RADIO-SENSITIVITY OF *BAMBUSA ARUNDINACEA* TO GAMMA RAYS

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LOKESHA, R., VASUDEVA, R., SHASHIDHAR, H. E., & REDDY, A. N. Y. 1994. Radio-sensitivity of *Bambusa arundinacea* to gamma rays. The radio-sensitivity of *Bambusa arundinacea* was assessed by exposing the seeds collected from a deciduous forest following a mast flowering, to gamma rays with 10 to 150 *kR* doses at 10 *kR* interval. Observations on seed germination, seedling mortality, shoot and root lengths, number of leaves and internodes were recorded. Lethal dose-50 (LD-50) was assessed by using linear regression analysis. Gamma rays enhanced seed germination in 10 *kR* treatment compared to the control, drastically reduced and delayed germination in 20 and 30 *kR* treatments respectively and completely inhibited germination above 30 *kR*. Seedling mortality was highest in 30 *kR* dose. Surprisingly, the control recorded comparatively higher mortality of emerged seedlings than the 10 and 20 *kR* treatments which is thought to be due to the death of weak seedlings originating from seeds with partial endosperms. Stimulatory effect was seen for shoot length, number of nodes and leaves. Root length decreased linearly with increase in dose. 'Albino' was the most frequently observed chlorophyll mutation type. LD-50 for seed germination was 19.37 *kR*, 26.30 *kR* for shoot length and 22.04 *kR* for root length indicating the high radio-sensitivity of *B. arundinacea*. Possible biological reasons are discussed.

Key words: Gamma irradiation - radio-sensitivity - *Bambusa arundinacea* - LD-50

LOKESHA, R., VASUDEVA, R., SHASHIDHAR, H.E., & REDDY, A.N.Y. 1994. Keradiopekaan *Bambusa arundinacea* terhadap sinar gama. Keradiopekaan *Bambusa arundinacea* telah dinilai dengan mendedahkan bijibenihnya pada sinar gama dengan dos sebanyak 10-150 *kR* dengan selang 10 *kR*. Bijibenih ini dikutip daripada hutan daun luruh selepas musim bunga. Pemerhatian pada percambahan bijibenih, kematian anak benih, panjang pucuk dan panjang akar serta bilangan daun dan

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bilangan ruas direkodkan. Dos Maut-50 [Lethal Dose (LD-50)] dinilai dengan menggunakan analisis regresi linear. Sinar gama pada rawatan 10 *kR* mempertingkatan percambahan bijibenih berbanding dengan kawalan. Sinar gama pada rawatan 20 *kR* dan 30 *kR* melambatkan dan mengurangkan dengan drastik percambahan bijibenih. Sinar gama pada rawatan yang melebihi 30 *kR* pula menghalang percambahan biji benih. Kematian anak benih yang paling tinggi berlaku pada dos 30 *kR*. Kawalan telah merekodkan kematian anak benih baru bercambah yang lebih tinggi daripada rawatan dalam dos 10 *kR* dan 20 *kR*. Ini menghairankan dan mungkin disebabkan oleh kematian anak benih yang lemah daripada bijibenih separa endosperma. Sinar Gama memberikan kesan yang merangsang pada panjang pucuk, bilangan nod dan bilangan daun. Panjang akar berkurangan secara linear dengan pertambahan dos. Jenis mutasi klorofil yang paling kerap diperhatikan ialah "balar". LD-50 untuk percambahan bijibenih ialah 19.37 *kR* manakala untuk panjang pucuk, LD-50 ialah 26.30 *kR* dan LD-50 untuk panjang akar ialah 22.04 *kR*. Ini menandakan keradiopekaan yang lebih tinggi untuk *Bambusa arundinacea.* Alasan dari segi biologi yang mungkin menyebabkan ini berlaku dibincangkan.

Introduction

Induced mutations have been adopted extensively in field crop improvement with considerable success (Nilan 1981). Though the potential of induced mutations for the improvement of forest plant species was recognised in early 1960's (Gustafsson 1960, Sparrow *et al.* 1968), reports on the use of this tool for tree improvement are scanty. This dearth may be because most tree species are out breeders and have long life cycle.

We are not aware of any documented evidence of the use of induced mutations to improve economic traits (like higher culm production and growth rate , *etc.*) in *Bambusa arundinacea* (Retz.) Willd. an important commercial forest species (Reddy *et al.* 1990). The likely reasons for this might be its very long and unpredictable pre-flowering period as well as its monocarpic nature. However, in the light of recent developments in tissue culture techniques (Nadgauda *et al.* 1990) to induce precocious flowering (which allows rapid advancement in regeneration), genetic improvement of bamboo through mutagenesis may become relevant. Bamboo has an additional advantage of propagation by vegetative means; hence superior and useful mutants for economic traits, if isolated, can easily be maintained and commercially exploited.

The initial and the important step in mutation breeding programme would be to assess the effective dose (lethal dose-50 or LD-50). In this paper we report the radio-sensitivity of *B. arundinacea* and the LD-50 of a physical mutagen (gamma rays) for a few biological parameters, *viz.*, seed germination, shoot length and root length.

Materials and method

Bambusa arundinacea, a common bamboo species of peninsular India, has a flowering cycle of 30-35 *y* (Varmah & Bahadur 1980). Seeds were collected from the Mudumalai Forest Range (11° 32'N, 76° 22' E) following a mast flowering of this species in March, 1991. A preliminary viability test was conducted (34.40%

germination, sample size n=1000) before seeds were exposed to gamma rays (source: Co 60) with 10 to 150 *kR* doses at 10 *kR* intervals at the Bhabha Atomic Research Centre, Bombay. The seeds had a mean moisture content of 5% (sample size n=300, mean moisture content $\bar{X} = 5.071 \pm 0.37\%$).

Following irradiation, seeds were dehusked before they were sown in trays (1.5 × 1 × 0.05 *m*) containing sterilized sand. Two treatments were accommodated in each tray and in each treatmeant 1000 seeds sampled at random from among the irradiated seeds were sown in furrows spaced 5 *cm* apart. Distilled water was sprayed on alternate days.

Observations on seed germination and seedling mortality were recorded on the 8th, 11th, 13th, 17th, 21st, and 28th days after sowing. Seedling survival, shoot and root lengths, number of leaves and internodes were recorded on the 28th day. Types and frequency of different chlorophyll mutations were also scored. LD-50 was estimated using linear regression analysis (Panse & Sukathme 1961).

Results and discussion

Though gamma rays enhanced seed germination in the 10 *kR* treatment compared to the control, they drastically reduced germination at doses of 20 and 30 *kR* and inhibited germination at dosage above 30 *kR* (Table 1). A major fraction of the germinated seeds emerged within eight days after sowing in the control and the 10 *kR* treatment (82% and 69% respectively), while in the 20 and 30 *kR* treatments there was a delay by three days (Figure 1). In the control, seedling emergence was completed within 13 days, whereas in the 10 and 20 *kR* treatments it continued up to 21 days. However, in the 30 *kR* treatment, except for one seedling which emerged between 13 and 17 days after sowing, all the others emerged within 13 days (Table 1 and Figure 1). Seedling mortality was highest in the 30 *kR* dose. Surprisingly, 10 and 20 *kR* treatments recorded comparatively lower mortality of emerged seedlings than the control (Table 1).

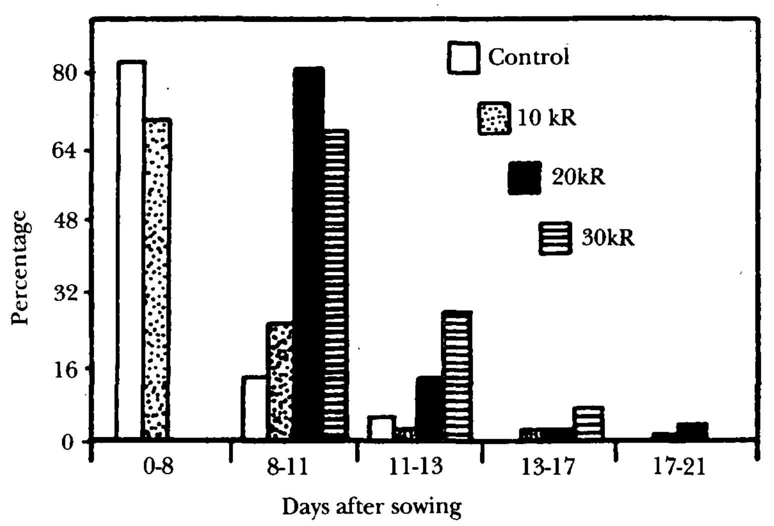

Figure 1. Percentage of seedlings emerged across days in *Bambusa arundinacea*

Table 1. Number of seeds germinated, seedlings died and cumulative frequency of seedlings survived under various treatments across days

Treatment (*kR*)	Seeds germinated	No. of seedlings died	Cumulative frequency of seedlings survived
8th day :			
0 (Control)	414	0	414 (41.40)
10	364	0	364 (36.40)
20	0	0	0
30	0	0	0
40	0	0	0
11th day :			
0 (Control)	68	0	482 (48.20)
10	135	0	499 (49.90)
20	138	0	138 (13.80)
30	10	0	10 (1.00)
40	0	0	0
13th day:			
0 (Control)	24	0	506 (50.60)
10	13	0	512 (51.20)
20	24	0	162 (16.20)
30	4	0	14 (1.40)
40	0	0	0
17th day:			
0 (Control)	0	4	502 (50.20)
10	13	0	525 (52.50)
20	5	0	167 (16.70)
30	1	0	15 (1.50)
40	0	0	0
21st day:			
0 (Control)	0	18	484 (48.40)
10	4	0	529 (52.90)
20	6	0	173 (17.30)
30	0	0	15 (1.50)
40	0	0	0
28th day:			
0 (Control)	0	60	424 (42.40)
10	0	14	515 (51.50)
20	0	11	162 (16.20)
30	0	5	10 (1.00)
40	0	0	0

Values in parentheses indicate percentage of total seeds (n=1000) sown under each treatment.

Enhanced germination and increased seedling vigour at low doses of radiation have been observed by several workers in tree species, *viz.*, pine (Dobrev 1986), subabul (Khamankar & Singh 1988) and *Albizia lebbek* (Singht & Paliwal 1987), which is frequently been referred to as stimulatory effect. This could be due to enhanced rate of respiration or auxin metabolism in seedlings.

The inability of seeds to germinate at higher doses of gamma rays has been attributed to several reasons, *viz.*, (a) numerous histological and cytological changes, (b) disruption and disorganisation of tunical layer which is directly proportional to intensity of gamma rays exposure, and (c) impaired mitosis or virtual elimination of cell division in the meristamatic zones during germination.

Higher mortality seen in the control could be due to death of seedlings originating from seeds with partially developed endosperms (Gadgil & Prasad 1989). However, increased seedling survival record in the 10 and 20 *kR* treatments may be attributed to enhanced number of leaves probably as a consequence of reduced internodal length leading to increased photosynthesis.

Stimulatory effect was not observed for mean root length which decreased linearly with dosage, while shoot lengh, number of nodes and leaves per seedling increased with initial dosage, but decreased at higher doses (Table 2). Stimulatory effect was seen for shoot length in the 10 *kR* treatment, for number of nodes in the 10 and 20 *kR* treatments and for number of leaves in all the treatments (Table 2).

Table 2. Effect of gamma rays on shoot length, root length, number of leaves and internodes per seedling on the 28th day

Treatment (*kR*)	n	Mean ± SE
1. Root length (*mm*):		
a. Control	51	4.02 ± 1.41
b. 10	50	3.63 ± 1.15
c. 20	25	2.48 ± 0.16
d. 30	10	1.01 ± 0.08
2. Shoot length (*cm*):		
a. Control	51	5.22 ± 2.33
b. 10	50	5.89 ± 3.53
c. 20	25	4.71 ± 0.32
d. 30	10	2.13 ± 0.38
3. Number of nodes:		
a. Control	51	1.65 ± 0.63
b. 10	50	1.70 ± 1.07
c. 20	25	2.00 ± 0.15
d. 30	10	1.20 ± 0.25
4. Number of leaves:		
a. Control	51	1.78 ± 0.58
b. 10	50	2.14 ± 0.88
c. 20	13	3.24 ± 0.19
d. 30	4	3.00 ± 0.30

'Albino' was the most frequently observed chlorophyll mutation type in all the treatments, 'xantha' was recorded only in the control while 'viridis' was not recorded in any treatment (Table 3). Though the 10 *kR* treatment recorded a slight reduction in frequency of chlorophyll mutations compared to the control, the 20 *kR* treatment recorded the highest, indicating the higher rate of mutations in chorophyll synthesis mechanism (Table 3). The chlorophyll mutations recorded even in the control indicate that bamboo cohorts carry substantial frequencies of recessive lethals.

Table 3. Type and frequency of chlorophyll mutations

	Treatment (kR)	Seeds sown	Seeds germinated	Chlorophyll mutant types albino	xantha	total
1.	Control	1000	506	3	1	4 (7.91×10^{-3})
2.	10	1000	526	3	-	3 (5.70×10^{-3})
3.	20	1000	173	2	-	2 (11.56×10^{-3})
4.	30	1000	15	-	-	0

Values in parentheses indicate frequency.

Lethal dose-50 computed according to linear regression analysis was found to be 19.37 *kR* for seed germination ($y = -3.0159x + 108.42$; $r^2 = 87\%$), and 26.30 *kR* for shoot length ($y = -2.6809x + 120.49$; $r^2 = 87\%$) and 22.04 *kR* for root length ($y = -2.65x + 108.40$; $r^2 = 97\%$). The low LD- 50 value observed for *B. arundinacea* in the present investigation is in conformity with the observations of Sparrow and Sparrow (1965) who opined that woody species are more sensitive to radiation. Kapoor (1981) has also observed lower LD-50 of 20 *kR* for seed germination in *Eucalyptus*. However, Goel (1987) has reported higher LD-50 of 60 *kR* for *Acacia auriculiformis*, *A.nilotica* and *Prosopis juliflora*.

On the basis of seed germination, seedling survival and LD-50 estimations, it is evident that *Bambusa arundinacea* is a highly radio-sensitive species. This triggers further questions as to what factors could be attributed for its radio-sensitivity. It is hypothesised that the sensitivity could perhaps be due to its larger chromosome size, high chromosome number or polyploidy nature (*Bambusa* spp. are hexaploids with 2n=72, Varmah & Bahadur 1980). Gradual enhancement of radiation dose around LD-50 value might increase the probability of recovering superior and useful mutations.

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