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Research Article

Impact of gamma radiations on wheat (*Triticum aestivum* L.) varieties (Batoor and Janbaz)

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Abstract

The present investigation was carried out to evaluate the effect of different doses of gamma rays (15, 25, 35 and 45 Krad) on various morphological and biochemical parameters of two wheat varieties (Batoor and Janbaz). A comparison of the results of different doses with control showed that gamma irradiations significantly affected various parameters. Days to germination were non-significantly delayed in Batoor while significantly decreased at 45 Krad in Janbaz. Germination percentage decreased significantly at 15 Krad in both varieties. Days to spike initiation significantly decreased at 45 Krad in Batoor but increased significantly at 45 Krad in Janbaz variety. Days to spike maturation were increased significantly at 45 Krad in both varieties. Plant height increased significantly at 15 Krad but decreased expressively at 25 Krad and 35 Krad in Batoor. In Janbaz plant height increased significantly at 45 Krad but decreased at 35 Krad. Number of nodes/plant decreased significantly at various doses in Batoor. While in Janbaz number of nodes/plant increased significantly at 15 Krad. Gamma radiation significantly increased number of fertile tillers/plant at 15 Krad in Batoor and at 45 Krad in Janbaz. Number of spikes/plant increased significantly at 15 Krad in Batoor and at 45 Krad in Janbaz. Number of spikelets/spike increased at 15 Krad in Batoor while a decreasing trend was seen in Janbaz with increasing doses. Spike length was non-significantly affected by gamma radiation in Batoor variety. However spike length was significantly increased at 45 Krad in Janbaz. Number of grains/spike increased significantly at 15 Krad in Batoor but decreased significantly at higher doses in both varieties. 1000 grain weight significantly increased at 45 Krad in Batoor and at 15 Krad and 25 Krad in Janbaz. Biochemical analysis revealed that gamma irradiation decreased the ash contents significantly at all the doses in both varieties. Moisture contents decreased significantly in Batoor through gamma irradiation except at 45 Krad which showed non-significant effect. However, in Janbaz moisture contents increased significantly at 25 Krad. Proteins contents were non-significantly decreased in Batoor, while in Janbaz, proteins contents decreased significantly at 35 Krad.

Keywords: Gamma irradiation; Morphology; Biochemical; Batoor; Janbaz

Introduction

Triticum aestivum is a cultivated wheat species, also known as common wheat or bread wheat and is a member of family Poaceae. Wheat is the major source of food in Pakistan. Pakistan ranks 6th in terms of wheat production, 8th in terms of area but 59th in terms of yield. It adds 12.5% to the value added in agriculture and 2.9% to GDP [1]. Wheat is nutritious food which provides proteins, minerals, B-group vitamins and dietary fibers more in quantity than other cereal crop and help in preparation of different types of foods. In general, 70% carbohydrates, 12% water, 2% fat, 12% protein, 1.8% minerals and 2.2% crude fiber are found in the wheat grain kernel. The history of wheat (*Triticum aestivum* L.) improvement by acclimatization, selection and hybridization dates back to the remote past. Nowadays, mutation induction has become an established tool in plant breeding to supplement existing germplasm and to improve cultivars in definite traits [2]. Plants created using mutagenesis are known as mutagenic plants or mutagenic seeds. Mutation breeding has made an official release of over 2700 newly developed crop cultivars in about 170 species [3]. Most of the mutant varieties (64%) are developed using physical mutagens such as Gamma rays [4]. [5] obtained three high grain yielding and early maturing mutants by treating seeds of *Brassica juncea* L.cv.S-9 with the combine effect of gamma rays and chemical mutagen i.e., Ethyl methane sulphonate (EMS). [6] developed a new oil seed *Brassica napus* L.cv ABASIN-95 by induced mutation using gamma rays. [7] Studied the effect of higher doses (30 and 35 Krad) of gamma irradiation on different wheat varieties which created some abnormalities in plant for example, a tiller having two ears attached with each and/or prevalence of sterile ears etc.

Materials and methods

The M2 seeds of two wheat varieties i.e. Batoor and Janbaz were selected for the research project. These seeds were obtained from M1 plants in 2013-14. Gamma irradiation used was generated from the Cobalt-60 source, at Nuclear Institute for Food and Agriculture (NIFA) Peshawar, Pakistan. Wheat seeds (M0) were irradiated with 15, 25, 35 and 45 Krad while non-irradiated seeds of each variety were kept as control. An experiment was executed in 2013-2014; M0 plants resulted in M1 seeds which were subjected to experiment in the present study. This study aimed to evaluate the effect of gamma rays in M2 generation.

Field experiment

A field experiment was carried out in botanical garden, Department of Botany, Islamia College Peshawar, during 2014-2015. M2 Seeds of each dose were sown on 24 November 2014 in pots; all pots were equally spaced with equal soil contents in each pot. The experimental design was completely random with each dose having 5 replicates. Equal numbers of seeds were sown in all pots.

Parameters

The parameters i.e., days to germination, germination percentage, days to spike initiation, days to spike maturation, plant height, number of nodes per plant, number of fertile tillers per plant, number of spikes per plant, number of spikelets per spike, spike length, grains per spike, 1000 grain weight, ash percentage, moisture percentage and proteins percentage were studied during this experiment.

Statistical analysis

Experimental data was statistically analyzed for the Analysis of variation (ANOVA) and least significant difference (LSD) at $\alpha = 0.05$ using Statistics 10.0 software.

Proximate analysis

Proximate analysis of seeds was carried out at Nuclear Institute for Food and Agriculture (NIFA), Peshawar, Pakistan.

Results and discussion

Gamma irradiation, being known for its mutagenic effect also showed pronounced effect on M2 generation of wheat varieties. Both varieties responded to gamma rays in M2 generation. However, the response was non-conventional; following results explore the findings of present investigation.

Days to germination

It is noticeable from Table 1 that days to germination were non-significantly affected by gamma irradiation in Batoor while in Janbaz, days to germination increased from control (9 days) at 25 and 35 Krad (11 days in both) and decreased significantly at 45 Krad (7 days). An early germination was obtained in Janbaz at 45 Krad as compared to control. Similar results were observed by **[8]**, **[9]** in *Zea mays* L. and **[7]** in *Triticum aestivum* L.

Germination percentage

Table 1 show that the lowest germination percentage was recorded at 15 Krad in Batoor and Janbaz (84% and 74%) as compared to control (90% in both). Germination percentage was non-significantly affected at 45 Krad in both varieties as compared to control **[10]** as well observed decrease in germination percentage at radiation doses. **[11]** find that germination percentage decrease at higher irradiation doses. These results also confirm the finding of **[12]**. Similarly, **[13, 14]** obtained low germination percentage at irradiation doses.

Plant height (cm)

Table 1 show that in M2 generation of Batoor verity, the highest height was obtained at 15 Krad (67.6 cm) followed by 45 Krad (66.2 cm) as compared to control (61.5 cm). **[15]** observed the same trend. These results are in agreement with the finding of **[16]**. In Janbaz, plant height decreased with higher doses of irradiation i.e., 15 Krad (70.1 cm), 25 Krad (67.5 cm), and 35 Krad (63.4 cm). The highest height was obtained at 45 Krad (72.5 cm) as compared to control (70.6 cm). **[14, 17]** have already shown that irradiation doses decrease plant height.

Days to spike initiation

Table 1 shows that in Batoor, an early initiation at 45 Krad (109 days) was observed as compared to control (112 days). **[17]** likewise observed an early heading in wheat mutants. Janbaz showed a slight delay in days taken to initiation of spike with increasing radiation i.e., at 35 Krad (111 days), and 45 Krad (112 days) as compared to control (109 days). **[7]** observed the same trend. **[18]** observed that increasing irradiation doses delay initiation. These results also confirm the finding of **[3]**.

Days to spike maturation

In Batoor, as shown in Table 1, days to spike maturation were varying with radiation doses such as 25 Krad (149 days), 35 Krad (154 days) and 45 Krad (157 days) as compared to control (152 days). Similarly in Janbaz, the data showed that at 25 Krad (152 days) and 45 Krad (155 days) days were taken to maturation as compared to control (152 days). These results confirm the finding of **[19]**. An early maturity was observed at 25 Krad in both varieties as compared to control which confirm the finding of **[20]**. Higher irradiation doses of 45 Krad delayed spike maturation in both verities.

Table 1. Effect of gamma irradiation on different parameters of wheat verities (Batoor and Janbaz)

Radiation Doses	Days to germination		Germination %		Days to spike initiation		Days to spike maturation		Plant height in cm	
	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz
Control	9 a	9 b	95% a	90% a	112 a	109 b	152 bc	153 ab	61.5 b	70.6 b
15 Krad	10 a	10 ab	84% c	74% c	110 bc	110 ab	151 cd	152 b	67.6 a	70.1 b
25 Krad	10 a	11 a	89% b	87% ab	111 ab	110 ab	149 d	152 b	61.7 b	67.5 c
35 Krad	10 a	11 a	91% b	80% bc	111 ab	111 ab	154 b	153 ab	61.5 b	63.4 d
45 Krad	10 a	7 c	95% a	90% a	109 c	112 a	157 a	155 a	66.2 a	72.5 a
LSD α=0.05	1.6158	1.2516	2.5032	7.0554	1.9568	2.2076	2.5377	2.2851	2.2719	1.7675

Data are represented as Mean (n = 05). Means followed by different letter within the column are significantly different (P < 0.05). (ANOVA followed by Tukey LSD test)

Number of nodes/plant

Data in Table 2 show that in Batoor, the number of nodes/plant decreased significantly with maximum decrease at 45 Krad (5.9 nodes/plant) as compared to control (6.46 nodes/plant). [21] also observed a decreasing tendency in the number of nodes/plant with increasing radiation doses. In Janbaz, the number of nodes/plant improved significantly at 15 Krad (5.93 nodes/plant) as compared to control (4.43 nodes/plant). The number of nodes/plant decreased at higher doses i.e., 35 Krad (4.01 nodes/plant) and 45 Krad (4 nodes/plant) in Janbaz.

Number of fertile tillers/plant

Table 2 shows that in Batoor, the highest number of tillers/plant was obtained at 15 Krad (4.18 tillers/plant) as compared to control (3.08 tillers/plant). Lowest number of tillers was recorded at 45 Krad (3.05 tiller/plant). In Janbaz, the highest number of tillers was obtained at 45 Krad (8 tillers/plant) as compared to control (3.18 tillers/plant). [14] observed the stimulatory effect of all the doses of gamma rays on the number of fertile tillers/plant. Similar results were observed by [15].

Number of spikes/plant

Data in Table 2 shows that in Batoor, the trait was improved at 15 Krad (4.14 spikes/plant) but inhibited significantly at 45 Krad (3.05 spikes/plant) as compared to control (3.06 spikes/plant). Similarly, [15] observed an improvement in the number of spikes/plant at 15 Krad. In Janbaz, the efficient dose was 45 Krad (8 spikes/plant) as compared to control (3.18 spikes/plant). [13] obtained mutants that produce higher number of spikes/plant through irradiation doses. [19] already concluded that gamma irradiation up to 30 Krad has little or no Inhibitory effect on number of spikes/plant. [22] also observed variation in number of spikes/plant at different radiation doses.

Number of spikelets/spike

Table 2 indicate that in Batoor, radiation doses increased number of spikelets/spike with maximum at 15 Krad (55.12 spikelets/spike) as compared to control (47.38 spikelets/spike). However in Janbaz, number of spikelets/spike decreased significantly at 15 Krad (55.55 spikelets/spike) as compared to control (63.02 spikelets/spike). Number of spikelets/spike decreased at all doses in Janbaz. Janbaz variety shows co-linearity with the studies of various workers including [15, 19, 23] and in which they observed significant decrease of spikelet number in nearly all the radiation doses.

Denotation: B = Batoor J = Janbaz

Spike length (cm)

In Batoor, as shown in Table 2, gamma irradiation showed non-significant effect on spike length. In Janbaz variety an improvement in spike length with increasing radiation has been noticed with maximum

significance at 45 Krad (10.60 cm) in comparison with control (8.69 cm). [20] also observed variation in this trait at different doses. These results are in agreement with the findings of [22]. [19] also observed variation in spike length at different doses. However, [23] observed that gamma rays decreased the average spike length with respect to the control.

Table 2. Effect of gamma irradiation on different parameters of wheat verities (Batoor and Janbaz)

Radiation Doses	Number of nodes/plant		Number of fertile tillers/plant		Number of spikelets/spike		Spike length in cm	
	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz
Control	6.46 a	4.43 c	3.08 c	3.18 b	17.70 cd	21.15 a	9.13 a	8.69 c
15 Krad	6.15 ab	5.93 a	4.18 a	3.29 b	21.33 a	19.18 b	9.18 a	9.69 b
25 Krad	5.95 b	5.06 b	3.21 c	3.10 b	19.80 b	15.25 c	8.52 a	9.03 c
35 Krad	6.21 ab	4.0 c	3.54 b	3.47 b	18.45 c	16.02 c	8.58 a	9.00 c
45 Krad	5.9 b	4 c	3.05 c	8 a	17.30 d	14.10 d	9.53 a	10.60 a
LSD α=0.05	0.5086	0.6009	0.2388	0.5325	0.8797	0.9598	0.9585	0.3681

Data are represented as Mean (n = 05). Means followed by different letter within the column are significantly different (P < 0.05). (ANOVA followed by Tukey LSD test)

Number of grains/spike

Table 3 shows that in Batoor as compared to control (35 grains/spike) the number of grains increased significantly at 15 Krad (42 grains/spike) but decreased significantly in 45 Krad (26 grains/spike). While in Janbaz number of grains decreased at highest dose of 45 Krad (19 grains/spike) as compared to control (38.71 grains/spike). Higher irradiation doses decreased grain yield/spike in both varieties. The present findings are in agreement with the studies of [15, 19, 23] and who observed a regular decrease in this trait with the increasing intensity of gamma radiations.

Ash contents (%)

As shown in Table 3 irradiation doses significantly decreased ash contents (%) in Batoor; maximum mean value was for control (1.67%). Similarly in Janbaz, ash contents (%) decreased at 15 Krad (1.13%), 25 Krad (1.17%), 35 Krad (1.35%), and 45 Krad (1.17%) as compared to control (1.37%). [24] observed a decrease in ash contents (%) due to irradiation doses in Pigeon pea. [25] reported a decrease in ash content (%) of velvet bean seed

Moisture contents (%)

In Batoor, as shown in Table 3, highest mean value for moisture contents (%) was obtained in control (0.50%) while a significant decrease was observed at 35 Krad (0.28%). [26] also observed a decrease in moisture contents (%) with higher doses. In Janbaz a significant increase in moisture contents was obtained at 25 Krad (0.68%) as compared to control (0.35%). [24] observed the same trend.

Proteins contents (%)

Data in Table 3 shows that in Batoor, highest mean value for proteins was obtained at 15 Krad (13.16%) followed by control (13.01%). In Janbaz, mean value for proteins contents was maximum in control (13.97%) and decreased at 35 Krad (13.16%). This decrease could be due to partial nitrogen destruction at different doses. [27] also observed a decrease in proteins content at higher irradiation doses (Table 3).

Table 3. Effect of gamma irradiation on different parameters of wheat verities (Batoor and Janbaz)

Radiation Doses	Number of grains/spike		1000 grains weight (g)		Ash %		Moisture %		Proteins %	
	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz	Batoor	Janbaz
Control	35 c	38.71 a	32.1 c	34.4 b	1.67% a	1.37% a	0.50% a	0.35% c	13.01% a	13.97% a
15 Krad	42 a	35.06 b	33.8 bc	39.4 a	1.09% c	1.13% b	0.31% c	0.39% b	13.16% a	13.86% ab
25 Krad	35.8 bc	28.92 c	33.7 bc	38.2 a	0.84% d	1.17% b	0.38% b	0.68% a	12.82% a	13.58% ab
35 Krad	37 b	28.13 d	35.2 b	33.3 b	1.45% b	1.35% a	0.28% d	0.38% bc	12.86% a	13.16% b
45 Krad	26 d	19 e	44.6 a	30.5 c	1.45% b	1.17% b	0.49% a	0.35% c	12.84% a	13.69% ab
LSD α=0.05	1.3944	0.7432	2.0103	1.7407	0.1427	0.073	0.0274	0.0396	0.5723	0.7208

Data are represented as Mean (n = 05). Means followed by different letter within the column are significantly different (P < 0.05). (ANOVA followed by Tukey LSD test)

Conclusion

The present study concludes that gamma irradiation significantly affected various morphological parameters while biochemical attributes were non-significantly affected in M2 generation. The most significant dose was 15 Krad as it improved various morphological and biochemical parameters while the most inhabitant dose was 45 Krad due to its negative effect on various parameters in both verities. It is concluded that lower doses can be used for agricultural purposes to improve yield attributes of wheat.

Authors' contributions

Conceived and designed the experiment: WM Khan, Performed the experiment: S Ahmed, S Hussain & SS Shah, Analyzed the data: WM Khan, N Umar & S Ali, Contributed reagents/ materials/ analysis tools: MS Khan & N Akhtar, Wrote the paper: S Ahmed & WM Khan.

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