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Long term productivity of selected mutagen induced variants of *Bambusa pallida* Munro

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Abstract

Bamboos are versatile multipurpose plants signifying sustainability and a sound socio-economics of the rural households in many parts of the world including the north-east India. Bamboo improvement is difficult because of its long flowering cycle and non-synchrony of flowering among the donor and the recipient species. Hence, genetic improvement of *B. pallida* through chemical mutation for traits such as fibre quality, growth and culm maturity was envisaged. The paper describes the cumulative performance of selected mutants. Observations on 15 selected clumps (3 colchicine treated and 10 ethrel treated) along with two untreated controls were recorded over seven years from 1995 to 2001. Total biomass per clump was very high in colchicine induced variants as compared to ethrel and control. Selections 1 and 11 (both colchicine treated) were marked for higher biomass/clump. Clump number 20, out of the ethrel treated variants, showed the highest culm dry matter (13.30 kg) in the experiment. Selected culm numbers 1 and 11 (both colchicine treated) and culm numbers 17 and 29 (both ethrel treated) were good for total culm weight.

Key Words : *Bambusa pallida,* Biomass, Colchicine, Ethrel, Mutant, Productivity

Introduction

Bamboos are versatile multipurpose plants signifying sustainability and a sound socio-economics of the rural households in many parts of the world including the north-east India (Singh, 2002). India has a rich diversity of over 130 bamboo species (Sharma, 1980) of which nearly half the species occur in north-east region (16 genera, 63 species) alone (Kochhar and Rana, 1993; Hore, 1998) A few of the bamboo species are commercially exploited worldwide. Improved varieties of bamboo species are also lacking. Bamboo improvement is difficult because of its life cycle. Long flowering cycle of many bamboo species and a possible non-synchrony of flowering among the donor and the recipient species are some of the specific reasons. Thus, despite the availability of diversity in bamboos for several desirable traits in many wild and semi-cultivated taxa, it is difficult to transfer them through conventional means for further improvement of the cultivated species. Nevertheless, few attempts of genetic improvements in bamboos have been made through random selection of superior types (Singh, 1986; Beniwal and Singh, 1990) or through induction of variation followed by selection (Kochhar *et al.*, 1994a, 1995). The study was carried out at ICAR Research Complex for NEH Region research farm in Arunachal Pradesh, India (27°95' North and 94°1' east of equator located at 660 meters above average sea level). The species was selected on the basis of some of its merits such as, (i) semi-cultivated habit, particularly its preferred cultivation and use by the tribal and rural communities in north-east India, and (ii) easy management and harvesting operations of clumps due to erect growth habit, slender culms, little branching, and non-spiny nodes, *etc*. Manifestation of all these characteristics together renders *B. pallida* suitable for cultivation under high density and management practices (Kochhar *et al.*, 1994a, 1995). It was hypothesized that genetic improvement of *B. pallida* through chemical induction of variability for traits such as fibre quality, growth and culm maturity and making selection for promising and desirable types can yield favourable results. The studies were initiated in 1988 and early reports have been published in 1994 and 1995. The scope of selections was enlarged with the inclusion of a few relevant agronomic parameters. This paper describes the cumulative performance of selected mutants of *Bambusa pallida* Munro.

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Materials and Methods

Research Farm, Indian Council of Agricultural Research (ICAR) at Basar, district West Siang, Arunachal Pradesh, India (27°95' North and 94°1' East of equator located at 660 meters above mean sea level) has been the site of experimentation since March 1988. The climate of Basar is humid subtropical. Mean annual rainfall is 2370 mm, which is spread over an average period of 149 days. Major precipitation period is between April to October wherein two rainfall peaks are recorded i.e. in the months of April and July. The mean maximum temperature ranges from 12.7°C (January) to 39.0°C (July to September) and mean minimum temperature varies from 3.3°C (February) to 28.3°C (August). The natural vegetation comprises of wet evergreen and tropical moist deciduous forests. The area represents an *Udic* soil moisture regime and hyperthermic soil temperature regime. The treated seedlings were planted in a narrow level field in valley area inside the farm where the soil was clay loam rich in organic matter (Kochhar *et al.,* 1994a). Selections made from the treatments were transplanted on a hill slope (25% gradient) having similar soil properties.

Seedlings of *B. palllida* were collected from natural habitat of Siji in West Siang district of Arunachal Pradesh, India. Chemical inductions with colchicine and ethrel were done in March 1988 (Kochhar *et al.,* 1994a). The treated seedling were divided in two sets, one for field nursery and another for polythene tube nursery consisting of polythene tubes (45x15 cm diameter) filled with sand and compost (3:1). The field nursery was transplanted at l x l m spacing. The polythene tube nursery was transferred to field nursery in two sets, *i.e*., when the age of seedlings was three and nine months in the early and late transplanted sets, respectively. As wide phenotypic variation was observed in the experimental nursery (Kochhar *et al*., 1994a, 1994b, 1995), early selections were made for the promising types. Out of a total population of 116 clumps in the experiment, 15 promising ones were selected at a two year nursery stage. These selections were then re-transplanted by rhizome splitting, at a spacing of 6 x 6 m, in two replications, at the hill slope (25%) at the research farm. Observations on selected parameters of agronomic importance were further recorded on the 15 selected clumps (3 colchicine treated and 10 ethrel treated) along with two untreated controls over seven years from 1995 to 2001.

Results and Discussion

Number of culms per clump

The cumulative production of culms in two colchicine treated selections, *viz*. clump numbers 1 and 11, was higher than that in the ethrel induced variant selections, which was at par with untreated control. This was in conformity with the visual selections made at the early stage. Similarly, two ethrel induced variant selections, *viz*., 29 and 26, recorded a higher cumulative culm production per clump. Among the individual treatments, the colchicine and ethrel treated clump numbers 1 and 29 respectively showed highest growth in the expression of this trait at later stage, *i.e*., between 1995 and 2001 (Table 1).

Table 1 : Cumulative production of culms/clump in different selections of chemically induced variants over the years

Selections	Number of culms/clump in different years						
	1995	1996	1997	1998	1999	2000	2001
Colchicine induced variants							
1	29	45	52	58	61	77	97
11	33	45	50	53	58	66	95
12	34	37	43	56	57	58	59
Mean	32.0	42.3	48.3	55.7	58.7	67.0	83.7
Ethrel induced variants							
15	26	32	41	43	46	47	48
17	29	34	38	42	52	58	65
20	20	24	38	40	44	44	45
21	23	31	35	53	57	59	59
23	27	40	43	44	51	56	62
24	27	31	36	39	40	61	68
25	38	45	51	53	59	60	61
26	26	28	44	61	64	69	74
29	21	36	45	51	58	72	82
31	26	28	32	42	45	51	58
Mean	26.3	32.9	40.3	46.8	51.6	57.7	62.2
Control							
43	14	30	36	38	44	48	52
71	34	46	53	62	63	65	67
Mean	24.0	38.0	44.5	50.0	53.5	56.5	59.5

Expansion of clump circumference

Three ethrel treated variant selections, *viz*., 26, 25 and 24 recorded the highest clump circumference expansion over the years with the respective values 9.79, 8.95 and 8.76 in 2001. However, the lowest value for this trait was also recorded in one of the ethrel treated variant selection only. Clump number 15 out of this treatment group recorded 6.62 meters clump circumference in 2001 (Table 2). On the other hand, colchicine induced mutants, in general, expressed low value for this trait.

Leaf characteristics

A perusal of table 3 indicates that leaf size in most of the selections was at par except in one of the colchicine treated clumps (clump number. 1), which showed slightly shorter and thinner leaves. This selection further showed significant difference in respect of number of internodes

Table 2 : Expansion of circumference of clump in different selections of chemically induced variants over the years

Selections	Clump circumference over the years (meters)						
	1995	1996	1997	1998	1999	2000	2001
Colchicine induced variants							
1	4.15	4.70	5.03	5.48	6.83	7.00	7.18
11	3.80	4.10	4.92	5.38	5.50	7.30	7.46
12	3.50	4.05	4.98	6.30	7.28	7.30	7.32
Mean	3.82	4.28	4.98	5.72	6.54	7.20	7.32
Ethrel induced variants							
15	3.15	4.20	4.95	5.63	6.38	6.50	6.62
17	4.05	4.05	5.15	5.45	5.60	7.40	7.60
20	3.40	3.70	4.10	5.08	6.33	6.50	8.10
21	2.90	3.49	4.25	5.38	7.05	7.20	7.35
23	4.15	4.60	5.65	5.70	7.30	7.70	8.12
24	4.83	5.39	5.35	4.58	5.73	7.00	8.76
25	4.23	4.65	5.20	6.70	6.80	7.80	8.95
26	3.50	4.85	5.50	6.83	8.53	9.10	9.79
29	4.35	5.08	5.25	5.89	7.18	7.50	7.83
31	3.40	3.95	4.80	7.10	6.55	7.20	7.91
Mean	3.80	4.40	5.02	5.83	6.75	7.39	8.10
Control							
43	3.15	3.95	4.85	5.58	6.45	7.10	7.82
71	3.80	5.30	5.55	6.72	7.90	7.90	8.10
Mean	3.48	4.63	5.20	6.15	7.18	7.50	7.96

per culm, which were lesser (28.2) than other selections, and mean internode length, which was longer (40.4 cm). Clump number 20, a selection from ethrel induced variants, showed the thickest culms (rind thickness 0.42 cm) as compared to other selections (mean thickness 0.35 cm). Another selection, clump number 23 showed conspicuous sparse habit as the average spacing between two culms was the widest (43.5 cm) among all the selections (mean value 34.7 cm). Thus, both the chemical treatments were effective in inducing additional variability for culm and leaf characteristics in this experiment.

Dry biomass yield

Contribution of leaf dry matter in total biomass production was high in both colchicine and ethrel induced variants in comparison to control (Table 4). On the other hand, the mean values for dry matter of individual culms and branches were lower than control. Overall, the selections clump number 1 (colchicine treated) and culm numbers 15, 17, 20 (all ethrel treated) were superior for leaf dry matter production, whereas selection 11 (colchicine treated) and selections 15, 17 and 20 (all ethrel treated) showed superiority for total dry matter production.

Total biomass per clump was very high in colchicine induced variants as compared to ethrel and control. Selections 1 and 11 (both colchicine treated) were particularly marked for higher biomass/clump. Clump number 20, out of the ethrel treated variants, showed the highest culm dry matter (13.30 kg) in the experiment but the dry matter for branches was low (0.88 kg). Overall, selections culm numbers 1 and 11 (both colchicine

Table 3 : Characteristics of leaves and culms in different selections of chemically induced variants during 2001

Selec-tions	Leaf characteristics Length (cm)	Width (cm)	Culm height (m)	Number of internodes per culm	Characteristics of internodes: Mean length (cm)	Mean diameters (cm)	Culm thickness (cm)	Hollowness diameter (cm)	Spacing between two culms (cm)
Colchicine induced variants									
1	16.92	1.77	12.2	28.2	40.4	11.3	0.38	3.20	35.0
11	18.18	1.90	14.3	39.0	35.5	11.2	0.36	3.19	33.5
12	18.96	1.95	12.0	32.4	35.9	11.4	0.36	3.26	32.6
Mean	18.02	1.87	12.83	33.2	37.3	11.3	0.37	3.22	33.7
Ethrel induced variants									
15	18.52	1.87	13.8	37.0	34.2	10.4	0.35	2.95	35.0
17	17.48	1.78	12.7	36.0	33.0	10.2	0.41	2.84	30.7
20	18.18	1.86	13.0	34.6	34.7	11.1	0.42	3.11	36.9
21	18.47	1.86	13.1	30.8	40.3	11.4	0.41	3.22	29.7
23	18.26	1.75	11.7	32.6	34.7	9.9	0.33	2.79	43.5
24	17.90	1.80	12.5	33.0	33.6	9.3	0.31	2.66	36.0
25	18.85	1.93	12.9	36.2	35.4	10.4	0.32	2.97	34.0
26	18.10	1.88	12.6	35.0	32.8	9.7	0.30	2.78	34.0
29	18.01	1.86	11.7	33.4	31.7	9.2	0.37	2.57	29.6
31	17.93	1.82	12.7	31.6	36.9	10.4	0.32	2.93	37.9
Mean	18.17	1.84	12.67	34.02	34.73	10.2	0.354	2.88	34.7
Control									
43	19.48	2.01	11.3	30.0	33.7	11.2	0.39	3.16	33.7
71	16.35	1.64	14.0	37.0	34.8	10.2	0.33	2.91	32.7
Mean	17.92	1.83	12.7	33.5	34.3	10.7	0.36	3.04	33.2

treated and culm numbers 17 and 29 (both ethrel treated) were particularly good for total culm weight. Figure 2 further illustrates the variation resulted from chemical induction in dry biomass production and the contribution of different components in its production.

Table 4 : Biomass accumulation in different components of a culm and total biomass produced by a clump in different selections of chemically induced variants during 2001

Selections	Dry matter (kg)				
	Leaves	Branches	Culm	Total weight	Total biomass /clump (kg)
Colchicine induced variants					
1	1.68	1.15	7.84	10.67	1132
11	1.02	1.22	11.6	13.84	1038
12	0.70	0.54	7.56	8.80	519
Mean	1.133	0.97	9.00	11.43	896
Ethrel induced variants					
15	1.60	0.86	11.20	13.66	656
17	1.34	1.06	11.34	13.74	893
20	1.50	0.88	13.30	15.68	607
21	0.58	1.14	9.30	11.02	650
23	1.00	0.66	7.36	9.02	559
24	0.66	1.02	8.84	10.52	610
25	1.00	1.00	9.54	11.54	704
26	1.06	0.86	9.00	10.92	808
29	0.96	0.82	8.80	10.58	868
31	1.20	0.70	9.16	11.06	642
Mean	1.09	0.90	9.78	11.77	700
Control					
43	1.08	1.48	8.72	11.28	587
71	0.78	1.04	11.68	13.50	905
Mean	0.93	1.26	10.20	12.39	746

Litter fall

Floor litter production is an important trait as it increases the soil organic matter. Both colchicine and ethrel induced variants performed better than control for this trait. Selections clump number 1 (colchicine treated) and clump numbers 15, 24, 29 and 26 (all ethrel treated) showed promise for this desirable trait (Table 5). The litter production over the years showed a linear increasing trend. However, the highest litter production (15.3 t/ha) was recorded in the ethrel treated clump number 24 in the year 2001.

As *B. pallida* is a long duration crop, hence, the present study aimed at selection of desirable plant types from the mutant population of *B. pallida* based on long term evaluation of selected culm. Further, these selections can be vegetatively propagated as improved variants at least for a period coinciding with the natural flowering cycle of *B. pallida, i.e.* 18 years. This is because with the natural,

Table 5 : Production of floor litter (t/ha) in different selections of chemically induced variants over the years at a density of 156 clumps/ha.

Selections	Floor litters (t/ha)				
	1997	1998	1999	2000	2001
Colchicine induced variants					
1	10.3	11.5	12.1	13.7	14.5
11	10.8	11.4	12.5	13.3	13.8
12	9.9	11.9	12.1	12.2	12.4
Mean	10.3	11.6	12.2	13.1	13.6
Ethrel induced variants					
15	13.2	13.8	14.8	14.5	14.7
17	9.4	10.4	12.9	13.6	14.0
20	11.8	12.4	13.7	13.1	13.6
21	8.1	11.3	12.2	12.4	12.3
23	10.2	10.4	12.1	12.7	13.0
24	11.8	12.8	13.1	14.8	15.3
25	10.9	11.4	12.7	12.9	13.0
26	9.3	12.9	13.5	14.0	14.3
29	9.9	11.2	12.7	14.2	14.7
31	9.0	11.8	12.6	13.4	14.3
Mean	10.36	11.84	13.03	13.56	13.92
Control					
43	9.1	9.6	11.1	11.6	11.8
71	10.5	12.3	12.5	12.7	12.8
Mean	9.8	11.0	11.8	12.2	12.3

gregarious flowering of the mother clump along with all its derivatives, their clump death will also occur. Another added advantage of the present approach could be that the variation induction, selection and vegetative clonal multiplication, as planned in this study, eliminated the problems such as, 'reverting back of mutants' or 'sterility of mutants', *etc.,* which may normally occur in the sexually reproducing plants through meiosis and fertilization.

Nevertheless, the results clearly indicated the effectiveness of both the chemicals used, *i.e.,* colchicine and ethrel in creating the variability in the target species, and thereby as a tool in genetic improvement of *Bambusa pallida*. This study further confirms the hypothesis and it also leaves further scope of expansion of the technical programme of work in the next cycle of improvement from the natural seedlings of *B. pallida* or that from the selected variants. The two chemicals were also quite effective in inducing variation in the plant type of *B. pallida*.

As the flowering behaviour of bamboos make them a difficult or nearly impossible target of conventional improvement programme (though hybridization and selection), induced mutation coupled with clonal propagation has shown the advantage in fixing the variation and selection for desirable traits. The plant types or improved clumps developed for suitability to different situations could be a new intellectual property that may be protected and maintained for exclusive commercial exploitation.

The induced variations can be attributed to physiological induction of vigour and / or chromosomal aberrations or aneuploidy as presumed by us in our previous communication (Kochhar *et al*., 1994a). However, these hypotheses are only subject to confirmation through planned studies. Another aspect that needs to be further studied is the dosage effect of individual chemical treatments used in the present studies. Thus, the suitable promising selections from the present study can be multiplied for large-scale plantation or for live fencing or ornamental purposes.

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