Global Journal of Science Frontier Research
Agriculture and Veterinary
Volume 13 Issue 13 Version 1.0 Year 2013
Type : Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Eco-Silvicultural Interventions for Rehabilitation of Gregariously Flowered Bamboo Forests with Special Reference to *Dendrocalamus Strictus* (Roxb) Nees

By O.P. Chaubey, Archana Sharma & Ram Prakash
State Forest Research Institute, Jabalpur, India

Abstract- Bamboo is of vital importance from ecological, commercial and socio-economic points of view. The bamboo resources in the country are shrinking day by day due to various reasons, particularly due to un-establishment of bamboo clump after the gregarious flowering of bamboo. After gregarious flowering, the natural regeneration of bamboo species forms carpet on forest floor and remained in whippy stage for several decades. The present paper deals with the eco-silvicultural interventions for rehabilitation of bamboo after gregarious flowering. The treatments were given after formation of bamboo elites. The findings revealed that after post flowering treatments, the clump formation and culms growth found significantly improved. Without post flowering treatments the bamboo growth found in whippy stage even after the decades of gregarious flowering. The post flowering treatments should include protection from fires and grazing, proper spacing along with digging of carpet regeneration, cut back operations, soil working and canopy manipulation.

Keywords: *gregarious flowering, rehabilitation, spacing, soil working, canopy manipulation.*

GJSFR-D Classification : *FOR Code: 300699p*

ECO-SILVICULTURAL INTERVENTIONS FOR REHABILITATION OF GREGARIOUSLY FLOWERED BAMBOO FORESTS WITH SPECIAL REFERENCE TO DENDROCALAMUS STRICTUS ROXB NEES

Strictly as per the compliance and regulations of :

Eco-Silvicultural Interventions for Rehabilitation of Gregariously Flowered Bamboo Forests with Special Reference to *Dendrocalamus Strictus* (Roxb) Nees

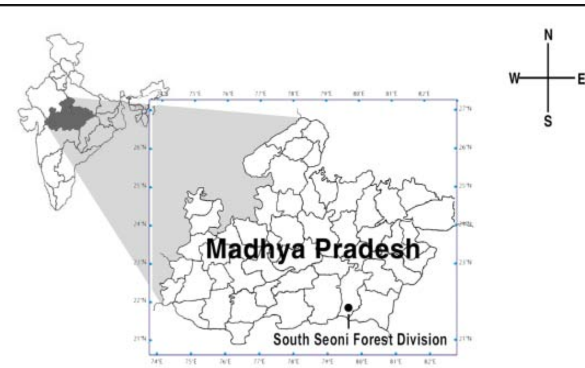
O.P. Chaubey [α], Archana Sharma [σ] & Ram Prakash [ρ]

Abstract- Bamboo is of vital importance from ecological, commercial and socio-economic points of view. The bamboo resources in the country are shrinking day by day due to various reasons, particularly due to un-establishment of bamboo clump after the gregarious flowering of bamboo. After gregarious flowering, the natural regeneration of bamboo species forms carpet on forest floor and remained in whippy stage for several decades. The present paper deals with the eco-silvicultural interventions for rehabilitation of bamboo after gregarious flowering. The treatments were given after formation of bamboo elites. The findings revealed that after post flowering treatments, the clump formation and culms growth found significantly improved. Without post flowering treatments the bamboo growth found in whippy stage even after the decades of gregarious flowering. The post flowering treatments should include protection from fires and grazing, proper spacing along with digging of carpet regeneration, cut back operations, soil working and canopy manipulation.

Keywords: gregarious flowering, rehabilitation, spacing, soil working, canopy manipulation.

I. Introduction

Traditionally, bamboo is recognized as "poor man's timber" as it is directly related with human life from cradle to eternal voyage. Versatile characteristics of bamboo make it useful for variety of purposes both in herbal and rural sectors, and play vital role for Indian prosperity. The bamboo has vital environmental value in reducing air pollution, water pollution, land pollution, and to ameliorate climate. The bamboo being a C-4 plant absorbs more carbon-dioxide from the atmosphere and gives out oxygen at faster rate. Its roots are highly capable of VAM infection, and consequently to improve soil conditions. The plant's leaves absorb toxic heavy metals like Fe and Zn. It is very promising species for planting on farmlands, homesteads, stream margins, boundaries and degraded lands. The bamboo resources in India are shrinking day by day due to gregarious flowering and seeding and subsequent dying. The flowering in bamboo is a rare phenomenon. Generally it occurs at long intervals. The period of physiological cycle (the period between two consecutive flowerings) is species-specific. The demand of bamboo has risen tremendously. For meeting the demand, it is therefore necessary to take steps to increase the yield of bamboo through developing rehabilitation techniques for gregariously flowered bamboo areas. Gregarious flowering is coupled partly due to genetic and partly by environmental factors. The seedlings which appear during rains are disappeared soon in the absence of congenial conditions, biotic closure and silvicultural treatments. In gregarious flowering, entire populations in a given area will bloom, with all clumps, and in all culms of the clumps. Time of flowering may extend from a few months to a few years. In gregarious flowering, the affected clumps will invariably die. The physiological cycle of gregarious flowering varied from 17 to 50 years in different areas. Very little attempts were made on eco-silvicultural interventions for management of gregariously flowered bamboo forests. The present paper deals with the effects of silvicultural treatments in bamboo forests flowered gregariously during 2005-2006 at Rukhad range of south Seoni forest division in the state of Madhya Pradesh, India (Map 1).



Map 1. India's map showing study site in the state of Madhya Pradesh (M.P.)

II. Materials and Methods

In south Seoni division, Rukhad range was identified for the study. This experiment includes 05 treatment plots of different spacing and 01 control plots

Authors α σ ρ : State Forest Research Institute, Jabalpur - 482008 (M.P.). e-mails: chaubey.dr@gmail.com, rchanasharma.sharma6@gmail.com, sdfri@rediffmail.com

without spacing. At Rukhad different spacing plots were fenced using barbed wire. In all spacing plots, all intervening rhizomes were dug out and kept in a rhizome bank established at the Institute (Table 1).

Table 1 : Silvicultural interventions pertaining to different spacing at Rukhad range of South Seoni forest division (Madhya Pradesh, India)

SN	Treatment code	Treatment detail of different spacing	Plot details	Compartment no.
1.	S-1	2m x 2m	Fenced and protected from grazing and fire, canopy density 0.4	409
2.	S-2	4m x 4m	Fenced and protected from grazing and fire, canopy density 0.4	409
3.	S-3	6m x 6m	Fenced and protected from grazing and fire, canopy density 0.4	409
4.	S-4	8m x 8m	Fenced and protected from grazing and fire, canopy density 0.4	409
5.	S-5	10m x 10m	Fenced and protected from grazing and fire, canopy density 0.4	409
6.	S-0	No spacing (Natural)	Open for grazing and fire (without fencing), canopy density 0.4	409

The randomized block design (RBD) was used. The plot size in all treatment was 50mX50m. Each treatment was divided into three replicates of 16.66 m X 16.66 m. The observation of height and girth of each plant was taken in each treatment. The mean observation of plants in each replicate was considered for statistical analysis. Each replicate had equal number of observations. The parameters taken for statistical analysis were height increment, girth increment and production of number of culms clump^{-1} during the five years period. The statistical analysis was made using SPSS software.

III. Results

At Rukahd (compartment no. 409), 5 spacing viz., 2mx2m, 4mx4m, 6mx6m, 8mx8m and 10mx10m were tried to study their effects on culms and clump growth. Of these 5 spacing tried, 4mx4m spacing gave better results in terms of height and girth increment of regeneration/elite seedling and other growth parameters of clump formation. The height and girth increments in five years period with 4mx4m spacing were found to be 589 cm and 10.31 cm respectively, followed by 2mx2m spacing (465 cm increase in height and 8.17 cm increase in girth), 6mx6m spacing (463 cm increase in height and 8.04 cm increase in girth), 8mx8m spacing (438 cm increase in height and 7.67 cm increase in girth), 10mx10m spacing (413 cm increase in height and 6.72 cm increase in girth). All the treatments were found significantly superior over control. In open (control), the average increase in height and girth after five years period was found to be 189 cm and 4.93 cm respectively. Besides the increase in culms growth, the clump formation (11.67 culms clump^{-1}) was also found superior with 4mx4m spacing, followed by spacing of 2mx2m (10.43 culms clump^{-1}), 6mx 6m (10.28 culms clump^{-1}), 8m x 8m (10.08 culms clump^{-1}), 10mx10m (10.04 culms clump^{-1}) and control (6.96 culms clump^{-1}) (Table 2).

Table 3 shows the descriptive statistics i.e. number of cases, mean, standard deviation, lower and upper bound at 95% confidence interval for mean, minimum and maximum values. The perusal of descriptive results reveals that treatments do differ in mean and range (i.e. maximum and minimum observation). One-way ANOVA reveals that all treatments differ significantly for parameters under study at 95 % level of significance. If the number 0.000 increases more than 0.05 the treatments may not differ significantly at 95% level of confidence. However, in the study site, it is less than 0.05, Hence, f value in the adjoining column in more than the tabulated F value at 95% level of significance. So, it is clear that all treatments show significant difference from each other on different parameters. Further it can be interpreted that height increment, girth increment and number of culms per clump were significantly different between and within groups among various treatments. To establish one treatment as the best among the lot, we have to compare it with others based on critical difference. If one treatment is the best among the group, its mean difference with any other should be more than the critical difference. Spacing treatments at different intervals are compared with each other with reference to increment in height, girth and number of culms per clump during the five years study period. In the first column, the dependent variable is shown as height increment, girth increment and number of culms per clump. The 6 spacing treatments viz; S1 (2mx2m), S2 (4mx4m), S3 (6mx6m), S4 (8mx8m), S5 (10mx10m) and S0 (Control) given in column 2 (I) were compared between the other groups as given in column 3 (J). The star (*) marks show that the mean difference is more than the critical difference at 95% significant level. The negative sign in the column of mean difference shows that treatment under comparison is inferior to other treatments. The positive sign indicates that the treatment is superior to other treatments under compared. Perusal of results indicated that treatment S2 (4mx4m spacing) was the best among the other treatments in terms of height and girth increment and number of culms per clump. The mean difference of treatment S2 (spacing of 4mx4m) is significant as compared to other treatments in terms of height increment, girth increment and number of culms per clump as the value of mean difference is significant at the 0.05 level. The negative sign in control showed that the height and girth increment and number of culms per clump were inferior to the other treated plots. In other words, different spacing treatments affect significantly the clump formation in bamboo.

Table 2 : Effect of different spacing on height and girth increment and average number of culms clump^{-1} of bamboo regeneration at Rukhad (years 2007- 12)

Treatment	Annual average height in cm (2007 to 2012)						Annual average girth in cm (2007 to 2012)						Increase in height (cm) during five years	Increase in girth (cm) during five years	Average no. of culms clump^{-1} in 2012
	07	08	09	10	11	12	07	08	09	10	11	12			
S-1 (2x2m)	110	141	290	517	535	575	2.00	3.54	4.86	8.89	9.32	10.17	465	8.17	10.43
S-2 (4x4m)	101	137	310	652	680	690	2.00	3.85	5.63	9.08	10.90	12.31	589	10.31	11.67
S-3 (6x6m)	104	131	286	402	490	567	2.00	3.66	4.12	6.65	9.71	10.04	463	8.04	10.28
S-4 (8x8m)	92	148	262	346	435	530	3.60	3.50	4.00	8.20	10.40	11.27	438	7.67	10.08
S-5 (10x10m)	141	179	253	375	415	554	3.10	3.42	3.98	7.00	8.44	9.82	413	6.72	10.04
S-0 (Open)	180	103	187	361	362	369	1.30	1.46	2.00	4.80	5.15	6.23	189	4.93	6.96

Table 3 : Statistical analysis (Descriptive, ANOVA and post hoc test) for spacing experiment

Descriptive									
		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean: Lower Bound	95% Confidence Interval for Mean: Upper Bound	Minimum	Maximum
Height increment	S1 2x2m	3	465.000	10.0000	5.77350	440.1586	489.8414	455.0	475.0
	S2 4x4m	3	589.000	14.0000	8.08290	554.2221	623.7779	575.0	603.0
	S3 6x6m	3	463.000	5.00000	2.88675	450.5793	475.4207	458.0	468.0
	S4 8x8m	3	438.000	6.00000	3.46410	423.0952	452.9048	432.0	444.0
	S5 10x10m	3	413.000	14.7309	8.50490	376.4064	449.5936	400.0	429.0
	S0 Control	3	189.000	10.53565	6.08276	162.8280	215.1720	179.0	200.0
	Total	18	426.167	123.4773	29.1038	364.7629	487.5704	179.0	603.0
Girth increment	S1 2x2m	3	8.1700	1.03058	0.59501	5.6099	10.7301	7.120	9.180
	S2 4x4m	3	10.3100	0.68432	0.39509	8.6100	12.0100	9.900	11.10
	S3 6x6m	3	8.0400	0.12000	0.06928	7.7419	8.3381	7.920	8.160
	S4 8x8m	3	7.6700	0.15716	0.09074	7.2796	8.0604	7.500	7.810
	S5 10x10m	3	6.7200	1.08130	0.62429	4.0339	9.4061	5.500	7.560
	S0 Control	3	4.9300	0.50764	0.29309	3.6689	6.1911	4.500	5.490
	Total	18	7.6400	1.77028	0.41726	6.7597	8.5203	4.500	11.10

No. of culms per clump in 2012	S1 2x2m	3	10.4300	1.10964	0.64065	7.6735	13.1865	9.150	11.12
	S2 4x4m	3	11.6700	0.43035	0.24846	10.6010	12.7390	11.25	12.11
	S3 6x6m	3	10.2800	0.52048	0.30050	8.9871	11.5729	9.950	10.88
	S4 8x8m	3	10.0800	0.08888	0.05132	9.8592	10.3008	9.980	10.15
	S5 10x10m	3	10.0400	0.99504	0.57449	7.5682	12.5118	9.050	11.04
	S0 Control	3	6.9600	0.37643	0.21733	6.0249	7.8951	6.530	7.230
	Total	18	9.9100	1.57953	0.37230	9.1245	10.6955	6.530	12.11

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Height increment	Between Groups	257822.500	5	51564.500	451.660	0.000
	Within Groups	1370.000	12	114.167		
	Total	259192.500	17			
Girth increment	Between Groups	47.284	5	9.457	18.936	0.000
	Within Groups	5.993	12	0.499		
	Total	53.276	17			
No of culms per Clump 2012	Between Groups	36.760	5	7.352	15.603	0.000
	Within Groups	5.654	12	0.471		
	Total	42.414	17			

Post Hoc Tests

Multiple Comparisons

LSD

Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Height increment	S1 2x2m	S2 4x4m	-124.00000*	8.72417	0.000	-143.0083	-104.9917
		S3 6x6m	2.00000	8.72417	0.823	-17.0083	21.0083
		S4 8x8m	27.00000*	8.72417	0.009	7.9917	46.0083
		S5 "10x10m"	52.00000*	8.72417	0.000	32.9917	71.0083
		S0 Control	276.00000*	8.72417	0.000	256.9917	295.0083
	S2 4x4m	S1 2x2m	124.00000*	8.72417	0.000	104.9917	143.0083
		S3 6x6m	126.00000*	8.72417	0.000	106.9917	145.0083
		S4 8x8m	151.00000*	8.72417	0.000	131.9917	170.0083
		S5 "10x10m"	176.00000*	8.72417	0.000	156.9917	195.0083
		S0 Control	400.00000*	8.72417	0.000	380.9917	419.0083
	S3 6x6m	S1 2x2m	-2.00000	8.72417	0.823	-21.0083	17.0083
		S2 4x4m	-126.00000*	8.72417	0.000	-145.0083	-106.9917
		S4 8x8m	25.00000*	8.72417	0.014	5.9917	44.0083
		S5 "10x10m"	50.00000*	8.72417	0.000	30.9917	69.0083
		S0 Control	274.00000*	8.72417	0.000	254.9917	293.0083
	S4 8x8m	S1 2x2m	-27.00000*	8.72417	0.009	-46.0083	-7.9917
		S2 4x4m	-151.00000*	8.72417	0.000	-170.0083	-131.9917
		S3 6x6m	-25.00000*	8.72417	0.014	-44.0083	-5.9917
		S5 "10x10m"	25.00000*	8.72417	0.014	5.9917	44.0083
		S0 Control	249.00000*	8.72417	0.000	229.9917	268.0083
	S5 "10x10m"	S1 2x2m	-52.00000*	8.72417	0.000	-71.0083	-32.9917
		S2 4x4m	-176.00000*	8.72417	0.000	-195.0083	-156.9917
		S3 6x6m	-50.00000*	8.72417	0.000	-69.0083	-30.9917
		S4 8x8m	-25.00000*	8.72417	0.014	-44.0083	-5.9917
		S0 Control	224.00000*	8.72417	0.000	204.9917	243.0083
	S0 Control	S1 2x2m	-276.00000*	8.72417	0.000	-295.0083	-256.9917
		S2 4x4m	-400.00000*	8.72417	0.000	-419.0083	-380.9917
		S3 6x6m	-274.00000*	8.72417	0.000	-293.0083	-254.9917

		S4 8x8m	-249.00000*	8.72417	0.000	-268.0083	-229.9917
		S5 "10x10m"	-224.00000*	8.72417	0.000	-243.0083	-204.9917
Girth increment	S1 2x2m	S2 4x4m	-2.14000*	.57700	0.003	-3.3972	-0.8828
		S3 6x6m	.13000	.57700	0.826	-1.1272	1.3872
		S4 8x8m	.50000	.57700	0.403	-0.7572	1.7572
		S5 "10x10m"	1.45000*	.57700	0.027	0.1928	2.7072
		S0 Control	3.24000*	.57700	0.000	1.9828	4.4972
	S2 4x4m	S1 2x2m	2.14000*	.57700	0.003	0.8828	3.3972
		S3 6x6m	2.27000*	.57700	0.002	1.0128	3.5272
		S4 8x8m	2.64000*	.57700	0.001	1.3828	3.8972
		S5 "10x10m"	3.59000*	.57700	0.000	2.3328	4.8472
		S0 Control	5.38000*	.57700	0.000	4.1228	6.6372
	S3 6x6m	S1 2x2m	-.13000	.57700	0.826	-1.3872	1.1272
		S2 4x4m	-2.27000*	.57700	0.002	-3.5272	-1.0128
		S4 8x8m	.37000	.57700	0.533	-0.8872	1.6272
		S5 "10x10m"	1.32000*	.57700	0.041	0.0628	2.5772
		S0 Control	3.11000*	.57700	0.000	1.8528	4.3672
	S4 8x8m	S1 2x2m	-.50000	.57700	0.403	-1.7572	0.7572
		S2 4x4m	-2.64000*	.57700	0.001	-3.8972	-1.3828
		S3 6x6m	-.37000	.57700	0.533	-1.6272	0.8872
		S5 "10x10m"	.95000	.57700	0.126	-0.3072	2.2072
		S0 Control	2.74000*	.57700	0.000	1.4828	3.9972
	S5 "10x10m"	S1 2x2m	-1.45000*	.57700	0.027	-2.7072	-0.1928
		S2 4x4m	-3.59000*	.57700	0.000	-4.8472	-2.3328
		S3 6x6m	-1.32000*	.57700	0.041	-2.5772	-0.0628
		S4 8x8m	-.95000	.57700	0.126	-2.2072	0.3072
		S0 Control	1.79000*	.57700	0.009	0.5328	3.0472
	S0 Control	S1 2x2m	-3.24000*	.57700	0.000	-4.4972	-1.9828
		S2 4x4m	-5.38000*	.57700	0.000	-6.6372	-4.1228
		S3 6x6m	-3.11000*	.57700	0.000	-4.3672	-1.8528
		S4 8x8m	-2.74000*	.57700	0.000	-3.9972	-1.4828
		S5 "10x10m"	-1.79000*	.57700	0.009	-3.0472	-0.5328
No. of culms per clump in 2012	S1 2x2m	S2 4x4m	-1.24000*	.56047	0.047	-2.4612	-.0188
		S3 6x6m	.15000	.56047	0.794	-1.0712	1.3712
		S4 8x8m	.35000	.56047	0.544	-0.8712	1.5712
		S5 "10x10m"	.39000	.56047	0.500	-0.8312	1.6112
		S0 Control	3.47000*	.56047	0.000	2.2488	4.6912
	S2 4x4m	S1 2x2m	1.24000*	.56047	0.047	0.0188	2.4612
		S3 6x6m	1.39000*	.56047	0.029	0.1688	2.6112
		S4 8x8m	1.59000*	.56047	0.015	0.3688	2.8112
		S5 "10x10m"	1.63000*	.56047	0.013	0.4088	2.8512
		S0 Control	4.71000*	.56047	0.000	3.4888	5.9312
	S3 6x6m	S1 2x2m	-.15000	.56047	0.794	-1.3712	1.0712
		S2 4x4m	-1.39000*	.56047	0.029	-2.6112	-.1688
		S4 8x8m	.20000	.56047	0.727	-1.0212	1.4212
		S5 "10x10m"	.24000	.56047	0.676	-.9812	1.4612
		S0 Control	3.32000*	.56047	0.000	2.0988	4.5412
	S4 8x8m	S1 2x2m	-.35000	.56047	0.544	-1.5712	.8712
		S2 4x4m	-1.59000*	.56047	0.015	-2.8112	-.3688
		S3 6x6m	-.20000	.56047	0.727	-1.4212	1.0212
		S5 "10x10m"	.04000	.56047	0.944	-1.1812	1.2612
		S0 Control	3.12000*	.56047	0.000	1.8988	4.3412

	S5 "10x10m"	S1 2x2m	-.39000	.56047	0.500	-1.6112	.8312
		S2 4x4m	-1.63000*	.56047	0.013	-2.8512	-.4088
		S3 6x6m	-.24000	.56047	0.676	-1.4612	.9812
		S4 8x8m	-.04000	.56047	0.944	-1.2612	1.1812
		S0 Control	3.08000*	.56047	0.000	1.8588	4.3012
	S0 Control	S1 2x2m	-3.47000*	.56047	0.000	-4.6912	-2.2488
		S2 4x4m	-4.71000*	.56047	0.000	-5.9312	-3.4888
		S3 6x6m	-3.32000*	.56047	0.000	-4.5412	-2.0988
		S4 8x8m	-3.12000*	.56047	0.000	-4.3412	-1.8988
		S5 "10x10m"	-3.08000*	.56047	0.000	-4.3012	-1.8588

**. The mean difference is significant at the 0.05 level.*

IV. Discussion

Without silvicultural intervention of flowered areas, the profuse uniformly dense mat of bamboo regeneration prevents the formation of bamboo clumps. In the state of Madhya Pradesh, the Kundam project (Jabalpur forest division) was started in 1976 as a constituent unit of the Madhya Pradesh State Forest Development Corporation with the objectives of raising commercial plantations of teak and bamboo. Consequent to gregarious bamboo flowering, bamboo regeneration was seen everywhere, but due to unchecked grazing and frequent fires, the bamboo regeneration was suppressed. Opening of the canopy (100 to 120 trees ha^{-1}) and protection measures adopted had resulted in promoting the luxuriant growth of bamboo. In order to promote the growth of bamboo regeneration, the approximate spacing of bamboo plants kept at 4mx4m interval along with weeding and soil working treatments. The increase in average height was recorded to be 96, 25, 46 and 179 cm from compartment no. 160, 162,163 and 164 respectively in the first season (Hakeem, 1985). In north Betul forest division, the gregarious flowering of bamboo occurred in Gawasen range in 1976-1977 in 10277 ha area and has remained unproductive over a period of 10 years due to lack of cultural operations/post flowering treatments to rehabilitate the flowered areas. The post flowering treatment consisted of *elite* selection at spacing of about 4mx4m and then digging of all rhizomes in one meter diameter around the elite. The flowered areas were strictly protected from fire and grazing. The observations/measurement of post flowering treatments on morphology of bamboo clumps was recorded in 2007-12 (Chaubey, 2012). The treated areas have converted into good bamboo forest comprising all aged bamboo culms in the clumps formed. The proper spacing and soil working around elite selection proved effective in forming clumps of bamboo with all aged culms. In Shahdol district including Bandhavgarh national park area of Madhya Pradesh, the gregarious flowering in bamboo (*Dendrocalamus strictus*) occupied an area of about 42500 ha during 1984-87 (Dwivedi, 1988). Even after 4 years, the height growth in seedlings was found between 100-170 cm. The dense carpet of bamboo regeneration at many places has suppressed the growth of all other species. The average number of bamboo seedlings per hectare was recorded to be seven times more than the number of grass seedlings. The rampant natural regeneration of *Dendrocalamus strictus* hampered development of the other species and thus, proved harmful for biodiversity of the region. The utilization pattern of *cheetal*, *sambhar* and *elephant* had been changed to a great extent due to thickets of bamboo regeneration as it prevents the germination of other perennial and annual forage/browse species in the area. The only possible operation that can be done in park areas is to adopt elite selection in such regenerated areas by creating spacing of 5mx5m by careful cutting and digging of the area to save the diversity of the habitat (Rajesh Gopal, 1989). In north Mandla forest division, the gregarious flowering occurred in 1971-73. In subsequent years, the fallen seeds germinated profusely. Under the programme of rehabilitation, the areas in patches of 50-100 hectares were closed by digging cattle-proof trenches in 1981. Cutback operations and soil working along with protection measures of fire and grazing were adopted under post-flowering treatments after 10 years of flowering. After five years of protection, 8293 established seedling and saplings of bamboo and other species were observed in protected areas against 3944 seedlings and saplings of bamboo and other tree species in unprotected areas (Prasad, 1985). The gregarious flowering of bamboo in Barela and Katni ranges of Jabalpur forest circle occurred between 1965 and 1974, resulting into reduction in bamboo resources in many areas. The cleaning and soil working was carried out in 1993. After the post-flowering treatments, mean recruitment of "Karlas" (current year's bamboo) in treated clumps was recorded to be 68% (Prasad and Parihar, 1994).

In the state of Maharashtra, the major bamboo species are *Dendrocalamus strictus*, *Bambusa arundinacea* and *Oxytenanthera ritcheyi*. Prabhu and Dabral (1989) reported that out of 48 forest divisions of the state, gregarious flowering of the *Dendrocalamus strictus* recorded in 16 divisions at 40 to 43 years of physiological cycle. After gregarious flowering, the natural regeneration of bamboo form carpet on the forest floor. Even after 25 years, the sporadic clumps formed in the area were not fit for harvesting (Prabhu and Dabral, 1989). These facts call for a serious, patient and concerted post flowering efforts for establishment and rehabilitation of bamboo regeneration. In various working plans of Maharashtra, tending operation is prescribed for establishing bamboo regeneration.

There is no scientific record available on historical occurrence of gregarious bamboo flowering in Northeast India. In Sikkim 29 bamboo species are reported. During 2006, 4 bamboo species viz., *Dendrocalamus hamiltomii, Dendrocalamus hookeri, Sinarundinaria intermedia, Arundinaria racemosa*, flowered gregariously. Under post flowering treatment strict protection from grazing and fire is followed in the area. As the flowering appears in the area, about 70% of the clumps is harvested and balance 30% clumps is retained for production of seeds and to provide a light shade for successful natural regeneration after seed fall. In Assam, about 30 species of bamboo are reported to be gregariously flowered, but till now no action is reported to be implemented (Goyal and Kishwan, 2004; Kishwan and Goyal, 2006; Prasad and Pattanaik, 2002).

V. Conclusion

Whereas bamboo is found occurring widely in different tropical forests of the country which apart from being a source of livelihood of forest dependent population and industry its ecological role in Sustainable Forest Management requires greater attention. Based on experimental findings and literature review, the following conclusions are drawn:-

1. Apart from establishment of *ex-situ* rhizome banks, establishment of *in-situ* rhizome banks should be encouraged.
2. The rehabilitation activities to promote clump formation should be initiated after 2-3 years of flowering period while elite formation get started.
3. Spacing of selected healthy seedlings/ elites is recommended to be 4mx4m in forests with open canopy (density 0.4 and below). Forests with moderate canopy (density 0.4-0.5) should have spacing of selected healthy seedlings by 5m x 5m. All the interwoven rhizomes/ seedlings must be dug out in all the spacing prescribed. The treatment area must be protected from all the biotic factors for 5 years period after initiation of treatments.
4. In wild life areas, unproductive whippy stage dense carpet of bamboo suppressed growth and diversity of other species, and habitat of wild life reduced to a great extent. In these areas, past review recommended the elites selection at 5mx5m spacing, and cutting down of other bamboo regeneration as and when required.
5. The complete grazing closure for at least five years period is recommended to stimulate growth of bamboo seedlings and formation of clumps.
6. The intermast periods of bamboos are not as rigid as they are made out. In *Bambusa bambos* and *Dendrocalamus strictus,* there are many cohorts differing in their intermast periods. Therefore, selection for long intermast period for raising planting stock will be very useful.
7. Most tropical forests are amenable to assisted natural regeneration (ANR) treatments. Therefore, while bamboo plantation may be a desirable forestry practice, ANR is the most desirable silvicultural intervention which is comparatively inexpensive, easy and reliable method of rehabilitation of flowered bamboo areas. Joint Forest Management Committees should be actively engaged in management decision making and implementation of ANR activities on care and share basis.
8. Digitized maps of bamboo flowered areas should be prepared, with separate action plan to rehabilitate the area apart from the existing working plan treatment schedule. This digitized map of flowered area, action plan of rehabilitation and action taken report should be appended in the working plan.

References Références Referencias

1. Chaubey O.P. 2012. Impact assessment of different treatments on rehabilitation of gregariously flowered bamboo areas in Madhya Pradesh. Final report submitted to the M.P. Forest Department, Bhopal, pp 1-121.
2. Dwivedi A.P. 1988. Gregarious flowering in *Dendrocalamus strictus* in Shahdol (M.P.) Some management considerations. *Indian Forester*, 114 (9):87-91.
3. Gopal Rajesh. 1989. Natural regeneration of bamboo (*Dendrocalamus strictus*) after gregarious flowering and its effect on the forage and browse availability in Bandhavgarh National Park (M.P), *Proc.Seminar on Silviculture and management of bamboos,* 13-15 Dec., Institute of Deciduous Forests, Jabalpur (M.P), pp 1-19.
4. Goyal A.K. and Kishwan Jagdish. 2004. Gregarious Flowering of bamboo in North-East India – Some Management Issues, XI World Bamboo Congress, Feb., New Delhi.
5. Hakeem K.L. 1985. Rehabilitation of flowered bamboo areas of Jabalpur. *Journal of Tropical Forestry*, 1 (1):70-78.
6. Kishwan Jagdish and Goyal A.K. 2006. Gregarious flowering of Bamboos in North-East India - Need for Intensive Management. *Indian Forester*, 134 (5):525-533.

7. Prabhu V.R. and Dabral S.L. 1989. A status paper on Bamboo in Maharashtra State. 1989, *Proc. Seminar on Silviculture and management of bamboos,* held at institute of Deciduous Forests, Jabalpur (M.P) on 13-15 Dec. pp. 59-77.
8. Prasad K.G. and Pattanaik S. 2002. 'Status of Bamboo Flowering in the Northeast India'. Paper presented during the meeting on 'The Strategies for Exploitation of Bamboo Resources in Assam' organized by the Assam Forest Department on 31st July 2002 at Assam Administrative College, Guwahati.
9. Prasad Ram and Parihar A.S. 1994. Rehabilitation and management of flowered bamboos in Mandla-Jabalpur forests of Madhya Pradesh. *Journal of Tropical Forestry*, 10(1): 3-7.
10. Prasad Ram. 1985. Effect of grazing closure on rehabilitation of flowered bamboos areas in Mandla forest in Madhya Pradesh. *Journal of Tropical Forestry*, 1 (II):145 -151.