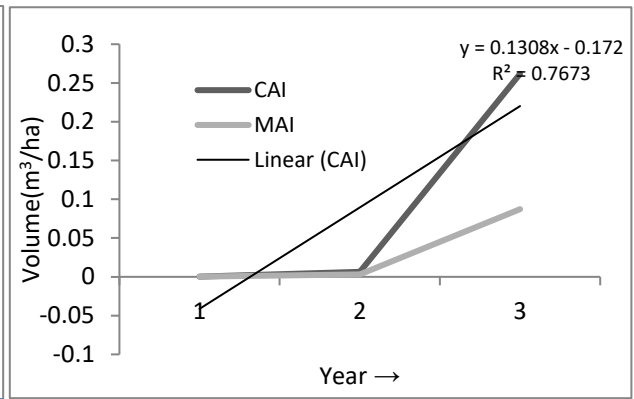
**Fig. 1.** Increment curve of *Bischofia Javanica*



**Fig. 2.** Increment curve of *Elaeocarpus floribundus*



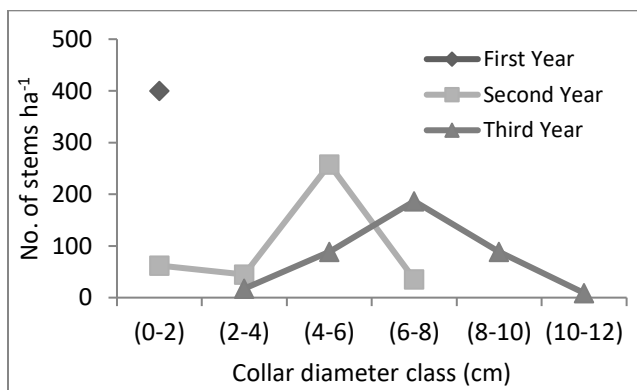
**Fig. 3.** Increment curve of *Swietenia macrophylla*



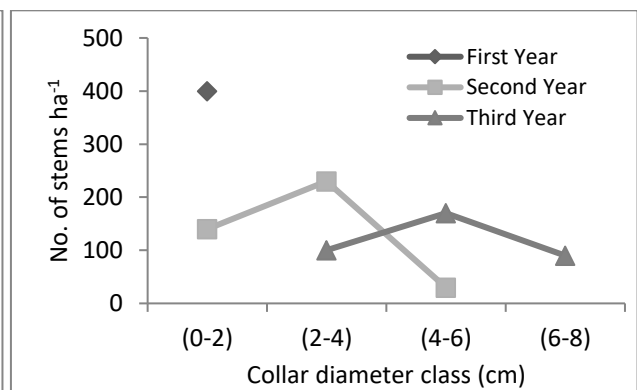
**Fig. 4.** Increment curve of *Cinnamomum zeylanicum*

Species distribution is an important parameter to know the evenness in growth pattern. In the initial year all the species represented 0-2 cm collar diameter class; however the representation of number of species varied with diameter class with advancement of age. *B. javanica* and *E. Floribundus* were represented each with 400 stems ha<sup>-1</sup>; whereas, *S. macrophylla* and *C. Zeylanicum* had 333.33 stems ha<sup>-1</sup> in first year. The net change in number of species in second year inventories showed the 0-2 cm diameter class losing trees and 2-4, 4-6 and 6-8 cm class gaining trees

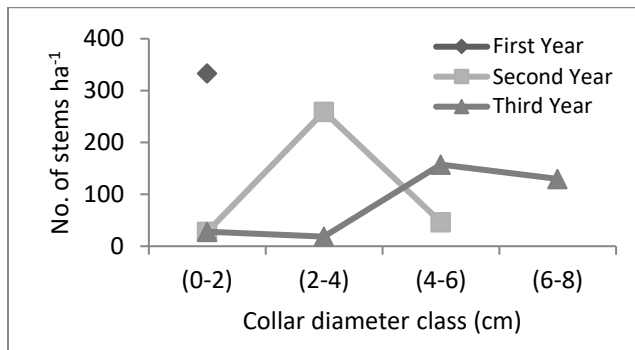
whereas in third year inventory the diameter class rise to 8-10 and 10-12 cm class in *B. javanica*. Dynamically, most of the trees in first year had grown enough to shift into next larger diameter class. Overall, there were fewer total numbers of trees and the average stand diameter was larger (Fig. 5). Similar trend was followed in *E. floribundus* and *S. macrophylla* as depicted in Fig. 6 and 7 respectively. But in case of *C. zeylanicum*, same pattern was followed with decreasing trend due to the high rate of mortality of trees with advancement of age (Fig. 8).



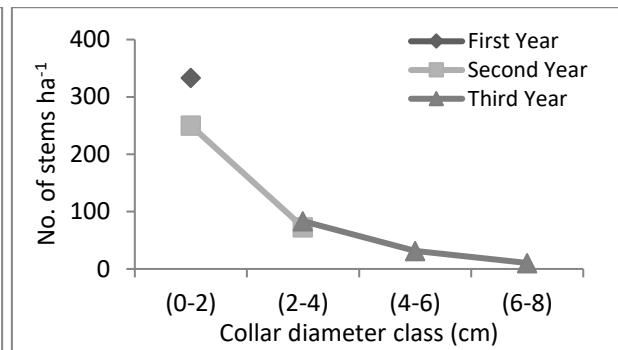
**Fig.5.** Distribution of *Bischofia javanica* with age gradation



**Fig.6.** Distribution of *Elaeocarpus floribundus* with age gradation



**Fig. 7.** Distribution of *Swietenia macrophylla* with age gradation



**Fig. 8.** Distribution of *Cinnamomum zeylanicum* with age gradation

All the species showed decreasing trend in representation of individuals along with shift of curve with more flatness in subsequent years. There were many factors such as soil and climate including fluctuating precipitation may change tree distributions and influence the plant uniformity in subsequent year (Yazaki et al. 2015).

## CONCLUSIONS

Among four species studied, *B. javanica* was the best performing species in all parameters including growth of collar diameter, height and volume increment. *S. macrophylla* 100% survival and most uniform growth and evenness. *E. floribundus* was an average performing species in all parameters, while *C. zeylanicum* was the less performing species.

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