Our Nature (2004) 2:13-17

Effect of Acute Exposure of Gamma Rays on Seed Germination and Seedling Growth of *Pinus kesiya* Gord and *P. wallichiana* A.B. Jacks.

C.B. Thapa

Department of Botany
School of Life Science
Northeastern Hill University
Shillong-793003, Meghalaya, India

Abstract

Present study deals with the effect of acute exposure of gamma rays on *Pinus kesiya* and *P. wallichiana*. Seeds were eradicated with a ^{60}cobalt sources emitting gamma rays at the rate of 2.8 kR/min. The seeds were given 1.0, 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0 kR exposures. Germination in control and treated seeds of both the species started simultaneously 26 days after sowing. In *P. kesiya* seeds exposed to 30kR germinated but in *P. wallichiana* 30 kR was lethal for seed germination and it was restricted up to 20 kR only. With increasing exposure root, hypocotyl and epicotyl elongation decreased in both the species. In *P. kesiya* more than 50% inhibition was induced by 10 kR but in *P. wallichiana* this exposure induced 100% inhibition of growth in all the cases. In both the species the intensity of inhibition increased with increasing exposures though lower exposure in some cases was stimulatory.

Keywords: Radiation exposure, gamma rays, ^{60}cobalt, intensity, stimulation, inhibition.

Introduction

The study of the effects of radiation on plants is a broad and complex field. Work is being done in many areas on a large number of plant species. Radiation has been found to affect the size and weight of plants. In many radiobiological reactions, the effect of a given dose depends on the intensity of radiation or the manner in which the total dose in fractioned (i.e., the time intensity factor).

Gamma rays are known to influence plant growth and development by inducing cytological, genetical, biochemical, physiological and morphogenetic changes in cells and tissues (Gunckel and Sparrow 1961). Rudolph (1971) studied radio sensitivity of *Pinus* spp. growing in USA and found that significant difference occur even between closely related species.

Several workers have studied effect of gamma rays on seed germination of Gymnosperms. The higher exposures were usually inhibitory (Bora 1961, Radhadevi and Nayar 1996, Kumari and Singh 1996), whereas lower exposures were sometimes stimulatory (Torne and Desai 1964,Taylor 1968, Sparrow 1966, Mujeeb 1974, Mathew and Gaur 1975, Mujeeb and Greig 1976, Raghava and Raghava 1989 , Thapa 1999).

Gunckel (1957) pointed out that the results from one species or varieties should not be applied to others as different types of responses are to be expected in different plants or even at different stages of development in

* Current add: Department of Botany, P.N. Campus (T.U.), Pokhara, Nepal

the same plant. Iqbal (1969) considered that radiation induced growth abnormalities were mainly due to cell death and suppression of mitosis at different exposures. On the light of above facts present study was carried out to evaluate the effect of gamma rays on seed germination and various growth parameters of *P. kesiya* and *P. wallichiana.*

Materials and Methods

Dry seeds of *P. kesiya* and *P. wallichiana* were irradiated at Bhabha Atomic Research Centre (BARC), Trombay (India) with a ^{60}cobalt source emitting gamma-rays at the rate of 2.8 kR per minute. The seeds were given 1.0, 2.5, 5.0, 10.0, 15.0, 20.0 and 30.0 kR exposures. The irradiated seeds were flown to Shillong and sown in the pots filled with 1:1 mixture of farmyard manure (FYM) and garden soil. The pots were kept in a waterproof net house and watered every alternate day to maintain sufficient moisture required for the germination of seeds. Emergence of radicle was taken as index of seed germination.

Growth observations both on the control and irradiated seedlings were recorded at 30, 60 and 120 days after germination (DAG) of seeds. The parameters taken into consideration were root length, hypocotyl length, and epicotyl length of both *P. kesiya* and *P. wallichiana*. Per treatment ten replicates were used.

$$\frac{\text{Control} - \text{treated}}{\text{Contol}} \times 100$$

Percent inhibition/stimulation over control was calculated as follows:

Results

Effect on germination

Germination in the control as well as in the treated seeds of *P. kesiya* and *P. wallichiana* started simultaneously 26 days after sowing (DAS). In *P. kesiya* seeds exposed to 30 kR germinated whereas in *P. wallichiana* 30 kR was lethal and seed germination was restricted up to 20 kR only. Mortality of the seedlings became evident with progression of time in both the species. At the end of four month in *P. kesiya* seedlings exposed up to 10.0 kR were survived but the survival rate in *P. wallichiana* was up to 5.0 kR only. It indicated that 15.0 kR and 10.0 kR were lethal for *P. kesiya* and *P. wallichiana*, respectively (Table-1).

Effect on roots length

Effect of gamma rays on the root length of *P. kesiya* and *P. wallichiana* is shown in Table-1. In both the species, at early stage of growth, root elongation was inhibited by gamma-rays exposures. This inhibition increased as the dose of exposure increased. But at the end of four month the percent of root elongation increased compared with control. This increase in percentage was high in lower exposure but decreased order as the rate of exposure is increased. In *P. kesiya* more than 50% inhibition was induced by 10.0 kR exposures of gamma rays but this exposure was not lethal. However, in *P. wallichiana* 10.0 kR exposure proved to be lethal exposure for root elongation.

Effect on hypocotyl

Effect of gamma-rays exposure on hypocotyl length of *P. kesiya* and *P. wallichiana* was evaluated and the data is shown in Table-1. In both the species, at early stage of growth, hypocotyl elongation was inhibited by gamma-rays exposure. This inhibition increased as the dose of exposure increased. But after 60 DAG lower exposure

Table 1: Effect of gamma rays exposure on root, hypocotyl and epicotyl length of *Pinus* spp. on 30,60 and 120 days after germination (DAG).

Treatments	Root Length cm						Hypocotyl Length cm						Epicotyl Length Cm					
	P. kesiya			*P. wallichiana*			*P. kesiya*			*P.wallichiana*			*P. kesiya*			*P. wallichiana*		
	30	60	120	30	60	120	30	60	120	30	60	120	30	60	120	30	60	120
	5.5	7.4	9.1	5.0	5.8	9.9	4.4	4.5	4.4	4.9	4.4	3.7	*	1.4	12.4	*	0.5	3.1
Control	±1.7	±1.9	±2.2	±1.6	±1.7	±2.2	±1.5	±1.5	±1.5	±1.6	±1.5	±1.4		±0.8	±2.5		±0.5	±1.3
	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)	(0.0)		(0.0)	(0.0)		(0.0)	(0.0)
1.0 kR	5.8	9.1	12.7	4.8	5.2	11.8	4.0	4.6	4.9	4.4	4.6	4.9	*	2.0	14.4	*	0.3	2.1
	±1.7	±2.2	±2.5	±1.6	±1.6	±2.5	±1.4	±1.5	±1.6	±1.5	±1.5	±1.6		±1.0	±2.7		±0.03	±1.1
	+(5.5)	+(23.0)	+(39.6)	-(4.0)	-(10.3)	+(19.2)	-(9.1)	+(2.2)	+(11.4)	-(10.2)	+(4.5)	+(32.4)		+(42.9)	+(16.1)		-(40.0)	-(32.3)
2.5 kR	5.0	6.9	11.1	4.5	4.8	10.5	4.0	3.9	4.6	4.3	4.3	4.4	*	1.3	8.4	*	0.1	2.2
	±1.6	±1.9	±2.4	±1.5	±1.6	±2.3	±1.4	±1.4	±1.5	±1.5	±1.5	±1.5		±0.4	±2.1		±0.01	±1.1
	-(9.1)	-(6.8)	+(22.0)	-(10.0)	-(17.2)	+(6.1)	-(8.6)	-(13.3)	+(4.5)	-(12.2)	-(2.3)	+(18.9)		-(7.1)	-(32.3)		-(80.0)	-(29.0)
5.0 kR	4.3	5.3	9.7	4.4	4.5	10.3	3.5	3.7	3.7	2.2	3.4	3.3	*	0.9	8.0	*	*	1.6
	±1.5	±1.6	±2.2	±1.5	±1.5	±2.3	±1.3	±1.4	±1.4	±1.1	±1.3	±1.3		±0.07	±2.0			±0.9
	-(21.8)	-(28.4)	+(6.6)	-(12.0)	-(10.0)	+(4.0)	-(19.5)	-(17.8)	-(15.9)	-(55.1)	-(22.7)	-(10.8)		-(35.7)	-(35.8)			-(48.4)
10.0 kR	2.5	3.8	8.3	*	3.7	•	3.4	3.4	3.3	*	3.5	•	*	0.5	5.7	*	0.1	•
	±1.1	±1.4	±2.1		±1.4		±1.3	±1.3	±1.3		±1.3			±0.05	±1.7		±0.01	
	-(54.5)	-(48.6)	-(8.8)		-(36.2)		-(22.7)	-(24.4)	-(25.0)		-(20.5)			-(64.0)	-(54.0)		-(80.0)	
15.0 kR	1.1	2.2	•	*	•	•	1.8	1.3	•	*	•	•	*	0.4	•	*	•	•
	±0.3	±1.1					±1.0	±0.4						±0.04				
	-(80.0)	-(70.3)					-(59.1)	-(71.1)						-(71.4)				
20.0 kR	*	•	•	*	•	•	*	•	•	*	•	•	*	•	•	*	•	•
30.0 kR	*	•	•	Δ	Δ	Δ	*	•	•	Δ	Δ	Δ	*	•	•	Δ	Δ	Δ

(Mean ± CL, n=10, p = 0.05, t = 2.26)
Δ = no germination, * = no growth, • = no survival
(The percent stimulation or inhibition in the parentheses)

(1.0 kR) was found stimulatory in both the species, although other doses of exposure showed inhibition in hypocotyl elongation. Further at the end of four months the percent of hypocotyl elongation increased up to 2.5 kR exposure in both the species. In the treated species early stage of growth as well as higher dose were inhibitory. These stimulation inhibitions were found more in *P. wallichiana* than *P. kesiya*.

Effect on epicotyl

In the case of epicotyl elongation both *P. kesiya* and *P. wallichiana* were found highly sensitive to gamma-rays exposures. Only in *P. kesiya* lower exposure (1.0 kR) stimulated epicotyl elongation but this stimulation decreased as the dose of gamma-rays exposure as well as time increased. In *P. wallichiana* all treatments showed inhibition in eplocotyl elongation. Percent of inhibition was found more in *P. wallichiana* than *P. kesiya*.

Discussion

It was observed during the present study that germination in the control as well as irradiated seeds of *P. kesiya* and *P. wallichiana* started simultaneously 26 days after sowing. In *P. kesiya* seeds exposed up to 30.0 kR alone germinated, but in *P. wallichiana* 30.0 kR was lethal and seeds exposed up to 20.0 kR alone germinated. The higher exposures are usually inhibitor on seed germination of Gymnosperm and Angiosperm (Saric *et al.* 1961, Akhaury and Singh 1993, Thapa 1999), whereas lower exposures are sometimes stimulatory (Taylor 1968, Chauhan 1978, Chauhan and Singh 1980). At the end of four months in *P. kesiya* seedlings exposed to 1.0-10.0 kR exposures of gamma-rays survived but in *P. wallichiana* the survival was restricted up to 5.0 kR only. Therefore compared to *Pinus kesiya*, *P. wallichiana* was more radiosensitive.

With increasing exposure the rate of root elongation decreased in both the species. In *P. kesiya* more than 50% inhibition was induced by 10.0 kR exposure of gamma rays but this exposure was not lethal. However in *P. wallichiana* 10.0 kR exposure proved to be lethal for root elongation. Compared to roots the hypocotyl elongation was less sensitive in *P. kesiya*. But in *P. wallichiana* root and hypocotyl died and had no differential sensitivity as was evident from the fact that 10.0 kR exposure induced 100% inhibition of growth in all the cases. Epicotyl elongation was also inhibited by all the exposures of gamma rays and the inhibition increased with the increasing exposure. In this case also *P. wallichiana* proved to be more sensitive than *P. kesiya*. Variation in the radio sensitivity of plants at interfamily, interspecific and intraspecific levels are reported (Sparrow 1966, Gunckel 1957). Retardation of growth process is one of the most common responses of plant subjected to ionizing radiation. This is particularly true for the radiosensitive tree of *P. kesiya* and *P. wallichiana* of this investigation. The pattern of radiation damage was similar to that described by Chauhan (1978) and Bora (1961).

Thus from the present investigation it can be concluded that compared to *P. kesiya*, *P. wallichiana* was more radiosensitive in all cases.

Acknowledgements

The author is grateful to Prof. Y.S. Chauhan, Department of Botany, North-Eastern Hill University, Shillong for guidance and to Prof. R.R. Mishra Head, Department of Botany, NEHU for providing the facilities.

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