International Journal of Bio-Science and Bio-Technology
Vol.5, No.6 (2013), pp.207-220
http://dx.doi.org/10.14257/ijbsbt.2013.5.6.22

Impact of Fires and Grazing Closure on Rehabilitation of Gregariously Flowered Bamboo (*Dendrocalamus strictus* (Roxb) Nees) Forests

O.P. Chaubey, Archana Sharma and Ram Prakash

State Forest Research Institute, Jabalpur - 482008 (M.P.)

chaubey.dr@gmail.com, archanasharma.sharma6@gmail.com, sdfri@rediffmail.com

Abstract

After gregarious flowering, the natural regeneration of Dendrocalamus strictus (Roxb.) Nees forms carpet on forest floor and remained in whippy stage for several decades in face of severe biotic factors. The present paper deals with the impact of different treatments of fire and grazing closures for rehabilitation of natural regeneration. The treatments were given after formation of bamboo elites. The findings revealed that lit of fire in the month of May proved better in terms of culms growth and clump formation, followed by fire in the month of March. Two fire in a year i.e., fire in March and May, showed detrimental effect on culms growth and clump formation. Similarly, in the experiment of different periods of grazing closures, complete closure for five years proved significantly effective to stimulate growth of bamboo seedlings. This was followed by six months grazing closure (from July to December), and three months (July to Sept.) grazing closure in a year.

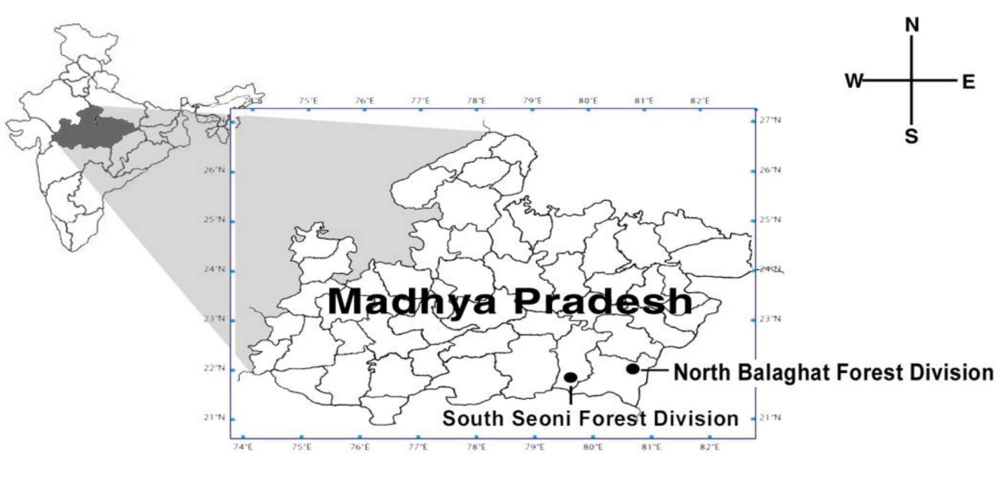
Keywords: *Natural regeneration, rehabilitation, fire, grazing closure, greagarious flowering*

1. Introduction

Bamboo is of vital importance from ecological, commercial and socio-economic points of view. Bamboo occupies an unparalleled position in plant kingdom in terms of its distribution, diversity, flowering and uses in the tropics and subtropics (Rai and Chauhan, 1998; Rawat and Kahduri, 1999; Ansari *et al*., 2002). Bamboo is a group of fast growing woody plant growing almost all over in India, except the Kashmir Valley. Bamboo forest constitutes about 13% of the total forest area of the country. The flowering of bamboo is typically of two types viz., (a) gregarious and (b) sporadic. 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. In sporadic flowering, not all culms in clumps will flower, or scattered sub sets of clumps of the population will flower. In sporadic flowering, when some culms flower, the affected culms will die, but there are species in which the clump will not die, but continue to produce healthy culms. Deogun (1937) has summarized all available knowledge regarding the flowering habit of *Dendrocalamus strictus*. He called it an "Irregularly flowering bamboo", based on his visit to bamboo forests in Uttar Pradesh, Orissa, Panjab and Madhya Pradesh. He reported that the physiological cycle of gregarious flowering of *Dendrocalamus strictus* in some localities was more than 65 years and might possibly be over a century. Chaturvedi

ISSN: 2233-7849 IJBSBT

(1988) reported the physiological cycle of *Dendrocalamus strictus* at long intervals of 20-65 years. Tatwawadi and Kali (1983) reported 35 years physiological cycle of *Dendrocalamus strictus* in Jarida range of East Melghat division of Maharashtra state. The average periodicity of physiological cycle of *D. strictus* in Allapalli, Chandrapur and Central Chanda division of Maharashtra was reported to be 43 years, 40.5 years and 40.5 years, respectively (Prabhu and Dabral, 1989). In Garhwal region, its gregarious flowering was reported by Gamble (1896) and Troup (1921). From Kalagarh, the gregarious flowering reported by Mathuda (1952) and Shah (1968) and from New Forest, Dehradun by Naithani (1993). The flowering culm may be of any age and may not necessarily be the oldest in the clump. The events of flowering were also recorded in seedlings of bamboo (Pathak, 1899; Birbal, 1899; Lauris, 1937; Ahmed, 1969). As per Troup (1921), the physiological cycle of *Dendrocalamus strictus* may be influenced to a slight extent by climatic and other causes, but primarily it is determined by physiological reasons. The bamboo resources in the country are shrinking day by day due to various reasons particularly gregarious flowering/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/guide lines for gregariously flowered bamboo areas. Notable contributions were made on gregariously flowered bamboo forests in India on various aspects of rehabilitation such as canopy manipulation by Hakeem (1985) grazing closure by Prasad (1985), soil working and other management aspects by Dwivedi (1988), Rajesh Gopal (1989) Prasad and Parihar (1994), RFRI (2002), GoI (2003), Goyal and Kishwan (2004), Kishwan and Goyal (2006), and Chaubey (2012). However, no scientific works reported in literature on effect of fire on rehabilitation of gregariously flowered bamboo forests. The present paper deals with the results of experiments pertaining to effect of successive ground fires and different periods of grazing closures in bamboo forests (flowered gregariously during 2005-2006) of south Seoni and north Balaghat forest divisions in the state of Madhya Pradesh, India (Map 1).



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

2. Materials and Methods

2.1. Effect of Fire on Rehabilitation of Gregariously Flowered Bamboo Forests

The fire treatments were undertakan at Rukhad range (Comptt. No. 419) of south Seoni forest division. The experiment included 03 treatments of artificial fire lit at different period viz., fire in March (F-1), fire in May (F-2), and fire in March and May (F-3). The ground fires lit for 2-3 hours periods annually for a period of five years from 2007 onwards. For comparison, control plot without fire was also taken for the same. The plot size for each treatment was of 50m x 50m. Different fire plots were fenced using barbed wire.

2.2. Effect of Grazing Closure on Rehabilitation of Gregariously Flowered Bamboo Forests

The grazing closure treatments were undertaken at east Baihar range (Comptt. No. 1574) of north Balaghat forest division. This experiment includes 03 treatments of grazing closure at different period viz., (G-1) Three months grazing closure (July-Sept), (G-2) Six months grazing closure (July-Dec), and (G-3) Complete grazing closure for the five years. The observations on growth of regeneration, clump formation were recorded each year from 2007 onwards. For comparison, control plot open for grazing was also studied for the same. The plot size for each treatment was 50m x 50m undertaken at east Baihar range of north Balaghat forest division of Madhya Pradesh. The experimental area is moderately grazed. The plots in different treatments were fenced using barbed wire. The observations were recorded periodically at one year interval from 2007 to 2012.

2.3. Statistical Analysis

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 at each site. 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 project period. The statistical analysis was made using SPSS software.

3. Results and Discussion

3.1. Effect of Fire on Rehabilitation of Gregariously Flowered Bamboo Forests

The observations on growth of regeneration and clump formation were recorded each year from 2007 to 2012 (Table 1). Perusal of data reveals that out of the three treatments of fires, fire in May gave better results in terms of height and girth increments of regeneration and clump formation. The height and girth increments in five years period with fire in May were found to be 460 cm and 7.75 cm respectively, followed by fire in March (398 cm increase in height and 5.68 cm increase in girth). Two fire in a year i.e., fire in March and May, showed detrimental effect on culms growth (increase in height of 256 cm and girth of 3.80 cm) and clump formation (5.65 culms clump^{-1}). The average increase in height and girth after five years protection from fire (F-0) was found to be superior from F-3 (Two fire in March and May) with respect to height increment (275 cm), girth increment (6.00 cm) and the clump formation (6.00 culms clump^{-1}) (Table 1).

Table 1. Effect of Fire on Height and Girth Increment and Average Number of Culms Clump^{-1} of Bamboo Regeneration at Rukhad (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
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012			
F-1 (Fire in March)	80	90	283	461	467	478	3.10	3.50	4.07	6.38	6.87	8.78	398 ±11.36	5.68 ±0.22	7.91 ±0.17
F-2 (Fire in May)	82	97	320	468	487	542	2.90	3.75	4.80	8.02	8.97	10.65	460 ±26.46	7.75 ±0.23	8.60 ±0.36
F3 (Fire in March & May)	104	93	266	287	308	360	3.00	3.20	3.50	3.65	5.10	6.80	256 ±15.62	3.80 ±0.18	5.65 ±0.02
F-0 (No fire)	75	125	222	322	295	350	2.50	3.00	3.90	8.19	8.25	8.50	275 ±21.79	6.00 ±0.70	6.00 ±0.53

Table 2 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 analysis of variance test for each parameter was taken for study. Perusal of data 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 this study, 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 in different replicates and treatments. Further, it can be concluded that height increment, girth increment and number of culms clump^{-1} were significantly different between and within groups among various treatments. The four fire treatments viz; F1 (Fire in March), F2 (Fire in May), F3 (Fire in March & May) and F0 (No fire) given in column 2 (I) were compared between the other groups as given in column 3 (J). The * 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 result indicated that treatment F2 (Fire in May) was the best among the other treatments in terms of height and girth increment and number of culms clump^{-1} (Figures 1, 2 & 3). The mean difference is significant at the 0.05 level as compared to other treatments. The negative sign in control showed that the height and girth increment and number of culms clump^{-1} were inferior to the treated plots. In other words, different Fire treatment affects significantly the clump formation in bamboo.

Table 2. Statistical Analysis (Descriptive, ANOVA and Post Hoc Test) for Fire Experiment

Descriptive									
						95% Confidence Interval for Mean			
Parameter	Treat ment	N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
Height increment	F1	3	398	11.358	6.557	369.786	426.214	385	406
	F2	3	460	26.458	15.275	394.276	525.724	440	490
	F3	3	256	15.621	9.019	217.197	294.804	246	274
	F0	3	275	21.794	12.583	220.860	329.141	250	290
	Total	**12**	**347.3**	**90.252**	**26.054**	**289.906**	**404.594**	**246**	**490**
Girth increment	F1	3	5.68	0.223	0.129	5.127	6.233	5.44	5.88
	F2	3	7.75	0.229	0.132	7.181	8.319	7.5	7.95
	F3	3	3.8	0.180	0.104	3.352	4.248	3.6	3.95
	F0	3	6	0.700	0.404	4.261	7.739	5.5	6.8
	Total	**12**	**5.808**	**1.502**	**0.434**	**4.853**	**6.762**	**3.6**	**7.95**
No. of culms clump^{-1} in 2012	F1	3	7.91	0.174	0.101	7.477	8.343	7.71	8.03
	F2	3	8.6	0.361	0.208	7.704	9.496	8.2	8.9
	F3	3	5.65	0.020	0.012	5.600	5.700	5.63	5.67
	F0	3	6	0.529	0.306	4.686	7.315	5.4	6.4
	Total	**12**	**7.04**	**1.331**	**0.384**	**6.194**	**7.886**	**5.4**	**8.9**

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Height increment	Between Groups	86504.250	3	28834.750	74.508	0.000
	Within Groups	3096.000	8	387.000		
	Total	89600.250	11			
Girth increment	Between Groups	23.570	3	7.857	50.315	0.000
	Within Groups	1.249	8	0.156		
	Total	24.819	11			
No. of culms clump^{-1} in 2012	Between Groups	18.613	3	6.204	56.299	0.000
	Within Groups	0.882	8	0.110		
	Total	19.494	11			

Post Hoc Tests

Multiple Comparisons							
LSD							
Dependent Variable	(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Height increment	F1	F2	-62.000*	16.062	0.010	-99.04	-24.960
		F3	142.000*	16.062	0.000	104.96	179.040
		F0	123.000*	16.062	0.000	85.96	160.040
	F2	F1	62.000*	16.062	0.010	24.96	99.040
		F3	204.000*	16.062	0.000	166.96	241.040
		F0	185.000*	16.062	0.000	147.96	222.040
	F3	F1	-142.000*	16.062	0.000	-179.04	-104.960
		F2	-204.000*	16.062	0.000	-241.04	-166.960
		F0	-19.000	16.062	0.270	-56.04	18.040
	F0	F1	-123.000*	16.062	0.000	-160.04	-85.960
		F2	-185.000*	16.062	0.000	-222.04	-147.960
		F3	19.000	16.062	0.270	-18.04	56.040
Girth increment	F1	F2	-2.070*	0.323	0.000	-2.814	-1.326
		F3	1.880*	0.323	0.000	1.136	2.624
		F0	-0.320	0.323	0.350	-1.064	0.424
	F2	F1	2.070*	0.323	0.000	1.326	2.814
		F3	3.950*	0.323	0.000	3.206	4.694
		F0	1.750*	0.323	0.000	1.006	2.494
	F3	F1	-1.880*	0.323	0.000	-2.624	-1.136
		F2	-3.950*	0.323	0.000	-4.694	-3.206
		F0	-2.200*	0.323	0.000	-2.944	-1.456
	F0	F1	0.320	0.323	0.350	-0.424	1.064
		F2	-1.750*	0.323	0.000	-2.494	-1.006
		F3	2.200*	0.323	0.000	1.456	2.944
No. of culms clump^{-1} in 2012	F1	F2	-.690*	0.271	0.030	-1.315	-0.065
		F3	2.260*	0.271	0.000	1.635	2.885
		F0	1.910*	0.271	0.000	1.285	2.535
	F2	F1	0.690*	0.271	0.030	0.065	1.315
		F3	2.950*	0.271	0.000	2.325	3.575
		F0	2.600*	0.271	0.000	1.975	3.225
	F3	F1	-2.260*	0.271	0.000	-2.885	-1.635
		F2	-2.950*	0.271	0.000	-3.575	-2.325
		F0	-0.350	0.271	0.230	-0.975	0.275
	F0	F1	-1.910*	0.271	0.000	-2.535	-1.285
		F2	-2.600*	0.271	0.000	-3.225	-1.975
		F3	0.350	0.271	0.230	-0.275	0.975

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

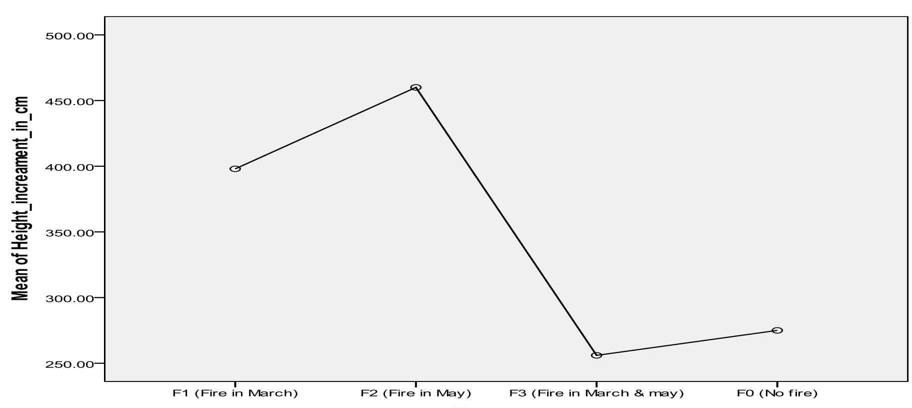


Figure 1. Showing Effect of Fire in Terms of Increment in Mean Height

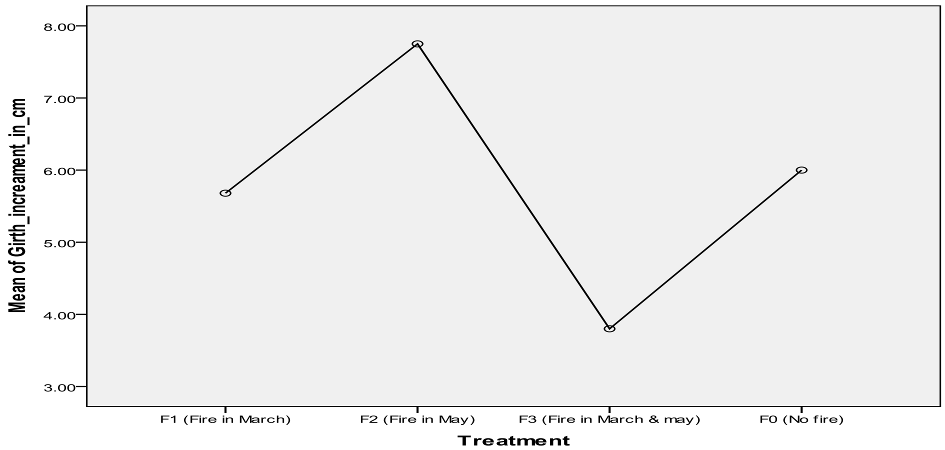


Figure 2. Showing Effect of Fire in Terms of Increment in Mean Girth

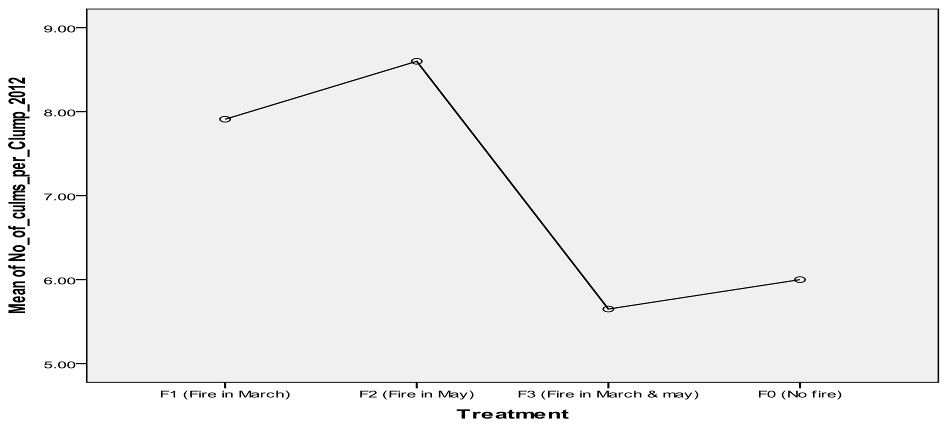


Figure 3. Showing Effect of Fire in Terms of Production of Mean Number of Culms Clump^{-1}

3.2. Effect of Grazing Closure on Rehabilitation of Gregariously Flowered Bamboo Forests

Perusal of data (Table-3) reveals that out of the three treatments of grazing closures, complete closure gave better results in terms of height and girth increment of regeneration and other growth parameters of clump formation, followed by six months and three months grazing closures. The height and girth increments in five years period with complete closure were found to be 345 cm and 6.42 cm, respectively, along with 6.45 culms clump^{-1}, followed by six months closure (327 cm increase in height, 6.35 cm increase in girth and 5.66 culms clump^{-1}) and three months closure (299 cm increase in height, 5.54 cm increase in girth and 3.75 culms clump^{-1}). The average increase in height and girth in open plot (free for grazing) after five years (G-0) was found to be 237 cm and 4.68 cm, respectively with the clump formation of 3.62 culms clump^{-1}. The data indicates that grazing closure is beneficial for the growth of culms and clump formation.

Table 3. Effect of Grazing Closure on Height and Girth Increment and Average Number of Culms Clump^{-1} of Bamboo Regeneration at East Baihar Range of North Balaghat Division (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
	2007	2008	2009	2010	2011	2012	2007	2008	2009	2010	2011	2012			
G-1 (3 - Months from July to September)	31	39	147	199	260	330	0.60	1.10	2.10	3.20	4.95	6.14	299 ±33.81	5.54 ±0.16	3.75 ±0.39
G-2 (6 - Months from July to December)	27	49	171	237	290	354	0.50	1.85	2.80	4.42	5.50	6.85	327 ±10.82	6.35 ±0.13	5.66 ±0.18
G-3 (12 - Months from July to June)	30	56	182	247	330	375	0.50	2.10	3.10	4.47	5.90	6.92	345 ±10.44	6.42 ±0.13	6.45 ±0.22
G-0 (Open for grazing)	33	49	120	177	220	270	0.80	0.80	1.60	2.80	4.35	5.48	237 ±10.82	4.68 ±0.23	3.62 ±0.46

Table 4 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 treatment wise observations for each parameter such as height increment, girth increment and number of culms clump^{-1} during the five years period were taken. The perusal of descriptive results reveals that treatments do differ in mean and range (*i.e.*, maximum and minimum observation). One-way analysis of variance test for each parameter taken for study 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 in different replicates and treatments. Further, it can be concluded that height increment, girth increment and No. of culms clump^{-1} were significantly different between and within groups among various treatments. After determining that all treatments are different, we should know which the best treatment for the parameters of interest is. 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 clump^{-1} during the five years study period. In the first column, the dependent variable is shown as height increment, girth increment and number of culms clump^{-1}. The four grazing closures viz; G1 (July to Sept 3 month), G2 (July to December), G3 (Total closure for the project period) and G0 (Open for grazing) given in column 2 (I) were compared between the other groups as given in column 3 (J). The * 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 G3 **(**July to June for the total project period) was the best among the other treatments in terms of height and girth increment and number of culms clump^{-1} (Figure 4, 5 & 6). The mean difference is significant at the 0.05 level as compared to other treatments. The negative sign in control showed that the height and girth increment and number of culms clump^{-1} were inferior to the treated plots. In other words, different grazing closure affects significantly the clump formation in bamboo.

Table 4. Statistical Analysis (Descriptive, ANOVA and Post Hoc Test) for Grazing Closure Experiment

Descriptive									
Parameter	**Treatment**	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean Lower Bound**	**95% Confidence Interval for Mean Upper Bound**	**Minimum**	**Maximum**
Height increment	G1	3	299	33.81	19.52	215.02	382.98	260	320
	G2	3	327	10.82	6.25	300.13	353.87	315	336
	G3	3	345	10.44	6.03	319.06	370.94	333	352
	G0	3	237	10.82	6.25	210.13	263.87	225	246
	Total	**12**	**302**	**45.82**	**13.23**	**272.89**	**331.11**	**225**	**352**
Girth increment	G1	3	5.54	0.16	0.09	5.15	5.93	5.38	5.69
	G2	3	6.35	0.13	0.08	6.02	6.68	6.25	6.50
	G3	3	6.42	0.13	0.08	6.10	6.74	6.27	6.50
	G0	3	4.68	0.23	0.13	4.12	5.24	4.42	4.84
	Total	**12**	**5.75**	**0.75**	**0.22**	**5.27**	**6.23**	**4.42**	**6.50**
No. of culms clump^{-1} in 2012	G1	3	3.75	0.39	0.23	2.78	4.72	3.36	4.14
	G2	3	5.66	0.18	0.10	5.22	6.10	5.46	5.80
	G3	3	6.45	0.22	0.13	5.91	6.99	6.30	6.70
	G0	3	3.62	0.46	0.26	2.49	4.75	3.10	3.95
	Total	**12**	**4.87**	**1.30**	**0.38**	**4.04**	**5.70**	**3.10**	**6.70**

ANOVA						
		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Height increment	Between Groups	20124	3	6708.000	18.057	0.001
	Within Groups	2972	8	371.500		
	Total	23096	11			
Girth increment	Between Groups	5.994	3	1.998	72.584	0.000
	Within Groups	0.220	8	0.028		
	Total	6.214	11			
No. of culms clump^{-1} in 2012	Between Groups	17.812	3	5.937	54.112	0.000
	Within Groups	0.878	8	0.110		
	Total	18.690	11			

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	G1	G2	-28.000	15.737	0.113	-64.291	8.291
		G3	-46.000*	15.737	0.019	-82.291	-9.709
		G0	62.000*	15.737	0.004	25.709	98.291
	G2	G1	28.000	15.737	0.113	-8.291	64.291
		G3	-18.000	15.737	0.286	-54.291	18.291
		G0	90.000*	15.737	0.000	53.709	126.291
	G3	G1	46.000*	15.737	0.019	9.709	82.291
		G2	18.000	15.737	0.286	-18.291	54.291
		G0	108.000*	15.737	0.000	71.709	144.291
	G0	G1	-62.000*	15.737	0.004	-98.291	-25.709
		G2	-90.000*	15.737	0.000	-126.291	-53.709
		G3	-108.000*	15.737	0.000	-144.291	-71.709
Girth increment	G1	G2	-0.810*	0.135	0.000	-1.122	-0.498
		G3	-0.880*	0.135	0.000	-1.192	-0.568
		G0	0.8600*	0.135	0.000	0.548	1.172
	G2	G1	0.810*	0.135	0.000	0.498	1.122
		G3	-0.070	0.135	0.619	-0.382	0.242
		G0	1.670*	0.135	0.000	1.358	1.982
	G3	G1	0.880*	0.135	0.000	0.568	1.192
		G2	0.070	0.135	0.619	-0.242	0.382
		G0	1.740*	0.135	0.000	1.428	2.052
	G0	G1	-0.860*	0.135	0.000	-1.172	-0.548
		G2	-1.670*	0.135	0.000	-1.982	-1.358
		G3	-1.740*	0.135	0.000	-2.052	-1.428
No. of culms clump^{-1} in 2012	G1	G2	-1.910*	0.270	0.000	-2.534	-1.286
		G3	-2.700*	0.270	0.000	-3.324	-2.076
		G0	0.1300	0.270	0.644	-0.494	0.754
	G2	G1	1.910*	0.270	0.000	1.286	2.534
		G3	-0.790*	0.270	0.019	-1.414	-0.166
		G0	2.04000*	0.270	0.000	1.416	2.664
	G3	G1	2.700*	0.270	0.000	2.076	3.324
		G2	0.7900*	0.270	0.019	0.166	1.414
		G0	2.83000*	0.270	0.000	2.206	3.454
	G0	G1	-0.130	0.270	0.644	-0.754	0.494
		G2	-2.040*	0.270	0.000	-2.664	-1.416
		G3	-2.830*	0.270	0.000	-3.454	-2.206

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

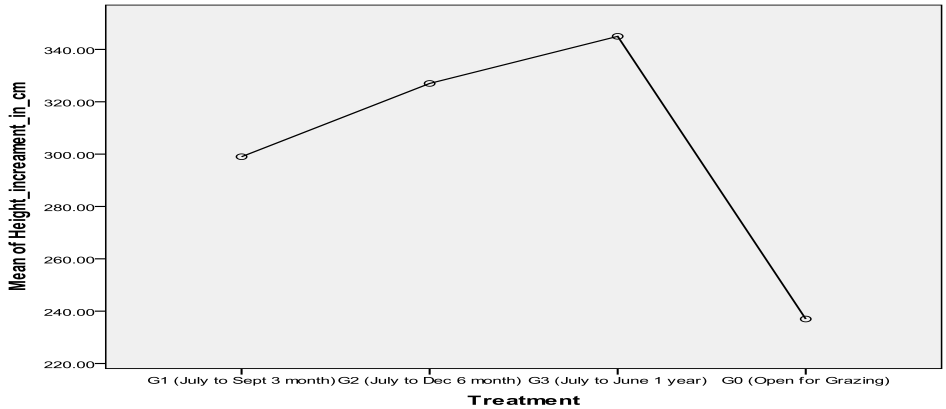


Figure 4. Showing Effect of Grazing Closure in Terms of Increment in Mean Height

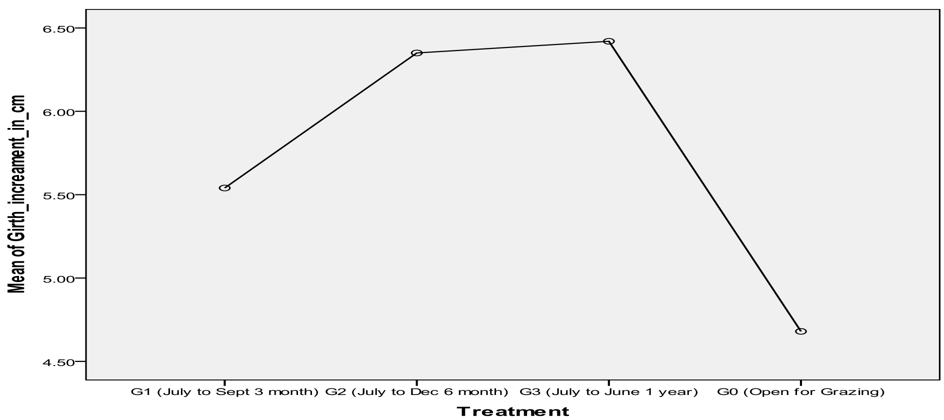


Figure 5. Showing Effect of Grazing Closure in Terms of increment in Mean Girth

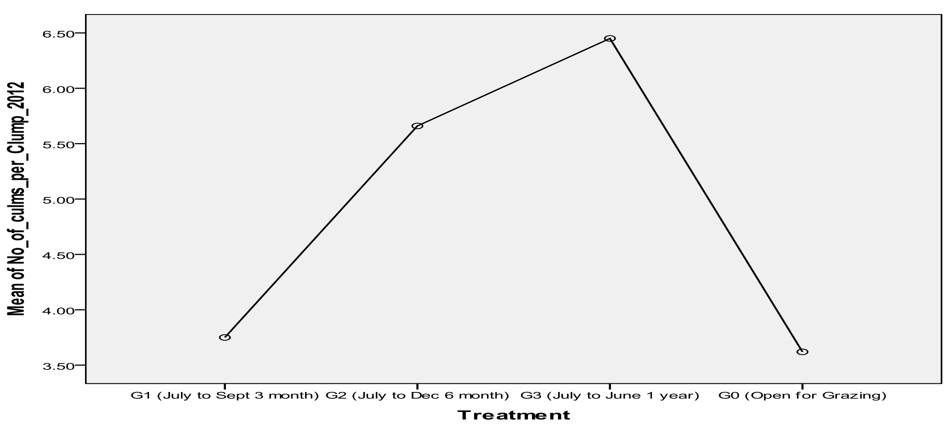


Figure 6. Showing Effect of Grazing Closure in Terms of Production of Mean Number of Culms Clump^{-1}

The root stock of bamboo (*Dendrocalamus strictus*) consists of a dense mass of short rhizomes in which the nodes are close to each other and provided with clusters of small rootlets. In addition, there are one or more eyes at every node which may develop into new rhizomes, and subsequently into new culms but mostly remain dormant. The stimulating effect of fire on culms and clump formation is primarily due to thinning out process of dense natural regeneration, and subsequently in development of more vigorous culms and clumps, as the new rhizomes and their culms have everywhere enough room to develop. Action of fire also stimulates the clump formation due to activation of some dormant buds, which may develop into new culms. The role of protection enjoyed by the grazing- closure leads to ameliorating the physical, chemical and biological conditions of the site. This could be attributed to the development and enhancement of number of culms clump^{-1}.

4. Conclusion

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

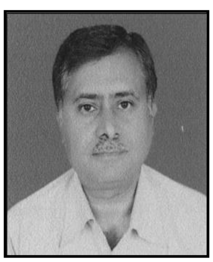
1. Apart from establishment of *ex-situ* rhizome banks, establishment of *in-situ* rhizome banks should be encouraged.
2. The rehabilitation activities to promote clump formation should be initiated after 2-3 years of flowering period while elite formation get started.
3. The single ground fire treatment either in March or in May in a year prove beneficial for natural pruning of dense bamboo carpet and gave better growth than protection from fire up to 5 years period. The fire stimulates the growth of bamboo and greater production of new culms. Thus, during initial period of rehabilitation while elites are formed, natural surface fire for 2-3 hours is recommended, provided that area is completely protected from grazing and other biotic factors.
4. The complete grazing closure for at least five years period is recommended to stimulate growth of bamboo seedlings and formation of clumps.

References

[1] M. Ahmed, “Flowering of seedlings of Dendrocalamus strictus”, Indian Forester, vol. 95, **(1964)**, pp. 214.
[2] A. A. Ansari, O. P. Chaubey, A. Sharma and A. Pandey, “Hand book of bamboos with particular reference to Madhya Pradesh”, SFRI bulletin, no. 45, **(2002)**, pp. 1-53.
[3] B. Birbal, “The flowering of seedlings of Dendrocalamus strictus”, Indian Forester, vol. 25, **(1899)**, pp. 305-306.
[4] A. N. Chaturvedi, “Management of bamboo forests”, Indian Forester, vol. 114, no. 9, **(1988)**, pp. 489-495.
[5] O. P. Chaubey, “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, **(2012)**, pp 1-121.
[6] P. N. Deogun, “The Silviculture and management of the bamboo Dendrocalamus strictus”, Indian Forest Records (NS) Silviculture, II, vol. 4, **(1937)**, pp. 1-173.
[7] A. P. Dwivedi, “Gregarious flowering in Dendrocalamus srtictus in Shahdol (M.P.) Some management considerations”, Indian Forester, vol. 114, no. 9, **(1988)**.
[8] J. S. Gamble, “Bambuseae of British India”, Ann.Roy.Bot.Grad., Calcutta, vol. 7, **(1896)**, pp. 1-133.
[9] GoI, Recommendations “Task Force on Regeneration”, constituted by the Steering Committee on Gregarious Flowering of Muli bamboo in North –East, MOEF, GoI, New Delhi. (Internal Notes), **(2003)**.
[10] A. K. Goyal and J. Kishwan, “Gregarious Flowering of bamboo in North-East India”, Some Management Issues, XI World Bamboo Congress, New Delhi, **(2004)** February.
[11] K. L. Hakeem, “Rehabilitation of flowered bamboo areas of Jabalpur”, Journal of Tropical Forestry, vol. 1, no. 1, **(1985)**, pp. 70-78.

[12] J. Kishwan and A. K. Goyal, "Gregarious flowering of Bamboos in North-East India-Need for Intensive Management", Indian Forester, vol. 134, no. 5, **(2006)**, pp. 525-533.
[13] M. V. Lauris, "Two years old bamboo seedling", Indian Forester, vol. 63, **(1937)**, pp. 857.
[14] G. S. Mathuda, "Flowering habit of the bamboo", Dendrocalamus strictus, Indian Forester, vol. 78, **(1952)**, pp. 86-88.
[15] H. B. Naithani, "Contributions to the taxonomic studies of Indian bamboos", Ph.D Thesis, Garhvwal University, Srinagar, vol. 2, **(1993)**, pp. 278.
[16] P. L. S. Pathak, "Seedlings of Dendrocalamus strictus in flower", Indian Forester, vol. 25, **(1899)**, pp. 22.
[17] V. R. Prabhu and S. L. Dabral, "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), **(1989)** December 13-15, pp. 59-77.
[18] R. Prasad, "Effects of grazing closure on rehabilitation of flowered bamboos areas in Mandla forest in Madhya Pradesh", Journal of Tropical Forestry, vol. 1, no. II, **(1985)**, pp. 145-151.
[19] R. Prasad and A. S. Parihar, "Rehabilitation and management of flowered bamboos in Mandla-Jabalpur forests of Madhya Pradesh", Journal of Tropical Forestry, vol. 10, **(1994)**, pp. 1, 3-7.
[20] S. N. Rai and K. V. S. Chauhan, "Distribution and growing stock of bamboos in India", Indian Forester, vol. 124, no. 2, **(1998)**, pp. 89-98.
[21] R. Gopal, "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, Institute of Deciduous Forests, Jabalpur (M.P), **(1989)** December 13-15, pp. 1-19.
[22] J. K. Rawat and D. C. Kahduri, "National Report on the status of Bamboos and Rattan in India", Submitted to, INBAR sponsored workshop on "Strategy 2005"Beijing (China), **(1999)** April 12-14.
[23] RFRI (Rain Forest Research Institute), Recommendations of Expert Consultation on "Strategies for sustainable utilization of bamboo resources subsequent to Gregarious Flowering in North-East", at RFRI, Jorhat (Assam), **(2002)** April 24-25.
[24] N. C. Shah, "Flowering of bamboos, Dendrocalamus hookeri and Dendrocalamus strictus in Assam and Bihar States", Indian Forester, vol. 94, **(1968)**, pp. 717.
[25] H. N. Tatwawadi and B. G. Kali, "Gregarious flowering of bamboo Dendrocalamus strictus in Jarida range of East Melghat division", Amravati Circle – Maharashtra State.Indian Forester, vol. 109, no. 2, **(1983)**, pp. 111-114.
[26] R. S. Troup, "The Silviculture of Indian Trees", Oxford Publication, vol. 3, **(1921)**, pp. 977-1013.

Authors



Dr. O. P. Chaubey, is working as Head of Forest Botany Branch in M.P. State Forest Research Institute, Jabalpur (M.P.) India. He was awarded in Ph.D. degree in Forest Ecology in 1986 from Dr. H.S. Gaur University, Sagar, (Madhya Pradesh, India). He has to his credit two books, 13 monograph of various forestry species and more than 75 research papers published in both National and International journals. He has 30 years of research experience in field of forestry. He has completed more than 22 externally funded research projects in the capacity of Principal Investigator. He has organized a number of symposia/ workshops at National and State levels. He has imparted trainings to field foresters, University scholars, NGOs and Rural Communities engaged in conservation and management of biological diversity.

Dr. Archana Sharma, is working as Head of Seed Technology Branch in M.P. State Forest Research Institute, Jabalpur. She was awarded in Ph.D. degree in Seed Science in 1993 from Dr. H.S. Gaur University, Sagar, (Madhya Pradesh, India). She has to her credit more than 50 research paper published in both National and International journals, three bulletins and fourteen brochures. She has 20 years of research experience in seed technology. She has completed more than 15 externally funded research projects in the capacity of Principal Investigator. She has organized a number of trainings and workshops at National and State levels. She has imparted trainings to field foresters, University scholars, NGOs and Rural Communities engaged in seed technology, sustainable management and harvesting of bio resources.

Dr. Ram Prakash, is an Indian Forest Service (IFS) Officer of 1981 batch, borne on Madhya Pradesh cadre. Besides working in various capabilities as field forester, he possesses long forestry research experience of about 20 years by serving as Additional Director and Director, State Forest Research Institute, Jabalpur (M.P.). He has worked in various fields of forestry research, like silviculture, management, extension, etc. He was awarded Ph.D. degree in Physics, by Agra University. He has to his credit a number of research reports, brochures and research papers published in various scientific journals. He has also conducted study tours to Norway. Currently he has been working as the director, State Forest Research Institute, Jabalpur since January 2012.