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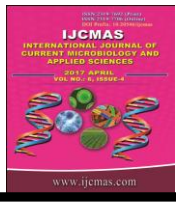

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Growth performance of Thorn less Bamboos *(Bambusa balcooa* Roxb. and *Bambusa vulgaris* Schrader ex J. C. Wendland)

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A B S T R A C T

Studies were undertaken to elicit information on performance of *Bambusa balcooa* and *Bambusa vulgaris* across five agro climatic regions as well as different age gradations, association among the biometric attributes. *Bambusa balcooa* proved its significant phenotypic superiority in terms of all the biometric attributes studied. The performance of *Bambusa balcooa* across the agro climatic regions *viz.*, North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone was also consistent and higher than the *Bambusa vulgaris* and *Bambusa bambos.*

Introduction

One of the most unique and versatile groups of plants known to mankind, the bamboos occupy a special place in the lives of the rural, especially in Asia. Often called the giant grass, the graceful weaving stalks give it, an enchanting appearance. Bamboo is known as 'poor man's timber', 'the cradle to coffin plant' and 'green gold'. More recently, bamboo has been called the "wonder plant" (INBAR, 2004), the "miracle grass" (ETI PROSEA, 2001) and the "raw materials of the 21st century". The plant shakes violently by the storm, bends but never breaks. Many bamboo species have high utilization value with more than 1500 documented uses. Bamboos play an important role in local economies and their commercial importance is growing at national and international level (Bystriakova *et al.*, 2004).

Bamboos are the most important items of forest produce used by the rural communities in Asia and the Pacific. Bamboos are woody perennial evergreen monocotyledonous having considerable economic, social and ecological importance. Woody bamboo belongs to the tribe Bambuseae that comprise 9 to 10 sub tribes, containing between 59 and 111 genera and at least 1447 species (Ohrnberger, 1999). The diversity observed within this group of plants is huge, ranging from very small members up to tall stately individuals measuring over 30 m tall. About 300 species are so far reported from China, 130 species from India, 55 species from the Philippines, 50 species from Thailand, 33 species from Bangladesh, 31 species from Indonesia, 26 species from Papua New Guinea and 12 species from Malaysia

(Sharma, 1987). The largest forest area under bamboos is in India with 9.57 million hectares of bamboo forests or 12.8 per cent of the total forest area. The major bamboos are *Dendrocalamus strictus* and *Bambusa bambos* with an overall annual production of 5 million tons. Above the productivity of bamboo is increased through tree outside forest as a source of paper industries, poles, handicrafts, cottage industries and etc., For that purposes, the productivity performance of different agroclimatic zone as well as age gradation of thorn less bamboos *viz.*, *Bambusa balcooa* and *Bambusa vulgaris* are evaluated and present hereunder.

Materials and Methods

The thorn less bamboos species *viz.*, *Bambusa balcooa* and *Bambusa vulgaris* grown in five agro climatic viz., Western Zone, Northern Zone, North Eastern Zone, Cauvery Delta Zone and Southern Zone were chosen as the experimental material for the present study. From the each agro climatic regions, one year, two year, three year, four year and five year old plantations of *Bambusa balcooa* and *Bambusa vulgaris* were selected. From each plantation, 25 clumps in three replications were selected for recording the biometric observations *viz.*, height, diameter, number of culms and internodal length. Similarly, *Bambusa bambos* was also deployed for recording the biometric observations across the age gradations as well as agro climatic regions. These observations were used to compare the performance of thorn less bamboos *viz.*, *Bambusa balcooa* and *Bambusa vulgaris* and assess its superiority over thorn bamboo.

Estimation of biometric attributes

The observations were recorded from the first year, second year, third year, fourth year and fifth year old *Bambusa vulgaris* and *Bambusa balcooa* plantations established in the five agro climatic regions of Tamil Nadu *viz.*, Western Zone, Northern Zone, North Eastern Zone, Cauvery Delta Zone and Southern Zone. The following biometric attributes were recorded as detailed below.

Height	**:**	The plant height was measured from ground level to the tip of the stem and expressed in meter.
Diameter	**:**	Diameter was measured at breast height at 1.37 m height from the base of the culm and expressed in cm.
Number of Culms	**:**	The number of culms was counted and expressed in number.
Internodal Length	**:**	The internodal length was measured in between two nodes of a culm and expressed in cm.

Statistical analysis

The data gathered from nursery and field experiments were analysed and tabulated. Estimates of mean, variance and standard error were worked out as per the procedure described by Panse and Sukhatme (1978).The significance test was carried out by referring to the standard 'F' table of Snedecor (1961).

Results and Discussion

The present investigation was carried out in five agro climatic regions of Tamil Nadu *viz*., North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone with two thorn less bamboo species *viz*., *Bambusa balcooa* and *Bambusa vulgaris* across different age gradations in order to elucidate the suitability of thorn less bamboos based on their growth performance. The

growth performance of *Bambusa bambos* was used for comparison. The results of statistically analyzed data are presented here under. The results of biometric attributes of *Bambusa balcooa* and *Bambusa vulgaris* over age gradations and in agro climatic regions are as follows.

Height

Significant variation in height at one percent level was observed among the thorn less bamboos *viz.*, *Bambusa balcooa* and *Bambusa vulgaris* across the age gradation as well as agro climatic regions. The highest grand general mean over five years was recorded by *Bambusa balcooa* (7.39 m). The percent increase in height of *Bambusa balcooa* over *Bambusa vulgaris* was (17.4 %). Whereas the per cent increase of height over *Bambusa bambos* was 30.6%. With respect agro climatic region wise performance, *Bambusa balcooa* exceled in height growth significantly and consistently over all the agro climatic regions in the order of Western Zone (8.10 m) followed by Northern Zone (7.51 m) and Southern Zone (7.40 m). However, *Bambusa vulgaris* registered only 6.84 m and 5.46 m and 4.46 m in Western Zone, Northern Zone and Southern Zone respectively (Table 1). Regarding age gradation wise height performance, *Bambusa balcooa* exhibited consistent and significant superiority over *Bambusa vulgaris* and *Bambusa bambos* at all the age gradations.

Diameter

This trait registered significant highest grand general mean of 5.42 cm in *Bambusa balcooa* over five years of growth period in five agro climatic regions. However, *Bambusa vulgaris* registered only 4.61 cm as grand general mean. The percentage increase in diameter over *Bambusa bambos* was 16.8 percentage and over *Bambusa vulgaris* was 8.10 percentage. The *Bambusa balcooa* recorded significant and constant higher diameter performance over *Bambusa vulgaris* in all the agro climatic regions. Among the five agro climatic regions, the significant maximum diameter growth was recorded in Southern Zone (5.72 cm) followed by Western Zone (4.82 cm) and Cauvery Delta Zone (4.74 cm).

The minimum diameter growth was observed in Northern Zone (3.38 cm) (Table 2). The diameter growth across the age gradations as well as among the thorn less bamboo species was significant at one per cent level. Across the age gradations, *Bambusa balcooa* registered its consistent superiority over *Bambusa vulgaris* as well as *Bambusa bambos.*

Numbers of culms

A significant variation in number of culms was observed at five per cent level among the thorn less bamboo species. The highest grand general mean of 19.44 culms was registered by *Bambusa balcooa* followed by *Bambusa vulgaris* (19.22). The *Bambusa bambos* recorded only 14.89 culms as its grand general mean.

The *Bambusa balcooa* exhibited 0.22 percentage increase in number of culms over *Bambusa vulgaris* across the age gradations as well as agro climatic regions. But the observed per cent increase in number of culms over *Bambusa bambos* was 4.55 percentage. With regard to performance in terms of number of culms under various agro climatic regions, *Bambusa balcooa* proved its superiority over *Bambusa vulgaris.* The maximum number of culms was recorded by *Bambusa balcooa* in Western Zone (20.16). Whereas, *Bambusa vulgaris* registered only 19.53 number of culms, this is 0.63 per cent increase of *Bambusa balcooa* over *Bambusa vulgaris* (Table 3).

Table.1 Variations in height (m) among the thornless bamboos across the age gradations and agro climatic regions

Age / Location	I Year			II Year			III Year			IV Year			V Year		
	B.balcooa	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*
Western zone	6.71**	5.86**	3.64*	7.58*	6.36*	3.96*	8.22*	6.84*	4.36*	8.78**	7.35	4.97*	9.21**	7.83*	5.86**
Northern zone	4.75	5.45*	3.27	5.72	6.59*	3.64	6.75	7.27**	4.59**	7.77	8.04	4.71	8.79	8.09	5.45
Northern eastern zone	6.53*	4.44	3.47	7.01	4.95	3.72	7.52	5.47	3.95	8.03	5.98	4.64	8.50	6.50	5.26
Southern zone	6.43*	3.46	3.46	6.97	3.94	3.66	7.49	4.46	3.94	8.00	4.98	4.59	8.11	5.48	5.36
Cauvery delta zone	5.09	5.47*	3.46	6.09	5.96	3.94*	6.89	6.46	3.96	7.70	6.98	4.95*	8.53	7.50	5.47
Mean	**5.90**	**4.94**	**3.46**	**6.67**	**5.56**	**3.78**	**7.73**	**6.10**	**4.16**	**8.06**	**6.67**	**4.77**	**8.63**	**7.08**	**5.48**
SEd	**0.3982**	**0.2317**	**0.0664**	**0.3390**	**0.3071**	**0.0892**	**0.2386**	**0.3268**	**0.0987**	**0.1404**	**0.3482**	**0.0809**	**0.0810**	**0.2772**	**0.1009**
CD (0.05)	**0.8442**	**0.4911**	**0.1407**	**0.7188**	**0.6511**	**0.1892**	**0.5058**	**0.6927**	**0.2092**	**0.2976**	**0.7381**	**0.1715**	**0.1717**	**0.5877**	**0.2139**
CD (0.01)	**1.1632**	**0.6767**	**0.1939**	**0.9903**	**0.8971**	**0.2607**	**0.6969**	**0.9544**	**0.2883**	**0.4100**	**1.0170**	**0.2363**	**0.2366**	**0.8098**	**0.2948**

Table.2 Variations in Diameter (cm) among the thornless bamboos across the age gradations and agro climatic regions

Age / Location	I Year			II Year			III Year			IV Year			V Year		
	B.balcooa	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*
Western zone	3.90**	3.15**	2.46**	4.35	4.05**	3.02	4.92	4.84**	3.98	6.52**	5.67	4.60	7.42	6.43	5.49
Northern Zone	4.21**	2.99**	1.51	5.09**	3.93**	2.61	5.47**	4.26	3.36	6.13	5.17	4.17	7.03	5.59	4.92
Northern eastern zone	3.17	1.90	2.13	3.78	2.52	3.50**	3.37	3.19	4.40**	5.05	3.83	4.93**	5.69	5.48	5.57
Southern zone	2.07	1.98	1.74	4.23	3.95**	2.85	6.23**	5.90**	3.79	8.42**	7.88**	4.82*	10.51**	8.91**	5.57
Cauvery delta zone	4.16**	3.47**	2.20*	4.48	4.15**	3.16	5.45**	4.75**	4.04	6.03	5.40	4.52	6.58	5.96	5.25
Mean	**3.50**	**2.70**	**2.01**	**4.46**	**3.72**	**3.03**	**5.29**	**4.59**	**3.91**	**6.43**	**5.59**	**4.61**	**7.45**	**6.47**	**5.36**
SEd	**0.0570**	**0.0501**	**0.0928**	**0.0408**	**0.0553**	**0.0820**	**0.0540**	**0.0553**	**0.1461**	**0.0318**	**0.1690**	**0.0786**	**0.0363**	**0.0629**	**0.1283**
CD (0.05)	**0.1209**	**0.1061**	**0.1967**	**0.0864**	**0.1173**	**0.1738**	**0.1145**	**0.1172**	**0.3098**	**0.0674**	**0.1333**	**0.1666**	**0.0769**	**0.3582**	**0.2721**
CD (0.01)	**0.1666**	**0.1462**	**0.2710**	**0.1191**	**0.1616**	**0.2395**	**0.1577**	**0.1615**	**0.4268**	**0.0928**	**0.1837**	**0.2295**	**0.1059**	**0.4936**	**0.3749**

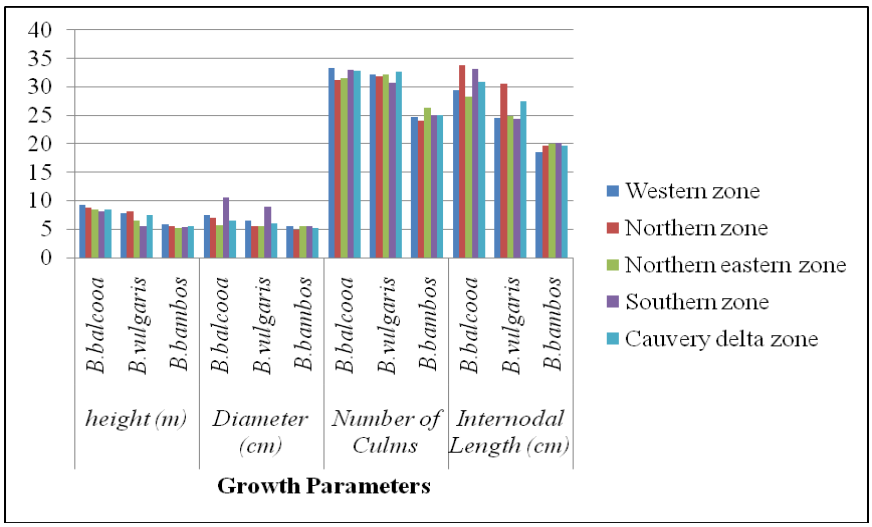
Table.3 Variations in Number of Culms among the bamboos across the age gradations and agro climatic regions

Age / Location	I Year			II Year			III Year			IV Year			V Year		
	B.balcooa	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*
Western zone	6.68	6.46	4.88	13.54**	13.13	9.47	20.25**	19.50	13.92	27.08**	26.36	19.72	33.27*	32.20	24.67
Northern Zone	5.93	6.22	5.27**	12.25	12.77	9.63	17.97	19.29	14.34	24.55	25.43	19.13	31.20	31.87	24.10
Northern eastern zone	6.37	6.53	5.29**	12.61	12.76	10.32**	18.99	19.37	15.58**	25.32	25.84	20.69**	31.52	32.25	26.30**
Southern zone	6.49	6.37	5.10	13.25	12.36	10.31**	19.55	18.53	15.15**	26.44	24.75	20.12	33.00	30.75	25.06
Cauvery delta zone	6.81*	6.62	4.49	13.37*	13.21	9.57	19.95**	19.57	14.51	26.85*	25.76	19.68	32.88**	32.65	25.04
Mean	**6.46**	**6.44**	**5.01**	**13**	**12.85**	**9.86**	**19.34**	**19.25**	**14.70**	**26.05**	**25.63**	**19.87**	**32.37**	**31.94**	**25.03**
SEd	**0.1490**	**0.0994**	**0.0611**	**0.1505**	**0.2345**	**0.1014**	**0.1705**	**0.2740**	**0.0581**	**0.3458**	**0.3290**	**0.1405**	**0.3785**	**0.4926**	**0.1221**
CD (0.05)	**0.3159**	**0.2292**	**0.1296**	**0.3191**	**0.4971**	**0.2150**	**0.3615**	**0.6319**	**0.1233**	**0.7330**	**0.7586**	**0.2978**	**0.8023**	**1.1360**	**0.2588**
CD (0.01)	**0.4353**	**0.3335**	**0.1786**	**0.4397**	**0.6849**	**0.2962**	**0.4981**	**0.9195**	**0.1698**	**1.0099**	**1.1038**	**0.4104**	**1.1055**	**1.6530**	**0.3566**

Table.4 Variations in Internodal Length (cm) among the bamboos across the age gradations and agro climatic regions

Age / Location	I Year			II Year			III Year			IV Year			V Year		
	B.balcooa	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*	*B.balcooa*	*B.vulgaris*	*B.bambos*
Western zone	28.22	22.77	17.30	28.56	23.67	17.68	29.06	23.87	17.88	29.24	24.29	18.32	29.43	24.54	18.57
Northern Zone	33.06**	26.88**	18.75	33.25**	28.21**	18.98	33.42**	29.32**	19.15	33.67**	29.99**	19.53	33.75**	30.62**	19.64
Northern eastern zone	27.86	24.07	19.17*	27.96	24.22	19.39*	28.00	24.44	19.60**	28.17	24.62	19.69*	28.35	24.84	19.98*
Southern zone	32.79**	23.50	19.14	32.90**	23.62	19.40*	33.01**	23.82	19.82**	33.19**	24.20	19.91**	33.25**	24.46	20.12**
Cauvery delta zone	30.41	26.92**	18.92	30.56	27.07**	19.28	30.62	27.15**	19.35	30.68	27.27**	19.56	30.89	27.43**	19.73
Mean	**30.47**	**24.83**	**18.66**	**30.65**	**25.36**	**18.94**	**30.82**	**25.72**	**19.16**	**30.99**	**26.07**	**19.40**	**31.13**	**26.38**	**19.61**
SEd	**0.2832**	**0.1710**	**0.2323**	**0.2041**	**0.3055**	**0.1950**	**0.1250**	**0.2707**	**0.1244**	**0.1245**	**0.2718**	**0.1173**	**0.2215**	**0.2849**	**0.1327**
CD (0.05)	**0.6004**	**0.3626**	**0.4925**	**0.4327**	**0.6476**	**0.4134**	**0.2650**	**0.5738**	**0.2637**	**0.2640**	**0.5761**	**0.2486**	**0.4695**	**0.6039**	**0.2813**
CD (0.01)	**0.8273**	**0.4996**	**0.6785**	**0.5963**	**0.8923**	**0.5696**	**0.3651**	**0.7906**	**0.3633**	**0.3638**	**0.7938**	**0.3425**	**0.6469**	**0.8321**	**0.3875**

Figure.1 Overall growth performance of thorn less bamboos at five year old among the different agro climatic regions



Bambusa balcooa exhibited its superiority over *Bambusa vulgaris* by producing maximum number of culms in first year (6.46), second year (13.00), third year (19.34), fourth year (26.05) and fifth year (32.37). However, in all these age gradations *Bambusa bambos* registered only minimum number of culms in the order of 5.01, 9.86, 14.70, 19.87 and 25.03 in first year, second year, third year, fourth year and fifth year respectively (Table 3).

Internodal length

Significant difference in internodal length at one percent level was witnessed among the thorn less bamboos *viz,*. *Bambusa balcooa* and *Bambusa vulgaris* across the age gradation as well as agro climatic regions. The highest grand general mean over five years was recorded by *Bambusa balcooa* (30.81 cm). The percent increase in internodal length of *Bambusa balcooa* over *Bambusa vulgaris* was (5.14 %). Whereas the per cent increase of internodal length over *Bambusa bambos* was 11.66 percentage. With respect agro climatic region wise performance, *Bambusa balcooa* shined in internodal length significantly and consistently over all the agro climatic regions in the order of North Eastern Zone (33.43 cm) followed by Southern Zone (33.02 cm) and Cauvery Delta Zone (30.63 cm). However, *Bambusa vulgaris* registered only 29.00 cm and 23.92 cm and 27.10 cm in North Eastern Zone, Southern Zone, and Cauvery Delta Zone respectively (Table 4). Regarding age gradation wise internodal length performance, *Bambusa balcooa* exhibited consistent and significant superiority over *Bambusa vulgaris* and *Bambusa bambos* at all the age gradations.

Genetic improvement of the thorn less bamboos *viz.*, *Bambusa balcooa* and *Bambusa vulgaris* through evaluation trial under various agro climatic regions can play a very significant role in improving productivity, yields, quality of produce and profitability. Hence genetic evaluation trials were conducted at various agro climatic regions and significant differences were found across the age gradations *viz.*, 1st year, 2nd year, 3rd year, 4th year and 5th year as well as among different agro climatic regions for the biometric attributes such as height, diameter, number of culms, internodal length, leaf

length and leaf width. The present study indicated that it could be possible to select potential species with greater genetic gain for commercially important traits. The largest, cheapest and fastest gains in most of the forestry tree improvement programmes will accrue if use of suitable species is assured (Zobel and Talbert, 1984).

Among the *Bambusa balcooa* and *Bambusa vulgaris*, the superiority of *Bambusa balcooa* was evidenced consistently in all the age gradations as well as across the agro climatic zones of Tamil Nadu. A superfluity of workers reported the existence of significant differences and superiority of few species, seed sources, progenies and provenances in various tree species like *Acacia nilotica* (Padmini and Banerjee, 1986). *Eucalyptus tereticornis* (Otegbeye, 1990), *Santalum album* (Bagchi and Sindhu Veerendra, 1991), *Tecomella undulate* (Jindal *et al.,* 1991), *Terminalia arjuna* (Srivastava *et al.,* 1993) *Lagerstroemia spp*. (Jamaludheen *et al.,* 1995), *Dalbergia sissoo* (Rawat and Nautiyal, 2007), *Pinus elliottii var. elliottii* (Vergara *et al.,* 2011), *Melia dubia* (Saravanan, 2012) *Madhuca latifolia* (Umesh Kanna *et al.,* 2013), acacia nilotica (jeya prakash, 2000), *Tectona grandis* (Parthiban, 2001) *Casuarina equisetifolia* (Paramathma *et al.,* 1994) bamboo species (Thiruniraiselvan, 2012), *Aibizia lebbeck* (Radhakrishnan, 2001), *Ceiba pentandra* (Rajendran, 2001) and Eucalyptus (Jude, 2005) which thus lend support to the current findings in *Bambusa balcooa* and *Bambusa vulgaris* (Figure 1).

Hence, trees growth performance could be a good indicator for the selection of best species in the evaluation programme. The present study revealed that thorn less bamboo, *Bambusa balcooa* would be recommended for the large scale plantation and further improvement due to their early superiority compared to *Bambusa vulgaris* and *Bambusa bambos*.

In conclusion investigations were carried out in *Bambusa balcooa*, *Bambusa vulgaris* and *Bambusa bambos* to access its performance across various agro climatic regions *viz*., North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone as well as various age gradations. Taking a holistic view of the biometric attributes, *Bambusa balcooa* proved significantly superior at one per cent level for all the traits *viz.*, height, diameter, number of culms, internodal length, leaf length and leaf width over *Bambusa vulgaris* and *Bambusa bambos*. The performance of *Bambusa balcooa* across the agro climatic regions *viz.*, North Eastern Zone, Northern Zone, Western Zone, Cauvery Delta Zone and Southern Zone was consistent and higher than the *Bambusa vulgaris* and *Bambusa bambos.*

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