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Strengthening and enriching the institute bambusetum

(Final Report of the project No. KFRI /502/2006)

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Abstract of Project Proposal

1. Title of the Project	:	**Strengthening and enriching the Institute Bambusetum.**
2. Code No.	:	KFRI - 502/2006
3. Principal Investigator	:	Dr. R. C. Pandalai Silviculturist Silviculture Division, KFRI
	:	Mr. K. K. Unni (Superannuated on 31/12/2011) Officer in Charge Field Research Center, Velupadam
4. Objectives	:	1. To protect the Bamboo clumps growing in areas with poor soil depth inside the Bambusetum 2. To carry out landscaping in essential areas of the Bambusetum to make it more attractive.
5. Duration & date of Commencement	:	April, 2006 to March, 2012
6. Sponsoring agency	:	KFRI Plan Grants
7. Budget	:	**Rs. 2,59,069/-**

Summary

The Sympodial Bambusetum established at Velupadam extends over an area of 12 ha, in the campus of Field Research Center (FRC) of Kerala Forest Research Institute (KFRI). The Bambusetum is situated in an undulated terrain with gentle slopes with lateritic soil having a sandy loam texture. The temperature in the area varies between 28 to 40 degree Celsius and the average rain fall is approximately 3000 mm per year. The total number of Bamboos so far established in the Bambusetum is sixty six, belonging to 15 genera.

The Barbed wire and chain link fencing provided along the boundary of the Bambusetum ensured maximum protection and clump survival in the experimental plots. A portion of the Bambusetum developed with a live hedge fencing using a shrubby species of *Bambusa striata* proved to be very successful, aesthetically appealing and is implementable in other places also. Soil mounding boosted bamboo growth and culm productivity increased multi-fold. The method can be suggested when ever bamboo plantations are to be established in areas with compacted soil. The boundary lines and the inspection pathways were being cleared periodically so as to enhance the aesthetic beauty of the Bambusetum. This not only helped free movement of the visitors inside the Bambusetum but also served as fire lines during the summer months and protected the clumps from summer fires.

In order to stabilize some of the steep slopes and to check the soil erosion, rampant in many areas of Bambusetum, staggered trenches were provided in between the bamboo clumps. The soil beneath the clumps growing in sloppy areas were leveled and made into inwardly slopping platforms which helped to stabilize the soil/clump and also to conserve the moisture along the lateritic tract of Bambusetum. This also proved to be an ideal soil management practice that can be followed in similar terrains/areas.

I. Introduction

The clump forming bamboos-otherwise known as sympodial bamboos grow well in the plains. Many of the sympodial bamboos grow profusely in the tropical humid climates of Kerala and the culm productivity is very high with low pest/disease incidence. Many of the species that grow in the North eastern states of India can be economically grown in Kerala also and harvesting can be initiated from the clumps from the seventh year of establishment. The prime objective of the KFRI Bambusetum is to drive in this message to the officials, researchers, visitors/farmers and entrepreneurs.

Though there are 136 species of Bamboo coming under 29 genera spread over India, Keralas share is only 22 species, two varieties, under 6 genera. KFRI initiated the establishment of a Sympodial Bambusetum in the campus of the Field Research Center at Velupadam in the year 1998. As and when new species were collected/ available they were be maintained in the FRC nursery, multiplied and planted in the Bambusetum during the monsoon season.

The present project mainly envisages to improve the aesthetic beauty and to add on new species in the already established Bambusetum. The Bambusetum at FRC, Velupadam is located in a denuded area with scanty growth of miscellaneous tree species and weeds. The terrain is undulated to mildly slopping, with the top soil gradually getting washed off. It was hence imperative that unless strengthening measures were taken, the Bambusetum will loss the aesthetic appeal. Moreover it was becoming difficult to gather scientific data from many of the experimental plots in the Bambusetum. Hence the project was implemented with the following specific objectives.

1. To protect the Bamboo clumps growing in areas with poor soil depth inside the Bambusetum
2. To carry out landscaping in essential areas of the Bambusetum to make it more attractive.

II. Materials and methods

The Location:

The 12 ha plot of the KFRI Bambusetum is located in the Field Research Center (FRC) campus at Velupadam, in Palapally Range of Chalakudy Forest Division. The FRC was established in the year 1993, though the Bambusetum came into existence only after five years in 1998. The total area of FRC is 47.43 ha and the Bambusetum is12 ha and is situated at 10' 22" East longitude and 76' 37" North latitude, by the side of the Amballore Chimmony main road. The altitude of the area is about 40 masl.

Methods:

As a reconnaissance, the areas which required immediate attention and silvicultural interventions were marked in a map. The survey sketch of the area was also made use of for assessing the sloppiness and to design specific soil treatments suitable for the area. The area, being located in an old and failed teak plantation, in addition to the coppice growth of teak a few miscellaneous tree species were also growing profusely along with other shrubby weed species. Weeding operations were taken up first and both clear knife and scrape weeding were carried out with the help of manual laborers. In areas with teak coppice growth and stumps of miscellaneous tree species, the stumps were completely uprooted from the ground to prevent further coppicing.

Fencing was taken up either by using barbed wires or chain links. As the chain link fencing was expensive it was done only in remote areas where watch and ward was difficult with poor accessibility, very less.

As the Bambusetum was intended to be maintained as a demonstration plot, proper aligning of the planting line was also done. Stakes made of bamboo splits were used to determine the exact planting position in each of the experimental plots.

Soil working was kept to the minimum as the area was already slopping and soil erosion was rampant in the site. The pathways were traced for the visitors to move around and to have closer view at each of the species and their growth pattern. All the fallen and dead culms were removed from each of the established clumps. In order to demonstrate the typical horse shoe pattern of working in bamboo clumps and to explain its advantages, a clump of *Bambusa bambos* is separately maintained

at the entrance of the Bambusetum. Name boards were placed in each of the plots with botanical name of the species after confirming their identity.

A cluster analysis was done to group similar species, based on the growth variables *viz*., increment in number of culms produced, height, girth and internodal length, so that the species within a cluster have a high degree of 'natural association' among themselves, while the clusters are 'relatively distinct' from one another. Clustering was done using average linkage between groups algorithm. This corresponds to the group average method reported by Everitt (1974). The distance measure used was squared Euclidean distance. The increment in growth parameters was worked out as the difference between the two periods such as 2006 and 2011 for each growth parameter. The analysis was conducted using SPSS software package.

III. Results

Demarcation and fencing

Though the boundaries of the Field Research Centre at KFRI, Velupadam was clearly demarcated way back in 1993, when it was established, a clear cut plot boundary exclusively for the Bambusetum, was essential so that the area can be set aside for planting only Bamboo species in future. In order to accomplish this, the 12 ha area of the Bambusetum was oriented and located towards one side of the campus and the demarcation was carried out using bamboo stakes. All the future plantings were carried out as per the design originally prepared by the Department of Silviculture in consultation with the Forest Management Information System, KFRI. The fencing with barbed wire and chain links ensured better survival and growth of the planted bamboos in each of the plots. (Fig.1) Chain link fencing though costly, prevented the entry of porcupines to the experimental plots especially during the culm emergence season and that was an added advantage. Live fencing (Fig.2) with *Bambusa striata* proved to be another cheap means of protecting the plots with the additional benefit of imparting more aesthetic beauty to the Bambusetum. (Fig.2).

Being a demonstration plot/garden the clumps/species were widely spaced irrespective of the structure of the clumps and the culm size. The spacing provided in the Bambusetum was 10 m X 10 m between clumps and adjacent lines. The wide spacing proved to be ideal for the clumps to establish, develop and produce more number of healthy culms. All the clumps were planted in pits of 45 X 45 X 45 cm and this ensured maximum survival and culm production probably due to uninterrupted rhizome proliferation and this was true for all the species and all the plots.

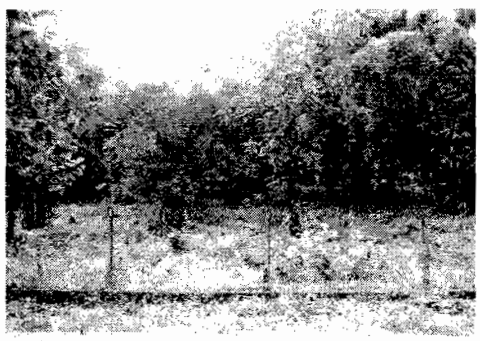

Fig.1: The fenced plots ensured aesthetic beauty and better clump survival.

Fig.2: Live fencing using *Bambusa striata*

Weeding/ uprooting of coppice stumps of teak/ miscellaneous species

The complete uprooting and removal of all visible remnants of teak coppice growth and stumps of a number of miscellaneous tree species like *Albizia odoratissima, Alstonia scholaris, Bridelia retusa, Cassia fistula, Dalbergia latifolia, Grewia tiliifolia, Macaranga peltata, Pterocarpus marsupium, Schleichera oleosa, Terminalia paniculata,* improved the aesthetic appearance besides enhancing the growth of the planted bamboo clumps in the Bambusetum.

In addition to the miscellaneous tree species, common herbaceous weeds like *Lantana camara, Chromolaena odorata, Helicteres isora and Glycosmis pentaphylla* growing in the area were weeded out periodically. (Fig.3, 4) Bamboos, in general during the initial stages of establishment, do not tolerate competition from weeds and over head shade. Hence all the less valuable species were completely removed from the plot and the enhanced growth was evident in the plots. These operations also helped in bringing down the recurring weeding expenditure common in any plantations/gardens.

Fig. 3& 4: Plots with and without weeding operations. Note the clean plot where weeding was done along with uprooting of the coppice stumps

Leveling, landscaping and labeling

Though majority of the weeding, uprooting and allied soil working was done by manual laborers, leveling and trenching was done by the help of earth moving equipments like JCB. Square platforms of 3 to 4 m were made at the basal portion of each of the clumps growing in sloppy areas with very shallow soil depth. The platforms were made in such a way that they were inwardly slopping with maximum

soil on the filled up portion. This also helped in anchoring the clump firmly to the soil and capturing the available moisture. This helped in maximum clump survival and progressive production of new culms in every year in a uniform pattern. This method also helped in reducing the toppling of the clumps during heavy winds especially in areas with poor soil depth (Fig.5).

The manual job of soil working, leveling and landscaping was time consuming and labor intensive. It is hence desirable to use machines like JCB whenever possible in Bamboo plantations whenever such works are to be taken up. Usually as the spacing provided in any Bamboo plantation will be wide, it may not be a problem to maneuver the machinery between the clumps. In the long run it will prove to be economical and time saving.

The new boards, after confirming identity of each of the species in the plot, made it easier for the visitors to understand and study the clump characteristics and the growth pattern of the species.

Fig. 5: Level platforms with bamboo safeguards helps in moisture retention and to prevent toppling of the clumps during heavy winds especially in areas with poor soil depth.

Pathway clearance and fixing plot boundaries

A minimum of half a meter to one meter pathways were provided all along the boundary of each plots thus demarcating the plots, so that visitors could go round and study the culm formation and developmental stages in different species of Bamboos growing in the Bambusetum (Fig.6). The pathway also permitted easy accessibility to each of the plots especially for data collection and growth

assessments. As the pathways were cleared periodically, they also served as fire lines and prevented the summer fires in the experimental plots.

Fig. 6: The main pathway all along the center of the Bambusetum for easy entry and exit from/ to experimental plots on either side.

Soil mounding and trenching

For fear of soil erosion, especially along the sloppy terrain, soil working and mounting was carried out only to the barest minimum and wherever it was absolutely necessary. The soil from the uphill side of the plots was used for filling and mounting the soil beneath the clumps (Fig.7). The trenching work also helped in conserving the available moisture (Fig.8). Both these interventions were carried out only in areas which had clumps precariously positioned in slopes.

Fig. 7: The soil mounts beneath the Clump.

Fig. 8: The trenches helped in moisture conservation

Ferro-Cement slabs for accelerating rooting and sprouting

Vegetative propagation in species like *Thyrsostachys oliveri and Dendrocalmus giganteus* are problematic as the cuttings fail to produce neither sprouts nor roots in the nursery. In such cases use of Ferro cement slabs (Fig.9) in the nursery helped to solve the problem to a limited extent. The ferro cement slabs were used as removable nursery beds (Fig.10.) in which specially prepared potting mixture containing finely cleaned soil, and sand in the ratio 3:1 was used for filling. Then the top portion of the bed was filled with a mixture of sand and compost in the ratio 2:1. The planting stock will be ready in about 6 to 9 months (Fig.11) and extraction of the planting stock will also be very easy as any side of the nursery bed can be easily dismantled (Fig.12) without causing damage to the rhizome system. *Thrysostachys oliveri* rhizomes gave a survival rate of 40% in the nursery and 70% in the field.

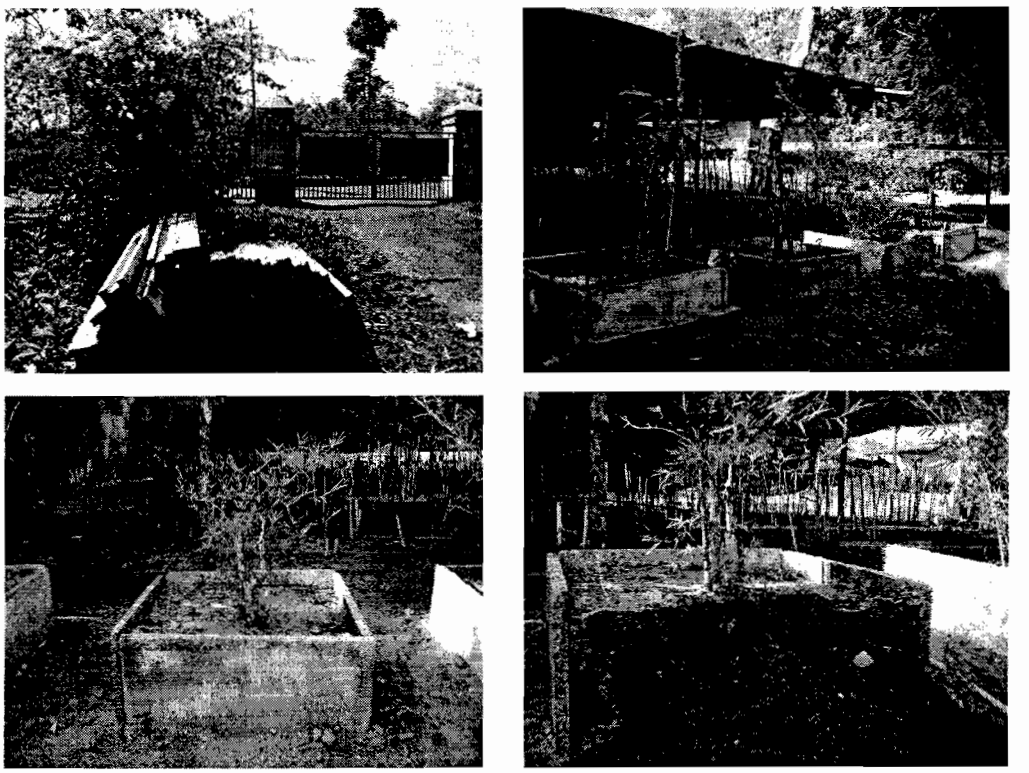

Fig. 9-12: The Ferro cement slabs as a portable partition material for making specialized nursery beds for rhizome proliferation in *Thyrsostachys oliveri*. Note the slabs arranged as cubicles, and the plank at one side removed for easy extraction of the proliferated rhizome without root injury.

Overall growth performance

The growth data on nine species established during the reporting period of six years is presented. The growth attributes include mean number of culms produced per clump, mean culm height, mean culm girth and mean internodal length.

Culms per clump

Culm productivity in new bamboo species planted and established during the project period is given in Table 1. Maximum number of culms was produced in clumps of *Phyllostachys sulphurea* (Mean number of 50 culms per clump) and *Melocanna baccifera* (49) followed by *Ochlandra talbotii* (36) and *Ochlandra wightii* (30).The rate of culm production was comparatively lower in the remaining species under study. Viz: *Bambusa albociliata* and *Gigantochloa nigrociliata* (16), *Oxytenenthera albociliata* (15) *O.abyssinica* (14) and *Teinostachyum attenuatum* (12 culms per clump).The first set of species probably responded well to the silvicultural interventions whereas the rest of the lot were slow responders as far as culm productivity was concerned.

Sl. No.	Species Name	Year of Planting	Source	Average of Culms/ clump	
				2006	2011
1	*Ochlandra talbotii*	2001	Virajpet (Karnataka)	30	66
2	*Ochlandra wightii*	2001	Agasthyamala (Kerala)	12	42
3	*Phyllostachys sulphurea*	2002	Wayanad (Kerala)	1	51
4	*Bambusa albociliata*	2002	Chessa (Arunachal Pradesh)	24	40
5	*Oxytenanthera albociliata*	2002	Chessa (Arunachal Pradesh)	4	19
6	*Oxytenanthera abyssinica*	2002	Chessa (Arunachal Pradesh)	4	18
7	*Teinostachyum attenuatum*	2002	Chessa (Arunachal Pradesh)	22	34
8	*Gigantochloa nigrociliata*	2004	Trivandrum (Kerala)	3	19
9	*Melocanna baccifera*	2004	Tripura	18	67

Table.1. Culm productivity in nine Bamboo species established during the project period (2006 to 2011).

Mean Culm height. The culm height in the above species followed a different trend and was not commensurate with the culm productivity (Table 2). The mean culm height was maximum in *Melocanna baccifera* (5m) followed by *Bambusa albociliata* (4.7m) *Gigantochloa nigrociliata*, and *Oxytenanthera albociliata* (4.5m) and *O.abyssinica* (4.09m).The height growth rate was lesser in *Ochlandra wightii* (2.9m) followed by *O.talbotii* (2.2m) *Teinostachyum attenuatum* (1.3m) and *Phyllostachys sulphurea* (1.2m) (Table 2).

Sl. No.	Species Name	Year of Planting	Source	Average Culm Height (m)	
				2006	2011
1	*Ochlandra wightii*	2001	Agasthyamala (Kerala)	2.6	5.5
2	*Ochlandra talbotii*	2001	Virajpet (Karnataka)	5.0	7.2
3	*Bambusa albociliata*	2002	Chessa (Arunachal Pradesh)	6.8	11.5
4	*Oxytenanthera albociliata*	2002	Chessa (Arunachal Pradesh)	6.03	10.5
5	*Oxytenanthera abyssinica*	2002	Chessa (Arunachal Pradesh)	6.01	10.1
6	*Teinostachyum attenuatum*	2002	Chessa (Arunachal Pradesh)	2.3	3.6
7	*Phyllostachys sulphurea*	2002	Wayanad (Kerala)	2.0	3.2
8	*Melocanna baccifera*	2004	Tripura	4.7	9.7
9	*Gigantochloa nigrociliata*	2004	Trivandrum (Kerala)	3.2	7.7

Table.2. Mean maximum culm length in nine Bamboo species established during the project period (2006 to 2011).

Mean culm girth. The culm girth was measured from the middle portion of the 5th internodal region of all these sympodial bamboos. This is because this height roughly corresponds to the standard breast height (girth at 1.37 m above ground) of other forest trees. *Melocanna baccifera* attained maximum culm girth of 32.5cm during the study period (Table 3). This was followed by *Oxytenanthera abyssinica* (13cm) *Bambusa albociliata* (5.4cm) and *Oxytenanthera albociliata* (4.3cm).The slow

responders included *Ochlandra wightii* (1.7cm) and *Gigantochloa nigrociliata* (1.5cm). Only very meager girth increment was noted in species like *Ochlandandra talbotti* (0.8cm) *Teinostachyum attenuatum* (0.4cm). Incidentally the culm girth remained unchanged at 3 cm throughout the study period in *Phyllostachys sulphurea* -the species that produced maximum number of culms per clump during the same period (Table 3).

Sl. No.	Species Name	Year of Planting	Source	Average Culm Girth(cm)	
				2006	2011
1	*Ochlandra wightii*	2001	Agasthyamala (Kerala)	3.9	5.6
2	*Ochlandra talbotii*	2001	Virajpet (Karnataka)	4.9	5.7
3	*Oxytenanthera abyssinica*	2002	Chessa (Arunachal Pradesh)	12.1	25.1
4	*Bambusa albociliata*	2002	Chessa (Arunachal Pradesh)	10.3	15.7
5	*Oxytenanthera albociliata*	2002	Chessa (Arunachal Pradesh)	10.6	14.9
6	*Teinostachyum attenuatum*	2002	Chessa (Arunachal Pradesh)	3.6	4.0
7	*Phyllostachys sulphurea*	2002	Wayanad (Kerala)	3.0	3.0
8	*Gigantochloa nigrociliata*	2004	Trivandrum (Kerala)	8.5	10.0
9	*Melocanna baccifera*	2004	Tripura	8.1	40.6

Table.3. Mean maximum culm girth in nine Bamboo species established during the project period (2006 to 2011).

Mean internodal length.

The internodal length had no direct correlation with the height of the culm as is evident from the present study. The species that attained maximum intermodal growth during the study period was *Oxytenanthera abyscinia* (18.6 cm) followed by *Ochlandra wightii* (18.4cm), *Phyllostachys sulphurea* (14cm) and *Melocanna baccifera* (10cm). In spite of the good increment in inter nodal length; the above species were ranked only 5th, 6th and 9th position in their height increment (Table 2). The performance of *Melocanna baccifera* was exceptional as the species had attained maximum culm height (5m) and had comparatively good internodal length increment

of 10cm during the study period thus showing a mild positive correlation in both these parameters (Table 4).

Species like *Ochlandra talbotti* (8.2cm) *Bambusa albociliata* (8.03 cm) and *Oxytenanthera albociliata* (6.1cm) recorded mean internodal length in the above sequence and could be classified as medium responders to the silvicultural interventions. Only minimal intermodal length increment was observed in *Tenostachyum attinuatum* (1.9cm) and a very meager 0.6 cm by *Gigantochloa nigrociliata* during te studhy period.

Sl. No.	Species Name	Year of Planting	Source	Average Internodal Length (cm)	
				2006	2011
1	*Ochlandra wightii*	2001	Agasthyamala (Kerala)	41.6	60.0
2	*Ochlandra talbotii*	2001	Virajpet (Karnataka)	35.3	43.5
3	*Oxytenanthera abyssinica*	2002	Chessa (Arunachal Pradesh)	11.6	30.2
4	*Phyllostachys sulphurea*	2002	Wayanad (Kerala)	5.0	19.0
5	*Bambusa albociliata*	2002	Chessa (Arunachal Pradesh)	32.33	24.3
6	*Oxytenanthera albociliata*	2002	Chessa (Arunachal Pradesh)	25.4	31.2
7	*Teinostachyum attenuatum*	2002	Chessa (Arunachal Pradesh)	32.2	34.1
8	*Gigantochloa nigrociliata*	2004	Trivandrum (Kerala)	24.5	23.9
9	*Melocanna baccifera*	2004	Tripura	18.6	28.6

Table.4. Mean internodal length in nine Bamboo species established during the project period (2006 to 2011).

Overall growth assessment

When the growth data of all the nine species under study was subjected to an overall assessment, it is seen that the performance of *Melocanna baccifera* with respect to culm production, mean culm height, mean culm girth and mean inter nodal length was the best and the species responded very well to the silvicultural interventions mentioned earlier in the chapter. Two species that comes second in the list are

Bambusa albociliata and *Oxytenanthera abyssinia*. Species that responded least to the interventions were *Gigantochloa nigrociliata* and *Teinostachyum attenuatum*.

Cluster analysis showed five distinct clusters among the species as seen in Figure 13 and it shows the distance thresholds at which the different clusters are formed. If a fairly homogeneous group of species is required, only those species linked at a low threshold distance should be included.

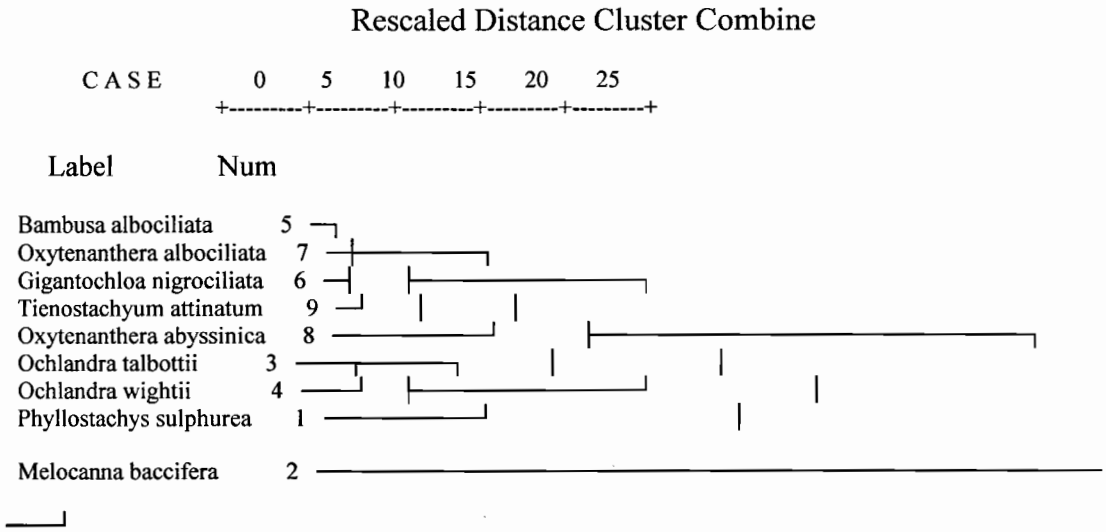

Figure.13. Dendrogram showing the resemblance structure among the species

Cluster number	**Species within cluster**	**Average increment in number of culms**	**Average increment in height of culms**	**Average increment in girth of culms**	**Average increment in intermodal length**
1	*Bambusa albociliata*	5	2	3	6
	Oxytenanthera albociliata	7	4	4	7
	Gigantochloa nigrociliata,	6	3	5	9
	Teinostachyum attenuatum	9	8	8	8
2	*Oxytenanthera abyssinica*	8	5	2	1
3	*Ochlandra talbottii,*	3	7	7	5
	Ochlandra wightii,	4	6	6	1
4	*Phyllostachys sulphurea*	1	9	9	3
5	*Melocanna baccifera*	2	1	1	4

Table.5. Comparison of clusters and average increment in each growth parameter corresponding to each cluster

The composition of clusters is shown in Table 5 along with average increment in each growth parameter. Cluster 1 comprised species of *Bambusa albociliata,, Oxytenanthera albociliata, Gigantochloa nigrociliata* and *Teinostachyum attenuatm.* Cluster 2 is that of *Oxytenanthera abyssinica.* Cluster 3 contained *Ochlandra talbottii* and *Ochlandra wightii. Phyllostachys sulphurea* and *Melocanna baccifera* formed cluster 4 and cluster 5.

IV. Conclusion

The Bambusetum requires regular maintenance and care for ensuring the survivability of the established clumps. Productivity can be enhanced through regular weeding at least once in a year. This will also impart aesthetic beauty to the Bambusetum. Periodic removal of top broken, dead and dying culms will create hygienic surroundings inside and around the Bambusetum. Fencing and protection, especially during the establishment and culm emergence stages of the Bamboo clump are prerequisites for ensuring higher survival rate and active growth. Uprooting of the old stumps of older trees, though an expensive exercise reduces subsequent weeding intensity and frequency thus cutting down the recurring expenditure on maintenance.

Growth and productivity is species specific and in Bamboos a progressive increment in culm production need not always happen every year. The growth attributes may fluctuate every year moreover proper silivicultural interventions and tending can ensure enhanced growth and more culm production every year.

V. References

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