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Study of population changes of *Melocanna baccifera*, *Dendrocalamus hamiltonii* and *Dendrocalamus longispathus* under one, three and five year fallow periods in Mizoram

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Abstract—For three bamboo species (*Dendrocalamus hamiltonii*, *D. longispathus* and *Melocanna baccifera*), the population flux was studied from 1995 to 1997. This study includes the number of culms in the beginning, the growth and loss, and the number at the end. The influence of three different fallow periods (1, 3 and 5 years) was studied.

Key words: Bamboo; plantations; growth rates; fallow period.

INTRODUCTION

Bamboo is one of nature's fastest growing woody plants; it possesses desirable structural properties with a short period of maturity, so there are many varieties which may be utilized. Ohrnberger and Goerrings [1] in their compilatory account on bamboo mention approximately 110 genera and 1010–140 species. Bamboo diversity in the the North-eastern region of India is quite rich with nearly 15 genera and 63 species [2]. Lalramnghinglova and Jha [3] have reported 9 genera and 22 species of bamboo in Mizoram. In Mizoram, bamboo occupies the lower story in the evergreen forest, and in its climatic climax stage it is found in riverine forests and valleys.

In the degraded jhum land, bamboo species emerges as a secondary crop, mainly due to presence of rhizomes in the sub-soil. The most common and dominant species is *Melocanna baccifera* [4].

The estimated weekly availability of edible bamboo shoots in the state is 291 436 in number. In Aizawl (the state capital) market nearly 100 000 shoots are collected

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Table 1.
The percentage availability of bamboo species in the vegetable market of Mizoram

Species	Percentage
Melocanna baccifera	50
Dendrocalamus longispathus	33
Dendrocalamus hamiltonii	15
Bambusa tulda	02
D. giganteus	Negligible

Source: Jha *et al.* [5].

and sold in a week for vegetables [5]. The availability of bamboo shoots by species in the state vegetable market are presented in Table 1.

The share of the non-clump-forming and clump-forming edible bamboo species in bamboo stock of the state is 98 and 2 percent respectively. If availability of bamboo shoots is analysed with respect to species, the share of non-clump-forming species in the vegetable market is 50 percent whereas it covers 98 percent of the total bamboo growing stock in the state. The clump-forming species (of which there are three) contributes 50 percent share in the vegetable market whereas in total growing stock of the state it represents only 2 percent [6]. This indicates a degree of deforestation on the clump- and non-clump-forming species in the Mizoram. Furthermore, the practice of shifting cultivation with shorter cycle also plays a major role in depletion of the growing stock of bamboo species.

Thus in order to maintain the current situation of growing stock of bamboo resources of the state, there is a need to study the population of bamboo species in different fallow lands. This paper deals with the changing population of different bamboo species on fallow land.

STUDY AREA

Geographical location, climate, soil and vegetation

The study area 'Kolasiv (Mizoram)' falls under the Tropical and Sub-Tropical region, covers an area of 1658 km^2, and lies between 19°N to 20°N latitude and 92°38′E longitude. The altitude varies from 40 m to 850 m.

It enjoys a moderate climate, owing to its tropical location: it is neither very hot nor too cold throughout the year. The region falls under the South West monsoon, so it receives an adequate amount of rainfall. The climate is humid tropical, characterised by short winter, long summer with heavy rainfall. Precipitation is heavy in summer, mainly from May to September and lasts until late October. Normally, July and August are the rainiest months, while December and January are the driest months [7].

Table 2.

Common tree species growing in the study area	Change in original plant composition due to excessive biotic pressure
The common tree species growing in the study area are *Acrocarpus fraxinifolius, Adina cordifolia, Albizzia lebbek, Areca catechu, Artocarpus chaplasa, Bauhnia variegata, Bombax ceiba, Butea parviflora, Calamus sps., Callicarpa arborea, Cedrella toona, Cordia myxa, Dillenia indica, Duabanga grandiflora, Erythrina stricta, Emblica officinalis, Ficus hirsuta, Garuga pinnata, Gmelina arborea, Lagerstroemia parviflora, Mesua ferrae, Michelia champaca, Parkia rouxburghii, Sapium baccatum, Quercus griffthi, Schima wallichi, Sterculia villosa, Tectona grandis, Tetrameles nudiflora, Thysanolaena maxima, Trevesia palmate.*	*Melocanna baccifera, Mikania scandens, Euphatorium odoratum, Saccharum spontaneum, Imperata cylindrica.*

(Source: Refs [9, 10]).

The cold season starts from November and lasts until February when the temperature is comparatively lower at 11°C–23°C; the warm season begins from March and last until the first part of May, with temperatures of 19°C–29°C.

Soil is generally young, immature and sandy. The surface soils are dark, highly leached and poor in bases, rich in iron and have low pH values ranging from 4.5–5.5, which is in the acidic range. They are well drained, and high in potash. The textures are loam to clay loam. The percentages of clay, silt and sand are 15–30%, 35–45% and 25–45%, respectively [6].

The study area falls under tropical and sub-tropical forest types [8]. More than 65% of the population practices shifting cultivation which has led to a severe degradation of forest and disturbed plant succession. The excessive biotic pressure has resulted in a change in original plant composition and bamboo has been replaced by species of lesser importance (Table 2).

METHODOLOGY

Three replicates of fallow periods of 1, 3, and 5 years were selected. Care was taken to ensure similar topography, slope, and soil type.

Five replicates of 100 m^2 permanent quadrates were laid at each site to study the population flux of culms during a two-year period from 1995 to 1997, for *Dendrocalamus hamiltonii*, *D. longispathus* and *Melocanna baccifera*. All individual culms present at the beginning of the study were considered to be more than 1 year old and classified as old population. Any individual culm appearing above the soil surface was counted as 'gain' and those lost through natural causes as 'losses'. Culm appearing in any given months was marked as a cohort.

Growth index of a stand in unit area was calculated as the ratio of the number of new culms produced (during the two-year study period) to the number of culms originally present. The clumps in the terms of clump area and the number of culms were analysed at each site at the end of the 2-year study period [11].

The following parameters were studied:

Number of culms/ha at the beginning of study, Table 3.

Number of culms produced/ha during study period, Table 4.

Number of culms lost/ha during study period, Table 5.

Number of culms/ha at the end of study, Table 6.

Number of culms/ha recorded during study period, Table 7.

Net change, Table 8, data of Table 6 minus data of Table 3.

Rate of change, Table 9, data of Table 6 divided by data of Table 3.

Percentage of annual mortality, Table 10 (Table 5/Table 7 $\times$ 100).

Growth index of population, Table 11 (Table 4/Table 3).

RESULTS

Number of culms present at the beginning of the study of the effect of fallow periods

The number of culms for the three species present at the beginning of each of the years of study for the three fallow periods and for the two one-year intervals are shown in Table 3.

Chi squared analysis was performed for a 3 $\times$ 3 matrix (3 species $\times$ 3 fallow periods) with the observation of two years pooled under each. Analysis revealed significant χ^2 values ($\chi^2 = 95.60$) suggesting a significantly differential pattern of species distribution. In the statistical analysis, the distribution was taken as Poisson, and the level of significance was taken at 5 percent.

Table 3.
Number of culms present/ha in the beginning of the study periods into the effects of fallow periods of various lengths

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	490	360	280	
1996–7	1350	960	980	
Total	1840	1320	1260	4420
3 year 1995–6	1500	1550	1200	
1996–7	2100	2340	1740	
Total	3600	3890	2940	10 430
5 year 1995-6	1900	1800	1900	
1996–7	2800	2970	2790	
Total	4700	4770	4690	14 160
Grand total	10 140	9980	8890	29 010

Number of culms produced during the study period after different fallow periods

Number of culms produced for the three species, observed over three fallow periods for the two one-year intervals are shown in Table 4, recorded at the end of the years of study.

Chi squared analysis was performed for a 3 × 3 matrix (3 species × 3 fallow periods) with the observation for a time interval of two years. Analysis revealed significant χ^2 ($\chi^2 = 425.04$) suggesting significantly differential pattern of growth pattern in the three species.

Number of culms lost during study period

Number of culms for the three species observed over three fallow periods for the years 1995–1996 and 1996–1997 are shown in Table 5.

Table 4.
Number of culms produced/ha during study period after fallow periods of various lengths

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	1250	900	890	
1996–7	1040	1100	520	
Total	2290	2000	1410	5700
3 year 1995–6	1100	1270	890	
1996–7	1260	2050	1310	
Total	2360	3320	2200	7880
5 year 1995–6	1000	1560	1140	
1996–7	1450	2300	2100	
Total	2450	3860	3240	9550
Grand total	7100	9180	6850	23 130

Table 5.
Number of culms lost/ha during study period

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	390	280	190	
1996–7	430	320	450	
Total	820	600	640	2060
3 year 1995–6	500	480	250	
1996–7	610	530	360	
Total	1110	1010	610	2730
5 year 1995–6	700	590	350	
1996–7	720	640	510	
Total	1420	1230	860	3510
Grand total	3350	2840	2110	8300

The overall pattern was analysed by applying a 3 × 3 chi squared analysis (using 3 species × 3 fallow periods). Analysis revealed significant χ^2 ($\chi^2 = 280.78$) suggesting significantly differential pattern of culms lost in the three species.

Number of culms at the end of study

The number of culms present at the end of the study for the three bamboo species observed over three fallow periods for the period of the study over the two intervals are given in Table 6.

The overall pattern was analysed by applying 3 × 3 chi squared analysis (3 species × 3 fallow periods). At this stage, the frequency data under each of the matrix cells were pooled. Analysis revealed significant χ^2 ($\chi^2 = 256.00$) suggesting differential pattern of culms at the end of the study in the three species.

Number of culms recorded during the study period

The number of culms recorded during the study period for the three species were observed over three fallow periods for a period of study of two one-year intervals and the data are given in Table 7. The number of culms recorded is the sum of culms recorded at the end of the study (Table 6) and the number of culms lost (Table 5); this is the difference with the number of culms produced in Table 4.

The overall pattern was assessed by applying a 3 × 3 chi squared analysis (3 species × 3 fallow periods) to the data. At this stage, the frequency data under each matrix cell were pooled. Analysis revealed significant χ^2 ($\chi^2 = 302.32$) suggesting differential pattern of number of culms in the three species.

A 3 × 3 (3 species × 3 fallow periods) χ^2 analysis showed significant χ^2 values each at the 0.001 level suggesting that the three bamboo species of culm recorded are not independent of the length of the three fallow periods.

Table 6.
Number of culms/ha at the end of study

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	1350	960	980	
1996–7	1960	1740	1450	
Total	3310	2700	2430	8440
3 year 1995–6	2100	2340	1740	
1996–7	2750	3860	2690	
Total	4850	6200	4430	15 480
5 year 1995–6	2800	2970	2690	
1996–7	3530	4690	4380	
Total	6330	7660	7070	21 060
Grand total	14 490	16 560	13 930	44 980

Net changes

The net change in culms recorded during the study period for the three species observed over three fallow periods over a period of study of two one-year intervals; the results are given in Table 8.

The overall pattern was analysed by applying a 3 × 3 chi squared test (3 species × 3 fallow periods). Analysis revealed significant χ^2 ($\chi^2 = 489.90$) suggesting a significant change in culm distribution over the study period for the three species. A 3 × 3 (3 species ×3 fallow periods) χ^2 analysis manifested significant χ^2 values at 0.001 level suggesting that the three bamboo species culms recorded are not independent of the three fallow periods. Also the result indicated that the highest net change in *Dendrocalamus longipathus*, *Dendrocalamus hamiltonni* being the

Table 7.
Number of culms/ha recorded during study period

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	1740	1260	1170	
1996–7	2390	2060	1900	
Total	4130	3320	3070	10 520
3 year 1995–6	2600	2820	2090	
1996–7	3360	4390	3050	
Total	5960	7210	5140	18 310
5 year 1995–6	3500	3560	3040	
1996–7	4250	5330	4890	
Total	7750	8890	7930	24 570
Grand total	17 840	19 420	16 140	53 400

Table 8.
Net changes in development of study species

Fallow; years	M.bacc.	D.long.	D.ham.	Total
1 year 1995–6	860	600	700	
1996–7	610	780	470	
Total	1470	1380	1170	4020
3 year 1995–6	600	790	540	
1996–7	650	1520	950	
Total	1250	2310	1490	5050
5 year 1995–6	900	1170	790	
1996–7	730	1720	1590	
Total	1630	2890	2380	6900
Grand total	4350	6580	5040	15 970

Table 9.
Rates of change in development of study species

Fallow; years	M.bacc.	D.long.	D.ham.
1 year 1995-6	2.7	2.6	3.5
1996–7	1.4	1.8	1.4
Total	4.1	4.4	4.9
3 year 1995–6	1.4	1.5	1.4
1996–7	1.3	1.6	1.5
Total	2.7	3.1	2.9
5 year 1995–6	1.4	1.6	1.4
1996–7	1.2	1.5	1.5
Total	2.6	3.1	2.9
Grand total	9.4	10.6	10.7

intermediate and the least in *Melocanna baccifera* species analysis with regard to period, irrespective of the species.

Rate of change in culm production

The rate of change in culm production for the three species observed over three fallow periods for the period of study during two one-year intervals are given together in Table 9. The rate of change is defined as the ratio of the number of culms/ha at the end of the study to the number of culms/ha at the beginning.

The overall pattern was analysed by applying a 3 × 3 chi squared test (3 species × 3 fallow periods). At this stage, the frequency data under each of the matrix cell were pooled. Analysis revealed not significant χ^2 value.

Percentage of annual mortality

The percentage of annual mortality for the three species observed over three fallow periods over the two one-year periods of study are given in Table 10. This percentage is calculated as the ratio of the number of culms lost and the number of culms recorded, or the ratio between data in Tables 5 and 7.

The overall pattern was analysed by using a 3 × 3 chi squared test (3 species × 3 fallow period). Analysis revealed a χ^2 value that was not significant at 5 percent level.

Results indicated that the highest mortality was observed in *Melocanna baccifera* species, *Dendrocalamus longispathus* being the intermediate and the least in the *Dendrocalamus hamiltonii* species. With regard to the fallow period (irrespective of the species) data gathered indicated high mortality in the 1-year fallow period followed by the 3-year and least in the 5-year.

Table 10.
Percentage of annual mortality

Fallow; years	M.bacc.	D.long.	D.ham.
1 year 1995–6	22.4	22.2	16.2
1996–7	17.9	15.5	23.6
Total	40.3	37.7	39.8
3 year 1995–6	20.0	17.0	11.9
1996–7	18.1	12.0	11.8
Total	38.1	29.0	23.7
5 year 1995–6	20.0	16.5	11.5
1996–7	16.9	12.0	10.4
Total	36.9	28.5	21.9
Grand total	115.3	95.2	85.4

Table 11.
Growth index of population of three study species

Fallow; years	M.bacc.	D.long.	D.ham.
1 year 1995–6	2.5	2.5	3.1
1996–7	0.7	1.1	0.5
Total	3.2	3.6	3.6
3 year 1995–6	0.7	0.8	0.7
1996–7	0.6	0.8	0.7
Total	1.3	1.6	1.4
5 year 1995–6	0.8	0.8	0.6
1996–7	0.5	0.7	0.7
Total	1.3	1.5	1.3
Grand total	5.8	6.7	6.3

Growth index of population

The growth index for the three species observed over three fallow periods for the period of study are given in Table 11.

The overall pattern was analysed by using the 3×3 chi squared test (3 species $\times$ 3 fallow periods). Analysis revealed that the χ^2 value was not significant at 5 percent level.

DISCUSSION

Results are summarised in Table 12. It is apparent that Mizoram has vast bamboo resources in comparison with other states of the North-eastern region. Kolasib division contributes the major share. The clump-forming bamboo species covers

Table 12.
Summary of results

	Highest	Intermediate	Least
Number of culms present			
Species	M.bacc., 10 140	D.long., 9980	D.ham., 8890
Fallow	5 years, 14 160	3 years, 10 430	1 year, 4420
Number of culms produced			
Species	D.long., 9180	M.bacc., 7100	D.ham., 6850
Fallow	5 years, 9550	3 years, 7880	1 year, 5700 (1)
Number of culms lost			
Species	M.bacc., 3350	D.long., 2840	D.ham., 2110
Fallow	5 years, 3510	3 years, 2730	1 year, 2060
Number of culms at the end			
Species	D.long., 16 560	M.bacc., 14 490	D.ham., 13 930
Fallow	5 years, 21 060	3 years, 15 480	1 year, 8440
Number of culms recorded in study			
Species	D.long., 19 420	M.bacc., 17 840	D.ham., 16 140
Fallow	5 years, 24 570	3 years, 18 310	1 year, 10 520
Net change			
Species	D.long., 6580	D.ham., 5040	M.bacc., 4350
Fallow	5 years, 6900	3 years, 5050	1 year, 4020
Rate of change			
Species	D.ham., 10.7	D.ham., 10.6	M.bacc., 9.4
Fallow	1 year, 13.4	3 years, 8.7	5 years, 8.6
Annual mortality			
Species	M.bacc., 115.3	D.long., 95.2	D.ham., 85.4
Fallow	1 year, 117.8 (1)	3 years, 90.8	5 years, 85.4
Growth index			
Species	D.long., 6.7	D.ham., 6.3	M.bacc., 5.8
Fallow	1 year, 10.4	3 years, 4.3	5 years, 4.1

(1) maybe due to the disturbance of jhumming.
All data are in culms per ha.

only 2 percent of the total growing stock but its share as edible bamboo species in the vegetable market is 50 percent [5].

Starting with a low recruitment of culms in one-year-old fallow, ultimately population size of three species improved up to five years of fallow age. The increment in the number of culms per unit area with fallow age may be related to the age of the stand, as shown under plantation conditions in Japan [12]. The low vigour in one-year fallow may be a consequence of a high degree of disturbance in the site during the preceding slash and burn operation followed by cropping for a year [13].

More monthly cohorts in five-year-old fallow than in others also supports the observation regarding the greater vigour of the three species at these sites. The larger recruitment of culms through the first cohort and the greater contribution of these cohorts to the population structure, though only next to the pre-existing population, extended the favourable time period for the population as a whole.

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in 1958, and showed that genetic variations were significant between provenances; growth of the twenty-year-old *Pinus mossoniana* provenances in Guangxi province were better than that of Fujian. Selection of optimal provenances could make full use of fine genetic properties, and gain significant genetic improvement. Hence, scientists from countries all over the world have looked on a provenance trial as the basis for improvement in tree species.

There are many different species of bamboo [4, 5]. Among the economic bamboo species in China, the resources of *Phyll. het.* cv. *pub.* species are the richest, covering about 2.7 million hectare, which are widely distributed in 16 provenances in the south. Some deformities in the shape, variations in the nutritional content of the fresh shoot, and other properties have been found in different product areas. To study the inherited character of clones of bamboo, it is difficult to collect the different provenance seeds from all over the county to launch a provenance trial of seeds of *Phyll. pub.*; hence, there is a gap in the studies of provenances by using vegetative propagation materials. With the rapid development of the Chinese economy of bamboo, and the important position of *Phyll. het.* cv. *pub.*, it was regarded as very important for bamboo economic development to develop the provenances trial, to explore the pattern of geographic variation of different *Phyll. het.* cv. *pub.* formations, and to select the best provenances.

2. MATERIAL AND METHODS

2.1. Conditions at trial location

The trial was carried out in the bamboo garden of Hua'an city and Nanyan town of Jian'ou city in Fujian [6].

2.2. Material source

The trial material came from 16 provenances derived from 8 provinces, the geographical locations of which are listed in Table 1.

The quality standard of the mother bamboo included bamboo 1–2 years old, with diameter of more than 3 cm but less than 6 cm, the height of the culm under the lowest branch more than 2 m, normal growth without pest and diseases, 4–5 wheel branches, roots under the earth intact and fresh, rhizome buds more than 3 and fully grown, coming root of 30 cm length, going root of 40 cm, stump with original soil, and rhizomes with wet rice straw banded. Then, every mother bamboo of different provenances was studied to record the diameter, age, height of the under branch, branch layer amount, length of rhizome, rhizome thickness, rhizome age and so on, to set up a reference bank of original data of the mother bamboo.

2.3. Trial designs

The trial adopted randomised and complete block design, including five blocks. In the course of planting, the groups including 5 bamboos made up the plum Blossom