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SHORT COMMUNICATION

Effect of gamma irradiation on seed germination and plant growth parameters of three rice varieties cultivated in Sri Lanka

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ABSTRACT

Development of rice varieties using induced mutation has seldom been applied in Sri Lanka. This study was carried out to determine the effect of gamma irradiation doses on seed germination and different plant growth parameters of three rice varieties in Sri Lanka. Two hundred grams of seeds of three rice varieties (Bg 94–1, Bg 1165–6, Suwandal) were irradiated varying doses of 200, 300 and 400 Gy using ^{60}Co Gamma Cell Irradiator facility at the International Atomic Energy Agency (IAEA) laboratories Seibersdorf, Austria. The experiment was designed as split plot with three replications and conducted at the plant house of Rice Research and Development Institute, Batalagoda. The effects of gamma irradiation on seed germination and different plant growth parameters were evaluated (radio sensitivity testing). With the increase in gamma doses, seed germination, seedling emergence, seedling height, root length, and plant survival in the field were declined. Significant ($P<0.05$) differences were observed between different varieties in seedling height, root length and percentage of field survival. Gamma irradiation showed significant ($P<0.05$) negative correlation with seed germination (–0.52), seedling emergence (–0.54), seedling height (–0.54), root length (–0.50) and field survival (–0.42). Percentage of survival in the field was the least affected while the percentage reduction was 8.56. The most efficient and optimum dose to induce rice mutation of the varieties under investigation is within the range of 200 – 300 Gy. More pronounced adverse effect was observed for all the growth characters at the highest dose in all three varieties. Increasing doses above 400 Gy caused severe morphological damages to the rice plants and increased doses of gamma irradiation have a negative correlation with germination and other parameters of plant growth. A comprehensive study should be carried out to determine the optimum doses for different rice varieties that could be useful in rice varietal improvement programmes in Sri Lanka.

Keywords*: Rice, gamma irradiation, correlation, mutation, growth parameters*

INTRODUCTION

Improvement of rice crops in Sri Lanka is mainly relied upon on conventional approaches of screening, hybridisation and germplasm selection. By conventional breeding, 84 high yielding and adaptable varieties have been released to the date. The combination of mutation breeding and conventional breeding methods should permit the breeder to derive the benefits of both the sources of variation to recover improved genotypes. Mutation has been successfully employed in breeding of several food crop varieties, ornamentals and export crops in the worldwide. Past research in mutation breeding reported seedling height, survival rate and production of tillers as important characteristics to improve for optimum

yields (Katoch *et al.*,1992). Though, a slight attention has been given to develop rice varieties by induced mutation in Sri Lanka. For example, mutation breeding activities in Sri Lanka led to release one rice variety called MI 273 in 1971. Moreover, information of the research related to irradiation of rice varieties is minimum. This study was therefore carried out on three Sri Lankan rice varieties to determine the effect of gamma irradiation on seed germination and different plant growth parameters that could be useful in rice varietal improvement programmes.

METHODOLOGY

Two hundred grams of seeds of three rice varieties (Suwandal, Bg 94–1 and Bg 1165–6) were subjected to gamma rays from ^{60}Co source using 3 doses of 200, 300 and 400 Gy. Irradiation was undertaken at the International Atomic Energy Agency (IAEA) laboratories Seibersdorf, Austria in 2014. Non irradiated seeds were used as the control for each variety. The experiment was designed as split plot with three replications and conducted at the plant house of Rice Research & Development Institute, Batalagoda in November 2014. Hundred seeds by doses and varieties of irradiated and non- irradiated rice varieties were sown in three replications per treatment on sand beds in 28 x 40 cm size plastic trays. Each tray was filled with fine sandy loam soil. Seeds of each treatment by each variety was sown by four rows with the row spacing of 3 x 3 cm and intra-row spacing of 1 cm. Accordingly, 12 trays with three replications were prepared for four treatments. After seed sowing, seeds were covered with fine soil. On the basis of need, seedling trays were kept moist with water.

The seeds were observed daily for a period of 20 d from sowing. Percentage of seed germination was recorded for the first seven days and total seedling emergence was recorded at the 10th day after sowing (DAS). Seedling height was measured at 20 DAS. At the 20th day, 10 seedlings were randomly selected and carefully uprooted to measure the root length. Twenty days old seedlings were transplanted in the field with the spacing of 15 x 40 cm and one seedling per hill. The area of 4.0 x 7.8 m was demarcated by wire for all the treatments in the field for easiness of counting. The number of survived seedlings was counted at 28 days after transplanting (DAT) and the percentage of field survival was calculated as follows:

$$\%\ of\ survival\ in\ the\ field = \frac{(Number\ of\ survived\ seedlings\ 28\ DAT}{50\ seedlings\ transplanted\ at\ 20\ DAS)} \times 100$$

Statistical Analysis

Transformation of the arc-sin was carried out to analyse data percentage. The data collected were analysed using the procedure General Linear Model (GLM) in SAS computer software package version 9.1.

RESULTS AND DISCUSSION

Seed germination, seedling emergence, seedling height, root length, percentage field survival, correlation and percentage reduction are presented in Table 1 in conjunction with that of the 3 rice varieties, 3 gamma doses and un-irradiated control.

Seed Germination

According to the results, germination percentage decreased after gamma irradiation. The decrease in germination was not directly proportional to the increase in dosage at 7 DAS. Mean percentage germination was acceptable level for Suwandal, Bg 94–1 and Bg 1165–6 at the doses of 200 and 300 Gy. At 400 Gy, the germination percentage was less than 85%. The minimum germination percentage recorded was 72.33 and that was for Bg 1165–6. Increased doses of gamma irradiation were shown to have a significant negative effect on seed germination. Harding *et al*. (2012) and Akbar and Barbar (2003) reported similar results in rice.

Seedling emergence

There was a definite pattern in decrease in percentage of seedling emergence to the increase in dosage. The percentage of seedling emergence decreased significantly ($P<0.05$) at 400 Gy in all three varieties. Similar pattern of response was observed for the seed germination.

Seedling height

The results of this study showed that increased doses from 0 to 400 Gy had a significant adverse effect on the height of the seedling. Further this study showed the seedling height variation in different varieties that primarily exist as a varietal character also exhibited similarly in mutated seeds. The highest mean seedling height recorded was 17.12 cm for Suwandal. Moreover, a drastic reduction in seedling height was observed at 400 Gy for Bg 1165–6. The reduction in seedling height with increased gamma doses is in agreement with the results of Muhammad *et. al*. (2003) and Sasikala and Kalairasi (2010).

Root length

Study of root length variation in this study showed that the reduction of root length with increased gamma doses. There was no significant variation in root length from 0 to 300 Gy doses while root development inhibition in all three varieties was higher in the dose of 400 Gy. Similar results have obtained from Sasikala and Kalairasi (2010) and Akbar and Baber (2003).

Percentage of field survival

According to the results, field survival declined with increased dose of irradiation. At 300 and 400 Gy, it was observed a significant ($P<0.05$) effect on field survival over the un-irradiated control.

Table 1: Effect of gamma irradiation on seed germination and different plant growth parameters of three rice varieties and response to increasing doses.

Parameter	Variety	Treatment/Gamma ray dose (Gy)					Response to increasing doses	
		0 (Un-irradiated)	200	300	400	Mean	Correlation	Reduction (%)
Mean % germination (7 DAS)	Suwandal	93.00	87.00	91.00	81.00	88.00[a]	(–0.52)*	20.3
	Bg 94-1	91.66	93.33	87.00	73.00	86.25[a]		
	Bg 1165-6	93.00	89.00	88.66	67.33	84.50[a]		
	Mean	*92.55[a]*	*89.77[a]*	*88.88[a]*	*73.77[b]*			
Seedling emergence % at 10 DAS	Suwandal	94.33	89.66	92.66	82.33	89.75[a]	(–0.54)*	17.8
	Bg 94-1	92.33	94.66	88.66	75.66	87.83[a]		
	Bg 1165-6	93.66	89.33	90.66	72.33	86.50[a]		
	Mean	*93.44[a]*	*91.22[a]*	*90.66[a]*	*76.77[b]*			
Seedling height (cm) at 20 DAS	Suwandal	19.31	17.27	16.73	15.17	17.12[a]	(–0.54)*	24.8
	Bg 94-1	15.39	15.26	14.23	14.19	14.77[b]		
	Bg 1165-6	16.79	14.73	13.98	9.36	13.70[b]		
	Mean	*17.16[a]*	*15.75[ab]*	*14.98[b]*	*12.90[c]*			
Root length (cm) at 20 DAS	Suwandal	4.84	4.49	4.37	3.61	4.33[b]	(–0.50)*	24.0
	Bg 94-1	5.32	5.06	5.62	4.15	5.04[a]		
	Bg 1165-6	5.72	5.08	4.11	4.30	4.80a[b]		
	Mean	*5.29[a]*	*4.88[a]*	*4.70[ab]*	*4.02[b]*			
Field survival % at 28 DAS	Suwandal	90.50	85.50	84.50	80.00	85.13[b]	(–0.42)*	8.6
	Bg 94-1	95.50	92.00	95.50	93.50	94.13[a]		
	Bg 1165-6	94.50	90.00	82.50	83.00	87.50[b]		
	Mean	*93.50[a]*	*89.16[ab]*	*87.50[b]*	*85.50[b]*			

Mean values of both columns and rows followed by same letters (superscript) are not significantly different by the DMRT at $P \leq 0.05$.
Reduction was the mean difference among 400 and 0 Gy doses and calculated as a percentage to the control.

All three varieties showed a survival rate of over than 85% in the field while the highest mean was recorded as 94.13% for Bg 94–1. Similar results were found by Akbar and Babar (2003) who worked on Basmathi rice and reported a decrease in plants survival in the field with an increase in irradiation dose.

Sensitivity of varieties to increasing gamma irradiation

Increasing doses of irradiation showed significant (P<0.05) negative correlations with all parameters tested. Thus seedling height and root length were greatly affected than other parameters tested. Survival at field condition in all three varieties was found to be the least affected character while 8.56 was recorded as a percentage reduction.

CONCLUSIONS AND RECOMMENDATIONS

This study showed that gamma irradiation can change the various desirable characters of rice varieties. The strength of the effectiveness depends on the irradiation dosage. It has been observed that varietal differences are not significant for germination and seedling emergence. The most efficient and optimal dosage to induce rice mutation can be predicted to be within the range of 200 – 300 Gy with the least negative impact on rice plants. More pronounced adverse effect was observed for all characters at the highest dose in three varieties. Moreover, increasing doses above 400 Gy caused severe morphological damages to the rice plants. Further increasing the doses of gamma irradiation has a negative correlation with the germination and other parameters of plant growth. A comprehensive study should be carried out to determine the optimum doses for Sri Lankan rice varieties. This information may be useful in rice varietal improvement programmes in Sri Lanka.

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